

# PATENT SPECIFICATION

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(19)



## (54) APPARATUS FOR CONTROLLING THE POSITION OF A VEHICLE COMPONENT

(71) We, CATERPILLAR TRACTOR Co., a Corporation organised and existing under the laws of the State of California, United States of America, of 100 N.E. Adams Street, Peoria, State of Illinois 61602, 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 apparatus for controlling the position of a vehicle component and may be used, for example, for selectively and automatically positioning buckets, blades, or other vehicle components on heavy equipment vehicles and the like.

Various types of control systems have been contemplated for providing automatic positioning of various vehicle components; for example, a bucket on a bucket loader. Typically, such positioning systems are hydraulically, mechanically or electrically controlled.

Hydraulic positioning systems suffer from control problems when malfunctions occur in the hydraulic system. For example, a leak in the slave cylinder or in the hydraulic circuits can cause bucket drifting simulating a slow dump. A broken supply line almost completely incapacitates the positioning control system. External repairs are time-consuming, particularly if the line to the tank has to be replaced. If an internal repair or adjustment has to be made in the hydraulic system, it is generally necessary to drain the hydraulic tank, which causes excessive down-time.

Electrical positioning systems overcome most of the inherent problems of the above-mentioned hydraulic systems, in that they are more reliable, more readily serviced, and are external and thus in-

dependent of the main hydraulic apparatus. However, most electrical positioning systems utilize micro-switch means mechanically coupled to cams, recessed rods, or the like, attached to the positioning hydraulic cylinder to indicate the position of the bucket. See for instance, U.S. Patent No. 3,420,393. Thus, the combination is subject to wear, dirt, and vibration common to earth-moving apparatus, with the associated maintenance and breakdown problems.

In addition, prior art electrical positioning systems fail to provide desired functioning flexibility in that no provisions are made to allow the operator to readily perform various operations, such as "fish tailing" i.e. rocking the bucket back and forth by repetitious movement of the control lever. Typical prior art electrical positioning systems provide the disadvantage of latching the operator controls in the "rack-back" position whenever the control lever is moved to the latter position, as when fish tailing. The operator must then manually override the latched condition. Accordingly, the operator must avoid moving the control lever to the rack-back position if he does not wish the lever be held in such position, which complicates the operator's handling of the vehicle, for example, as when performing the fish tailing action.

According to the invention, there is provided apparatus for controlling the position of a vehicle component which can be positioned by means of a hydraulic system including a hydraulic cylinder and a reciprocable cylinder rod coupled to the vehicle component, the apparatus comprising a control member operable to control the reciprocation of the cylinder rod and arranged to be self-returning from a selected operating position, an electromagnet disposed to latch the control

element in the selected operating position  
 when the electromagnet is energised, and  
 means responsive to reciprocation of the  
 cylinder rod for controlling the operation  
 of the latch comprising first and second  
 magnetic field responsive switches, mag-  
 netic field producing means being mounted  
 for reciprocation with the cylinder rod ad-  
 jacent the switches, and a control circuit  
 connected to said switches and to said  
 electromagnet for energising the elec-  
 tromagnet in response to movement of the  
 field producing means past the switches in  
 a first direction and for deenergising the  
 electromagnet in response to movement of  
 the field producing means past the  
 switches in a second direction opposite to  
 said first direction.

The preferred embodiment of the in-  
 vention provides an improved solid state  
 electronic control circuit for controlling the  
 tilt, position, attitude, or the like of a  
 selected component on a loader or grader  
 vehicle or the like. To this end, a control  
 lever is coupled to a self-centering control  
 valve, which selectively directs hydraulic  
 fluid to a tilt cylinder having a reci-  
 procatable rod coupled to the vehicle  
 component. An electromagnet is disposed  
 to hold or latch the lever in the "rack-  
 back" position when energized. The elec-  
 tromagnet is coupled to a solid state switch  
 assembly, which contains a pair of ad-  
 jacent, normally non-conducting switches,  
 and a control circuit adapted to distinguish  
 the component operating mode and to  
 selectively provide energizing current to the  
 electromagnet. The pair of switches are ad-  
 apted to become conductive when placed  
 in a magnetic field, which is selectively  
 provided by a permanent magnet secured  
 to the end of a rod which is, in turn,  
 secured to the reciprocable cylinder rod.  
 The magnet passes adjacent the switches  
 as the cylinder rod reciprocates.

