

Jan. 6, 1970

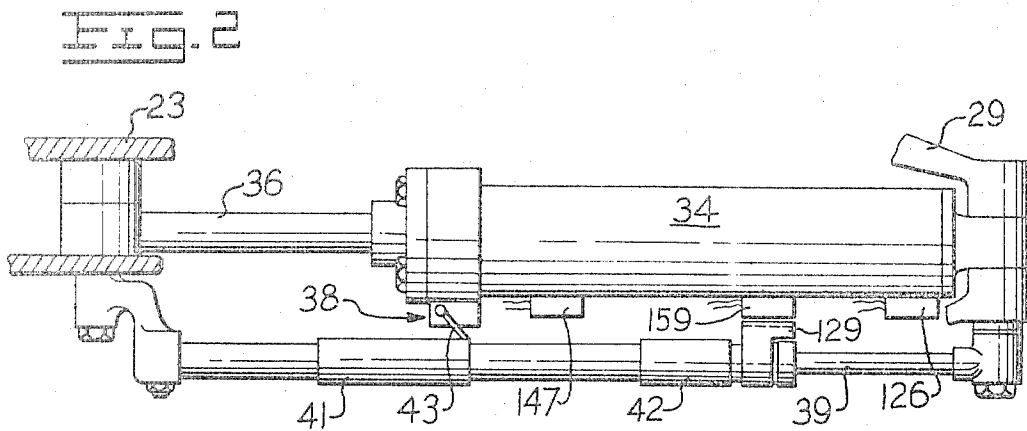
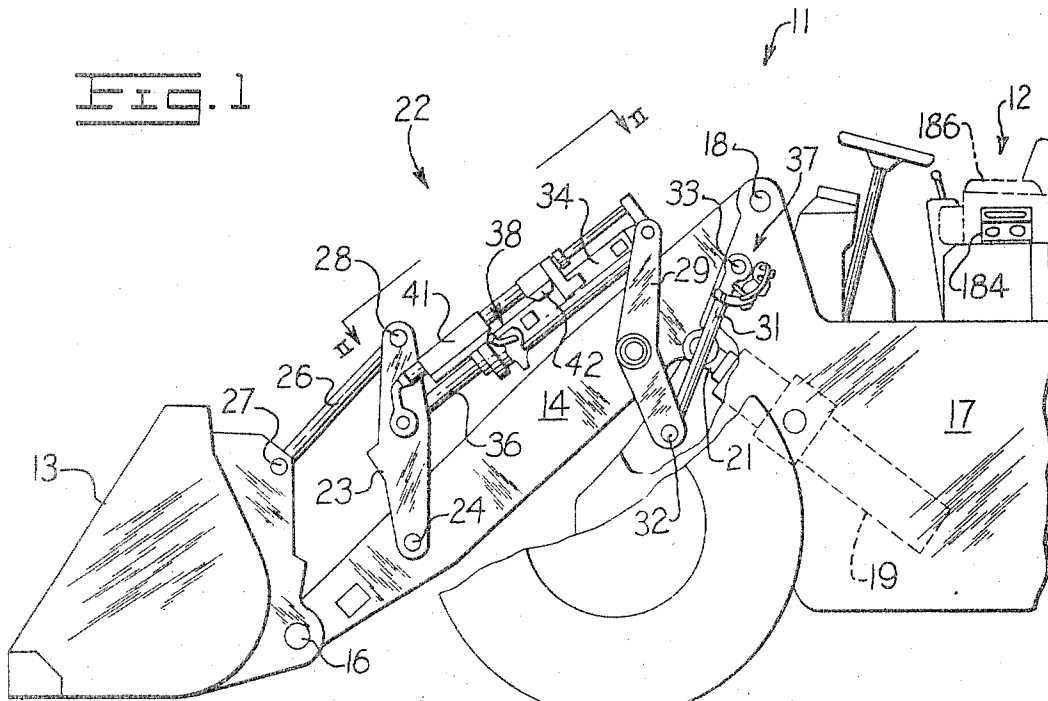
D. L. SHOOK ET AL

3,487,958

SELF-CYCLING LOADER

Filed Jan. 31, 1968

5 Sheets-Sheet 1



INVENTORS
DONALD L. SHOOK
PHILIP J. COSTA
BERNARD J. McGUIRE, JR.

BY

Fryer, Bismarck, Reis, Phillips & Lempis
ATTORNEYS

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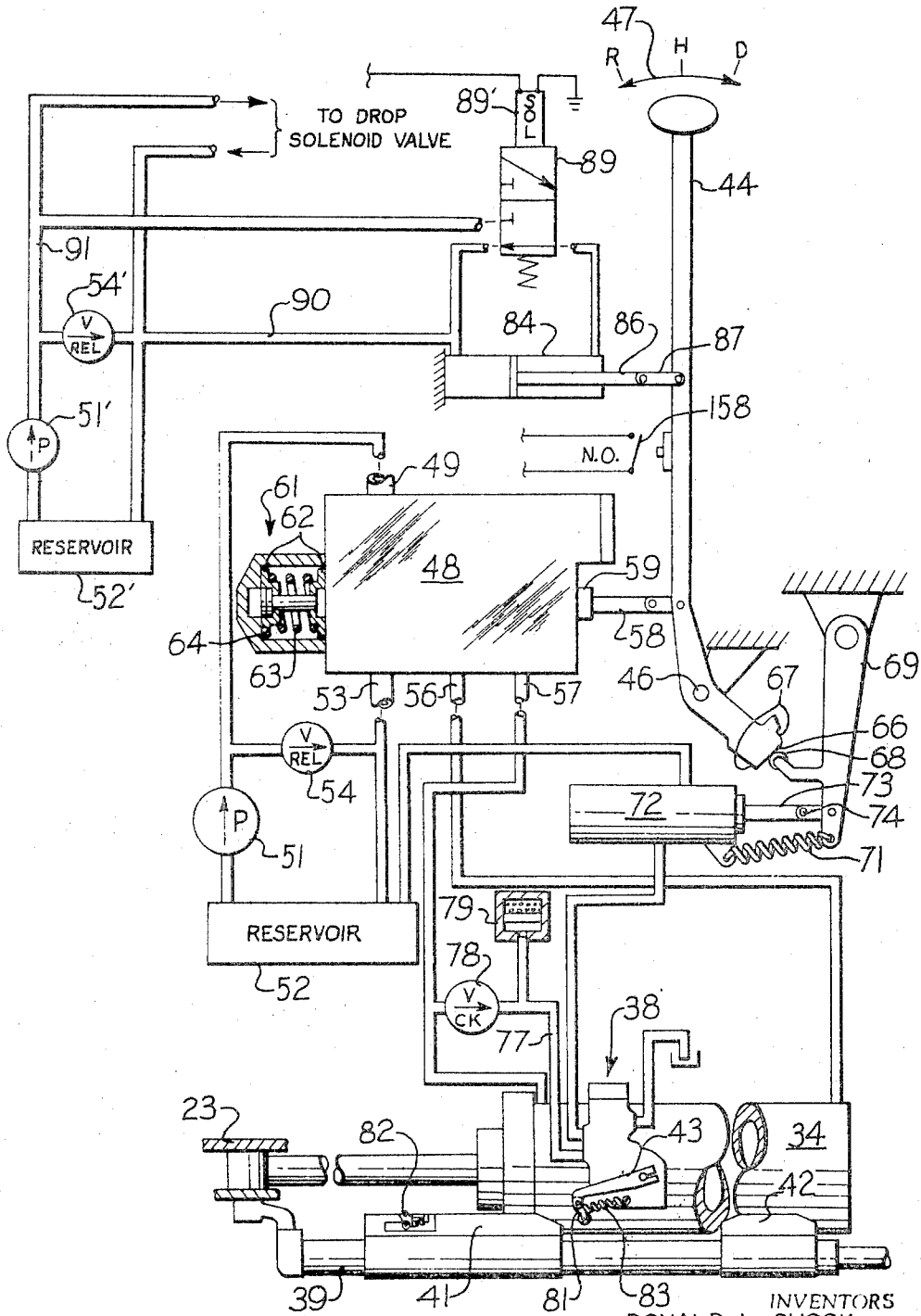


FIG. 3A

INVENTORS
DONALD L. SHOOK
PHILIP J. COSTA
BERNARD J. McGUIRE, JR.

