

Sept. 23, 1952 J. A. ACKERMAN 2,611,246
PUMP AND MOTOR HYDRAULIC SYSTEM AND ELECTRICAL
CONTROL CIRCUITS THEREFOR
Filed April 28, 1950

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UNITED STATES PATENT OFFICE

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PUMP AND MOTOR HYDRAULIC SYSTEM
AND ELECTRICAL CONTROL CIRCUITS
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Application April 28, 1950, Serial No. 158,814

3 Claims. (Cl. 60—52)

1

This invention relates to hydraulic systems and controls therefor in industrial lift trucks, and particularly to tilting lift trucks of the roll clamping and roll rotating type, in which the clamping force is supplied by a hydraulic system.

An object of this invention is the provision of a control system by which the load clamping pressure is automatically maintained within a desired predetermined range, without the necessity of continuous operation of the hydraulic pump.

Another object is to provide a hydraulic activating system for a hydraulic clamp on a lift truck by which the clamping, once instituted, is maintained positively to the exclusion of the institution of the clamp releasing action, when the operator leaves the truck.

Still further objects and advantages will appear in the following description, and drawing in which:

Fig. 1 shows a preferred arrangement of hydraulic and electric circuits and controls for a roll clamp, activated and controlled by this invention;

Fig. 2 is the electric circuit of Fig. 1 presented independently for the sake of clarity.

For the handling of paper rolls, drums and other cylindrical objects, the common industrial trucks of the tier lift tiltable frame type have been provided with a roll clamping and grasping mechanism. In addition to the truck body and chassis with the ordinary electrical or mechanical means for propulsion and steering, and mechanical, hydraulic or electrical means for tilting the upright frame and raising and lowering the load carriage carried by the frame, a rotatable clamp is provided on the load carriage. The clamp rotating mechanism, which is interposed between the load carriage and the clamp proper, may be electrically or hydraulically operated, its main feature being rotatability through at least 90° so that objects may be picked up from a horizontal position and rotated to the vertical in tiering, or vice-versa. The particular form of the clamp may be rather varied, but almost universally the roll clamp comprises jaws with curved interior faces surfaced in whole or in part with rubber or some other, preferably resilient, friction padding, and a hydraulic cylinder means for opening and closing the jaws to apply or release clamping pressure.

The hydraulic circuit and controls therefore which constitute the present invention are intended primarily for the actuation and control of such a clamp. Since the clamp can be elevated with a load to a height well above the floor, and

2

can be retained there, safety considerations demand that the possibility of slipping of the roll from the clamp, or of accidental release, say when the operator is off the truck, be obviated. The present invention has features meeting these requirements in the form of a "dead-man" control for the clamp releasing action, and in a means for automatically restoring or maintaining the requisite clamping pressure without continuous operation of the hydraulic pump in the clamp circuit. Further, the hydraulic circuit of this invention is such as allows the use of a free and quick acting oil control or oil reversing valve. Since it is possible to use such a valve, a solenoid of reasonable size is sufficient to operate it, so that full electric control of the hydraulic operation is possible.

The hydraulic circuit system for operating the clamp and the electrical control system for the same are shown in Fig. 1. A reservoir 30 for the hydraulic fluid, usually oil, is connected by a line 31 to the inlet of the hydraulic pump 32 driven by the electric motor 33. The outlet of the pump delivers oil by line 34 to the inlet port 35 of oil reversing valve 36, which is here operated by solenoid 37. The oil return line 38 connects the oil return port 39 of the oil reversing valve to the line 31 or equivalently to the reservoir 30. The hydraulic clamping cylinders 40 are double-acting so that application of hydraulic pressure to one side of the pistons therein effects the clamping and to the other side the clamp releasing action. Hence, the line 41, joining the ends of the cylinders where releasing pressure is to be applied, is connected by line 42 to the unclamping port 43, while the clamping port 44 is connected to the clamping or work stroke pressure end of the cylinders, joined by line 45, by line 46 leading to the inlet port 47 of the check valve 48, and line 49 from the outlet port 50 of the check valve to line 45. The actuating pressure port 51 of the check valve is connected by line 52 to a point in the circuit between the clamp releasing or return stroke pressure end of the cylinders and reversing valve port 43, as here shown, to line 41. To the lines between the outlet port 50 of the check valve and the clamping pressure ends of the cylinders, a pressure switch 53 and pressure gauge 54 are connected. This switch is adjustable with respect to the upper and lower pressures of its range of operation, so that it opens when the clamping pressure attains a certain value and closes when the pressure drops below some determined lower value.