During the rod extension, the magnet  
 successively passes adjacent the pair of  
 switches in one direction, which causes the  
 solid state control circuit to energize the  
 electromagnet. When the control lever is  
 then placed in the rack-back position,  
 it is held in such position by the elec-  
 tromagnet. Deenergization of the elec-  
 tromagnet occurs via the control circuit  
 when the hydraulic rod is retracted,  
 whereby the permanent magnet passes ad-  
 jacent the switches in the opposite direc-  
 tion. The control valve and the control  
 lever return to a neutral position, where-  
 upon further movement of the hydraulic  
 rod, and thus of the component, ceases.  
 Selected placement of the permanent mag-  
 net with respect to the degree of extension  
 of the hydraulic rod determines the pre-  
 selected position, tilt, orientation, etc. of

the vehicle component being controlled.

An embodiment of the invention will  
 now be described by way of example and  
 with reference to the accompanying draw-  
 ings, in which:

FIG. 1 is a simplified elevation of a  
 track-type loader vehicle with loader  
 bucket, including a component positioner  
 according to the invention;

FIG. 2 is a simplified electrohydraulic  
 schematic diagram of the component  
 positioner of FIG. 1; and

FIG. 3 is a schematic diagram of the  
 logic control circuit depicted in block form  
 in FIG. 2.

As shown in FIG. 1, a track-type loader  
 10 has a bucket 12 pivotally supported as  
 at 14 by one end of a pair of laterally  
 spaced lift arms, only one of which is  
 shown at 16. The lift arms 16 are pivotally  
 secured at their other ends to a pair of  
 laterally spaced towers integrally secured to  
 the loader frame, one of which is indicated  
 at 18. A hydraulic tilt cylinder 20, having  
 an extensible cylinder rod 22, is pivotally  
 connected between each tower 18 and the  
 bucket 12 via a tilt linkage, which includes  
 a lever 24 pivotally mounted to lift arm 16  
 and a link 26 connecting the lever 24 to  
 the bucket 12.

Regarding more particularly the  
 positioner apparatus, and referring to  
 FIGS. 1 and 2, a manually operable con-  
 trol lever 28 is located adjacent an oper-  
 ator's station 30, and is operably connected  
 to a spring-activated, self-centering con-  
 trol valve 32. The latter is designed to  
 selectively direct hydraulic fluid from a  
 pump source 34 to the tilt cylinder 20, to  
 control the position of the bucket 12. An  
 electromagnet 36 is suitably located,  
 whereby the control lever 28 can be  
 pivoted against the electromagnet and thus  
 be held in the "R" or "rack-back" position  
 when the electromagnet is energized.

The electromagnet 36 is connected by a  
 lead 38 to a switch assembly 40, containing  
 a pair of spaced-apart switches 42, 44. The  
 switch assembly 40 further includes a con-  
 trol circuit 46 (FIG. 3) which detects the  
 bucket operating mode and provides cur-  
 rent to selectively energize the elec-  
 tromagnet at predetermined points during  
 the bucket positioning and in dependence  
 on its direction of motion.

Switches 42, 44 are preferably solid state  
 switches which operate via the Hall effect,  
 and conduct current when placed in a  
 magnetic field. A magnetic field is  
 provided by a permanent magnet 48  
 secured to one end of a control rod 50, the  
 other end of the control rod 50 being de-  
 mountably attached to the extensible cylin-  
 der rod 22. The control rod 50, with at-  
 tached magnet 48, is disposed to pass ad-

jacent the switches 42, 44 as the rod 22 is extended and retracted.

Extension of rod 22 from the fully retracted rack-back position to the dump position, causes the magnet 48 to pass over switches 42 and 44 from left to right on the schematic of Fig. 2. As will be more fully explained with respect to a detailed description of the circuitry of FIG. 3, this action permits current to flow to the electromagnet 36.

Upon completion of the dump operation, the operator may place the control lever 28 in the "R" position, and since the electromagnet 36 is energized, the lever 28 will remain in this position until released by cessation of current to the electromagnet. Deenergization of the electromagnet 36 is provided by passage of magnet 48 over the switches 44, 42 from right to left on the schematic, as the rod 22 retracts to rotate the bucket 12 back from the dump position. The self-centering spring of the hydraulic control valve 32 then urges the control lever 28 to the "H" or hold position, stopping further retraction of the cylinder rod 22 and thus preventing further movement of the bucket 12. Suitable positioning of the magnet 48 with respect to the rod 22 will assure that the bucket 12 is stopped in the proper loading position to begin the next work cycle.