BY
Fryer, Ginnvold, Fisk, Phillips & Lewis
ATTORNEYS

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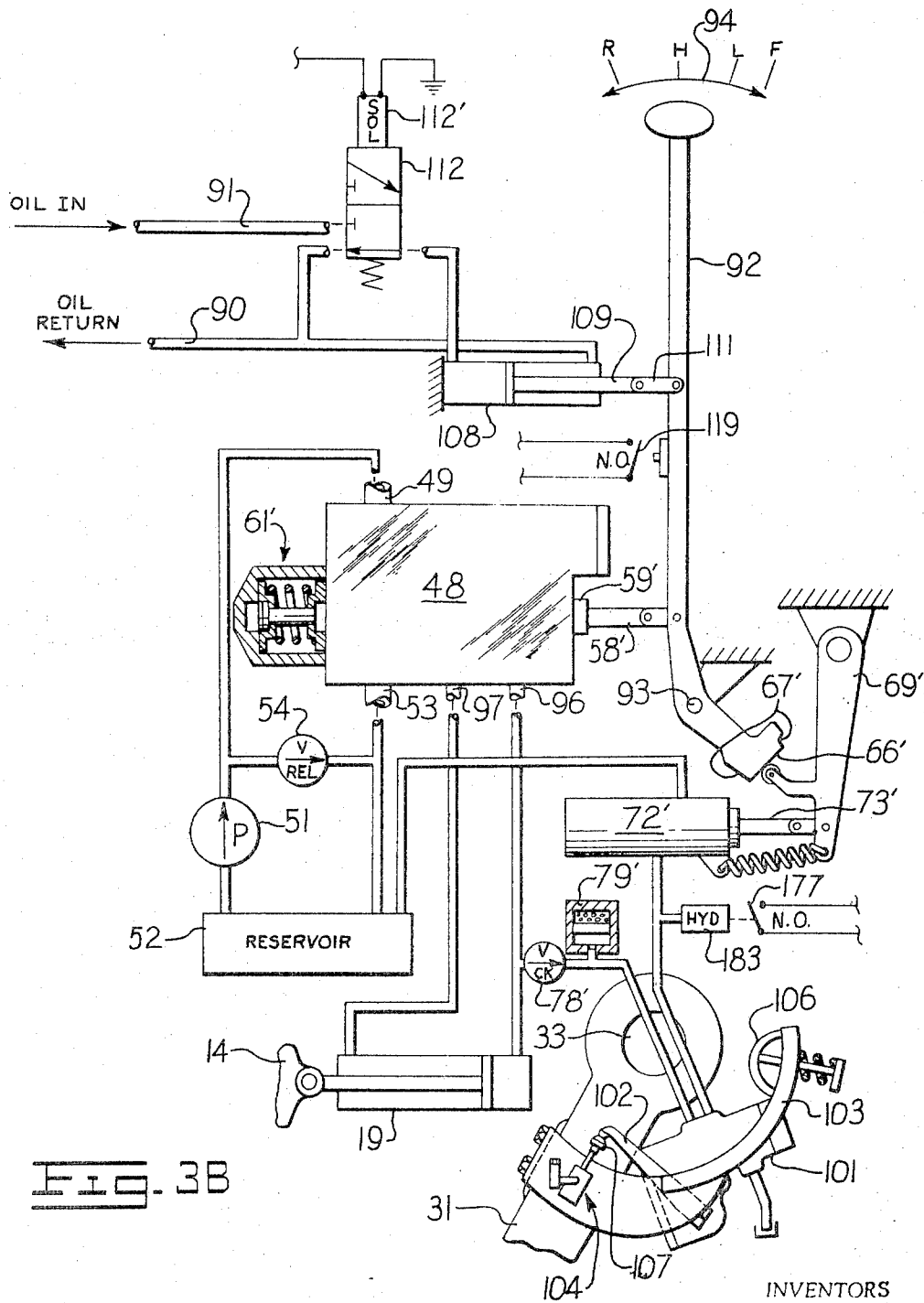


FIG. 3B

INVENTORS
DONALD L. SHOOK
PHILIP J. COSTA
BERNARD J. Mc GUIRE, JR

BY
Fryer, Ginnwald, Fint, Phillips & Lempio
ATTORNEYS

Jan. 6, 1970

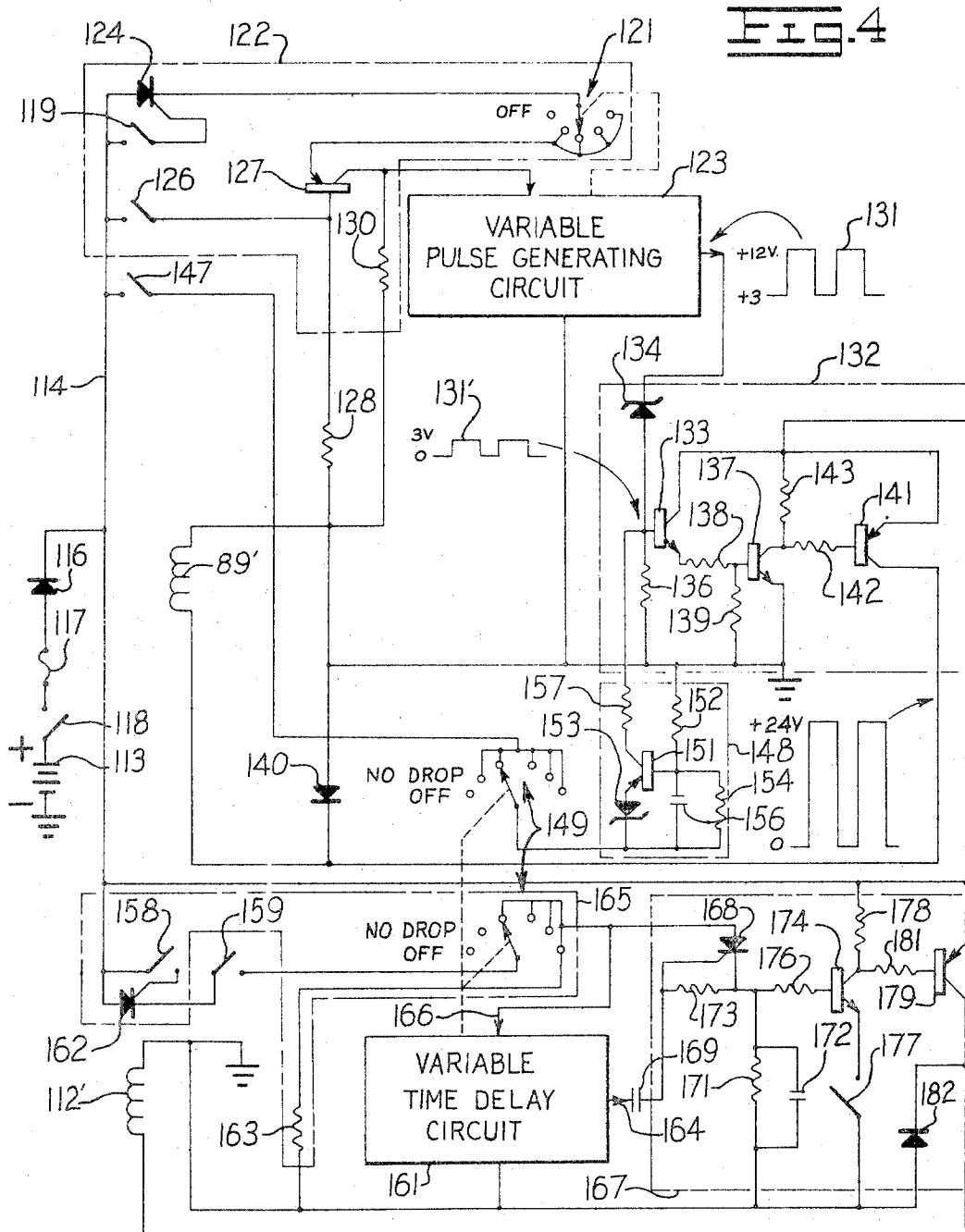
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5 Sheets-Sheet 4



INVENTORS
DONALD L. SHOOK
PHILIP J. COSTA
BERNARD J. McGUIRE, JR.