The oil reversing valve has the function of reversing the direction of oil flow in the controlled

circuit, which is connected to the controlled ports 43 and 44 of the valve. Hence, the oil reversing valve is of that type, known to the art, which, at one operating position, internally connects inlet port 35 and controlled releasing port 43, while at the same time the controlled clamping port 44 is internally connected to the oil return port 39, and at the other position reverses these connections, inlet 35 to clamping port 44 and releasing port 43 to oil return port 39.

The check valve is of that type which allows flow in one direction, here into inlet port 47 and out port 50, but not in the reverse direction unless actuating pressure is applied at port 51. The actuating pressure applied at port 51 moves a piston within the check valve which unseats the positively seating flow checking means of the valve to allow reverse flow.

Pump motor 33 is shown connected to the negative terminal of a storage battery (not shown) by conductor 111 and to one side of the solenoid operated motor switch 112 by conductor 113. The other side of switch 112 is connected to the positive battery terminal by conductor 114 and also to one side of the solenoid 115, which closes motor switch 112 against the opening bias of a spring. The oil valve solenoid, generally indicated 37, has two coils 116 and 117 by which the armature 118 can be shifted forward and backward to move the oil reversing valve from a neutral position respectively to the clamping or releasing position. Spring means (not shown) are provided to urge the valve back to its neutral position. The other side of solenoid 115 is connected by conductor 119 to one side of both coils 116 and 117. The other side of coil 117 is connected by conductor 120 to pedal switch 121 mounted on the truck at the operator's control station. This pedal switch is provided as a safety device so that the load can't be released when the operator is off the truck. It is normally biased open, and is closed only by the operator's foot when the operator is on the truck at the controls, thus serving as a type of "dead-man" control for the clamp releasing circuit. The other side of coil 116 is connected by conductor 122 to one terminal of the pressure switch 53.

The operating switches, namely, the clamping switch 123 and releasing switch 124, are operationally related, so that when one is closed the other must be open and vice-versa. Moreover, the clamping switch automatically locks in its closed position so that a positive unlocking action is necessary. These two switches 123 and 124 are usually incorporated in one control device operated by a single manual operating lever, wherein placing the operating lever in one extreme clamping-releasing position closes switch 124 and simultaneously opens switch 123, while placing the operating lever in the other extreme clamping position opens 124, and closes 123. Whatever type of mechanical arrangement is used for switches 123 and 124, the system must be such that both can't be closed at the same time, that switch 124 must be held closed by the operator for releasing or opening the clamp, and that switch 123 upon closure automatically locks, so that some positive action is necessary to release it.

One contact of each of these switches is connected by conductor 125 to conductor 111. The other side of clamping switch 123 is connected to pressure switch 53 by conductor 126. The other side of the unclamping switch is connected by conductor 127 to the pedal-switch 121.

When the clamping action of this hydraulic

system is to be set in operation, clamping switch 123 is closed and is thereupon automatically held. The pressure switch 53 is closed, since no hydraulic pressure is yet developed. Hence there is a closed circuit from conductor 114 coming from the positive battery terminals over to conductor 111 leading to the negative terminal of the battery, and the current flows from 114 through motor switch solenoid 115, conductor 119, through the clamping control branch of the circuit, comprising clamping coil 116 of the oil valve solenoid, conductor 122, pressure switch 53, conductor 126, clamping switch 123, and conductor 125 to conductor 111. This current causes the closing of motor switch 112, so that the motor 33 and pump 32 come into operation. This same current also causes the clamping solenoid coil 116 to throw the armature 118 and so move the oil reversing valve to a position for clamping action, that is, so that inlet port 35 connects to clamping port 44, and oil return port 39 is connected to release port 43. Thus the oil delivered by the pump 32 to line 34 passes into port 35, through the oil reversing valve and out port 44 to line 46 which carries it to the check valve inlet port 47. As the oil is flowing in the direction for which the check valve normally allows flow, the oil passes out through port 50 to line 49, and then to line 45 by which it is delivered to the clamping end of the hydraulic cylinders. As the pistons in cylinder 40 are moved in a work stroke for clamping action by the oil admitted from line 45, oil on the other side of the pistons is expelled from the cylinders into line 41, whence it flows through line 42 to releasing port 43, through the oil reversing valve to oil return port 39 and line 38, leading back to the line 31 joining oil tank 30 and intake of pump 32. The direction of arrows adjacent the hydraulic lines in Fig. 1 show the direction of oil flow during this institution of the clamping pressure.