The solid state switch assembly 40 is connected by a lead 52 to the positive terminal of a battery 54. A fuse 56 is inserted between the assembly and the battery for circuit overload protection. The electromagnet 36 and the negative terminal of the battery are grounded. A hydraulic system pressure switch 58 is disposed between the battery and ground, and remains closed during the operation of the vehicle, but automatically functions to break the circuit when the vehicle is shut down. Similarly, the switch 58 may be operated by engine oil pressure, or other operating parameters. Additional switches, such as a master disconnect switch (not shown) may also be placed in the circuit as required.

A schematic diagram of an embodiment of the control circuit 46 contained within the solid state switch assembly 40 is shown in FIG. 3. A diode 70 providing reverse polarity protection is disposed in the positive lead 52. A zener diode 72 and a current-limiting resistor 74 are connected between the positive supply and ground to provide a predetermined reference voltage to the normally non-conducting switches 42 and 44. The output of switch 42 is connected via a limiting resistor 68 to the base of a first transistor 62, the emitter of which is connected to ground and the collector of which is connected to the positive supply via a resistor 76. A resistor 80 con-

24 23 24  
3  
nected between the base of transistor 62 and ground ensures that transistor 62 is held off when switch 42 is non-conducting. A second transistor 60 is connected between the positive lead 52 and the lead 38 to electromagnet 36.

The collector of transistor 62 is also connected to the base of an additional transistor 64, the collector of which is connected to the positive supply via a resistor 78. The emitter of transistor 64 is connected to the anode of a silicon controlled rectifier (SCR) 66, the cathode of which is connected to the base of transistor 60. The gate of the SCR 66 is connected to the output of switch 42, via a diode 82 and a limiting resistor 84 which provide high voltage and current protection respectively for the switch 44 when the SCR is conducting.

To prevent transient electric pulses from triggering the SCR 66, a capacitor 86 is placed between the anode and cathode thereof, and a capacitor 88 is similarly placed between its gate and cathode.

To provide a low potential to the base of transistor 60 and thereby assure that the transistor remains in a non-conducting state when the SCR 66 is nonconducting, a resistor 90 is placed between the base of the transistor and the lead 38. A diode 92, placed between the lead 38 and ground serves to eliminate induced transients arising when the current supplied to the electromagnet 36 is changed.

In operation, the above-described circuit functions in the following manner. With the bucket 12 loaded and in the rack-back position, rod 22 and consequently rod 50 attached thereto will be in retracted position. In the absence of a magnetic field in the proximity of the switches 42, 44, the switches are nonconducting, thereby preventing the application of a positive voltage to the base of the transistor 60. The absence of such a positive voltage prevents transistor 60 from conducting current to the electromagnet 36.

The circuit is thus inactive, and the operator is thus free to move the control lever 28 to the "D" or dump position to empty the bucket 12. The control valve 32 then directs pressurized fluid, as required, to the cylinder 20, and rod 22 begins an outward extension.

During extension, the permanent magnet 48, mounted on rod 50 which in turn is secured to rod 22 for movement therewith, first passes adjacent switch 42. When magnet 48 is directly adjacent switch 42, the switch will conduct current to the base of transistor 62 permitting the transistor to become conductive. Since the emitter of transistor 62 is grounded, the collector of transistor 62 and base of the transistor 64 will also be at substantially zero potential.

Transistor 64 will therefore be non-conductive. As the rod 22 continues its extension, the magnet 48 will move away from the switch 42, whereby current is no longer conducted to the base of the transistor 62 and the latter transistor becomes nonconductive. As a result, a positive voltage is thus provided to the base of transistor 64, permitting the transistor 64 to conduct current to the anode of the SCR 66.

The continued extension of rod 22 will next bring the magnet 48 directly opposite the switch 44 whereby current is conducted by the switch 44 to the gate of SCR 66. This will trigger the gate, enabling the SCR to conduit current to the base of the transistor 60. The SCR will continue to conduct as long as a current flows therethrough. With a positive voltage thus provided at its base, transistor 60 conducts current to the electromagnet 36 to energize the latter.

After completion of the dump operation, when the operator is desirous of returning the bucket 12 into position for another load, the control lever 28 is moved to the "R" or rack-back position. As electromagnet 36 is now energized, the lever 28 is held in the rack-back position until the electromagnet is deenergized or until its holding force is manually overridden by the operator.

The bucket 12 returns from the dump position as rod 22 retracts. The magnet 48 first passes adjacent the switch 44 to once again supply current to the gate of the SCR 66. Since the SCR is already conducting this action has no effect on the operation of the circuit, and the electromagnet 36 remains energized. As the rod 22 continues its retraction, the switch 44 becomes inoperative again. As magnet 48 passes directly adjacent the switch 42 it becomes conductive, and a positive voltage is supplied to the base of the transistor 62. The latter transistor thus becomes conductive, thereby interrupting the positive voltage present at the base of the transistor 64.