BY
Fryer, Ginnarold, Fink, Phillips & Lewis
ATTORNEYS

Jan. 6, 1970

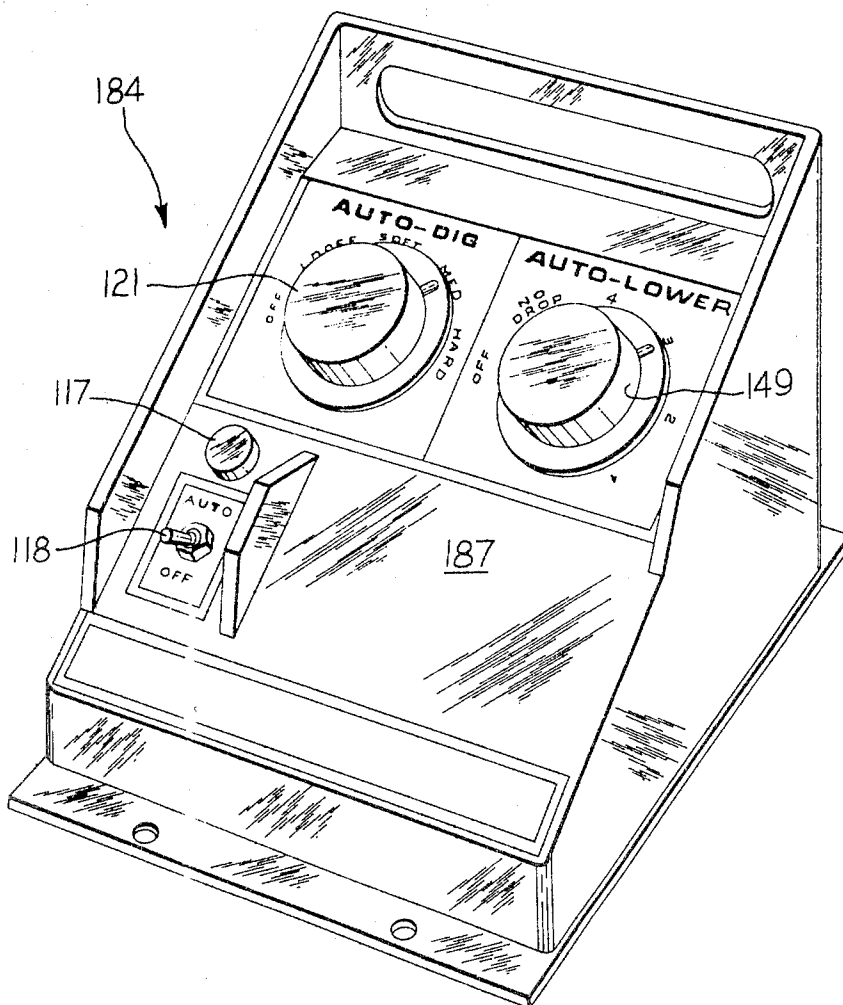
D. L. SHOOK ET AL
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FIG. 5



INVENTORS
DONALD L. SHOOK
PHILIP J. COSTA
BERNARD J. McGUIRE, JR.

BY
Fryer, Zimavold, Fink, Phillips + Lempis
ATTORNEYS

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3,487,958

SELF-CYCLING LOADER

Donald L. Shook, East Peoria, Philip J. Costa, Chillicothe, and Bernard J. McGuire, Jr., Peoria, Ill., assignors to Caterpillar Tractor Co., Peoria, Ill., a corporation of California

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18 Claims

ABSTRACT OF THE DISCLOSURE

A loader vehicle having lift arms which are raised and lowered by hydraulic jacks and carrying a bucket which is pivotable relative to the arms by additional jacks is provided with an automatic control system which actuates and stops the several jacks in a predetermined sequence. Loading and dumping movements of the lift arm and bucket, including repetitive digging motions, are initiated and timed automatically whereby the operator may concentrate on driving the loader to a greater extent than has heretofore been possible.

CROSS REFERENCES TO RELATED APPLICATIONS

Copending application Ser. No. 666,292 of Howard B. Austin et al., filed Sept. 8, 1967, for "Bucket Positioning Kick-Out Controls for Bucket Loaders," now Patent No. 3,429,471, and assigned to the assignee of this application. Copending application Ser. No. 646,394 of Dorrance Oldenberg et al., filed June 15, 1967, for "Multi-Spool Control Valve With Limited Series Operation," and assigned to the assignee of this application.

BACKGROUND OF THE INVENTION

This invention relates to loaders of the type having a bucket carried on a wheeled or crawler tractor vehicle by pivotable lift arms and more particularly to a system for automatically controlling certain movements of the bucket which have heretofore required taxing manual control on the part of the operator.

Although bucket loaders are an extremely useful and extensively employed means for handling earth and other materials in large quantities, full potential productivity has not always been realized as the controlling of a loader has been a very exacting and fatiguing task demanding considerable skill on the part of the operator. This problem arises in part from the fact that the bucket must often be made to undergo a complex pattern of movement and it may be necessary to drive the vehicle at the same time.

A typical loading operation requires repeated partial rack-back movements of the bucket alternated with partial raising of the lift arms. This has required repeated manipulations of two separate control levers in addition to operation of the several controls for driving the vehicle. The vehicle must then be driven to the unloading point where another complicated sequence of control manipulations may be required. Actuation of the loader controls to effect these operations must often be done in very rapid succession, sometimes simultaneously, and with considerable precision.

The severe demands which this imposes on the operator are apparent. In practice, the ability of an operator to perform the necessary control manipulations and to sustain the degree of concentration and physical effort required is often the most significant limiting factor in the efficiency of loader operations. This is an undesirable situation from both the productivity and personnel point of view.

SUMMARY OF THE INVENTION

The present invention relieves the problem discussed above by providing for automatic control of movements of the loader bucket during loading and dumping. A control system is provided which actuates and stops the jacks or other means which operate the bucket and lift arms to effect a predetermined sequence of bucket movements with a predetermined timing. In a preferred form, the automatic control system may be set to provide any of a plurality of different sequences of bucket movement to accommodate to differences in the characteristics of the material being handle. Also in a preferred form, the control system operates the loader by manipulating the existing control levers at the operator's station. This makes the invention compatible with existing loader equipment and facilitates overriding of the automatic system when the operator desires to control bucket movement manually.

Utilizing this system the sustained effort and skill demanded of the operator is greatly reduced by relieving him of many control lever manipulations. The operator is able to devote more attention to driving the vehicle while still being able to control the bucket movement manually when this is desirable.

Accordingly it is an object of this invention to increase the productivity of loaders and to reduce the effort demanded of the operator thereof.

It is another object of the invention to provide for selective self-cycling of many of the movements of a bucket loader and to provide means for this purpose which is adaptable to a variety of operating conditions, is compatible with existing loaders, and which may be manually overridden when necessary.

The invention together with further objects and advantages thereof will best be understood by reference to the following description of a preferred embodiment in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIGURE 1 is a side elevation view of the forward portion of a bucket loader having the present invention associated therewith;

FIGURE 2 is a view of elements of the invention associated with the tilt linkage of the loader of FIGURE 1 taken along line II—II thereof;

FIGURE 3A is a diagrammatic view of portions of the loader including the tilt control lever and associated mechanisms and showing elements of the present invention which coact therewith;

FIGURE 3B is a diagrammatic view of other portions of the loader including the lift control lever and associated mechanisms and showing elements of the invention which are associated therewith;

FIGURE 4 is a circuit diagram of certain of the electrical elements of the automatic control system; and

FIGURE 5 is a perspective view of the exterior of a control unit housing which is situated near the operator station of the loader and showing switches which may be actuated by the operator to effect the automatic control provided by the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to FIGURE 1 of the drawing, there is shown the front end of a powered loader vehicle 11 which includes an operator's station 12 having the various loader controls thereat as will hereinafter be described. While the invention is herein described as employed in conjunction with a wheel loader, it will be apparent that it is equally applicable to loaders of the crawler tractor type.

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Loaders of either type are provided with a bucket 13 for receiving and carrying soil or other material, the bucket being supported on lift arms 14 and being coupled thereto by pivot means 16. The rearward ends of the lift arms are in turn coupled to the body 17 of the loader vehicle by additional pivot means 18 and thus the bucket 13 can be lowered by pivoting of the lift arms about means 18 and may be raised to the carry position by an opposite pivoting movement of the lift arms. To effect these movements, a pair of hydraulic lift jacks 19 are pivotably coupled to the loader body 17 and have extensible rods 21 pivoted to the lift arms.

