United States Patent

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[54] AUTOMATIC CONTROL SYSTEM FOR FRONT END LOADER

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[51] **Int. Cl.** **E02f 3/00**

[58] **Field of Search** 214/762, 778, 771, 138, 132, 214/41, 764

[56] **References Cited**

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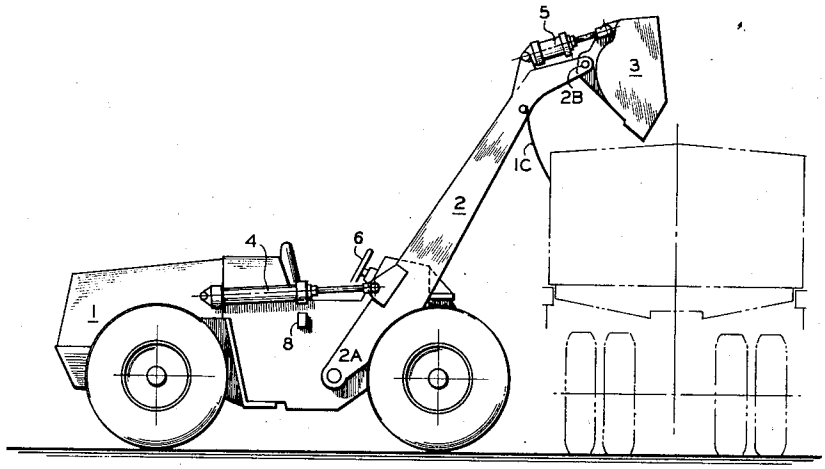
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[57] **ABSTRACT**

Automatic control system for a front end loader utilizing a bucket or fork at the end of a rigid boom. An automatic digging and dumping cycle is in parallel operation with a manual control system and which automatic control system may be changed to manual by an operator or be preselected for automatic or manual operation. Pressure sensitive means are utilized to determine and control the position and attitudes of the various elements that perform the necessary work functions.

4 Claims, 6 Drawing Figures



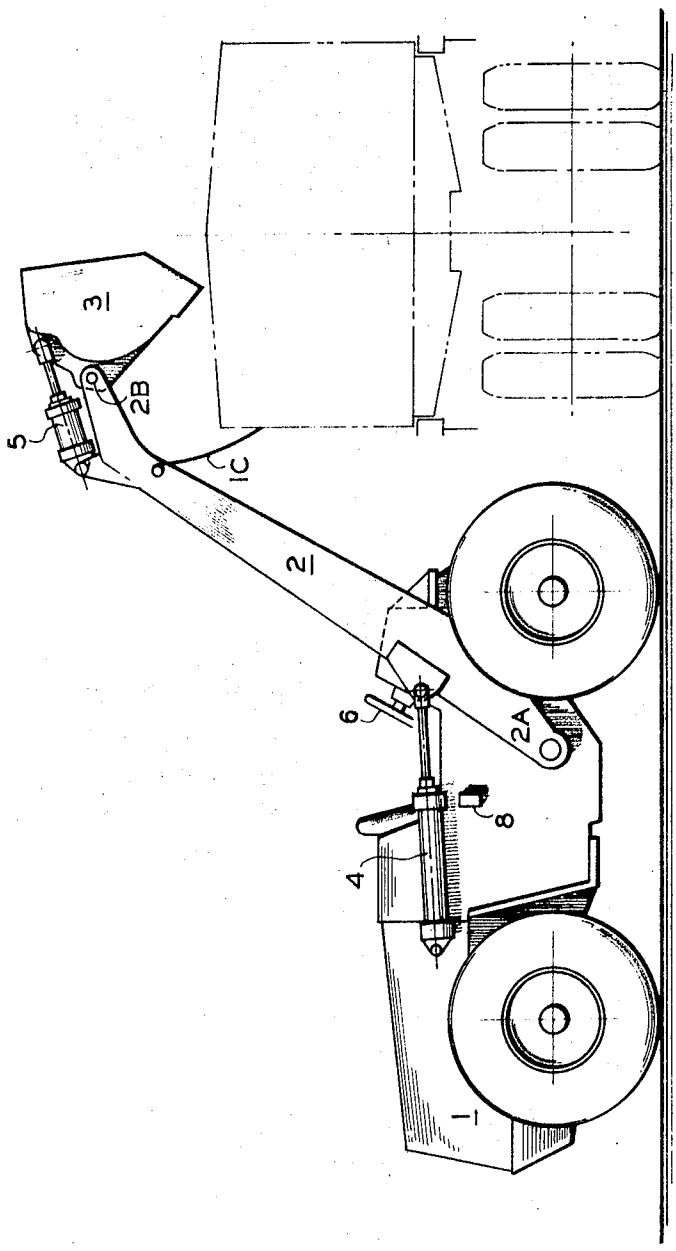


FIG. I

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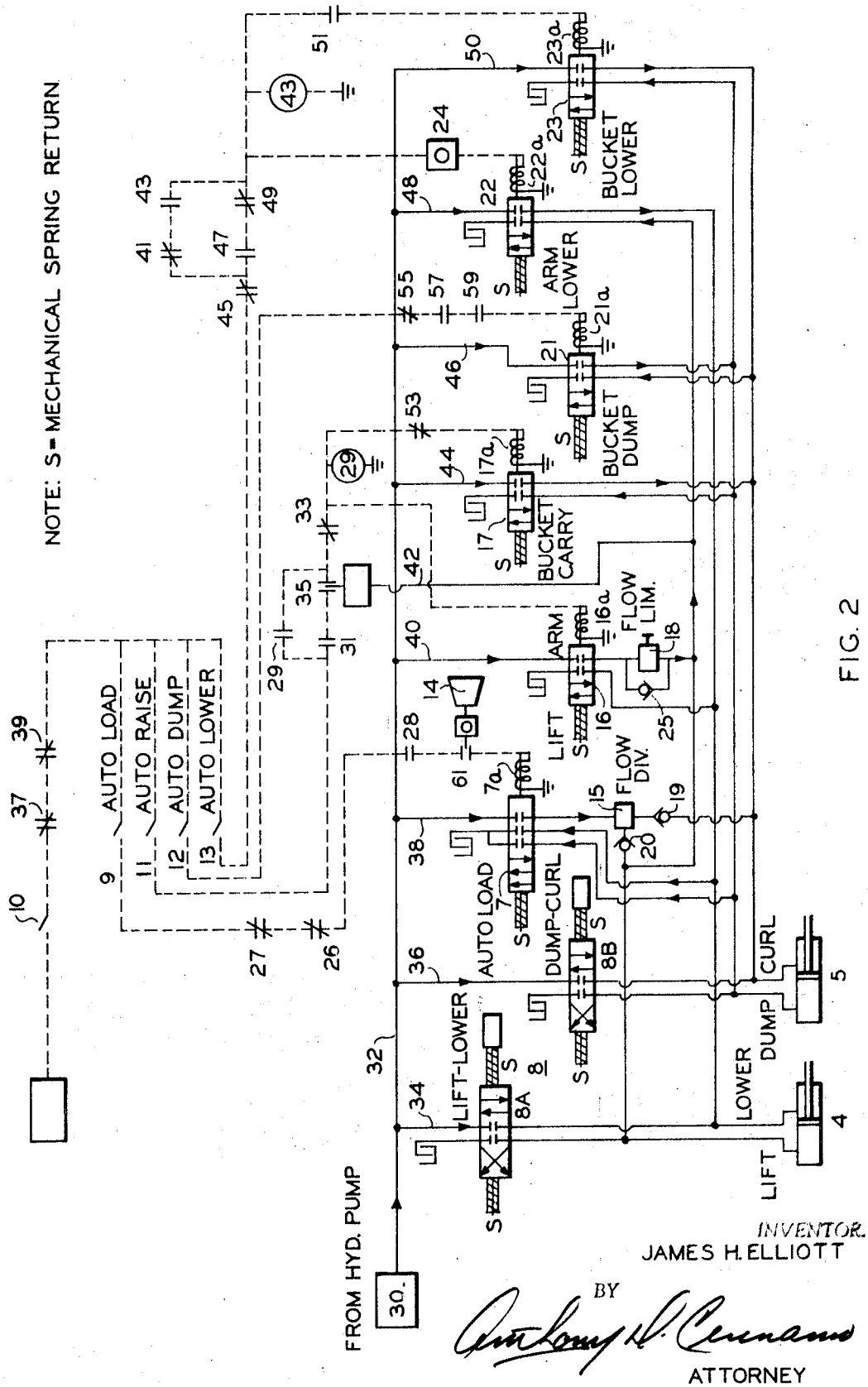