As a result, transistor 64 becomes non-conductive, and the SCR 66 turns off to this interrupt the current to the base of the transistor 60. Consequently, transistor 60 also becomes nonconductive and current flow to the electromagnet 36 is interrupted, causing the latter to deenergize. When this occurs, the self-centering spring of the hydraulic control valve 32 urges the control lever 28 to the "H" or hold position, thus stopping further retraction of the rod 22. Such action occurs at a predetermined position of the rod 22 such that the bucket 12 is in the desired position for subsequent loading or digging.

It may be seen that, with a loaded bucket 12 in the rack-back position, the

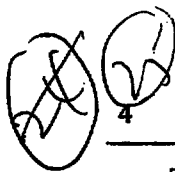
operator may dump the load by moving control lever 28 to the dump position. As the load is being dumped, the electromagnet 36 is energized when the magnet 48 passes adjacent the magnetic field sensitive switches 42, 44 from left to right on the schematic.

Having dumped the load, the operator may retract the bucket 12 from the dump position by moving the control lever 28 to the rack-back position. Because the electromagnet is now energized, the lever 28 is maintained in the latter position until the magnet 48 passes adjacent the switches 44, 42 proceeding from the opposite direction, i.e. from right to left on the schematic. As this occurs, the electromagnet 36 is deenergized and the bucket 12 automatically stops in the proper loading position, ready to begin the next work cycle, without direction from the operator subsequent to his placing the lever 28 in the rack-back position.

It is to be noted that the arrangement described above will allow the operator to "fish tail" the bucket 12 to facilitate the loading operation without interference from the rack-back detent apparatus. Fish tailing is the operation wherein the bucket 12 is rocked back and forth by the repetitious movement of the control lever 28 from the rack-back to the dump position. Fish tailing is unhindered by the described bucket positioner since bucket movement is normally limited to movement between the loading position and the full rack-back position during the fish tailing operation. Although the control lever is moved to the dump position, the bucket never fully reaches the dump position and the electromagnet 36 is never energized in this mode. Thus, there is no effect on the movement of the lever 28, i.e. the lever is not latched via the electromagnet.

#### WHAT WE CLAIM IS:—

1. Apparatus for controlling the position of a vehicle component which can be positioned by means of a hydraulic system including a hydraulic cylinder and a reciprocable cylinder rod coupled to the vehicle component, the apparatus comprising a control member operable to control the reciprocation of the cylinder rod and arranged to be self-returning from a selected operating position, an electromagnet disposed to latch the control element in the selected operating position when the electromagnet is energized and means responsive to reciprocation of the cylinder rod for controlling the operation of the latch comprising first and second magnetic field responsive switches, magnetic field producing means being mounted for reciprocation with the cylinder rod adjacent the switches, and a control circuit



Transistor 64 will therefore be non-conductive. As the rod 22 continues its extension, the magnet 48 will move away from the switch 42, whereby current is no longer conducted to the base of the transistor 62 and the latter transistor becomes nonconductive. As a result, a positive voltage is thus provided to the base of transistor 64, permitting the transistor 64 to conduct current to the anode of the SCR 66.

The continued extension of rod 22 will next bring the magnet 48 directly opposite the switch 44 whereby current is conducted by the switch 44 to the gate of SCR 66. This will trigger the gate, enabling the SCR to conduit current to the base of the transistor 60. The SCR will continue to conduct as long as a current flows therethrough. With a positive voltage thus provided at its base, transistor 60 conducts current to the electromagnet 36 to energize the latter.

After completion of the dump operation, when the operator is desirous of returning the bucket 12 into position for another load, the control lever 28 is moved to the "R" or rack-back position. As electromagnet 36 is now energized, the lever 28 is held in the rack-back position until the electromagnet is deenergized or until its holding force is manually overridden by the operator.

The bucket 12 returns from the dump position as rod 22 retracts. The magnet 48 first passes adjacent the switch 44 to once again supply current to the gate of the SCR 66. Since the SCR is already conducting this action has no effect on the operation of the circuit, and the electromagnet 36 remains energized. As the rod 22 continues its retraction, the switch 44 becomes inoperative again. As magnet 48 passes directly adjacent the switch 42 it becomes conductive, and a positive voltage is supplied to the base of the transistor 62. The latter transistor thus becomes conductive, thereby interrupting the positive voltage present at the base of the transistor 64.