The angular position of bucket 13 relative to lift arms 14 is determined in part by tilt linkage 22 coupled therebetween. The tilt linkage has forward levers 23 with lower ends coupled to lift arms 14 by pivot means 24 and links 26 extend between pivots 28 at the upper ends of the forward levers and pivots 27 at the back of bucket 13. Angled crank arms 29 are pivoted to lift arms 14 rearwardly from forward levers 23 and additional links 31 extend from pivot means 32 at the lower ends of the crank arms to pivots 33 on the loader body 17. One of a pair of hydraulic tilt jacks 34 is pivotably coupled to the upper end of each crank arm 29 and has an extensible rod 36 pivoted to an intermediate point on the corresponding forward lever 23.

Thus, extension of the tilt jacks 34 forces the bucket 13 to pivot forwardly relative to the lift arms 14 and contraction of the tilt jacks racks the bucket back in an opposite direction. The angular position of the bucket 13 relative to the lift arms 14 is also affected by movement of the lift arms about pivots 18 without any extension or contraction of tilt jack 34, owing to the action of the linkage defined by the lever arms 23, crank arms 29, links 26 and 31 and the tilt jacks 34. The effect of this linkage is to tend to maintain the bucket 13 at a given inclination relative to the ground when the lift arms are raised or lowered.

Self-cycling of the loader requires, among other functions, that the pivoting movements of both the lift arms 14 and bucket 13 be automatically stopped at predetermined points at certain stages of operation. For this purpose it is convenient to employ detent and kickout devices of the type described in the hereinbefore identified copending application Ser. No. 666,292. As hereinafter discussed in more detail, these include a lift arm kickout valve assembly 37 disposed at the rearward end of link 31 and which is activated by movement of the link when the lift arms reach either the carry position or the loading position. Upon actuation, the kickout valve assembly 37 functions to stop the extension or contraction of the lift jacks 19.

Pivoting of the bucket 13 is stopped automatically at the dump position and at the loading position by another kickout valve 38 secured to the rod end of a tilt cylinder 34. As best shown in FIGURE 2, a telescoping rod assembly 39, known as a trombone, extends between the crank arm 29 and forward lever 23 and is pivoted to each thereof at the pivot points which couple the rod 36 and tilt cylinder 34 thereto, the trombone rod being parallel to the tilt cylinder and being displaced small distance sidewardly and upwardly therefrom. First and second ramps 41 and 42 respectively are positioned on the trombone 39 to operate an actuating lever 43 which projects from kickout valve 38 when the bucket reaches either the loading inclination or the dump inclination. This automatically stops tilt cylinders 34.

The loader structure as described to this point is typical of existing equipment insofar as a majority of the raising and lowering motions of the bucket 13, as well as the tilting movements thereof, would necessarily be controlled by an operator at station 12 and would require difficult and taxing manipulations of control levers. Considering now the self-cycling system of the present invention, means are provided whereby the operator's control manipulations, aside from those connected with driving the loader, may be limited to a single manipulation to initiate loading and a single manipulation to initiate dumping.

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In order to better understand the mechanism and circuitry of the automatic controls, it is desirable to first consider the sequence of bucket movements involved in the normal loading operation. At the start of a loading cycle, the lift arms 14 are lowered and the bucket 13 is level as shown in FIGURE 1. The loader 11 is then driven towards the material which is being handled. Where very soft or loose materials are involved, the bucket 13 can be substantially filled at this time by one continuous rack-back movement of the bucket followed by raising of the lift arms. Such movement of the bucket and lift arms is then stopped at the carry position, through the action of the hereinbefore described kickout valves 37 and 38, and the vehicle may be backed away and driven to the unloading site which is frequently a truck into which the material is to be dumped. More often, where the material handled is hard, heavy or compacted, the loading operation may not be accomplished with one continuous motion of the bucket and lift arms as described above and it is necessary to execute a series of digging movements. In particular, after the loader has made its initial forward movement towards the material being handled the bucket 13 is racked-back only partially and the lift arms 14 are then pivoted upward a small distance. The loader is then driven still further into the material and the bucket 13 and lift arms 14 are again moved a small distance in the same manner. Anywhere from two to five of these digging movements may typically be required in order to fully load the bucket 13 depending on the characteristics of the material.

At the dumping site, the raised bucket 13 is tilted fully forward to discharge the material and it may be necessary to hold the bucket at this dump position for a brief interval to ensure the ejection of all material. The operator then backs the loader vehicle away from the dump site and returns to the loading point while the lift arms 14 are lowered and the bucket 13 is partially racked-back to resume the initial loading position.

Control of the bucket and lift arm movements is thus a matter of actuating and stopping the two sets of hydraulic jacks 19 and 34 in predetermined sequences and with predetermined timing. The present invention provides an automatic control system for the tilt jacks 19 and lift jacks 34 which effects this result.

It is advantageous if the automatic control system operates by physically manipulating the control levers at the operator's station in the manner in which the operator himself would manipulate the levers. This facilitates the providing of a manual override in that at any time the operator may grasp an appropriate control and find it in the position corresponding to that which it would occupy if the loader had been controlled manually. This arrangement also makes the control system more readily compatible with existing loaders in that automatic control components can be disposed at the operator station and may be coupled to existing control levers with a minimum of complication and difficulty.

Referring now to FIGURE 3A, the customary means for manually controlling the tilt jacks 34 is a control lever 44 situated within reach of the operator. Lever 44 in this instance is coupled to the loader body by a pivot pin 46, situated a short distance from the lower end of the lever, whereby the lever may be shifted to three different positions along an arc 47 including a central or hold position, a forward or dump position and a rearward or rack-back position.

Lever 44 operates a first spool 59, of a multiple spool valve 48, which controls the flow of high pressure oil to the tilt jacks 34. For this purpose, spool valve 48 has an inlet 49 coupled to a pump 51 which draws oil from a reservoir 52 and has a return conduit 53 for returning oil to the reservoir when it is not being utilized to oper-

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ate the associated jacks. To avoid over-pressures, inlet 49 is communicated with return line 53 through a relief valve 54. Spool valve 48 also has a pair of outlets 56 and 57 which communicate with the head ends and rod ends respectively of the tilt cylinders 34. At the rack-back setting, spool 59 acts to transmit high pressure oil to outlet 57 to contract jacks 34 and at the dump setting the spool valve transmits high pressure oil to outlet 56 to extend the jacks. To shift the spool 59 between the three positions thereof an articulated linkage 58 connects the spool with tilt lever 44 at a point above pivot 46.

For reasons to be hereinafter discussed it is desirable that the tilt control lever 44 be spring-biased towards the center or hold position and mechanism 61 for this purpose is associated with the spool 59 of valve 48. Such mechanism is comprised of a pair of spaced apart discs 62 disposed coaxially on a narrow section of the spool 59 and a compression spring 63 disposed therebetween each disc being abutted against a stop such as the end walls of a housing 64 when the spool is in the center or hold position. Thus axial movement of the spool 59 in either direction will tend to compress spring 63 establishing a force tending to return the spool, and lever 44, to the hold position.

The system also utilizes detent means for temporarily holding the tilt control lever 44 in either of the rack-back and dump positions against the action of the spring-biased mechanism 61. To provide the detent action, the angled lower end of lever 44 has a flat end surface 66 and fore and aft surfaces 67 which are sharply inclined relative thereto. A cam projection 68 on a pivoting detent arm 69 rides against the end surface 66 when the lever 44 is in the center or hold position. Detent arm 69 is pulled towards end surface 66 by a spring 71 connected in this instance to a detent kickout cylinder 72 whereby if the lever 44 is moved to either the rack-back or dump positions the cam 68 rides up along one of the surfaces 67 and thereby temporarily prevents return of the lever to the center position by the spring-biasing mechanism 61. Kickout cylinder 72 has an extensible rod 73 connected to detent arm 69 through an articulated joint 74 so that upon extension of the rod cam 68 is withdrawn from the lever surfaces 67 causing spring-biased mechanism 61 to restore the lever to the center or hold position.