When the desired clamping pressure is attained in the cylinders, for which pressure switch 53 is pre-set, switch 53 opens, thereby interrupting the current flow. Hence solenoid 115 is de-energized allowing motor switch 112 to open, so that motor 33 and pump 32 cease to operate. The armature 118 of solenoid 37 moves from its neutral or non-operative position only under the positive influence of either coil 116 or 117 when energized. When current ceases to flow in one of these coils, the armature 118, and therefore the connected oil reversing valve 36, is returned to the neutral position. When the pressure in the system between the outlet of pump 32 and check valve inlet 47 drops on stopping of the pump, there is no back flow from the clamping ends of cylinder 40 through lines 45 and 49, because of the checking action of the valve 48. Since this checking action prevents back flow of oil from the clamping side of the pistons, the clamping pressure is thereby maintained without need of continuous operation of the pump.

If slow leakage or thermal changes in the clamping lines between cylinders and check valve cause a drop in pressure below a certain necessary minimum, for which pressure switch 53 is set to respond by going into closed or "on" position, then the closing response of 53 to this pressure drop immediately causes current to flow, as above explained, through solenoid coils 115 and 116, and switches 53 and 123. The current flow in coil 116 again moves the armature 118 and valve 36 to clamping position, and in solenoid 115 the current flow closes switch 112 to start the pump operating

to restore the clamping pressure. After this pressure is restored, pressure switch 53 again opens to stop pump operation as above explained. If a pressure drop in clamping lines again occurs, this cycle will be repeated to maintain clamping action, as long as the clamping switch 123 is not unlocked from its closed position. As different sizes, weights and materials of the rolls being clamped may require different clamping pressures, the pressure switch 53 is set as needed for opening at a definite high pressure and closing at a definite low pressure with the aid of pressure gauge 54 which is on the same line as the pressure switch and hence indicates the pressures at which 53 responds.

To open the clamp, it is necessary that pedal switch 121 and clamp releasing switch 124 be closed. The current then flows from the conductor 114 connected to the positive terminal of the battery, through solenoid 115, conductor 119, through the releasing control branch of the circuit, comprising solenoid coil 117, conductor 120, pedal switch 121, conductor 127, switch 124 and conductor 125, to reach conductor 111 connected to motor 33 and to the negative terminal of the battery. This current flow energizes releasing coil 117 in solenoid 37 so that armature 118 moves oil valve 36 away from neutral position to the releasing position, wherein inlet port 35 is connected to releasing circuit port 43, while clamping circuit port 44 is connected to oil return port 39. The current flow also energizes solenoid 115 closing motor switch 112, thereby starting motor 33 and pump 32. The oil flow in the hydraulic circuit now differs from that during the work stroke or clamping action because of the change in oil switch position. Oil entering inlet port 35 now leaves clamp release circuit port 43 to traverse lines 42 and 41 to reach the clamp release pressure end of cylinders 40. The pressure in line 41 is communicated by line 52 to the inlet 51 of the check valve 48, causing the check valve to open to the reverse flow which it normally blocks. Now as the pistons in cylinders 40 are moved in a return stroke to a releasing position by oil pressure in line 41, oil is discharged from the cylinders on the other side of the piston into line 45, whence it goes into line 49, through the check valve 48, now open due to the action as above explained, through line 46 to clamping circuit port 44, through the oil reversing valve to oil return port 39, and so thereafter, as in the clamping action, back to the pump.

The pedal switch 121 is provided in the clamp opening control circuit as a safety measure. This pedal switch is placed on the floor of the truck so that it can be closed only when the operator is on the truck at his control or operating station. If the operator is not in such a position, but is off the truck, the roll cannot be released, even if the control lever of the operating switch is thrown so as to close switch 124. The previously explained clamping operation and control system maintains a sure clamping pressure, and that without need of continuous pump operation, as long as the switch 123 is not unlocked. Thus the operator may leave the truck while a roll is elevated, without danger of the roll slipping by gradual drop in clamping pressure due to oil leakage or thermal changes; or from a casual manipulation of the controls by anyone who does not mount the truck.

The whole clamping and control system above described can be mounted on the clamp itself, except for pedal switch 121 on the truck floor and operating switches 123 and 124, which would

be mounted on the truck within easy reach of the operator. The batteries, conductors 125 and 127 would of course be on the truck proper, while conductors 111, 114 and 120 and 126 may be flexible conductors extending from the truck proper to the clamping mechanism. All conductors and the hydraulic lines, with the above exceptions, may be contained within the clamp assembly.