As a result, transistor 64 becomes non-conductive, and the SCR 66 turns off to this interrupt the current to the base of the transistor 60. Consequently, transistor 60 also becomes nonconductive and current flow to the electromagnet 36 is interrupted, causing the latter to deenergize. When this occurs, the self-centering spring of the hydraulic control valve 32 urges the control lever 28 to the "H" or hold position, thus stopping further retraction of the rod 22. Such action occurs at a predetermined position of the rod 22 such that the bucket 12 is in the desired position for subsequent loading or digging.

It may be seen that, with a loaded bucket 12 in the rack-back position, the

operator may dump the load by moving control lever 28 to the dump position. As the load is being dumped, the electromagnet 36 is energized when the magnet 48 passes adjacent the magnetic field sensitive switches 42, 44 from left to right on the schematic.

Having dumped the load, the operator may retract the bucket 12 from the dump position by moving the control lever 28 to the rack-back position. Because the electromagnet is now energized, the lever 28 is maintained in the latter position until the magnet 48 passes adjacent the switches 44, 42 proceeding from the opposite direction, i.e. from right to left on the schematic. As this occurs, the electromagnet 36 is deenergized and the bucket 12 automatically stops in the proper loading position, ready to begin the next work cycle, without direction from the operator subsequent to his placing the lever 28 in the rack-back position.

It is to be noted that the arrangement described above will allow the operator to "fish tail" the bucket 12 to facilitate the loading operation without interference from the rack-back detent apparatus. Fish tailing is the operation wherein the bucket 12 is rocked back and forth by the repetitious movement of the control lever 28 from the rack-back to the dump position. Fish tailing is unhindered by the described bucket positioner since bucket movement is normally limited to movement between the loading position and the full rack-back position during the fish tailing operation. Although the control lever is moved to the dump position, the bucket never fully reaches the dump position and the electromagnet 36 is never energized in this mode. Thus, there is no effect on the movement of the lever 28, i.e. the lever is not latched via the electromagnet.

#### WHAT WE CLAIM IS:—

1. Apparatus for controlling the position of a vehicle component which can be positioned by means of a hydraulic system including a hydraulic cylinder and a reciprocable cylinder rod coupled to the vehicle component, the apparatus comprising a control member operable to control the reciprocation of the cylinder rod and arranged to be self-returning from a selected operating position, an electromagnet disposed to latch the control element in the selected operating position when the electromagnet is energized and means responsive to reciprocation of the cylinder rod for controlling the operation of the latch comprising first and second magnetic field responsive switches, magnetic field producing means being mounted for reciprocation with the cylinder rod adjacent the switches, and a control circuit



connected to said switches and to said electromagnet for energising the electromagnet in response to movement of the field producing means past the switches in a first direction and for deenergising the electromagnet in response to movement of the field producing means past the switches in a second direction opposite to said first direction.

- 10 2. Apparatus as claimed in claim 1 wherein the control member comprises a manually pivotable control lever operatively coupled to a self-centering control element of a hydraulic control valve  
15 adapted to control the flow of hydraulic fluid to said hydraulic cylinder.

3. Apparatus as claimed in claim 1 or 2 wherein said switches are normally conductive and are actuated into a conductive state when the field producing means passes adjacent them, said control circuit being arranged to energise the electromagnet when the second switch becomes conductive and to deenergise the electromagnet when the first switch becomes conductive.

4. Apparatus as claimed in claim 3 wherein the control circuit includes a first transistor arranged to be non-conductive  
30 when the first switch is non-conductive and conductive when the first switch is conductive and a second transistor connected to energise the electromagnet in response to the second switch becoming conductive

when the first transistor is non-conductive 35 and to deenergise the electromagnet in response to the first transistor becoming conductive.

5. Apparatus as claimed in claim 4 including a silicon controlled rectifier 40 coupled to the second switch and connected to render conductive the second transistor in response to the second switch becoming conductive.

6. Apparatus as claimed in claim 5 45 wherein the first switch is coupled to the base of the first transistor, and including an additional transistor whose base is coupled to the collector of the first transistor and whose emitter is coupled to the anode of the silicon controlled rectifier, the base of the second transistor being coupled to the cathode of the silicon controlled rectifier and the emitter of the second transistor being coupled to the elec- 55 tromagnet, the gate of the silicon controlled rectifier being coupled to the second switch.

7. Apparatus for controlling the position of a vehicle component substantially 60 as herein described with reference to the accompanying drawings.

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