Detent kickout cylinder 72 is actuated to release control lever 44 from either the rack-back or dump setting by high pressure fluid supplied through the hereinbefore described tilt kickout valve 38 situated at tilt cylinder 34 and which has an actuator arm 43 operated at appropriate times by the ramps 41 and 42. Tilt kickout valve 38 receives such high pressure fluid through a conduit 77 communicated with outlet 57 of spool valve 48 through a check valve 78 that limits flow to a direction towards the kickout valve. To insure that adequate oil pressure is available to the tilt kickout valve 38, an accumulator 79 is coupled to conduit 77 between the check valve 78 and the tilt kickout valve.

The primary function of tilt kickout valve 38 is to restore control lever 44 to the center or hold position when the bucket reaches either of two predetermined positions in the travel thereof. In particular, ramp 42 is appropriately positioned along telescoping rod 39 to operate the lever 43 of kickout valve 38 when the bucket has reached its full dump position. This extends the rod 73 of kickout cylinder 72, releasing the detent cam 68. The control lever 44 is then returned to the center or hold position by the spring-biased mechanism 61. Similarly, ramp 41 is positioned along rod 39 to operate the kickout valve actuator lever 43 when the bucket has returned to the loading position. This again extends the rod of kickout cylinder 72 to release control lever 44 from the dump detent position whereby it is returned to the center or hold position by spring mechanism 61.

Ramp 41 extends along rod 39 for a substantial dis-

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tance causing the detent kickout cylinder 72 to remain actuated when the bucket 13 is between the load or level position and the carry or full rack-back position during the loading cycle. Thus there is no detent action at the rack-back setting of control lever 44 during the loading cycle. In the absence of additional provisions, the operator would be required to hold the control lever 44 in the dump position for a substantial period when he wished to initiate dumping, as the kickout valve lever 43 would remain actuated by the elongated ramp 41 until the bucket reached the level position at which point the dump detent action would become effective. To relieve the operator of this requirement so that he may initiate dumping by only momentarily holding the control lever 44 at the dump setting, a toggle 81 is provided on the end of kickout valve actuator lever 43 to coact with a spring biased retracting latch 82 on ramp 41. Latch 82 is situated to be overridden by the toggle 81 as the bucket reaches the carry or fully racked-back position. The effect of the latch 82 is to pivot the toggle 81 against the action of a spring 83 when dumping movement of the bucket commences so that the kickout valve 38 is deactivated even though lever 43 is still over the ramp 41. This contracts the detent kickout cylinder 72 whereby the detent cam 68 becomes effective to hold the control lever 44 in the dump setting without assistance from the operator.

The construction and mode of operation of the tilt hydraulic system, including spool valve 48, detent kickout cylinder 72, kickout valve 38, toggle 81 and retractable latch 82 are described in greater detail in the hereinbefore identified copending application Ser. No. 666,292. Accordingly, such elements have been herein described only to the extent necessary for understanding the coaction of additional automatic control elements therewith.

The bucket tilt control system as described to this point would necessarily be manually controlled except insofar as detents are provided so that the operator need not hold the control lever 44 in a selected position throughout the entire period of movement corresponding to that position and except insofar as automatic kickouts are provided to terminate the tilt and rack-back movements of the bucket at predetermined points. Considering now the means which relieve the operator of the need to manipulate the tilt control lever 44 at all during a loading operation, a tilt control hydraulic cylinder 84 has a fixed head end and a contractable rod 86 which connects to the tilt control lever 44 by means of a pivot link 87. Thus contraction of cylinder 84 pulls the control lever to the rack-back setting. For this purpose, the rod end of cylinder 84 may be supplied with oil from a second reservoir 52', through a pump 51', by energization of a two-position solenoid controlled valve 89. Valve 89 has an alternate, unenergized position at which the rod end and head end of the cylinder 84 are communicated whereby the control lever 44 may be moved without constraint from the cylinder. The head end of cylinder 84 is always vented to reservoir 52' through a return line 90. To avoid over-pressures a relief valve 54' is coupled between the oil supply line 91 to solenoid valve 89 and reservoir 52'.

Solenoid valve 89 is energized to shift the tilt control lever 44 to the rack-back setting at appropriate times, by an electrical control circuit which will hereinafter be described.

While the tilt control cylinder 84 may be operated from a high-pressure oil source such as pump 51 associated with tilt jacks 34, it is advantageous to use a separate source such as pump 51' which has a more constant pressure output. This provides for proper sizing of cylinder 84 to permit automatic operation of lever 44 at a control pressure that can be manually overridden if desired. In one example of the invention, the reservoir 52' is the oil system of the vehicle transmission.

Referring now to FIGURE 3B, the lift control system operates on essentially similar principles and includes a

lift control lever 92 pivoted to the loader body at a point 93 near the lower end of the lever so that it may be shifted along an arc 94 to any of four settings corresponding to raise, hold, lower and float respectively. An angled lower end of the lift control lever 92 has a flat end surface 66' and fore and aft surfaces 67' which coact with a roller cam 68' carried on a pivoting detent lever arm 69' to provide a detent action in the raise and float settings of the control lever in a manner essentially similar to that hereinbefore described with reference to the tilt control lever detent. As in the previous instance, a detent kickout cylinder 72' has an extensible rod 73' coupled to the detent lever 69' for releasing the detent at predetermined points in the travel of the lift arms.

Lift lever 92 is coupled to a second spool 59' of the spool valve 48 by articulated linkage 58' to move the spool between four positions. At the raise position, valve 48 transmits high pressure oil to the head ends of the lift jacks 19 through a conduit 96 while venting the rod ends through a conduit 97 and at the lower position the high-pressure oil is routed to the rod ends of the jacks through conduit 97 while the head ends are vented through conduit 96. At the hold position valve 48 blocks both conduits 96 and 97 thereby locking the lift jacks 19 at the instantaneous position thereof. At the float position the rod and head ends of the lift jacks 19 are communicated so that the lift arms 14 may rise and fall in accordance with external forces bearing thereon.

To actuate the detent kickout cylinder 72' when the lift arms 14 reach either the fully lowered position or the fully raised position, a lift kickout valve 101 is mounted on the loader body. Valve 101 has an actuating lever 102 which extends towards an arcuate cam carrier 103 secured to one of the rear links 31 and having a center of curvature coincident with the axis of the associated pivot 33. Kickout valve 101 receives high pressure oil from conduit 96 through a check valve 78' which limits flow to the direction towards the kickout valve. As in the previous instance an accumulator 79' is coupled to the kickout valve inlet between the valve and check valve 78' to assure adequate oil pressure for operation of cylinder 72'.

Cam mechanism 104 and 106 are attached to the carrier 103 and positioned thereon to operate kickout valve actuator lever 102 when the loader bucket is at ground level and at dump height respectively. Such operation of the kickout valve 101 supplies high pressure oil to detent kickout cylinder 72' thereby releasing the detent in the manner hereinbefore described whereupon the lift control lever 92 is restored to the hold setting by a second spring-bias mechanism 61' at spool valve 48. Cam 104 is of a specialized dashpot construction in which the element 107 which operates the kickout valve actuator lever 102 is slowly depressed by the pressure of the lever so that the kickout valve does not remain actuated after the detent has been released. This allows the lift control lever 92 to be redetented at the raise setting, while the kickout valve lever 102 is still in contact with cam 104 when the operator wishes to initiate a loading cycle. After raising of the lift arms has commenced and kickout valve actuator lever 102 has moved out of contact with cam element 107, the cam element again extends in preparation for a subsequent cycle of operation.

The construction and mode of operation of the lift hydraulic system including spool valve 48, detent kickout cylinder 72', kickout valve 101 and the cam mechanisms 104 and 106 are set forth in more detail in the hereinbefore identified copending application Ser. No. 666,292. An important characteristic of the spool valve 48 is that the tilt control system has priority over the lift system. Thus if the lift control lever is detented in the raise setting, the resulting rise of the lift arms is interrupted if the tilt control lever is then operated. However the lift control lever remains detented and the lift arm motion resumes when the tilt control is returned to hold. Suitable internal mechanism in spool valve 48 for producing this hydraulic

priority of tilt over lift is described in the hereinbefore identified copending application Ser. No. 646,394.