FIG. 2

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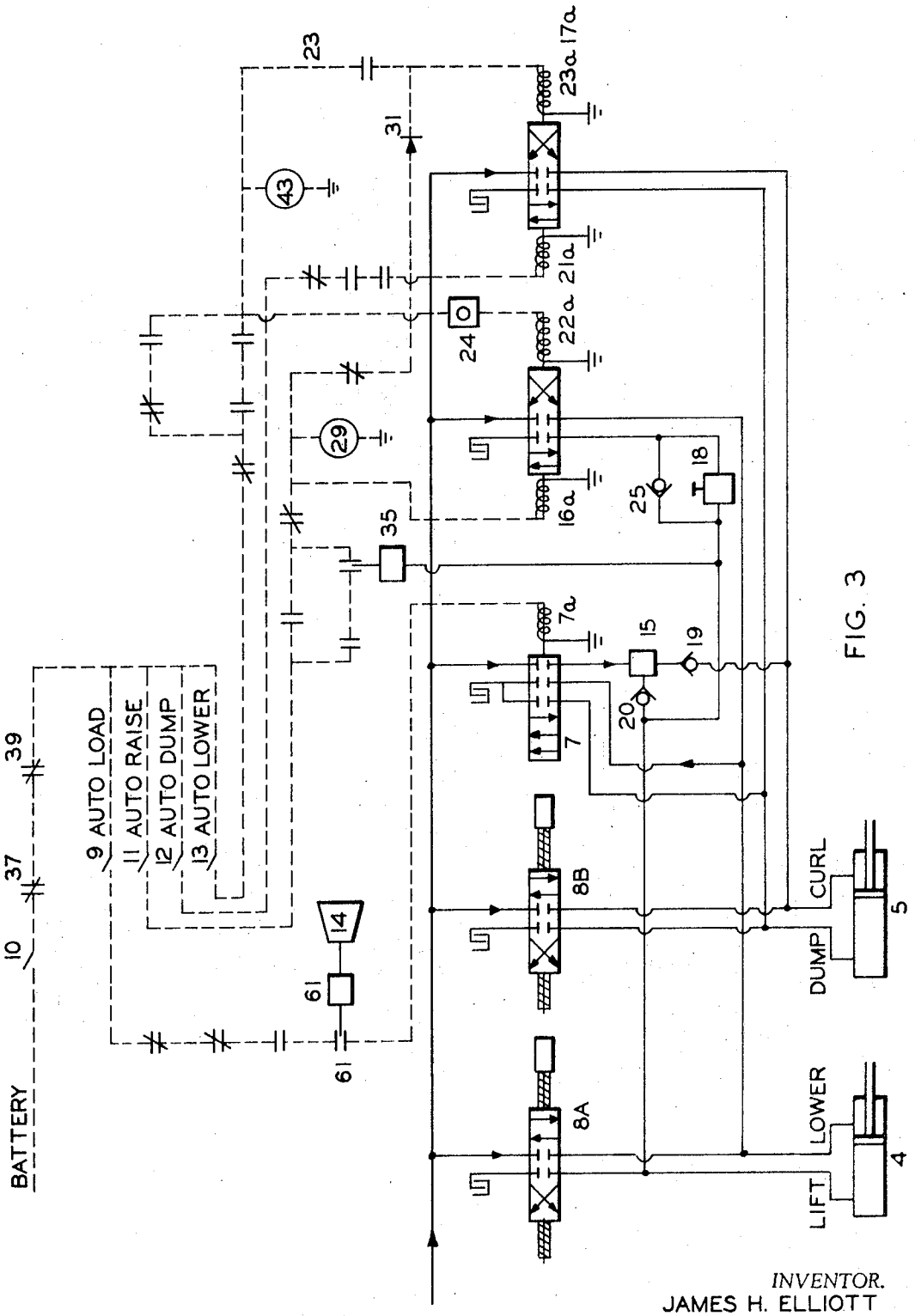


FIG. 3

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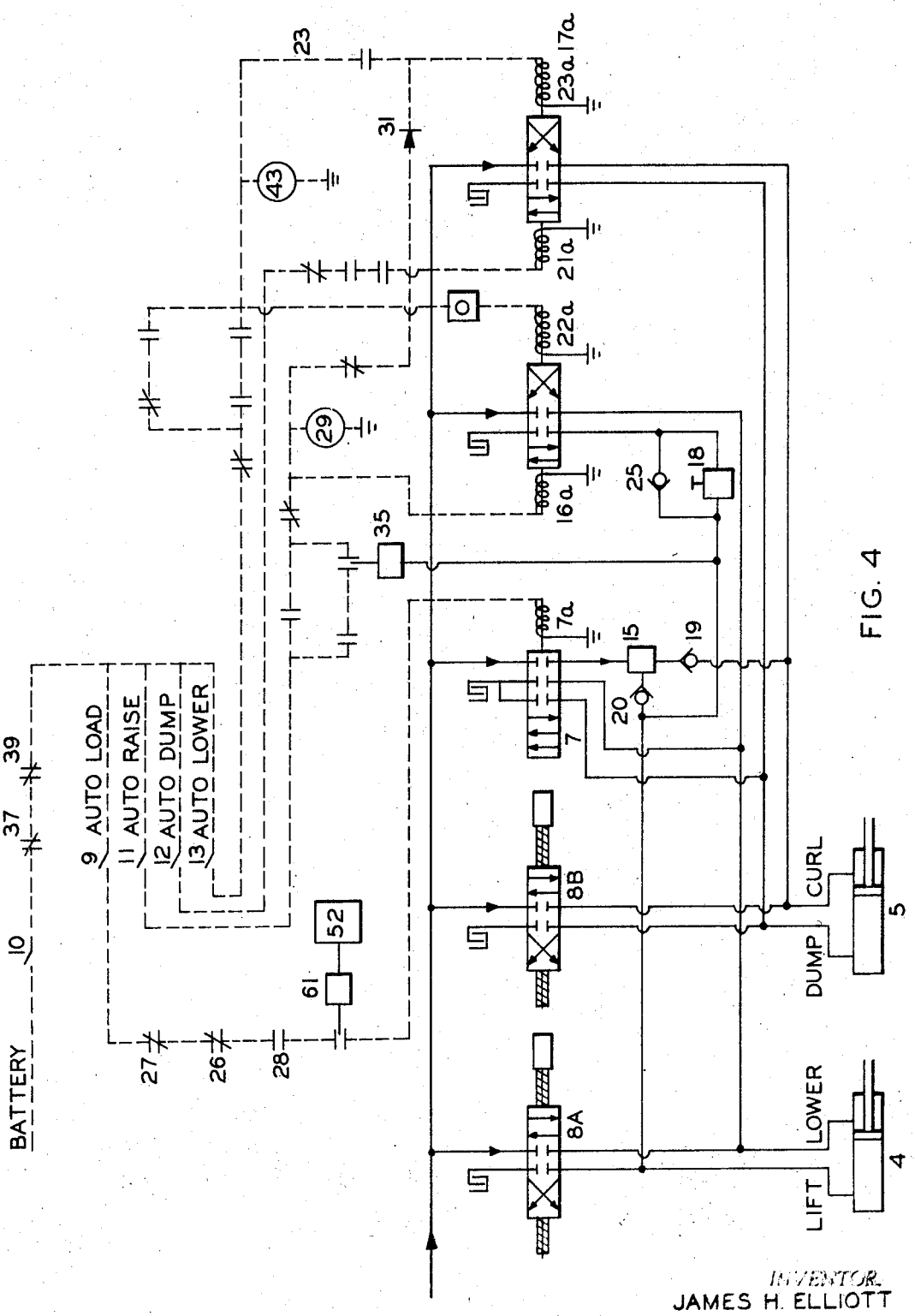


FIG. 4

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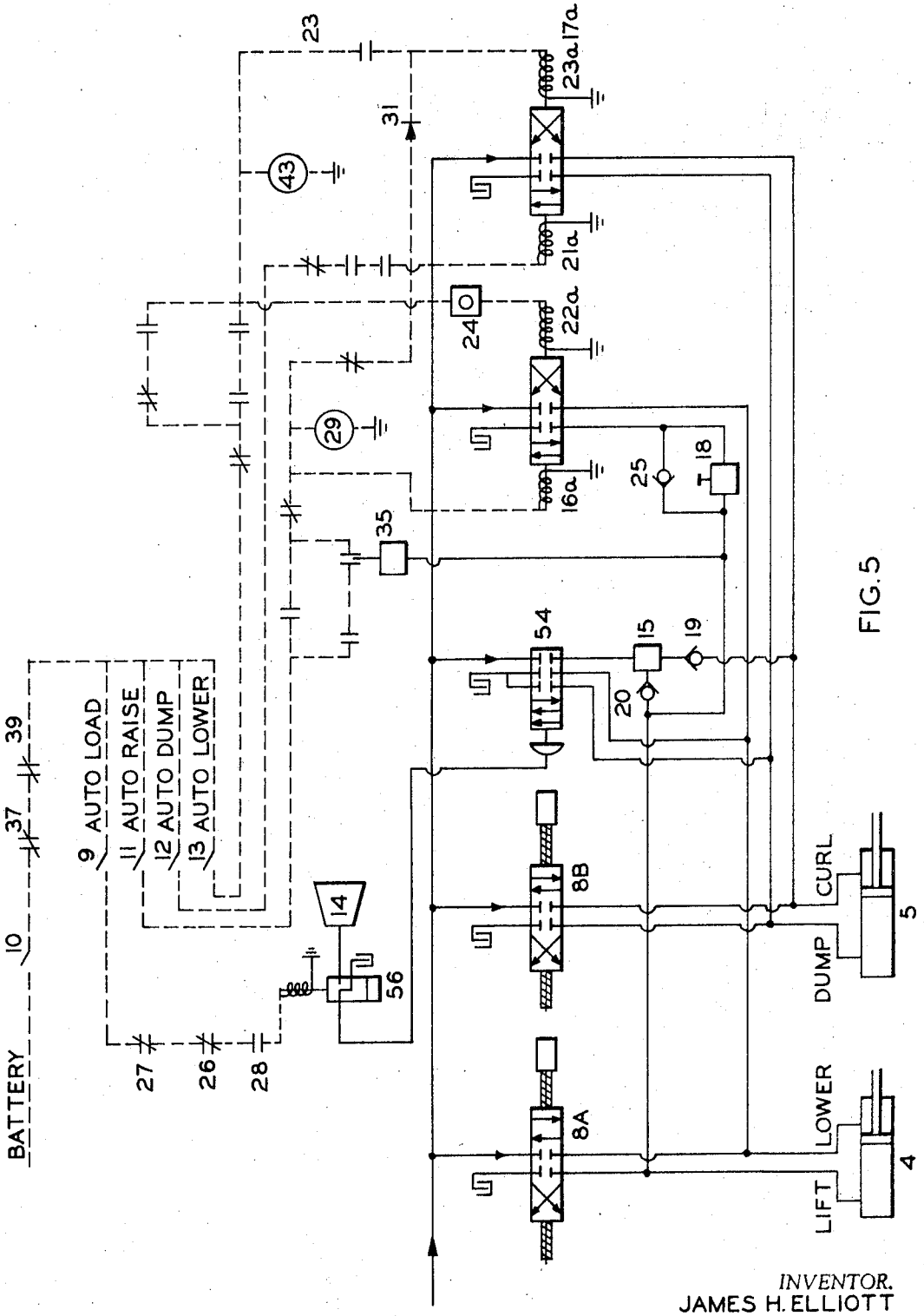


FIG. 5

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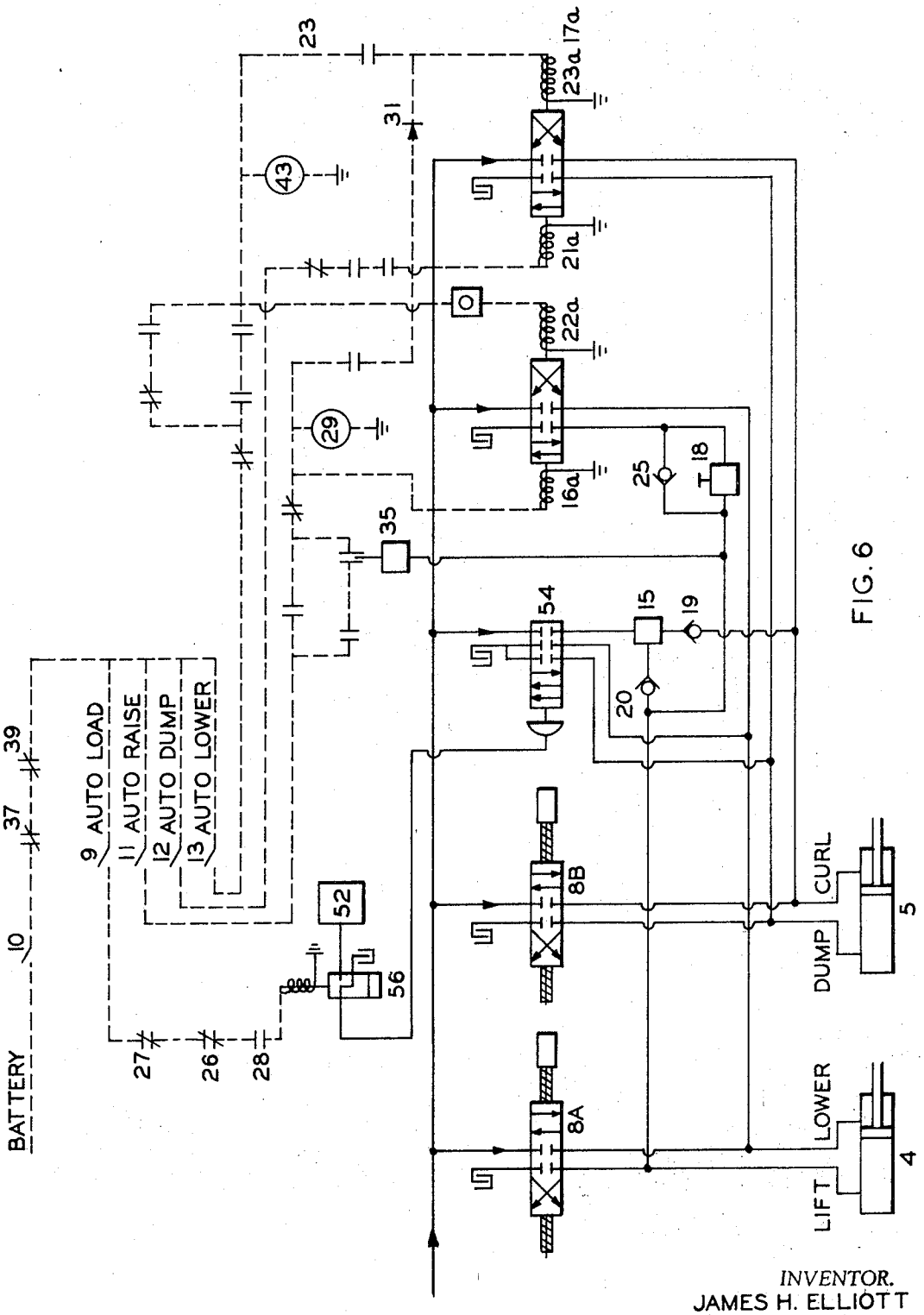


FIG. 6

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AUTOMATIC CONTROL SYSTEM FOR FRONT END LOADER

BACKGROUND

Front end loaders generally consist of a leading bucket mounted on the front of a tractor chassis (of some type or special manufacture) by two parallel arms. These arms are actuated either by mechanical means or by hydraulic cylinders. The machine is operated by lowering the bucket to the desired level, driving the machine into the spoil pile (which in turn loads the bucket), backing the machine out of the spoil pile, raising the bucket, driving the loader to the desired unloading point, and then dumping the bucket. At that time, the bucket is lowered and the loader driven back to the spoil pile. The loader units find their most valuable applications in loading out bulk material from stockpiles, loading trucks in sand and gravel pits, backfilling excavations, loading shot material in mines, etc.

The front end loaders in present use require the constant attention of the operator to the various functions. The operator must operate numerous levers and steering mechanisms to carry out the necessary sequence of operations. Throughout each step of the digging and loading operation, the operator must make continual decisions as to the necessary attitudes and movements of the digging bucket, and pull or push levers at the proper time to direct the digging cycle. For these reasons, considerable time and attention is required of the operator to maintain efficient operation and maximum loading rates.

SUMMARY OF INVENTION

The automatic hydraulic control system of this invention is adaptable to operate in parallel with a manually operated control system so that the operator of the loader may choose either manually or automatically to operate the machine, may pick any portion of the cycle as manual or automatic, and may switch from manual to automatic operation and vice versa at any stage of the operation. Manual operation of the loader requires the operator to dexteriously position the lift arms, bucket and loader by manipulation of levers to control the arms and bucket and by levers, foot pedals and steering apparatus to position the loader. The invention provides an automatic control system in which the lift arms and the bucket are automatically actuated, relieving the operator of the effort and judgement normally required and allowing the operator to concentrate on moving the loader itself.

OBJECTS

The primary object of this invention is to provide a system which will automatically cause some of the loading and dumping functions to be performed, thereby allowing the operator to spend a greater portion of his time in the driving and safe handling of the loader.

Another object of this invention is to provide an automatic loading and dumping cycle which may be placed in parallel with the manual controls.

Another object of this invention is to provide an automatic loading and dumping cycle, of which any desired portion can be preselected by the operator for either manual or automatic operation.

Still a further object of this invention is to provide an automatic loading and dumping cycle which can be changed at the operator's will, at any portion of the cycle, from manual to automatic and vice versa.

Other objects and advantages, as well as a full understanding of the invention, will be had from the following description and claims, taken in conjunction with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a carrier and front end loader to which the automatic hydraulic control system of this invention has been applied;

FIG. 2 is a pictorial flow diagram and electrical schematic of a preferred embodiment of the basic automatic control system;

FIG. 3 is a pictorial flow diagram and electrical schematic of the automatic control system with certain of the control valves combined;

FIG. 4 is a pictorial flow diagram and electrical schematic of the automatic control system of this invention and differs from FIG. 3 in that a different transducer than the torque converter has been used to determine the loading resistance to the bucket;

FIG. 5 is a pictorial flow diagram and electrical schematic of the automatic control system of this invention and differs from FIG. 3 in that a modulating valve is used to control the bucket movements during the loading process; and

FIG. 6 is a pictorial flow diagram and electrical schematic of the automatic control system of this invention and differs from FIG. 3 in that a modulating valve is used to control the bucket movements during the loading process and a different transducer than the torque converter has been used to determine the loading resistance to the bucket.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with the general concepts of the invention and with reference to the drawings, a pressure sensitive means is utilized together with the lift arms, the lift arm to bucket connection, the lift arm to loader connection, etc., providing a signal output when the loading resistance to the loader increases above a value preselected by the operator. Means responsive to the signal output is utilized to actuate the bucket cylinder and lift arm cylinders to decrease the loading attitude of the bucket and raise the lift arms. When the loading resistance decreases to less than the preselected value the responsive means is deactivated. The loader machine includes means responsive to the bucket load. In this way, when the operator reverses the loader transmission, a limit switch is actuated (if the pressure transducer in the lift arms senses a vertical load on the bucket) and signals the bucket cylinder valve to tilt the bucket to carry position. Also actuated is the lift arm cylinder valve to raise the bucket to a preselected height. Limit switches are provided to stop the fluid flow to the bucket cylinders and lift cylinders whenever the bucket reaches the carry position and carry height. The loader machine further includes means to automatically dump the bucket when the loader contacts the side of the dump truck. A limit switch, mounted on the loader engages the side of the truck body, another limit switch on the lift arms senses that the lift arms are at dump height, and a signal is sent to the bucket cylinder control valve to dump the bucket. This in turn provides hydraulic fluid under pressure to the bucket cylinders and pivots the bucket to the dump position. As the bucket reaches the dump position, a limit switch mounted on the lift arms is actuated and shuts off the bucket control valve, thereby stopping fluid flow to the bucket cylinders and leaving the bucket in the dump position. The loader machine also includes means to automatically lower the bucket and return it to a loading attitude and height when the carrier vehicle is backed away from the dump truck by the operator. As the limit switch mentioned above disengages the side of the truck body, another limit switch senses that the bucket is in the dump position, another limit switch senses that the carrier vehicle is in reverse, a limit switch senses that the lift arms are in the raised position and a relay is engaged which actuates the control valve to the bucket cylinder. The hydraulic fluid flows from the source to the bucket rams, tilting them back until the bucket actuates a limit switch on the lift arms and stops the bucket in the preset load position. At the same time that the bucket starts its return to the load position, the relay actuates a delay timer in the circuit to the lift arm lower valve. This timer is field adjustable by the operator to allow sufficient time for the bucket to finish clearing the side of the truck. At the end of the preset period, the lift cylinder lower valve is actuated and the bucket is automatically lowered until it reaches

a preset height. At that time a limit switch measures the elevation of the lift arms and disengages the relay supplying power to the lift cylinder valves, shutting off the flow of fluid and stopping the bucket at the correct height for loading.

Referring now to FIG. 1, a front end loader is shown consisting of the basic components of a carrier vehicle 1, having mounted at the front thereof a pair of lift arms, indicated generally by the number 2, a bucket 3 pivoted to the end of the lift arms 2, a double- or single-acting pair of rams 4 pivotally connected at one end to the carrier 1 and at the other end to the lift arm 2 whereby the lift arm 2 is pivoted in a vertical plane, these rams being known as the lift cylinders or rams. One or two double-acting rams 5 are pivotally connected at one end to the lift arm assembly 2 and at the other end to the bucket assembly 3 where by the bucket 3 is pivoted in a vertical plane, these rams being known as the bucket cylinders or rams.

All of the components of the front end loader machine described to this point are standard in the industry. The bucket 3 is controlled by hydraulic fluid pressure directed into the rams 4 and 5, the fluid flow being normally directed by an operator manipulating manual valve 8, generally indicated. In addition, the carrier 1 has a steering wheel 6, plus various other controls such as throttle, brake, gear shift, clutch, etc., all of which are common to wheeled or tracked carriers. Typically, there are two levers operating the manual valve 8, each of which basically consists of a closed center three-position valve, wherein the valve pushed outwardly conducts fluid to cause a ram to operate in one direction and, when pulled inwardly, conducts fluid flow to cause a ram to move in the opposite direction with the center position being the off or no-flow position.

The present invention consists essentially in its most general sense of applying, to the typical hydraulically operated front end loader unit described to this point, an electric-hydraulic control system whereby substantially all of the manual manipulation of the valves 8 is replaced by automatically controlled systems.

Referring now to FIG. 2, a pictorial flow diagram is shown of the basic hydraulic circuit of a preferred embodiment wherein the loading, raising, carrying, dumping, and repositioning for loading cycles are automatically controlled.

With specific reference to FIG. 2, and continued reference to the loader of FIG. 1, of the automatic loading cycle, there is positioned in parallel with the manual valves 8A and 8B, a solenoid operated two-position automatic load valve 7. This valve 7 controls hydraulic fluid pressure to the lift side of the lift ram 4 and the curl side of the bucket ram 5 when the solenoid 7*a* is energized, and blocks the movement of the rams when the solenoid 7*a* is deenergized. The operation of the hydraulic circuit is initiated when the lift arms 2 are lowered to the loading position closing limit switch 26 mounted on the carrier 1. The bucket 3 is then leveled to the loading attitude closing limit switch 27 mounted on the lift arm 2 assembly, as the mode selector switch 9 and the master automatic switch 10 are energized, the transmission of the carrier is in low gear closing limit switch 28. When the operator drives the loader bucket into the spoil pile and the bucket of the loader encounters sufficient resistance, the pressure in the torque converter 14 will rise and transmit a signal to the pressure switch 61. The pressure at which the contacts of switch 61 close is adjustable by the operator depending upon the type of soil being loaded and the condition of the ground the loader is operating on. At a preset pressure of the torque converter, somewhere just below the stall point of the carrier, the contacts of switch 61 will close and energize the solenoid 7*a* of the automatic loading valve 7. Fluid will flow via hydraulic line 38 from the carrier source 30 to the flow divider 15 and then to the lift side of the lift ram 4 and the curl side of the bucket ram 5. The flow divider 15 will insure that the bucket 3 will curl in a predetermined ratio to the amount of lift of the bucket. This is accomplished as the flow divider will split the flow from valve 7 in a predetermined ratio between the bucket cylinder 5 and the lift cylinder 4. As the bucket is raised, the amount of bucket curl will be in direct proportion to the amount of lift. As the bucket 3 lifts and curls in the spoil pile, the resistance to the loader bucket 3 will decrease and the loader bucket 3 will drive deeper into the spoil pile. At the same time, the lessened resistance to the loader bucket 3 will decrease the pressure in the torque converter 14, open the contacts of pressure switch 61 and stop the movement of the bucket 3 until sufficient bucket resistance is again encountered to start the cycle all over again. In this manner the loader continually moves into the spoil pile under the constant drive of the automatic transmission and the bucket raises and curls to obtain a full load. Pressure switch 61 will be preset by the operator to a value that raises and curls the bucket 3 just before the loader stalls or starts to spin its wheels, whichever occurs first. As soon as the bucket 3 is full, the operator reverses the carrier vehicle 7, this opens limit switch 28 and deenergizes the automatic loading solenoid valve 7. At any time the automatic loading cycle can be stopped by either opening the master control switch 10, the mode selector switch auto load 9, or by operating either of the manual control valves 8A and 8B which in turn will open their respective limit switches 37 and 39. Any of the above operations will deenergize the automatic loading solenoid valve 7. However, as soon as the manual control valves are returned to the neutral position, their limit switches will close and restart the loading cycle at a point where it was stopped.

For the automatic raising cycle, positioned in parallel with the manual valves 8A and 8B, respectively, are solenoid operated two-position valves, lift arm automatic raise valve 16 and bucket automatic carry valve 17. The lift arm automatic raise valve 16 controls hydraulic fluid pressure to the lift side of ram 4 when the solenoid 16*a* is energized, and blocks the movement of the rams 4 when the solenoid 16*a* is deenergized. The bucket automatic carry valve 17 controls the hydraulic fluid pressure to the curl side of the bucket rams 5 when the solenoid 17*a* is energized and blocks the movement of the bucket 3 when the solenoid 17*a* is deenergized. The operation of the automatic raise cycle is initiated when the operator energizes master automatic switch 10, mode selector switch auto raise 11, loads the bucket and shifts the carrier transmission to reverse.

When limit switch 31 is closed by the reverse lever of the transmission, pressure switch 35 measures the hydraulic fluid pressure in the bucket lift rams 4 and determines that the bucket 3 is loaded. When the pressure switch contact 35 closes, it completes a circuit to the auxiliary relay 29, the contacts on the relay 29 close and hold the relay 29 energized regardless of whether or not the transmission is now placed in reverse or forward. At the same time that the auxiliary relay 29 is energized, a circuit is completed to both solenoids 16*a* and 17*a* of the lift arm automatic raise valve 16 and bucket automatic carry valve 17. Hydraulic fluid under pressure is supplied via hydraulic line 44 at full volume through valve 17 to the bucket curl ram 5 and tilts the bucket 3 to the carry position. When the bucket 3 is in the proper position for carry, limit switch 53, mounted on the lift arm assembly 2, is actuated by the bucket 3 and opens the circuit to the solenoid 17*a* of valve 17. This in turn blocks the bucket ram 5 in the carry position. At the same time that the automatic bucket carry valve 17 is energized, the automatic lift arm raise valve 16 is energized. In this condition hydraulic fluid under pressure is supplied via hydraulic line 40 through the adjustable flow restrictor 18 to the lift arm cylinders 4, raising the bucket 3 in the air. The purpose of the flow restrictor control valve 18 is to give the bucket time to tilt from the load position to the carry position before it gets too high in the air. Also on rough terrain, an operator would adjust the rate of lift of the bucket so that it would not be high in the air for any period longer than necessary and would reach its maximum height just as the carrier was approaching the truck. When the bucket 3 reaches the proper height in the air, a preset limit switch 33 mounted on the carrier 1 would contact the lift arm 2, limit switch con-

tact 33 would open deenergizing both the auxiliary relay 29 and the automatic lift arm raise valve 16 which in turn would shut off the fluid flow from the lift arm rams 4 and hold the bucket 3 in the raised position.

As in the automatic loading cycle, the automatic raise cycle can be stopped at any time either by opening the master control switch 10, the mode selector switch auto raise 11, or by operating either of the manual control valves 8A and 8B which in turn will open their respective limit switches 37 and 39. Any of the preceding operations will deenergize the auxiliary relay 29, the automatic raise valve 16, and the automatic carry valve 17. However, as soon as the manual control valves are returned to the neutral position, their limit switches will close and restart the raise and carry cycle where it stopped, provided that the transmission is still in reverse. Check valves 19, 20, and 25 prevent the hydraulic fluid from flowing in the wrong direction and actuating a ram at the wrong time.

For the automatic dump cycle, positioned in parallel with the manual valve 8B, is a solenoid operated two-position automatic dump valve 21. This valve controls hydraulic fluid pressure to the dump side of the bucket ram 5 when the solenoid is energized, and blocks the movement of the ram when the solenoid 21*a* is deenergized. The operation of the hydraulic cycle is initiated when the master automatic switch 10 and the mode selector switch automatic dump 12 are energized. The lift arms are raised to the dump position closing limit switch 59 mounted on the carrier 1. The bucket 3 is in the carry position closing limit switch 55 mounted on the lift arm assembly, and the operator drives the carrier up to the truck. This in turn actuates limit switch 57 mounted on the loader lift arm assembly when it touches the truck body. Limit switch 57 and 45 are normally mechanically retracted out of harms way to prevent mechanical damage when the lift arms are lowered and are only extended in operating position when the lift arms are raised in position to dump. As soon as limit switch 57 is actuated, the circuit is completed to solenoid automatic dump valve 21 and hydraulic fluid under pressure is supplied through valve 21 to the bucket dump ram 5 which tilts it to the dump position. When the bucket is in full dump position, limit switch 55 mounted on the lift arm assembly is actuated by the bucket and opens the circuit to the solenoid dump valve 21, which in turn blocks the bucket ram 5 in the dump position.

As in the automatic loading cycle, the automatic dump cycle can be stopped at any time either by opening the master control switch 10, the mode selector switch auto dump 12, or by operating either of the manual control valves 8A and 8B which in turn will open their respective limit switches 37 and 39. Any of the preceding operations will deenergize the automatic raise valve 21. However, as soon as the manual control valves are returned to the neutral position, their limit switches will close and restart the dump cycle where it stopped.

For the automatic lower cycle, positioned in parallel with the manual valves 8A and 8B, respectively, are solenoid operated two-position valves, lift arm automatic lower valve 22 and bucket automatic lower valve 23. The lift arm automatic lower valve 22 controls hydraulic fluid pressure to the lower side of ram 4 when the solenoid 22*a* is energized, and blocks the movement of the rams 4 when the solenoid is deenergized. The bucket automatic lower valve 23 controls hydraulic fluid pressure to the curl side of the bucket rams 5 when the solenoid 23*a* is energized and blocks the movement of the bucket 3 when the solenoid 23*a* is deenergized. The operation of the automatic lower cycle is initiated when the operator energizes the master automatic switch 10 and mode selector switch auto lower 13. At this time the lift arms are in the raised position closing limit switch 41 mounted on the carrier 1, the bucket 3 is in the dump position closing limit switch 47 mounted on the lift arm assembly. Also at this time the operator shifts the carrier into reverse closing limit switch 49 mounted on the gear shift. The carrier backs away from the truck closing limit switch 45 mounted on the lift arms which had previously been in contact with the truck body. As soon as limit switch 45 closes, a circuit is completed to the auxiliary relay 43, the contacts on the 43 relay close and hole the relay energized regardless of whether or not the transmission is now placed in reverse or forward gear. At the same time that the auxiliary relay 43 is energized, a circuit is completed through the solenoid 23*a* of the bucket automatic lower valve 23.

Hydraulic fluid under pressure is supplied via hydraulic line 50 at full volume through valve 23 to the bucket curl ram 5. This causes the bucket 3 to tilt from the dump position to the load position. When the bucket is in the proper position for loading, limit switch 51 mounted on the lift arm assembly is actuated by the bucket 3. This opens the circuit to the solenoid 23*a* of valve 23, which in turn blocks the bucket ram 5 in the load position. At the same time that the automatic bucket lower valve is energized, delay timer 24 to the automatic lift arm lower valve 23 is energized. The amount of delay is preset by the operator to allow sufficient time for the loader bucket to finish clearing the sides of the truck before the lift arms start to lower. At the end of the preset interval, a contact in delay timer 24 is closed and the automatic lift arm lower valve 22 is energized. Hydraulic fluid under pressure now flows through valve 22 to the lift arm cylinder 4, lowering the bucket down toward the ground. When the bucket 3 reaches the proper height above the ground for loading, a preset limit switch 41 mounted on the carrier 1 contacts the lift arm 2. The limit switch contact 41 then opens deenergizing both the auxiliary relay 43 and the automatic lift arm lower valve 22. This in turn shuts off the fluid flow from the lift arm rams 4 and holds the bucket 3 at the correct height for loading. Relay 43 cannot be reenergized as limit switch 47 mounted on the lift arm assembly is opened by the bucket as soon as it moves out of the dump position toward the load position.

As in the automatic loading cycle, the automatic lower cycle can be stopped at any time either by opening the master control switch 10, the mode selector switch auto lower 13, or by operating either of the manual control valves 8A and 8B which in turn will open their respective limit switches 37 and 39. Any of the preceding operations will deenergize the auxiliary relay 43, the automatic lift arm lower valve 22 and the automatic bucket lower valve 23. However, as soon as the manual control valves are returned to the neutral position, their limit switches will close and restart the automatic lower cycle where it stopped provided that the transmission is still in reverse and the bucket has not moved far enough out of the dump position to trip limit switch 47 mentioned previously.

The loader has now completed its cycle and is ready to start the automatic loading cycle again whenever the operator drives the bucket 3 into the spoil pile. From the previous description it is seen that any of the cycles can be performed either automatically or manually without affecting the operation of the following cycle. The portions can be preselected by the mode selector switches 9, 11, 12, 13 by either setting them in the automatic or manual position at the operator's discretion.

In the working embodiment of the systems of this invention, it is desirable that flow control valves be utilized in certain instances to slow the action of the hydraulic cylinders. In addition, devices to cushion the stopping of the cylinders may be desired plus pressure relief valves, filters, etc. Since such devices are well known in the industry and are not basic to the systems of this invention, they have not been shown. Also, the system has been described in its simplest form for easy comprehension of the various elements involved. In actual practice, economy would probably be achieved by combining some of the valves as shown in FIG. 3. In this embodiment valves 21 and 23 are combined into one valve with dual solenoids, 21*a* and 23*a*. When solenoid 21*a* is energized the bucket moves in the dump direction and when solenoid 23*a* is energized the bucket moves in the curl position. In addition, valve 17 is eliminated and the control circuit for solenoid 17*a* is connected to solenoid 23*a* through an isolating diode 31. Valves 16 and 22 are combined into one valve with dual solenoids 16*a* and 22*a*. When solenoid 16*a* is energized, the lift arms move in the raise position and if solenoid 22*a* is energized, the lift arms move in the lower position.

Referring now to FIG. 4, a pictorial flow diagram is shown of the basic hydraulic circuit of this invention, wherein the loading, raising, carrying, dumping, and repositioning for loading cycles are automatically controlled. Since FIG. 4 differs from FIG. 3 in the control of the loading cycle only, this is the only portion that will be described. In this embodiment the control transducer is located on bucket arms to measure the loading reference.

With specific reference to FIG. 4 and general reference to FIGS. 1, 2 and 3 for the automatic loading cycle, there is positioned in parallel with the manual valves 8A and 8B the solenoid operated two position automatic load valve 7. The function of the valve is to control the hydraulic fluid pressure to the lift side of the lift ram 4 and the curl side of the bucket ram 5 (FIG. 1). When not energized, the solenoid 7*a* blocks the movement of the rams. The operation of the hydraulic circuit is initiated when the lift arms are lowered to the digging position closing limit switch 26 mounted on the carrier 1, and the bucket is leveled to the loading attitude closing limit switch 27 mounted on the lift arm assembly. This causes the mode selector switch 9 and the master automatic switch 10 (both shown in FIG. 2) to become energized. The transmission of the carrier at this time is in low gear closing limit switch 28 as the operator drives the loader bucket into the spoil pile. When the bucket encounters sufficient resistance, the load on the transducer 52 will rise and transmit a signal to the switch 61.

The transducer 52 could be placed in several different places to measure the loading force on the bucket or forks, such as on the lift arm 2 connection 2A to the loader 7 to measure the horizontal loading force, on the lift arm 2 to bucket 3 connection 2B to measure the horizontal loading force on the bucket, in the lift arm 2 itself to measure the force along the lift arms, or in the driving train from the carrier engine to the carrier wheels or tracks. If the carrier were of the type to be electrically propelled, the transducer 52 could be placed to measure the current flow to the propelling motors. If the carrier 1 was propelled by hydraulic motors, the transducer 52 could be placed to measure the pressure to the hydraulic motors, etc.

The signal level at which the contacts of 61 close is adjustable during the cycle by the operator depending upon the type of soil being loaded and the condition of the ground the loader is operating on.

At a preset signal from the transducer 52, somewhere just below the stall point of the carrier, contacts 61 will close and energize the solenoid 7*a* of the automatic loading valve 7. Fluid will flow from the carrier source to the flow divider 15 (FIG. 2) and then to the lift side of the lift ram 4 and the curl side of the bucket ram 5 (FIG. 1). The flow divider 15 will insure that the bucket 3 will curl in a predetermined ratio to the amount of lift of the bucket. As the bucket lifts and curls in the spoil pile, the resistance to the carrier bucket 3 will decrease and the loader will drive bucket 3 deeper into the spoil pile. At the same time, the lessened resistance to the bucket will decrease the signal level from the transducer 52, open the contacts of switch 61 and stop the movement of the bucket until sufficient bucket resistance is again encountered to start the cycle all over again. In this fashion, the carrier will continually move into the spoil pile under the constant drive from the its engine and the bucket will raise and curl to obtain a full load.

As soon as the bucket is full, the operator reverses the carrier, this opens limit switch 28 and deenergizes the automatic loading solenoid valve 7. At any time the automatic loading cycle can be stopped by either opening the master control switch 10, the mode selector switch auto load 9, or by operating either of the manual control valves 8A and 8B which in turn will open their respective limit switches 37 and 39 (FIG. 2). Any of the above operations will deenergize the automatic loading solenoid valve 7. However, as soon as the manual control valves 8 are returned to the neutral position, their limit switches 37 and 39 will close and restart the loading cycle in a position where it was interrupted.

Referring now to FIG. 5, a pictorial flow diagram is shown of the basic hydraulic circuit of the present invention, wherein the loading, raising, carrying, dumping and repositioning for the digging cycles are automatically controlled. Since FIG. 5 differs from FIG. 3 in the control of the loading cycle only, this is the only portion of FIG. 5 that will be described.

With specific reference to FIG. 5 and with general reference to FIGS. 1, 2, and 3 for the automatic loading cycle, there is positioned in parallel with the manual valves 8A and 8B the power operated two position automatic load modulating valve 54. The valve 54 controls hydraulic fluid pressure to the lift side of the lift ram 4 (FIG. 3) and the curl side of the bucket ram 5 (FIG. 3) when the modulating valve 54 is energized and blocks the movement of the rams when the valve 54 is deenergized. The operation of the hydraulic circuit is initiated when the lift arms 2 are lowered to the loading position, closing limit switch 26 mounted on the carrier 1. At this time the bucket is leveled to the loading attitude closing limit switch 27 mounted on the lift arm assembly. This causes the mode selector switch auto load 9 and the master automatic switch 10 (FIG. 3) to become energized. The transmission of the carrier at this time is in low gear closing limit switch 28 which in turn will energize the two position solenoid valve 56. This last named valve 56 controls the flow of the torque converter pressure to the modulating operator of the automatic load valve 54.

In operation, as the operator drives the bucket 3 into the spoil pile the bucket 3 will encounter resistance. When sufficient resistance is met, the pressure in the torque converter 14 will rise and in turn the rising pressure will be transmitted to the modulating actuator of the automatic load valve 54.

The amount of pressure required to start modulating valve 54 is adjustable during the cycle by the operator depending upon the type of soil being loaded and the condition of the ground the loader is operating on. Generally, the modulating valve 54 will be preset by the operator to a value that it raises and curls the bucket 3 just before the carrier stalls or starts to spin its wheels, whichever occurs first.

At the preset pressure from the torque converter, valve 54 will start to open and fluid will flow from the carrier source to the flow divider 15 (FIG. 3) and then to the lift side of the lift ram 4 (FIG. 3) and the curl side of the bucket ram 5 (FIG. 3). The flow divider 15 will insure that the bucket will curl in a predetermined ratio to the amount of lift of the bucket. As the bucket lifts and curls in the spoil pile, the resistance to the loader bucket will decrease and the loader will drive deeper into the spoil pile. At the same time, the lessened resistance to the bucket will decrease the pressure in the torque converter 14, and start to close valve 54 which will slow the rate of lifting and curling of the bucket. If the resistance to the loader bucket is lessened sufficiently to drop the pressure from the torque converter 14 below the preset value required to operate valve 54, valve 54 will close completely and the lifting and curling of the bucket will be stopped until sufficient resistance is again encountered to start the cycle all over again. Accordingly, the carrier continually moves toward the spoil pile under the constant drive of the engine and the bucket 3 raises and curls in direct proportion to the horizontal bucket loading resistance to obtain a full load. As soon as the bucket is full, the operator reverses the carrier, this opens limit switch 28 and deenergizes solenoid valve 56 which in turn shuts off the modulating signal flow to the automatic load valve 54 and shuts down the automatic loading cycle.

At any time the automatic loading cycle can be stopped by either opening the master control switch 10 (FIG. 3) the mode selector switch auto load 9, or by operating either of the manual control valves 8A and 8B which in turn will open their respective limit switches 37 and 39 (FIG. 3). Any of the above operations will deenergize the control solenoid valve 56 which in turn will close the automatic load valve 54. However, as soon as the manual control valves are returned to their neutral position, their limit switches 37 and 39 (FIG. 3) will close and restart the loading cycle where it was interrupted.

Referring now to FIG. 6, a pictorial flow diagram is shown of the basic hydraulic circuit of the present invention, wherein the loading, raising, carrying, dumping and repositioning for the digging cycles are automatically controlled. Since FIG. 6 differs from FIG. 3 in the control of the loading cycle only, this is the only portion of FIG. 6 that will be described.

With specific reference to FIG. 6 and general reference to FIGS. 1, 2 and 3, for the automatic loading cycle, there is positioned in parallel with the manual valves 8A and 8B (FIG. 3) the power operated two-position automatic load modulating valve 54. This valve controls hydraulic fluid pressure to the lift side of the lift ram 4 (FIG. 3) and the curl side of the bucket ram 5 (FIG. 3) when the modulating valve 54 is energized and blocks the movement of the rams when the valve 54 is deenergized. The operation of the hydraulic circuit is initiated when the lift arms 2 are lowered to the loading position, closing limit switch 26 mounted on the carrier 1. At this time the bucket 3 is leveled to the loading attitude, closing limit switch 27 mounted on the lift arm assembly 2. This causes the mode selector switch auto load 9 and the master automatic switch 10 (FIG. 3) to become energized. The transmission of the carrier is in low gear closing limit switch 28 which in turn will energize the two position solenoid valve 56. This valve controls the signal flow from transducer 52 to the modulating operator of the automatic load valve 54.

In operation, as the operator drives the bucket 3 into the spoil pile, the bucket will encounter resistance, when sufficient resistance is met, the load on the transducer 52 will rise and in turn transmit a signal through the solenoid valve 52 to the modulating actuator of the automatic load valve 54.

The transducer 52 could be placed in several different positions to measure the loading force on the bucket 3 or forks, such as on the lift arm 2 connection 2A to the carrier 1 to measure the horizontal loading force, on the lift arm 2 to bucket 3 connection 2B to measure the horizontal loading force on the bucket, in the lift arm 2 itself to measure the force along the lift arms, in the driving train from the loader engine to the loader wheels or tracks, if the loader was electrically propelled, the transducer 52 could be placed to measure the current flow to the propelling motors, if the loader was propelled by hydraulic motors, the transducer 52 could be placed to measure the pressure to the hydraulic motors, etc.

The signal level required to start modulating valve 54 is adjustable during the load cycle by the operator depending upon the type of soil being loaded and the condition of the ground the loader is operating on. Generally, the modulating valve 54 will be preset by the operator to a value that it raises and curls the bucket just before the carrier stalls or starts to spin its wheels, whichever occurs first.

At a preset signal level from the transducer 52, valve 54 will start to open and fluid will flow from the carrier source to the flow divider 15 (FIG. 3) and then to the lift side of the lift ram 4 (FIG. 3) and the curl side of the bucket ram 5 (FIG. 3). The flow divider will insure that the bucket will curl in a predetermined ratio to the amount of lift of the bucket. As the bucket 3 lifts and curls in the pile, the resistance to the loader bucket 3 will decrease and the carrier 1 will drive deeper into the spoil pile. At the same time, the lessened resistance to the bucket 3 will decrease the pressure on the transducer 52 and start to close valve 54, which will slow down the rate of lifting and curling of the bucket 3. If the resistance to the loader bucket 3 is lessened sufficiently to drop the signal level from the transducer 52 below the preset value required to operate valve 54, valve 54 will close completely and the lifting and curling of the bucket 3 will be stopped until sufficient resistance is again encountered to start the cycle all over again. Accordingly, the carrier 1 continually moves into the spoil pile under the constant drive of the engine and the bucket 3 raises and curls in direct proportion to the horizontal bucket loading resistance to obtain a full load in an efficient manner. As soon as the bucket 3 is full, the operator reverses the carrier, this opens limit switch 28 and deenergizes solenoid valve 56 which in turn shuts off the modulating signal flow to the automatic load valve 54 and shuts down the automatic loading cycle.

At any time the automatic loading cycle can be stopped by either opening the master control switch 10 (FIG. 3), the mode selector switch auto load 9 or by operating either of the manual control valves 8A and 8B (FIG. 3) which in turn will open their respective limit switches 37 and 39 (FIG. 3). Any of the above operations will deenergize the control solenoid valve 56 which in turn will shut down the automatic load valve 54. However, as soon as the manual control valves 8 (FIG. 3) are returned to their neutral position, their limit switches 37 and 39 (FIG. 3) will close and restart the loading cycle where it was interrupted.

Although certain and specific embodiments have been shown it is to be understood that modifications may be made without departing from the true spirit and scope of the invention.

What is claimed is:

1. An automatic control system for a front end loader of the type wherein a lift arm carrying a tiltable bucket is mounted on a self-propelled carrier which drives the lift arm and bucket into the material to be loaded, the improvement comprising: automatic control means for actuating said lift arm; automatic control means for actuating the tilt of said bucket; pressure sensing means associated with the horizontal loading resistance encountered by said bucket upon engagement with the material being loaded; transducer means connected to said pressure sensing means to provide a signal output related to the loading resistance sensed; switch means operatively connected to said transducer means and to each of said automatic control means to selectively actuate said control means responsive to a predetermined pressure value; manual control means for overriding each of said automatic control means; and second switching means responsive to a second sensed pressure signal indicating a given vertical load on said bucket, said second switching means activating said automatic control means to fully tilt said bucket to a carry position.

2. The automatic control system of claim 1 further including third switch means actuated when said bucket moves to a fully tilted carry position to activate the raising of said lift arm to a predetermined carry position.

3. The automatic control system of claim 1 including means for adjusting the rate which said lift arm raise to said carry position.

4. The automatic control system of claim 1 including switch means activated upon contact to actuate tilting said bucket from a carry position to a dump position and further including means responsive to reversing said carrier to automatically actuate the tilting of said bucket from said dumping position to a loading position and to actuate said lift arms to lower at a predetermined rate to a predetermined loading position.

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