The use of the operated check valve in the clamping circuit restricts the extent of the hydraulic circuit in which clamping pressure must be maintained after the motor and pump are cut off. By use of the check valve, only oil leaks occurring between the check valve 48 and the pistons of cylinders 40 will affect clamping pressure.

Thus leakage at the oil switch valve 36 is not of any consequence, so that a relatively lightly fitted, easy acting oil reversing valve may be used, which can be operated by a solenoid to give quick positive reversing action. Were a check valve not used, the oil reversing valve would have to be closely, tightly fitted to prevent leakage; and such a valve would be too sluggish to be operated by a reasonable sized solenoid or current in such a control circuit.

In the case of trucks having other hydraulically operated equipment for such service as tilting the upright frame or operating the load elevating mechanism, wherein the use of a single hydraulic pump and oil reservoir might be sought, the hydraulic circuit and controls of this invention can be adapted for use. In that event, the oil reversing valve 36 can be made one section of a multiple oil valve having other sections to operate each of the other hydraulic services; also pressure switch 53 would be omitted and the conductor 122 could be connected to one side of switch 123 where conductor 126 is connected in Fig. 1. To adjust the maximum clamping pressure, when the pressure switch is not used, an adjustable relief valve would be interposed in line 46 between clamping port 44 and check valve inlet 47 with an oil relief line to return released oil to the oil reservoir. Both conductors 119 and 125 could then be connected directly to the battery line. With such an arrangement, all the equipment concerned would be on the truck, with the exception of the cylinders 40 and check valve 48 which would of course be mounted in the clamp structure, with hydraulic lines 42 and 46 then being flexible connecting lines between truck and clamp.

I claim:

1. In a hydraulically operated mechanism having a double-acting hydraulic cylinder and an electric motor powered pump and a fluid reversing valve for reversing the direction of fluid flow with respect to the cylinder, an electrical control system comprising a solenoid operated motor switch in series with the motor and the source of electrical power therefor; solenoid means for operating the fluid reversing valve, said means comprising an armature mechanically linked to said valve and two connected coils for moving said armature to each of two operating positions for the valve; and an electrical circuit immediately connected to the electrical power source, said circuit comprising in series a solenoid coil to close said motor switch and a work stroke control branch and a return stroke control branch, said branches being connected to said power source, in parallel relation to each other, said work stroke control branch including in series one coil of said solenoid means and a work stroke control switch, said return stroke control branch

including in series the second coil of said solenoid means and a return stroke control switch.

2. In a hydraulically operated mechanism having a double-acting hydraulic cylinder and an electric motor powered pump and a fluid reversing valve for reversing the direction of fluid flow with respect to the cylinder, an electrical control system comprising a solenoid operated motor switch in series with the motor and the electrical power source therefor; solenoid means for operating the fluid reversing valve, said means comprising an armature mechanically linked to said valve and two connected coils for moving said armature to each of two operating positions for the valve; and an electrical circuit immediately connected across the electrical power source, said circuit comprising in series a solenoid coil to close said motor switch and a work stroke control branch and a return stroke control branch, said branches being in parallel relation to each other, said work stroke control branch including in series one coil of said solenoid means, a pressure actuated switch responsive to the work stroke pressure in said hydraulic cylinder and a work stroke control switch, said return stroke control branch including in series the second coil of said solenoid means and a return stroke control switch.

3. In a hydraulically operated roll clamping mechanism for an industrial tier lift truck, having a hydraulic clamping cylinder and an electric motor powered pump and a fluid reversing valve for reversing the direction of fluid flow with respect to the cylinder, an electrical control system comprising a solenoid operated motor switch in series with the motor and the electrical power source therefor; solenoid means for oper-

ating the fluid reversing valve, said means comprising an armature mechanically linked to said valve and two connected coils for moving said armature to each of two operating positions for the valve; and an electrical circuit immediately connected to said power source, said circuit comprising in series a solenoid coil to close said motor switch and a clamping control branch and a release control branch, said branches being in parallel relation to each other, said clamping branch including in series one coil of said solenoid means, a pressure actuated switch responsive to the clamping pressure in said hydraulic cylinder and a clamping control switch, said release control branch including in series the second coil of said solenoid means, a normally open pedal switch mounted at the operator's station to be held closed by the operator, and a release control switch, said pressure switch being adjustable to open at one pressure and close at a lower pressure.

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