The components of the lift control system as described to this point with reference to FIGURE 3B again constitute a basically manually controlled system except insofar as detent action is provided in the raise and float settings together with automatic kickout at the upper and lower limits of lift arm travel. Considering now means by which the operator's manipulation of lift control lever 92 may be limited to a single shifting of the lever to initiate loading, a lift control hydraulic cylinder 108 has an extensible rod 109 coupled to the lift control lever 92 by a pivot link 111. The head end of cylinder 108 is fixed and thus extension of the rod 109 pushes the lift control lever 92 to the detented float setting. Cylinder 108 is actuated for this purpose by a solenoid valve 112 having a first unenergized position at which the head end of the cylinder is vented and having a second position, when energized, at which low-pressure oil is supplied to the head end of the cylinder from the previously described reservoir 52' by pump 51. The rod end of cylinder 108 is vented to reservoir 52' at either position of valve 112.

In order to realize the automatic operation provided by the invention, it is necessary that the solenoid valves 89 and 112 of FIGURES 3A and 3B respectively be energized and de-energized to manipulate the associated control levers 44 and 92 respectively in a predetermined pattern and with predetermined timing. Referring now to FIGURE 4, an electrical circuit for effecting this result is shown.

The control circuitry operates from the loader vehicle battery 113 and has a B+ power conductor 114 coupled to the positive terminal of the battery through a diode 116, fuse 117 and two-position switch 118, the negative side of the battery being grounded to the vehicle frame. Switch 118 is thus the on-off switch for the control circuit and determines whether or not the automatic control system is activated. With switch 118 open, the loader bucket and lift arms may be controlled by manual manipulation of the control levers 44 and 92 in the conventional manner.

With the bucket at ground level and in the loading position, automatic digging is initiated by the closing of a normally open dig switch 119 which turns on an SCR (silicon controlled rectifier) 124 connected between B+ conductor 114 and the wiper of a multiple position dig cycle selector switch 121. As shown in FIGURE 3B the dig switch 119 is situated near the lift control lever 92 in position to be closed by movement of the lever into the raise setting thereof. Thus the operator starts a loading cycle by shifting the lift control lever to the raise position.

Referring now again to FIGURE 4, the dig switch 119, SCR 124 and dig cycle selector switch 121 are components of a dig latching circuit 122 which functions to supply B+ voltage to a dig pulse timing circuit 123 during the loading cycle. The dig switch 119 connects B+ to the gate of SCR 124 to start conduction therethrough so that the SCR rather than switch 119 will carry all of the current to circuit 123. SCR 124 remains conductive until its cathode circuit is later opened by an additional switch 126 as will hereinafter be described.

Further components of the dig latching circuit 122 include a transistor 127 having an emitter supplied with B+ voltage through the wiper and contacts of switch 121 at any of the settings thereof with the exception of an "off" position. The base of transistor 127 is biased negatively by a connection to ground through a resistor 128 and the collector is coupled to the input of dig pulse timing circuit 123. Accordingly, when dig switch 119 is closed by movement of the lift lever to the raise position and selector switch 121 is not at the off setting transistor 127 becomes conducting and supplies B+ voltage to the input of the dig pulse timing circuit 123. The hereinbefore described switch 126 is connected between the base of transistor 127 and B+ conductor 114. Referring now to

FIGURE 2 in conjunction with FIGURE 4, the switch 126 is preferably of the reed type and is mounted at the head end of one of the tilt cylinders 34. A magnetic actuator 129 is carried on rod 39 in position to close the switch 126 when the bucket has been fully racked back to the carry position indicating that a loading cycle has been completed. Such closing of switch 126 applies B+ voltage to the base of transistor 127 stopping conduction through the transistor and SCR 124 as well. This in turn de-energizes the timing circuit 123. Sufficient current is passed through the transistor 127 to keep the circuit 122 latched between dig pulses by a bleed resistor 130 connected between the collector of the transistor and ground.

Referring again to FIGURE 4 in particular, the dig pulse timing circuit 123 functions to produce a series of square wave positive pulses, indicated by a wave form 131, having a duration and frequency which determines the number of times the raising of the lift arms is interrupted and the bucket partially racked-back, in the course of a single loading cycle, to effect the desired digging motion. The duration of pulses 131 determines the period of lift interruption and hence the amount the bucket racks back during each dig pulse. Suitable circuitry for producing trains of such pulses, such as a free-running multi-vibrator circuit for example, is known to the art and accordingly the dig pulse timing circuit 123 is shown in block form in FIGURE 4. The timing circuit 123 is of the type with which the duration of the pulses and the interval therebetween may be varied according to the setting of control switch, here constituted by the multiple position dig cycle selector switch 121, which provides for different time constants in the circuit at different settings of the switch.

The dig cycle selector switch 121 may typically be arranged to have four settings in addition to the off setting which causes the dig pulse timing circuit 123 to vary the frequency and pulse width of the output pulses 131 so that at a first setting only a single very long pulse is produced and thus at this setting the bucket racks back in one continuous motion during the loading cycle. This setting of switch 121 is termed the "loose setting" in that it is employed where the material being handled is uncompacted and no repetitive digging motions are needed to fill the bucket. In a second or "soft" setting of the switch 121, the time constants of the dig pulse timing circuit 123 are changed to produce two or three shorter pulses to rack the bucket back partially two or three times between lifting movements before reaching the full rack-back position. In the third or "medium" setting of switch 121 three to four digging motions occur and in the final or "hard" setting four or five digging motions are produced. It may be observed that the setting of the dig cycle selector switch 121 determines the number of pulses per unit time from timing circuit 123 and this will not vary regardless of other loader operations, such as engine speed. The amount of bucket movement per pulse however, depends on the rate at which oil is supplied to the tilt cylinders and thus may be subject to some variation.

The output pulses from dig pulse timing circuit 123 are transmitted to a first switching circuit 132 which responds to each pulse by energizing the solenoid 89' of the valve 89 which operates the tilt lever control cylinder 84. Pulses from timing circuit 123 are transmitted to the base of an impedance matching transistor 133 through a Zener diode 134 which shifts pulses 131 negatively to produce corresponding pulses 131' varying between 0 and plus 3 volts. This assures that the base of transistor 133 will go to 0 volt (cutoff) at the end of each dig pulse. The base of transistor 133 is coupled to ground through a resistor 136 and the collector connects with B+ conductor 114. The emitter of transistor 133 is connected to the base of a power transistor 137 through a resistor 138 to switch transistor 137 to conduction in response to each positive dig timing pulse 131'. The base of power

transistor 137 is also connected to ground through an additional resistor 139. Power transistor 137 acts as a driver for a switching transistor 141 which is also a power transistor. The collector of the driver transistor 137 is connected to B+ conductor 114 through resistor 143 and to the base of transistor 141 through a resistor 142. The emitter of switching transistor 141 is connected directly to B+ conductor 114. By using a power transistor 137 as a driver for another power transistor 141, which performs the switching operation, and causing the switching transistor to operate in supersaturation, an important advantage is realized. This increases the base current and decreases the voltage drop across the emitter-collector circuit of transistor 141. Owing to the decreased voltage drop, the transistor is capable of passing increased current without undue heating. One practical consequence is that no bulky heat sink need be employed in conjunction with the transistor.

The collector of the switching transistor 141 is coupled to the solenoid coil 89' of the valve 89 which actuates the tilt lever control cylinder 84. The suppress high voltage transients, a diode 140 is connected across the solenoid coil 89'. Thus the switching transistor 141 conducts to energize the dig solenoid valve 89 in response to each pulse from timing circuit 123 and each such energization initiates a partial racking-back of the bucket in the course of a loading cycle. This produces the desired digging movement of the bucket in that the tilt system has hydraulic priority over the lift system and thus any time that the tilt control lever is shifted to the rack-back position, the lifting motion is temporarily interrupted.

When the bucket has been fully racked back and is loaded, switch 126 of the latching circuit 122 closes as hereinbefore described to de-energize the timing circuit 123. Following the above described loading cycle operations, the loaded bucket is in the elevated carry position and owing to the action of the hereinbefore described detent kickout systems the tilt and lift control levers are both in the center or hold positions thereof. The operator then drives the loader to the dump location and positions the elevated bucket over a truck or other unloading site.

Referring again to FIGURE 3A, the automatic cycling involved in the dumping operation is initiated by the operator who moves the tilt control lever 44 to the dump setting thereof. Once the actuator lever 43 of kickout valve 38 has cleared the latch 82, detent kickout cylinder 72 is de-energized and the detent mechanism becomes effective to hold the tilt lever in the dump setting without the operator's assistance. Dumping movement of the bucket thus continues until the kickout valve 38 is again actuated by ramp 42 on rod 39 when the bucket has reached full dump position. This releases the detent 68 in the manner hereinbefore described causing the tilt lever 44 to be returned to the center or hold position, by spring-bias mechanism 61, with the bucket at the full dump inclination.

Referring now to FIGURE 2, the movement of the bucket to the full dump position closes a normally open reed switch 147 which is mounted near the rod end of tilt cylinder 34 in position to be closed by the magnetic actuator 129 when the bucket reaches the dump position. Referring now again to FIGURE 4, the closing of reed switch 147 applies B+ voltage to a time delay circuit 148 through a multiple position drop timing selector switch 149. Time delay circuit 148, of the type described in copending application Ser. No. 809,874 of Philip J. Costa, filed Mar. 24, 1969, functions to provide a predetermined period at which the bucket remains in the dump position to assure discharge of all the contents thereof. After this time delay, switching circuit 132 is again actuated to move the tilt control lever into the rack-back setting to return the bucket towards the level or loading position.

For this purpose the time delay circuit 148 has a transistor 151 having its base connected to ground through

a resistor 152 and having an emitter connected to a first wiper of drop timing selector switch 149 through a voltage regulating Zener diode 153. The first wiper of switch 149 connects to B+ voltage at each of its multiple positions except the first thereof which is an off position at which no automatic return of the bucket to the loading position occurs.

A resistor 154 and capacitor 156 are connected in parallel between the base of transistor 151 and B+ voltage through the wiper of switch 149 and switch 147. Thus the transistor 151 is non-conducting after switch 147 has been closed until the voltage across capacitor 156 has risen a predetermined amount as determined by the time constant of the network formed by the capacitor and resistor 154. This time constant is selected to provide the desired dwell time of the bucket at the full dump position, typically one second. The collector of transistor 151 is coupled to the base of transistor 133 of switching circuit 132 through a resistor 157. Thus when transistor 151 becomes conducting after the predetermined delay, a signal is sent to the switching circuit 132 which again energizes the dig solenoid valve coil 89' causing the tilt control lever 44 to be moved to the rack-back position. Referring now to FIGURES 2 and 3A, switch 147 is positioned to stay closed long enough for the tilt kickout valve actuator lever 43 to clear ramp 42 so that the tilt control lever 44 stays in the rack-back setting owing to the action of the detent 68 although the switch 147 subsequently opens and deenergizes the time delay circuit 148. Owing to the detenting of the tilt lever at this position, the bucket continues to rack-back until it is stopped at the level position by contact of ramp 41 with the tilt kickout actuator lever 43 as hereinbefore described.

Considering now the control circuitry for automatically lowering the lift arms after dumping of the bucket, with reference first to FIGURE 3A, a normally open switch 158 is disposed near the tilt control lever 44 in position to be closed by movement of the lever to the rack-back setting thereof. Referring now to FIGURE 2, an additional normally open switch 159 of the reed type is mounted at an intermediate point along tilt cylinder 34 in position to be closed by the magnetic actuator 129 just before the bucket reaches the level position after dumping.

As shown in FIGURE 4, closing of switch 159 in this manner transmits B+ voltage to an adjustable time delay circuit 161 through a second wiper and set of contacts of the drop timing selector switch 149. Switch 159 is connected to the B+ conductor 114 through an SCR 162 which has a gate connected to B+ conductor 114 through the first switch 158. Thus the drop timing circuit is not activated until both of the switches 158 and 159 are closed as described above but remains energized when switch 158 is subsequently opened, by movement of the tilt control lever, owing to the latching action of SCR 162. To assure adequate current flow to keep the SCR 162 turned on, a bleed resistor 163 is connected between switch 149 and ground.

Switches 158, 159 and 149 together with SCR 162 and resistor 163 thus are elements of a second latching circuit 165 which initiates lowering of the lift arms after the bucket has racket-back to the intermediate position following dumping.

Time delay circuit 161 may be of any of various known types which deliver a pulse at an output 164, a predetermined interval after a voltage has been applied to an input 166 and having provisions for selecting any of a plurality of time delay intervals as determined by the setting of a multiple position switch, which in this instance is the drop timing selector switch 149. The switch 149 and time delay circuit 161 may typically have six positions of which the first is an off setting and the second is a "no drop" setting neither of which energizes the time delay circuit 161 so that there is no automatic lowering

of the lift arms following dumping. The remaining positions of the switch 149 may typically provide for time delays of 2, 3, 4 and 5 seconds before lowering of the lift arms commences. This enables the operator to adjust the timing of the lowering of the lift arms in accordance with working conditions, particularly with respect to providing sufficient time to back the loader away from a truck before the bucket drops.

The delayed output pulse from time delay circuit 161 initiates operation of a second switching circuit 167 which then applies power to the driver coil 112' of the hereinbefore described solenoid valve 112 causing the lift lever to be shifted into the float position thereof. This in turn causes the lift arms and bucket to drop to the loading position. The switching circuit 167 may be comprised of a latching SCR 168 having an anode side connected to the input 166 of time delay circuit 161 and having a gate connected to the output 164 thereof through a coupling capacitor 169. SCR 168 is thus energized when the delay circuit 161 is energized and becomes conductive in response to the delayed output pulse therefrom. A resistor 171 and parallel capacitor 172 are connected between the cathode side of SCR 168 and ground and the cathode side is also coupled to capacitor 169 through an additional resistor 173 and is further coupled to the base of a power transistor 174 through still another resistor 176. Power transistor 174 has an emitter which may be grounded through a normally open switch 177 and has a collector coupled to B+ conductor 114 through a resistor 178.

Power transistor 174 is utilized as a driver for a switching power transistor 179 and accordingly, the collector of transistor 174 is also coupled to the base of the switching power transistor 179 through still another resistor 181. Switching transistor 179 has an emitter coupled to B+ conductor 114 and the collector is connected to ground through the coil 112' of the lift lever operating solenoid valve 112. High voltage transients, which may accompany energizing of solenoid coil 112' are suppressed by a diode 182 connected in parallel therewith.

Thus when SCR 168 is latched on by an output pulse from time delay circuit 161, power transistor 179 becomes conductive and energizes solenoid valve 112. Referring again to FIGURE 3B, this actuates cylinder 108 to shift lift control lever 92 to the detented float setting and the lift arms drop towards the loading position. Generally, at this time, the operator is returning the vehicle to the loading site.

The above described switch 177 is normally open and is of the type operated by a hydraulic actuator 183 which in this instance is responsive to the fluid pressure between lift kickout valve 101 and detent kickout cylinder 72' as shown in FIGURE 3B. Switch 177 will thus be closed when the switching circuit is energized as kickout valve 101 is actuated at such time. Once the lift arms commence dropping, switch 177 opens and de-energizes the drop timing circuit.

When the lift arms have dropped to the loading position, kickout valve 101 is operated as hereinbefore described to apply high-pressure fluid to detent kickout cylinder 72' thereby releasing the detent whereby the lift control lever 92 is restored to the hold position.

The bucket and lift arms are now restored to the loading position and a complete cycle of operation has been completed. The operator can again drive the vehicle towards the material to be loaded and initiate a subsequent loading cycle by momentarily pulling the lift lever 92 into the raise position as previously described.

Certain of the components of the circuit of FIGURE 4 are situated at specific points on the loader mechanism and vehicle for the purpose of sensing the movements of mechanical or hydraulic components thereof as has been described above. It is advantageous if other components of the circuit of FIGURE 4 are grouped together within a compact control housing which can readily be disposed

at the operator's station. Referring now to FIGURE 1, such a control circuit housing 184 is shown situated at one side of the operator's seat 186 within easy reach of the operator's hand. As shown in FIGURE 5, the housing 184 preferably has a face 187 through which the control knobs or actuating elements of the several manually operated switches protrude. These include the on-off switch 118, the dig timing selector switch 121 and the drop timing selector switch 149. The fuse 117 may also be situated at the face of the housing 184 for convenience in replacement when necessary. Preferably, the solid state components within housing 184 are potted, by techniques known to the art, to protect the circuit against moisture.

While the invention has been described in detail with respect to a specific embodiment it will be apparent that many variations are possible. Certain of the sensing, timing, and control actuation functions herein described as accomplished by electrical means may, for example, be performed by hydraulic circuitry while some of the hydraulic functions may be accomplished by electrical means. Many other modifications are possible and accordingly, it is not intended to limit the invention except as defined by the following claims.

What is claimed is:

1. A loader of the class having lift arms carrying a bucket and having lift drive means for pivoting the arms relative to the loader body and tilt drive means for pivoting the bucket relative to the lift arms, further comprising a self-cycling system automatically controlling said lift drive and tilt drive to produce a predetermined pattern of lift arm and bucket movements, wherein said self-cycling system has a dig timing component initiating periodic operation of said tilt drive at fixed predetermined time intervals as said lift drive raises and lift arms.

2. A loader as defined in claim 1 wherein said dig timing component has a manual adjustment for varying the number of said operations of said tilt drive in the course of raising of said lift arms by said lift drive.

3. A loader as defined in claim 1 wherein said dig timing component has a manual adjustment for varying the number of said operations of said tilt drive in the course of raising of said lift arms by said lift drive.

4. A loader as defined in claim 1 wherein said dig timing component is actuated automatically in response to manual actuation of said lift drive.

5. A loader of the class having lift arms carrying a bucket and having lift drive means for pivoting the arms relative to the loader body and tilt drive means for pivoting the bucket relative to the lift arms, further comprising a self-cycling system automatically controlling said lift drive and tilt drive to produce a predetermined pattern of lift arm and bucket movements, wherein said self-cycling system has a dump timing component holding said bucket at the dump position thereof for a predetermined period, and means automatically actuating said tilt drive to return said bucket to an intermediate position relative to said arms following said predetermined period.

6. A loader as defined in claim 5 wherein said self-cycling system is further comprised of a drop timer initiating operation of said lift drive to lower said lift arms a predetermined time after said return of said bucket to said intermediate position thereof.

7. A loader as defined in claim 6 wherein said drop timer has a manual adjustment for selectively varying the time delay between said return of said bucket to said intermediate position thereof and said lowering of said lift arms.

8. A loader of the class having lift arms carrying a bucket and having lift drive means for pivoting the arms relative to the loader body and tilt drive means for pivoting the bucket relative to the lift arms, further comprising a self-cycling system automatically controlling said lift drive and tilt drive to produce a predetermined pattern of lift arm and bucket movements, wherein said self-cycling system provides for said automatic actuation of

one of said lift drive means and said tilt drive means in response to manual actuation of the other thereof, and wherein said self-cycling system has means automatically actuating said lift drive to lower said lift arms a predetermined time after manual actuation of said tilt drive to shift said bucket to the dump position thereof.

9. A loader having lift arms carrying a bucket and having lift drive means for pivoting the arms relative to the loader body and tilt drive means for pivoting the bucket relative to the lift arms, and having a manually actuatable lift control lever and tilt control lever operatively coupled to said lift drive and said tilt drive respectively, further comprising a self-cycling system automatically controlling said lift drive and tilt drive to produce a predetermined pattern of lift arm and bucket movements, wherein said self-cycling system has a lift control lever shifting means and a tilt control lever shifting means coupled to said lift lever and said tilt lever respectively for automatically manipulating said levers to effect said predetermined pattern of lift arm and bucket movements.

10. A loader having lift arms carrying a bucket and having lift drive means for pivoting the arms relative to the loader body and tilt drive means for pivoting the bucket relative to the lift arms, and a manually operated lift control member for actuating said lift drive means to raise said lift arms, a manually operated tilt control member for actuating said tilt drive means to pivot said bucket forward toward the dumping position thereof, and a self-cycling system automatically controlling said lift drive and tilt drive to produce a predetermined pattern of lift arm and bucket movements, wherein said self-cycling system is further comprised of a dig timing component operating said tilt drive in response to said manual actuation of said lift control member to periodically rack-back said bucket as said lift arms rise, means automatically stopping said lift drive and tilt drive as said bucket reaches the elevated racked-back carry position thereof, means automatically stopping said bucket at the dump position thereof following manual actuation of said tilt control member, a dump timer responsive to stopping of said bucket at said dump position and initiating operation of said tilt drive to partially rack said bucket a predetermined time after said bucket has reached said dump position, means automatically stopping said bucket at the loading inclination thereof following operation of said dump timer, a drop timer actuating said lift drive to lower said lift arm a predetermined time after said bucket is stopped at said loading inclination thereof, and means automatically stopping said lift drive as said lift arms reach the lowered loading position thereof.

11. A loader comprising
a powered vehicle having an operator's station and controls thereat for driving and maneuvering said vehicle;

lift arms pivoted to said vehicle;

at least one lift jack connected between said vehicle and said lift arms for pivoting said arms between a lower loading position and an elevated carry position;

a lift kickout stopping operation of said lift jack at said lowered position and at said raised position of said lift arms;

a bucket pivotably carried on said lift arms;

at least one tilt jack coupled between said bucket and said lift arms for pivoting said bucket relative thereto between a dumping position, a racked-backed carry position and an intermediate loading position;

a tilt kickout stopping operation of said tilt jack at said dumping position and at said intermediate position of said bucket; and

a self-cycling control having a dig timing component activated by raising of said lift arms to periodically actuate said tilt jack to pivot said bucket toward said racked-back position thereof as said arms rise.

12. A loader as defined in claim 11 wherein said tilt jack is operated by fluid under pressure supplied through

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an electrically operated valve and wherein said dig timing component of said self-cycling control is an electrical pulse generating circuit, and wherein said self-cycling control further comprises switching means coupled between said pulse generating circuit and said electrically operated valve and actuating said valve in response to pulses from said generating circuit.

13. A loader as defined in claim 12 wherein said pulse generating circuit is of the class capable of producing sequential pulses and wherein the duration of the pulses and the interval therebetween may be varied between any of a plurality of values and has a manual adjustment for selecting any of said plurality of values.

14. A loader as defined in claim 12 further comprised of a manually manipulated control member for initiating operation of said lift jack and having a raise setting for initiating raising of said lift arm; a switch positioned to be operated by movement of said lift control member to said raise setting thereof, and a latching circuit responsive to operation of said switch to activate said pulse generating circuit.

15. A loader comprising

a powered vehicle having an operator's station and controls thereat for driving and maneuvering said vehicle;

lift arms pivoted to said vehicle;

at least one lift jack connected between said vehicle and said lift arms for pivoting said arm between a lower loading position and an elevated carry position;

a lift kickout stopping operation of said lift jack at said lowered position and at said raised position of said arms;

a bucket pivotably carried on said lift arms;

at least one tilt jack coupled between said bucket and said lift arms for pivoting said bucket relative thereto between a dumping position, a racked-back carry position and an intermediate loading position;

a tilt kickout stopping operation of said tilt jack at

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said dump position and at said intermediate position of said bucket; and

a self-cycling control having a dump timing component activated in response to movement of said bucket to said dump position thereof to actuate said tilt jack to return said bucket toward said intermediate position thereof a predetermined time after said bucket reaches said dump position.

16. A loader as defined in claim 15 wherein said tilt jack is operated by fluid under pressure supplied through an electrically operated valve, and wherein said dump timing component is an electrical time delay circuit activated by movement of said bucket to said dump position thereof, and wherein self-cycling control further comprises switching means actuated through said timing delay circuit to operate said electrically operated valve.

17. A loader as defined in claim 15 wherein said self-cycling control further comprises a drop timing delay circuit activated by return of said bucket to said intermediate position thereof following dumping of said bucket and switching means actuated by said time delay circuit to initiate lowering of said lift arms.

18. A loader as defined in claim 17 wherein said time delay circuit is of the class having a manual adjustment for selecting and of a plurality of predetermined time delays.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,487,958 Dated January 6, 1970

Inventor(s) DONALD L. SHOOK, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 42, "mechanism" should be --mechanisms--.
Column 13, line 25, "crrying" should be --carrying--.
Column 13, line 34, "and" should be --said--.
Column 14, line 42, after "said bucket," insert --back--.
Column 16, line 9, "leader" should be --loader--.
Column 16, line 25, "and" should be --any--.

SIGNED AND
SEALED
JUN 30 1970

(SEAL)

Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents