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[54] **HYDRAULIC LOAD CARRIER**
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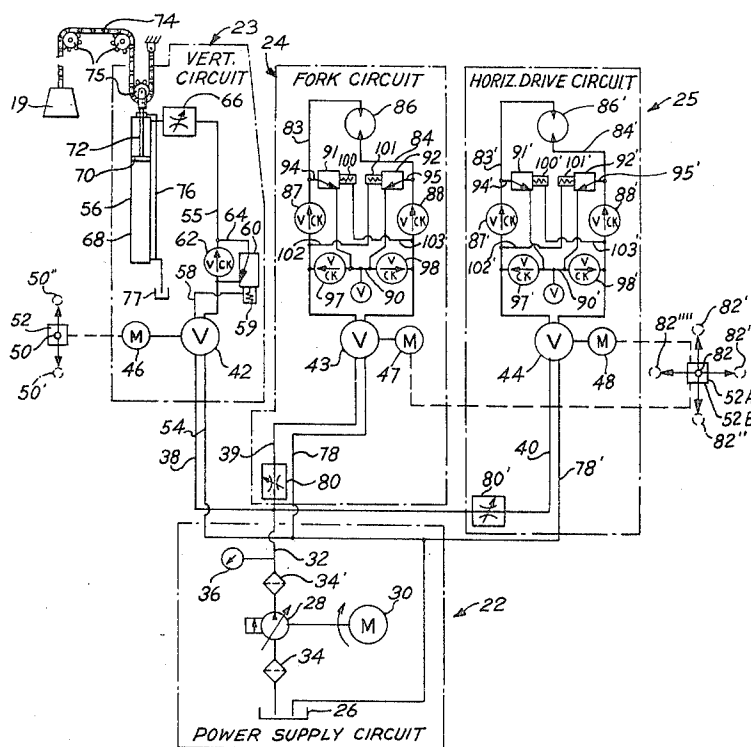
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16.7 A, 730, 16.14 C, 16.14 E; 187/9; 91/424;
180/82

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ABSTRACT: A hydraulic load carrier having a hydraulic powered lift platform, forks and horizontal drive includes variable proportional flow valves to variably control the flow of hydraulic power fluid to the lift platform, forks and drive and an electrical control circuit to variably operate each of the valves. The control circuit is constructed to require the load carrier operator to maintain both hands on manual operating handles in order to effect movement of the lift platform or horizontal movement of the load carrier. In addition, the control circuit includes switches which prevent horizontal movement of the load carrier when the forks are not centered and movement of the forks when the load carrier is moving horizontally. End of run slowdown and cutout means are also provided in the circuit to slow and stop movement of the forks and the load carrier when they have reached their end of run and the forks are operable either manually or automatically after manual movement has been initiated.



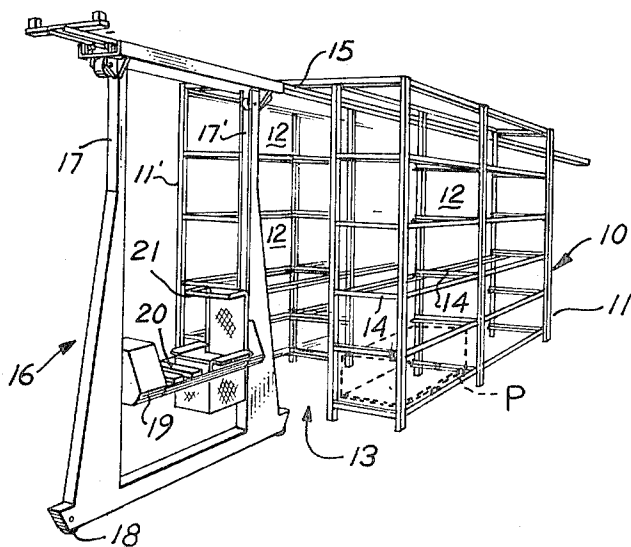


Fig. 1

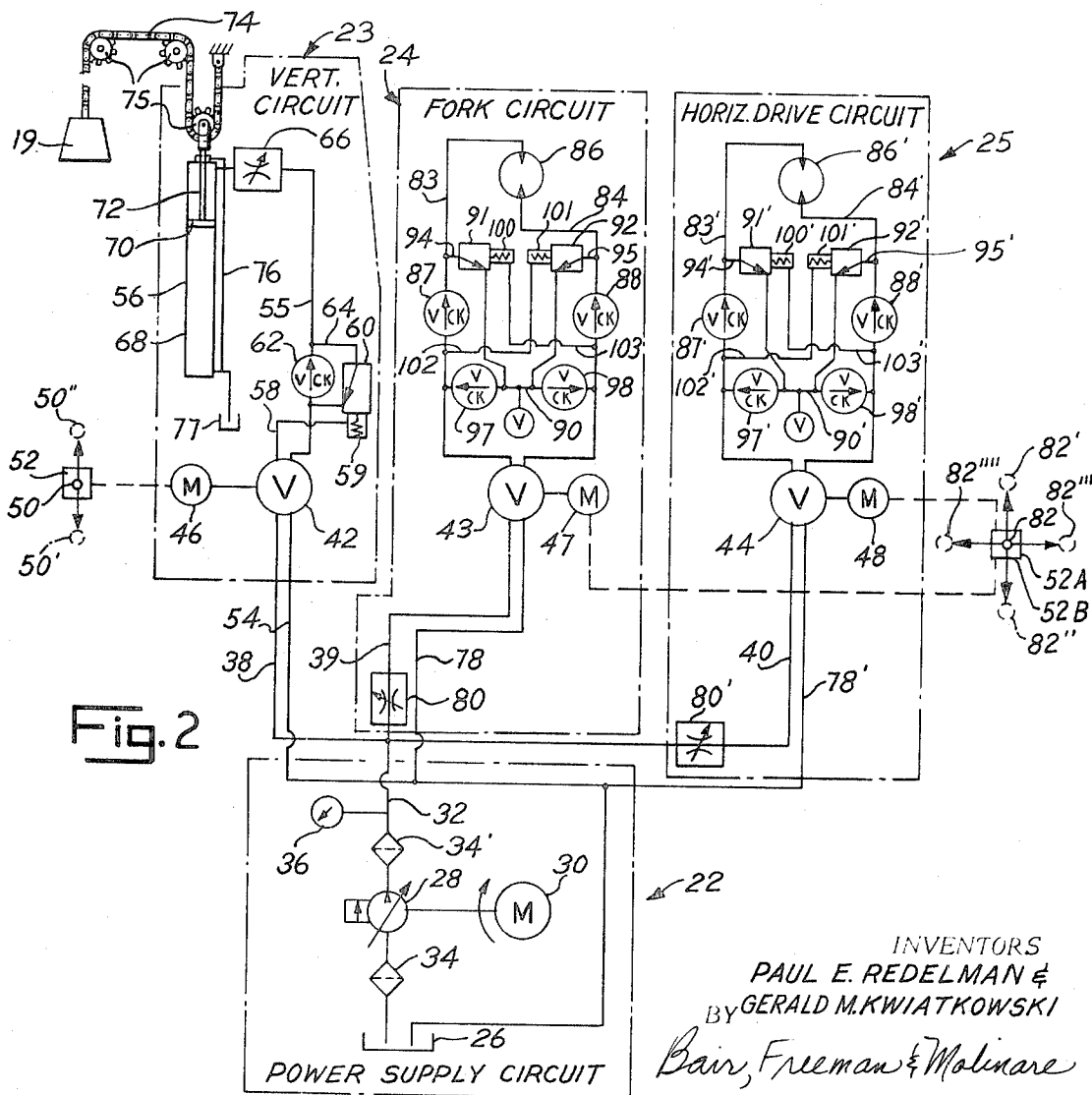
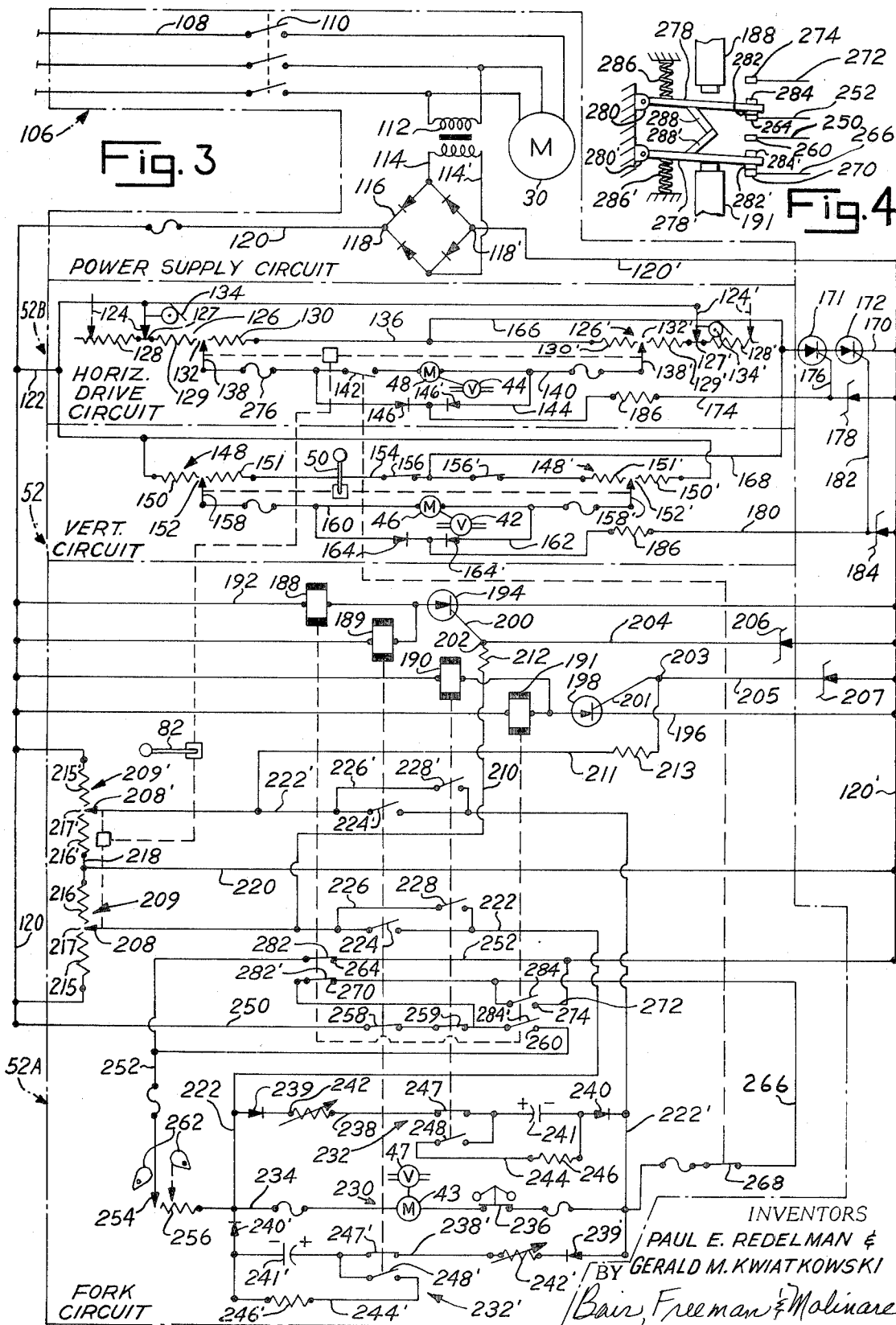


Fig. 2

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HYDRAULIC LOAD CARRIER

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to a load carrier and, more particularly to a control arrangement and hydraulic load carrier for storing and retrieving articles in a storage installation.

Load carriers have been provided in the past for horizontally moving articles into and out of storage installation, vertically positioning the articles in alignment with vertically spaced bins by way of a lift platform, and extendible forks carried upon the lift platform for transferring articles between the bins and the lift platform. In such load carriers, it is highly desirable that the speed at which the load carrier is horizontally moved, as well as the speed at which the lift platform is elevated or lowered, be capable of wide variation and be easily controlled over the wide range of speeds. For example, it is extremely desirable that the speed of the load carrier in the horizontal direction be variable over a wide range between a relatively high speed for operation between the pickup or delivery station and the bin and a substantially slower inching speed adjacent the station or bin to insure accurate and exact positioning of the load carrier and its lift platform.

The hydraulic load carrier and control circuit incorporating the principles of our invention is capable of operating over a wide range of infinitely variable speeds in both the horizontal and vertical. Since the load carrier is capable of operation at a wide variety of speeds, the load carrier is capable of handling substantially heavier loads since the load carrier may be operated at a slow speed with high mechanical advantage when handling loads of substantial weight and at a higher speed when handling light loads. In the load carrier of our invention, the forks are not only automatically centered on the load carrier, but also are capable of either manual or automatic extension or retraction and will automatically and gradually slow down when approaching either their centered or fully extended positions, thereby substantially reducing the likelihood of inertial damage to the articles being handled. Moreover, the load carrier and control arrangement of our invention enables control of three dimensional movement of the articles by the use of only two manual controls. In our invention, both hands of the load carrier operator must be positioned on a control lever in order to effect either horizontal movement of the load carrier or vertical movement of the lift platform, thereby substantially reducing the likelihood of injury to operating personnel during operation. In the load carrier of our invention, both the horizontal movement of the load carrier, as well as the vertical movement of the lift platform may be independently varied over a wide range of speeds. Moreover in our invention, not only is horizontal movement of the load carrier prevented when the forks are extended off center of the lift platform, but also movement of the forks off center of the lift platform is prevented when the load carrier is in horizontal motion, thereby preventing inadvertent damage to the load carrier forks or storage installation due to the collision between the forks and the storage structure. Finally in the load carrier and control arrangement of our invention, end of run protection is provided which gradually slows down and stops horizontal movement of the load carrier and/or transverse movement of the forks when they approach their end of run, thereby preventing overrun of the load carrier and/or forks without inertial damage to the article.

In the load carrier of our invention, power circuit means is provided for supplying power to drive means for manipulating the articles in at least two of three directions including a vertical direction, a direction transverse to the load carrier, and a horizontal direction. The power circuit means includes power control means which selectively introduce power to the respective drive means. At least a pair of electrical control circuits selectively energize the power control means, each of the control circuits including electrical control means which are moveable between a first position in which the power control means are operated to secure power to the drive means and a second position in which the power control means are

operated to introduce power to the drive means. Switching means is provided in the pair of control circuits which open both of said circuits when the electrical control means of either is in the first position, whereby the horizontal and vertical manipulation can only occur when both electrical control means are each in their second positions.

In another principal aspect, a control arrangement for a load carrier is provided which includes a fluid-powered fork means and drive means for moving the load horizontally. Proportional fluid control valves selectively control the supply of fluid to the fork means and drive means and motor means on each of the valves variably opens the valves to vary the fluid supplied therethrough. An electrical control circuit having variable resistance means therein operates the motor means to vary the flow of power fluid and movement prevention means in the control circuit prevents movement of the fork means out of its centered position when the load carrier is in motion and movement of the load carrier in the horizontal when the fork means are not centered.

These and other objects, features and advantages of the present invention will be more clearly understood through a consideration of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

In the course of this description, reference will be frequently made to the attached drawing in which:

FIG. 1 is an isometric view of a preferred embodiment of load carrier and storage installation which incorporates the principles of our invention;

FIG. 2 is a schematic view of a preferred embodiment of hydraulic circuit of our invention;

FIG. 3 is a schematic circuit diagram of a preferred embodiment of electrical control circuit of our invention; and

FIG. 4 is a schematic view of a latching relay of the type suitable for use in the circuit of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a load carrier and storage installation is shown for the storage and retrieval of articles. The storage installation, generally 10, comprises a plurality of upstanding racks 11 and 11' which form a plurality of horizontally and vertically spaced bins 12 for the storage of articles. Each series of racks 11 and 11' are spaced from each other so as to provide an aisle 13 therebetween. The storage bins may be formed by way of vertically spaced angles 14 or the like upon which palletized articles, for example P, may be set. An overhead guide rail 15 is mounted adjacent the top of the racks in the overhead of the aisle 13 and the load carrier, indicated generally as 16, is moveable along the guide rail back and forth along the floor of the aisle 13. Additional guide rails (not shown) may be mounted to the racks adjacent the bottom of the load carrier for preventing undesirable lateral movement of the latter during operation if necessary.

The load carrier 16 preferably comprises a pair of upstanding masts 17 and 17' extending between the overhead rail 15 and the aisle floor and includes a horizontal drive means which powers one or more of the wheels 18 of the load carrier so as to effect horizontal movement of the entire load carrier back and forth along the aisle. A lift platform 19 is mounted between the masts 17 and 17' and is elevatable by way of a vertical drive means and hoist chain arrangement between a vertical position adjacent the overhead rail 15 to a position adjacent the bottom of the load carrier. A pair of extendible forks 20 are mounted on the horizontal bed of the lift platform 19 and are telescopically extendible transversely to either side of the lift platform by fork drive means so as to position and remove articles in or from the individual bins 12. An operator cage 21 may also be carried as part of the lift platform 19 in which operating personnel may stand while operating the load carrier. The cage 21 is preferably carried for movement with the lift platform.

Thereby it will be seen that the load carrier is capable of manipulating a given article in any one of three dimensions. Horizontal movement of the load carrier 16 back and forth along the aisle 13 will effect horizontal movement of the article between a pickup or delivery station (not shown) and the bins. Elevation of the lift platform 19 will effect vertical movement of the article. An extension or retraction of the telescopic forks 20 will effect movement of the article transverse to the load carrier and lift platform into and out of the bins.

THE HYDRAULIC CIRCUIT

Each of the load carrier horizontal drive means, the lift platform drive means, and the fork drive means is preferably powered by way of hydraulic fluid. A preferred embodiment of hydraulic circuit is shown in FIG. 2 and will now be described.

In general, the overall hydraulic circuit includes four subcircuits, including a power supply circuit 22, a vertical circuit 23, a fork circuit 24 and a horizontal drive circuit 25.

The power supply circuit 22 includes a suitable hydraulic fluid reservoir 26 from which hydraulic fluid is pumped to the respective drive means and returned thereto through a return line. Fluid is drawn from the reservoir 26 by a pump 28, which is preferably a pressure compensated variable volume pump which is driven by an electric motor 30. The fluid is delivered by the pump under pressure to a hydraulic supply line 32. Filters 34 and 34' may be positioned in the intake and discharge lines of the pump 28 to insure that the fluid which is delivered to the respective drive means is clean and free of sediment and other foreign matter. In addition, a pressure gage 36 may be carried by the supply line 32 to indicate the pressure therein.

From the supply line 32 the pressurized power fluid is delivered by way of hydraulic conduits 38, 39 and 40 to suitable power control means which preferably take the form of hydraulic proportional control valves 42, 43 and 44 in each of the vertical circuit 23, the fork circuit 24 and the horizontal drive circuit 25, respectively. In general, the proportional control valves 42, 43 and 44 are constructed to deliver a varying amount of pressurized hydraulic fluid from conduits 38, 39 and 40 to the drive means of each circuit and return the fluid therefrom. The degree of opening and closing of the control valves may be varied and is effected by way of an operating electrical force motor 46, 47 and 48, whereby each valve is capable of delivering hydraulic fluid which is selectively variable over a wide range of flow rates in order to operate the different drive means at a wide variety of speeds. The detailed construction of the proportional control valves 42, 43 and 44 does not form a part of the subject matter of our invention and numerous valves of various constructions are available which could be employed satisfactorily. For this reason, the construction of the control valves will not be set forth in detail herein.

The proportional control valve 42 and its force motor 46 of the vertical circuit 23 is preferably operated by way of a manual operating handle 50 which manipulates a rheostat in an electrical control circuit 52 which is shown in box form in FIG. 2 and in detail in FIG. 3. The control circuit 52 operates to variably drive the motor 46 of control valve 42 so as to either close the control valve or variably open the valve. The valve 42 and its motor are constructed so as to be reversible, whereby the drive means of the vertical circuit may be operated in either direction. A plurality of conduits are connected to the control valve 42, including the hydraulic conduit 38, a return conduit 54, a conduit 55 which extends between the control valve and the drive means 56 of the vertical circuit, and a conduit 58 which extends between the control valve and the pilot section 59 of a directional flow valve 60. A check valve 62 is located in conduit 55. The check valve 62 allows flow only in a direction from valve 42 to the drive means 56. A bypass 64 bypasses the check valve 62 and the directional flow valve 60 is positioned in the bypass.

The directional flow valve 60 provides a path for return of the hydraulic fluid to the reservoir 26. Valve 60 is constructed such that when hydraulic fluid at system pressure is delivered through conduit 58 to the pilot section 59 of the valve, the valve will be deactuated and, in effect, open for substantially unrestricted flow in the direction indicated by the arrow. However, when conduit 58 is closed to the pilot section, the valve becomes loaded so as to close. The operation of valve 60 will be described in more detail when describing the operation of the vertical circuit 23. The specific construction of valve 60 will not be set forth herein in detail, a suitable variety of valves of varied construction being within the selection of one skilled in the art once he has considered the teachings of the invention.

The vertical circuit also includes a variable resistance orifice 66 which is adjusted so as to have a constant pressure drop thereacross for a given system. The orifice 66 is positioned between the check valve 62 and the drive means 56. The variable orifice 66 acts to control the maximum velocity at which the drive means 56 may be operated, and also since the variable orifice is positioned between the control valve 42 and the drive means 56, it prevents accidental free fall of the lift platform in the event of a power failure by limiting the outflow of hydraulic fluid from the drive means. If it is desired to increase or decrease the maximum system velocity, the orifice may be simply adjusted without changing any of the other components of the system. Thereby, a given system is rendered capable of use under a wide variety of conditions simply by varying the orifice 66.

The lift platform drive means 56 comprises a cylinder 68 and piston 70. Conduit 55 communicates with the upperside of the piston 70 and the piston rod 72 of the piston is connected to the lift platform 19 by way of suitable hoist chains or the like 74 and sprockets 75 shown schematically in FIG. 2.

In operation, when the piston 70 is driven downward as viewed in FIG. 2 by the hydraulic fluid, the hoist chains 74 are tensioned and the platform 19 is hoisted upward. When it is desired to lower the lift platform 19, the weight of the platform and any article positioned upon the platform, is exerted by way of the hoist chains 74 upon the piston rod 72 to pull the piston 70 upward as viewed in FIG. 2, thereby discharging the fluid from above the cylinder back through conduit 55.

A gland seal drain conduit 76 may be provided to collect any hydraulic fluid which may escape from around the piston rod 72. Such fluid may be collected in an individual reservoir 77, as shown, or returned directly to reservoir 26.

The vertical operation of the hydraulic circuit will now be described.

When it is desired to elevate the lift platform 19, the operating handle 50 is moved in one direction, for example to 50' as shown in FIG. 2. Movement of the operating handle from its offcenter position will effect operation of the control valve 42 by way of the electrical control circuit 52 and motor 46 so as to at least partially open the control valve. As will be described more fully in the description of the electrical control circuit, the degree to which handle 50 may be moved may be varied between any one of a number of positions so as to selectively vary the amount by which the valve is opened.

Hydraulic fluid, supplied under pressure from pump 28 to conduit 32, passes through conduit 38 to the control valve. Opening of the valve 42 to elevate the lift platform now connects conduit 38 with conduit 55 and conduit 58 with the return conduit 54. Pressurized hydraulic fluid is thereby delivered through the conduit 55 via check valve 62 to variable orifice 66 and then into cylinder 68 to the top of piston 70, driving the piston downward and hoisting the lift platform 19 by way of hoist chain 74. Since conduit 58 is in communication with the return conduit 54, the pilot section 59 of the directional flow valve 60 is vented to substantially atmospheric pressure which obtains in reservoir 26, shutting the flow valve 60.

Once the piston and lift platform have been set into motion, the maximum velocity at which the piston and its platform will

move is determined by the variable orifice 66, since the variable orifice setting is adjusted so as to limit the maximum flow rate therethrough.

When the platform has been elevated to its desired height, the handle 50 is again centered. In such position, the valve 42 is closed isolating conduits 38 and 54 from conduits 55 and 58 to trap the fluid and maintain the platform at its desired elevation.

If it is now desired to lower the lift platform 19, the operating handle 50 is moved from its dead center position in the opposite direction, for example to 50'' as shown in FIG. 2. Movement of the operating handle may again be to any one of a number of positions so as to variably operate control valve 42 by way of the electrical control circuit 52 and motor 46. In lowering the lift platform, the control valve 42, is lined up so as to communicate conduit 38 with conduit 58 and conduit 55 with the return conduit 54.

Pressurized hydraulic fluid is now supplied to the pilot section 59 of the flow valve 60 to open the flow valve for substantially unrestricted flow in the direction indicated by the arrow in FIG. 2. The weight of the lift platform 19 now pulls upward upon the piston 72 by way of the hoist chain 74, to move the piston 70 upward in the cylinder. As the piston moves upward, the hydraulic liquid above the piston is displaced from the cylinder back through the orifice 66, through the bypass 64 and now open flow valve 60 around the check valve 62, back to conduit 55, through the control valve 42, through the return conduit 54 and back to the reservoir 26.

It should be noted that the variable opening of the control valve 42 normally acts to limit and variably control the rate of descent of the lift platform by controlling the rate at which the liquid is returned from the cylinder. If for any reason, for example due to power failure of the electrical control circuit 52, the control valve 42 is accidentally fully opened and cannot be shut, a dangerous rate of descent of the lift platform 19 will be prevented by the action of the orifice 66 which will effectively set the maximum rate of return flow which may pass through the conduit 55.

Now referring to the fork circuit 24, in addition to supply conduit 39 which connects the pump 28 with control valve 43, a return conduit 78 is also provided which connects the valve 43 with the reservoir 26. A variable orifice 80, similar to orifice 66, is provided in the supply conduit 39 before the control valve. The force motor 47 of the control valve 43 is controlled by way of a 4-way operating handle 82, the operating handle being moveable in a first linear direction, for example between positions 82' and 82'' in FIG. 2, to effect operation of an electrical control circuit 52A and the force motor 47 of control valve 43 and in a second linear direction, for example between positions 82''' and 82'''' in FIG. 2, to effect operation of an electrical control circuit 52B and the force motor 48 of the control valve 44 of the horizontal drive circuit 25. Thus, only two operating handles 50 and 82 need be provided in order to control the three control circuits 52, 52A and 52B, operating handle 50 controlling the vertical circuit 23 and operating handle 82 controlling both the fork and horizontal drive circuits 24 and 25.

A pair of hydraulic conduits is provided in the fork circuit 24, one of the conduits 83 communicating between the control valve 43 and one side of a reversible hydraulic motor 86 and the other conduit 84 communicating between the hydraulic motor 86 and the control valve 43. Check valves 87 and 88 are located in each of the conduits 83 and 84 and provide for flow only from the valve 43 to the motor 86. A cross connect conduit 90 is also provided which extends between the conduits 83 and 84 before the check valves 87 and 88 and a pair of directional flow valves 91 and 92 are each located in bypasses 94 and 95. The bypasses communicate at one end with the conduits 83 and 84 between the check valves 87 and 88 and the motor 86 and at the other end with conduit 90. A pair of check valves 97 and 98 are each located in conduit 90 between one end of the bypasses 94 and 95 and conduits 83 and 84 providing for flow only from the bypasses to the respective conduits, as shown in FIG. 2.

In order to pressurize and vent the pilot sections 100 and 101 of the flow valves 91 and 92 respectively to enable operation of the flow valves, a conduit 102 is connected between pilot section 101 of valve 92 and conduit 83 before check valve 87 and another conduit 103 is connected between pilot section 100 of valve 91 and conduit 84 before check valve 88.

The operation of the fork circuit 24 will now be described.

If it is desired to extend the forks 20 from their centered position on the lift platform 19, the operating handle 82 is moved toward one of the positions 82' and 82'' to one of any one of a number of positions so as to effect a variable opening of the control valve 43 by way of the electrical control circuit 52A and force motor 47. For example, movement of the handle in one direction will operate the valve 43 so as to communicate the hydraulic supply conduit 39 with conduit 83 and the conduit 84 with the return conduit 78. Thus, hydraulic fluid under pressure is delivered through the variable orifice 80, through conduit 39 to the control valve 43, to conduit 83, through the check valve 87 and is delivered to the hydraulic motor 86 to drive the motor. The pressure in conduit 83 is also supplied to the pilot section 101 of the flow valve 92 through conduit 102 to open the valve and allow return of the exhaust fluid around check valve 88. Thus, the exhaust fluid from the hydraulic motor 86 flows from the motor to conduit 84, through the bypass 95 and now open valve 92 to conduit 90, through check valve 98 back to conduit 84, through the control valve 43 and through the return line 78 to the reservoir 26. Since the exhaust fluid is at a substantially lower pressure than the supply fluid in conduit 83, no flow will occur across check valve 97 to the conduit 83.

If it is now desired to move the forks 20 in a direction opposite to that previously described, for example if it is desired to return the forks from the extended position or extend the forks to the opposite side of the platform, the operating handle is moved in the opposite direction, thereby effecting a variable opening of the control valve 43 opposite to that previously described. More specifically, movement of the control valve 43 in the opposite direction will communicate the hydraulic supply conduit 39 with conduit 84 and conduit 83 with the return conduit 78. Pressurized hydraulic fluid will now flow through the variable orifice 80, supply conduit 39, the control valve 43, conduit 84 and check valve 88 into the motor 86. The pressure in conduit 84 will be transmitted to the pilot section 100 of the flow valve 91 to open the valve. Thus, the exhaust from the motor 86 will flow from the motor through conduit 83, through bypass 94 and the now open valve 91, through check valve 97, back to the conduit 83, through the control valve and through the return line 78 to the reservoir 26.

It will be noted that, without regard to the direction in which the motor is operated, the variable orifice 80 will act to limit the maximum velocity of the motor 86 as previously described with respect to the variable orifice 66 in the vertical circuit 23, since the conduit 39 is always a supply conduit.

Additionally, each of the flow valves 91 and 92 will operate to limit the maximum acceleration rate of the motor 86 no matter which way the motor is being operated. In operation, the flow valves are normally shut when their respective pilot sections are not pressurized, but will open in the event that the pressure in their conduit 83 or 84 exceeds a certain value. Thereby, if the motor 86, for example, is to be started in one direction and the "peak" pressure in conduit 83 or 84 which is necessary to overcome the inertia of the motor exceeds the setting of the closed valve 91 or 92, the valve 91 or 92 will dump a portion of the fluid to the return line, thus acting to limit the "peak" pressure and, in turn, control maximum acceleration.

The components of the horizontal drive circuit are substantially similar to the components previously described in the fork circuit 24, except for possible variation in size or capacity between the circuits. Accordingly, in describing the construction and operation of the horizontal drive circuit 25, the same reference numerals employed in the identity of the components of the fork circuit will be used, except that they will be primed (').

The horizontal drive circuit 25 includes a supply conduit 40 which communicates between the pump 28 and the control valve 44 and a return conduit 78' communicating between the control valve 44 and the reservoir 26. A variable orifice 80' is positioned in the conduit 40 before the control valve 44. A pair of conduits 83' and 84' are provided, one of which communicates between the control valve 44 and the hydraulic motor 86' and other of which communicates between the motor and the control valve. Each of the conduits 83' and 84' includes check valves 87' and 88' and a pair of flow valves 91' and 92' are positioned in bypasses 94' and 95' which communicate with conduits 83' and 84' at one end and with cross conduit 90' at the other end. A pair of check valves 97' and 98' are provided between the ends of the bypasses 94' and 95' and the conduit 83' and 84' and provide for flow in one direction only as indicated in FIG. 2. Also, a pair of conduits 102' and 103' each communicate between the conduits 83' and 84' and the pilot sections 100' and 101' of valves 91' and 92'.

Since the operation of the horizontal hydraulic drive circuit 25 is substantially the same as previously described with respect to the fork circuit 24, the operation will not be set forth herein in detail. In order to provide hydraulic fluid to motor 86', however, the operating handle 82 is moved in the other linear direction between positions 82''' and 82'''' as shown in FIG. 2, to thereby variably actuate force motor 48 rather than 47.

THE ELECTRICAL CONTROL CIRCUIT

Referring now to FIG. 3, the electrical control circuitry of our invention is schematically shown. The control circuit, in general, comprises substantially four subcircuits, including the main power supply circuit 106, the horizontal drive control circuit 52B, the vertical control circuit 52, and the fork control circuit 52A.

The power supply circuit 106 preferably comprises a three-wire main power supply 108 which is supplied with a source of electrical power (now shown) and which drives the motor 30 of the hydraulic pump 28. A disconnect switch 110 is located in the power supply 108 for deenergizing or energizing the pump and the control circuits.

A conventional stepdown transformer 112 is tapped across two of the leads of the power supply 108 to provide reduced voltage power to the remainder of the electrical control circuit. The reduced voltage taps 114 and 114' of the transformer are connected to a full wave rectifier 116. The full wave signals of the rectifier are tapped between terminals 118 and 118' of the rectifier and pass through the circuit formed by leads 120 and 120', the horizontal drive control circuit 52B, vertical control circuit 52, and fork control circuit 52A as will now be described in detail.

The horizontal drive circuit 52B includes a conductor 122 which is connected between lead 120 and a pair of moveable taps 124 and 124'. A pair of rheostats 126 and 126' each comprising two resistances 129 and 129', and 130 and 130', respectively are connected by way of leads 127 and 127' to another resistance 128 and 128'. Resistances 129, 129' and 130, 130' are gapped from each other in order to provide a null gap position 132 and 132'. The resistance taps 124 and 124' are moveable by a mechanical end-of-aisle slowdown and cutout device 134 and 134', the mechanical details of which will not be described herein. One or the other of the taps 124 or 124' are moved mechanically by device 134, 134' in response to the load carrier arriving at one or the other end of the aisle from a normal contacting position between leads 127 or 127' where no resistance is placed in the circuit by resistances 128 or 128', over the length of resistance 128 or 128' to a position in which contact between one or the other of the resistances and their respective moveable taps 124 and 124' such as to maximize the resistance in the circuit, as shown in the dot-and-dash line position of the taps in FIG. 3. Resistances 130 and 130' of the rheostats are connected by a common conductor 136.

A second pair of moveable taps 138 and 138' are provided, each of which is moveable from the open null gap position 132 or 132' of rheostats 126 and 126' along the length of either resistances 129, 129' and 130 and 130'. Moveable taps 138 and 138' are mechanically connected for simultaneous operation by operating handle 82 when the handle is moved between positions 82''' and 82'''' shown in FIG. 2. Thus, as tap 138, for example, is moved from the open null position 132 to the left along resistance 129 of rheostat 126, the other moveable tap 138' likewise moves to the left, but along resistance 130' of rheostats 126'.

The force motor 48 of control valve 44 is electrically connected between the taps 138 and 138' by conductor 140. Conductor 140 also includes a fork limit switch 142 which will open the circuit through the force motor 48 in the event the forks 20 are extended so as to be off center from the lift platform 19, as will be described in more detail when the operation of the fork control circuit 52A is described. A conductor 144 is connected in parallel to the force motor 48 between the fork limit switch 142 and tap 138 and the force motor and tap 138' and includes a pair of diodes 146 and 146' therein.

Now turning to the vertical circuit 52, conductor 122 also connects lead 120 to another pair of gapped rheostats 148 and 148'. Rheostats 148 and 148' are arranged in parallel to rheostats 126 and 126' and each comprises a pair of resistances 150, 150' and 151, 151' having null gaps 152, 152' respectively therebetween. Resistances 151 and 151' of rheostats 148 and 148' are connected to each other by way of a conductor 154 in which a pair of vertical travel limit switches 156 and 156' are located. One of the limit switches is constructed to be mechanically opened when the lift platform 19 reaches its maximum elevation and the other is mechanically opened when the lift platform reaches its minimum elevation. The mechanical actuating structure of the switches 156 and 156' is not shown and will not be described in detail since the selection of such structure is considered to be well within the skill of one skilled in the art.

A pair of moveable taps 158 and 158' are provided on each rheostat and are mechanically coupled to each other for simultaneous movement. The taps 158 and 158' are moveable in one direction or the other along the gapped rheostats 148 and 148' by the operation of operating handle 50. The taps are connected by a common conductor 160 in which the force motor 46 of control valve 42 is located. A conductor 162, having diodes 164 and 164', is connected to conductor 160 in parallel to the force motor 46 between the force motor and the taps 158 and 158'.

Referring now to both the vertical control circuit 52 and the horizontal control circuit 52B, a return conductor 166 is connected to conductor 136 between the rheostats 126 and 126' of the horizontal circuit 52B and another conductor 168 is connected to conductor 154 between the rheostats 148 and 148' and vertical limit switches 156 and 156' of the vertical circuit 52. Each of the return conductors 166 and 168 are connected to lead 120' by way of a common conductor 170 in which a pair of silicon controlled rectifiers 171 and 172 are arranged in series. A lead 174 is connected between the diodes 146 and 146' of parallel conductor 144 of the horizontal drive circuit and lead 120' and the control terminal 176 of rectifier 171 is connected to lead 174 before a zener 178. A second lead 180 is connected between the diodes 164 and 164' of parallel conductor 162 of the vertical circuit and lead 120' and the control terminal 182 of rectifier 172 is connected to lead 180 before a zener 184. The zeners 178 and 184 protect the rectifiers in the event of excessive power surges. In addition, resistors 186 may also be located in the leads, if desired.

Now turning to the fork control circuit 52A, four relay coils 188, 189, 190 and 191 are provided, relay coils 188 and 191 being the coils of a latching relay and coils 189 and 190 being the coils of control relays. Latching relay coil 188 is connected by a conductor 192 between lead 120 and lead 120' and a silicon controlled rectifier 194 is positioned in conductor 192 between the coil and lead 120'. Latching relay coil

is aligned with the bin in which it is desired to insert or remove an article.

To initiate horizontal movement, the operator will move the operating handle 82 to one of its offcenter positions, for example toward position 82''' shown in FIG. 2. Movement of the handle 82 mechanically drives the moveable taps 138 and 138' of the horizontal control circuit 52B in one direction or the other from their open circuit null center positions 132 and 132'. Let us assume that movement of the operating handle toward position 82''' will move the taps to the left as viewed in FIG. 3. Upon movement to the left, a circuit will now be completed through lead 120, conductor 122, tap 124 which is in the neutral position in lead 127 between resistances 128 and 129 as shown in FIG. 3, through a portion of the resistance 129 of rheostat 126 between taps 124 and 138, through tap 138, through conductor 140 and its closed fork limit switch 142 and force motor 48, tap 138', the remaining portion of resistance 130' of rheostat 126', conductor 166, rectifiers 171 and 172, if they have previously been "fired," and lead 120'.

If for some reason the forks 20 were not in their centered position with respect to the load carrier, the circuit through the force motor 48 would be broken by the opening of the fork limit switch 142 through its mechanical couple with switch 268 and no power would be supplied to the force motor of valve 44 to effect opening of the valve. Thereby, protection is afforded to prevent horizontal movement of the load carrier when the forks are extended from their offcenter position.

Moreover, it will be noted that the degree of opening of the control valve 44 may be accurately controlled by the magnitude of the voltage which is applied to the force motor 48 which, in turn, is accurately controlled by the degree to which the operating handle 82 is moved from its offcenter position. The farther handle 82 is moved toward 82''', the smaller will be the resistance in the circuit presented by resistances 129 and 130' of the rheostats 126 and 126'.

As mentioned previously, both of the rectifiers 171 and 172 must be "fired" in order to complete the circuit through the force motor 48. In order to fire both rectifiers, it is necessary that the operator also slightly move the vertical control operating handle 50 from its centered position and maintain the handle off center. Since both handles 50 and 82 are spring loaded back to the centered position, a "dead man" control results in which both hands of the operator must be kept upon the handles during either horizontal or vertical movement, thereby positively avoiding any damage to the operator during horizontal movement of the load carrier. Depending upon which direction the vertical control operating handle 50 is moved to "fire" rectifier 172, a circuit is also completed from lead 120 and conductor 122, through one of the rheostats 148 or 148' of the vertical circuit 52, one of the taps 158 or 158', conductor 160, parallel conductor 162 and one of its diodes 164 or 164', lead 180 and resistor 186 to the control terminal 182 of rectifier 172. Since parallel conductor 144 has previously been energized by operation of handle 82, rectifier 171 is also "fired" through one of the diodes 146 or 146', lead 174 and resistor 186, and the control terminal 176 of rectifier 171, to complete the circuit through the force motor 48.

It will be evident that movement of the operating handle 82 in the opposite direction toward position 82'' of FIG. 2, will reverse the current flow through the force motor 48 and thereby reverse the control valve 44 as previously described to effect horizontal movement of the load carrier in the opposite direction.

Let us now assume that the load carrier has arrived in a position in which it is horizontally aligned with the desired bin of the storage installation 10 and it is desired to elevate the lift platform 19 to the desired height in vertical alignment with the bin. The operator will manually move the operating handle 50 off center toward either position 50' or 50'' and by an amount to achieve the desired rate of elevation.

Movement of the operating handle toward position 50', for example, will move the taps 158 and 158' to the left as viewed

in FIG. 3. When the taps move from their open circuit null position 152 and 152' into contact with resistances 150 and 151' of rheostats 148 and 148', the force motor 46 of control valve 42 will be energized by way of the following circuit: lead 120 and conductor 122, at least a part of resistance 150 of rheostat 148, tap 158, conductor 160, force motor 46, tap 158', at least part of resistor 151' of rheostat 148', the closed vertical limit switch 156', and the fired rectifiers 171 and 172 to lead 120'.

The lift platform 19 will continue to be elevated until either the operating handle 50 is recentered or the lift platform reaches its maximum elevation. If the latter occurs, the vertical limit switch 156' will open to break the circuit through the force motor 46. If the handle 50 is recentered, the circuit will be broken through the force motor 46 also resulting in closure of the control valve 42 and the lift platform will stop wherever it is positioned.

Again it will be evident that movement of the operating handle 50 in the opposite direction toward position 50'' will establish a reverse current flow through the force motor 46 so as to operate the valve 42 to effect return flow from the cylinder 68 and allow downward movement of the lift platform.

As previously described with respect to the operation of the horizontal drive control circuit 52B, before vertical operation may be initiated and while vertical operation continues, it is necessary that the other hand of the operator be positioned on the other operating handle 82, thereby preventing accidental injury to the operator during elevation of the lift platform, since handle 82 must be moved slightly offcenter by the other hand of the operator in order to "fire" rectifier 171 to complete the circuit through force motor 46.

Although both the taps 138 and 138' of the horizontal drive control circuit 52B and the taps 158 and 158' of the vertical control circuit 52 must be moved from their open circuit null gap positions and into contact with one or the other of the resistances of their respective rheostats to "fire" the rectifiers, horizontal motion of the load carrier does not result when the lift platform is being vertically moved and vice versa. To prevent such undesirable movement, the resistances 129, 129', 130 and 130' of rheostats 126 and 126' and resistances 150, 150', 151 and 151' of rheostats 148 and 148' are each selected to be of a size such that the maximum total resistance in any one of the circuits prevents a current flow through the force motors which is sufficient to operate the motor. Such maximum resistance is placed in the force motor circuits when the taps of the circuits are moved into a position in which they just begin to contact their respective resistances. Thereby, in order to effect any operation of either control valve 42 or 44, the respective taps must be moved further along the resistances of the control valve rheostats than mere beginning contact only.

Since the load carrier has now been positioned horizontally in alignment with the desired bin and the lift platform has been elevated to the elevation of the bin, it will now be desired to extend the forks 20 of the lift platform into the bin either to insert the article into or remove the article from the bin. Operation of the forks 20 may be effected either completely manually or by way of a combination of manual and automatic modes. In either event, movement of the operating handle 82 from its offcenter position toward positions 82' or 82'' will always effect manual operation of the forks so as to initiate manual movement of the forks or override any present automatic operation of the forks which is in progress at the time the operating handle is moved.

Let us first assume that it will be desired to extend the forks 20 automatically into the bin. Such automatic extension must be first initiated manually and is initiated in the following manner. The operating handle 82 is moved toward either position 82' or 82'' depending on which direction it is desired to extend the forks. Movement of the operating handle 82, for example toward 82', will mechanically drive taps 208 and 208' from their open circuit null gap positions 217 and 217' as

191 is also connected between leads 120 and 120' by a conductor 196 and a second silicon controlled rectifier 198 is positioned in conductor 196 between coil 191 and lead 120'. Coils 189 and 190 are connected between lead 120 and conductors 192 and 196 between the latching relay coils 188 and 191 and the rectifiers 194 and 198, respectively.

The control terminals 200 and 201 of the rectifiers 194 and 198 are connected to junctions 202 and 203. Junctions 202 and 203 are respectively connected to the lead 120' by way of conductors 204 and 205, having zeners 206 and 207 therein, and to moveable rheostat taps 208 and 208' of rheostats 209 and 209' by way of conductors 210 and 211 having fixed resistors 212 and 213 therein.

Taps 208 and 208' are mechanically moveable simultaneously by way of operating handle 82 along a pair of resistances 215, 215' and 216, 216' in each of the rheostats 209 and 209' which are arranged in parallel to lead 120. Each of the resistances 215, 216 and 215', 216' is separated from each other by a null gap 217 and 217' and the moveable taps 208 and 208' are moveable from the gaps along the length of each of their respective rheostat resistances 215, 215' and 216, 216'. Resistance 216 and 216' of rheostats 209 and 209' are connected to each other by a conductor 218 and to lead 120' by conductor 220.

Tap 208 is also connected to conductor 222 which includes a normally open relay switch 224 which is operated by control relay coil 189 and a conductor 226 is arranged in parallel to switch 224 and includes a normally open switch 228 which is operated by control relay coil 190. Tap 208' also is connected to a conductor 222' having a normally open relay switch 224' therein which is operated by control relay coil 189 and a conductor 226' is arranged in parallel to switch 224' having a normally open switch 228' therein operated by coil 190.

Conductors 222 and 222', in turn, are connected together by way of the fork force motor control valve circuit, generally indicated as 230, and a pair of surge prevention circuits, generally indicated as 232 and 232'.

The force motor circuit 230 comprises a conductor 234 which extends between conductors 222 and 222'. A zero speed switch 236, which opens and closes in response to horizontal motion of the load carrier, is located in conductor 234 in series with the force motor 43 of control valve 47. When the load carrier is at rest, the zero speed switch 236 is mechanically closed and when the load carrier is in horizontal motion, the switch opens to break the circuit through conductor 234.

The surge prevention circuits 232 and 232' are provided for the purpose of preventing jerky starting of the forks in manual due to initial power surges on operation of the handle 82 as will be described in more detail later. Each of the surge prevention circuits comprises a conductor 238 and 238' which extends between conductors 222 and 222'. Each of the conductors 238 and 238' includes, in series, a pair of diodes 239, 239' and 240, 240', a capacitor 241, 241' and a variable potentiometer 242, 242', the latter serving the purpose of providing for adjusting the charge rate of the capacitor of each circuit. A conductor 244, 244' is also arranged in parallel to the capacitor of each circuit for discharging the capacitor and includes a resistor 246, 246' for controlling the discharge rate of its capacitor. In addition, a pair of switches 247, 247' and 248, 248' are provided in the surge prevention circuit, one switch 247, 247' being normally closed and the other switch 248, 248' being normally open. Switches 247 and 248 are operated by control relay coil 190 and switches 247' and 248' are operated by control relay coil 189.

A conductor 250 is also connected directly between lead 120 and a conductor 252 which, in turn, is connected to a moveable tap 254 of a resistance 256. Two normally closed switches 258 and 259, which are operated by control relay coils 189 and 190, respectively, and one of the switching contacts 260 of the latching relay is positioned in conductor 250. The resistance 256 is connected in series with the force motor 43 and the tap 254 is moveable between an open circuit posi-

tion, as shown in solid in FIG. 3, to any one of a number of contact positions along the resistance as shown in the dot-and-dash position in FIG. 3. The tap 254 is mechanically moved between its positions by way of suitable cams or the like 262 which are operated by the forks 20 such that the tap 254 is moved into a contacting position with the resistance only when the forks are positioned somewhere between their fully extended and centered positions with respect to the lift platform 19.

Conductor 252 is also connected to lead 120' through a switching contact 264 of the latching relay.

Also connected in series with the force motor 43, is a conductor 266 having a switch 268 therein which is mechanically coupled with the fork limit switch 142 in the horizontal drive control circuit 52B for simultaneous operation therewith. Switch 268 is also mechanically actuated by any movement of the forks 20 from their offcenter position with respect to the lift platform 19, so as to close switch 268 and simultaneously open the fork limit switch 142 in the horizontal drive control circuit to prevent any horizontal movement of load carrier when the forks are extended from either side of the lift platform. Conductor 266 is connected at the other end to conductor 250 between switch 259 and switching contact 260. Switching contact 270 of the latching relay is also positioned in conductor 266 and a conductor 272 is connected to conductor 266 between switch 268 and switching contact 270 and to conductor 252. Conductor 272 also includes a latching relay switching contact 274.

Suitable fuses, for example 276, may be positioned about the control circuit, if desired, to protect various components from damage in the event of excessive power surges.

It will be appreciated that the latching relay arrangement is only very broadly depicted in FIG. 3. The latching arrangement is illustrated by way of a somewhat more detailed schematic view in FIG. 4. It will be appreciated that the following latching relay description and the construction shown in FIG. 4 is, still at best, crude and is included only for the purpose of clarifying the operating of the electrical control circuit. Numerous forms of latching relays may be employed so long as the sequence of operation, which will be described later, occurs.

Referring to FIG. 4, a suitable latching relay includes a pair of moveable contact carrying armatures 278 and 278' which are mounted for pivotal movement about fixed pivot points 280 and 280'. A pair of contacts 282, 282' and 284, 284' are positioned on each side of armatures 278 and 278' for contact with switching contacts 264, 270, 274 and 260 respectively. The armatures are spring loaded toward each other by springs 286 and 286' and each armature includes abutting means 288 and 288' to provide for coaxing movement of the armatures.

In operation, when coil 191 is initially energized, its core is magnetized and attracts armature 278' toward it and downward as viewed in FIG. 4. When armature 278' moves downward, armature 278 is also urged downward by the spring force exerted by spring 286. Downward movement of the armatures closes switching contacts 270, 282' and 264 and 282 and opens switching contacts 260, 284' and 274, 284.

Now if coil 191 is now deenergized, the armatures will remain positioned as before, since latching abutment 288 bears against abutment 288' to latch armature 278' in the latter position. In order to reverse the position of the contact arms from that shown in FIG. 4, the coil 191 must be deenergized and coil 188 must be energized so as to draw armature 278 and its latching abutment 288 away from abutment 288'. Once armature 278 is moved from the position shown in FIG. 4, armature 278' will follow under the force spring 286', and its abutment 288' will latch armature 278 in its new position.

Operation of the electrical control circuit will now be described. Initially, let us assume that the disconnect switch 110 is closed so as to energize the hydraulic pump motor 30 and the electrical control circuit by way of transformer 112 and it is desired to move the load carrier 16 horizontally down the aisle 13 of the storage installation to a position in which it

shown in FIG. 3, to one of any one of a number of positions along the length of the respective rheostats 209 and 209'. Let us assume that such movement of the operating handle 82 will move the taps 208 and 208' upward as viewed in FIG. 3. Such movement energizes the tap 208' and its conductor 222' up to the open switches 224' and 228' by way of lead 120, resistance 215' of rheostat 209', and tap 208'. When conductor 222' is energized, the rectifier 198 will be "fired" by way of conductor 211, resistor 213 and control terminal 201. Firing of rectifier 198 completes a circuit through coil 190 and the coil 191 of the latching relay. When the circuit is completed through coil 190, normally open switch 228' closes to bypass open switch 224' and provide a completed circuit through conductor 222' down to the surge prevention circuits 232 and 232' and force motor circuit 230. When a circuit is completed through coil 191 of the latching relay, armatures 278, 278' move downward as viewed in FIG. 4, closing contacts 282, 264 and 282', 270.

If the load carrier is in horizontal motion when the operating handle 82 is moved, the force motor circuit 230 will be open since the zero speed switch 236 will be open. Thus, damage to the forks or the storage installation is prevented since extension of the forks from their offcenter position is impossible if the load carrier is in horizontal motion.

Assuming that the load carrier is not in horizontal motion and the speed switch 236 is closed, a circuit is now completed through the switch 236, force motor 43, conductor 222, previously closed switch 228 of energized relay 190, tap 208, resistance 216 of rheostat 209, conductors 218 and 220 to lead 120'. Once this circuit is completed, the force motor 43 will operate control valve 47 to open the valve by the desired amount and introduce hydraulic fluid to the fork motor 86 and extension of the forks is connected.

Although switching contacts 264, 282 and 270, 282' were previously closed, conductors 252 and 266 will not yet be energized at this point for several reasons. One reason is that energization of coil 190 has previously opened the switch 259 in conductor 250. Moreover, until some movement of the forks from either the offcenter position or from a position in which the forks are fully extended occurs, the tap 254 is out of contact with the resistance 256. In addition, some movement of the forks from their centered position is necessary in order to close switch 268 in conductor 266. Once movement of the forks has progressed to the point where switch 268 closes, since switch 268 is mechanically coupled to the fork limit switch 142 in the horizontal drive control circuit 52B, switch 142 will open thereby preventing movement of the load carrier in the horizontal direction while the fork control circuit is being operated.

Once movement of the forks has been initiated manually as above described to the point where switch 268 closes and tap 254 is moved into contact with resistance 256 by cams 262, the operating handle 82 may be returned to its centered position and the forks will continue to be extended or retracted automatically depending upon whether extension or retraction was in progress manually immediately proceeding recentering of the handle. Return of the operating handle 82 to its center position, returns the taps 208 and 208' to their open circuit null gap position 217 and 217' as shown in FIG. 3. When the taps are so positioned, the conductors 222 and 222' will be deenergized and the rectifier 198 will again be "turned off." When the rectifier 198 is "turned off," both of the relay coils 190 and 191 will be deenergized, deenergization of control relay coil 190 causing normally closed switches 259 to close and deenergization of the latching relay coil 191, without energizing coil 188, will result in no change in the position of their switching contacts, these contacts remaining in the condition they were previously in just before deenergization of the latching relay coil. In this manner, the latching relay, in effect, "remembers" which direction the forks were being manually moved in and continues movement in the same direction automatically.

Thus, a direct circuit will now be established through the force motor 43 as follows: from lead 120, through conductor 250 and its closed switch 258 and now closed switch 259, through conductor 266 and its previously closed switching contacts 270, 282' of the latching relay and now closed switch 268, the zero speed switch 236, the force motor 43, the resistance 256 and its tap 254, the previously closed switching contacts 264, 282 of the latching relay, and conductor 252 to the lead 120'. Thereby, the rheostats 209 and 209' are cut out of the circuit and movement of the forks continues at a speed determined by the amount of resistance obtaining due to the position of the tap 254 along resistance 256.

In order to prevent surges through the force motor 43 when the operation is shifted to automatic which might result in a jerky transition between manual and automatic operation, excess power surges are absorbed by way of surge circuit 232', excess power passing through potentiometer 242' and closed switch 247' and is stored in capacitor 241'. Later when fork operation is reversed so as to energize coil 189, switch 248' is closed and the capacitor is equalized through resistor 246'.

Continuing with the operation of the forks in automatic, as movement of the forks continues, the tap 254 will continue to move toward the right, as viewed in FIG. 3, along the resistance 256, progressively decreasing the amount of resistance in the force motor circuit. Thereby, the force motor first progressively opens the control valve 47 to increase the speed at which the forks are extended. At some point intermediate the fully extended fork position, the tap 254 reaches its minimum resistance and furthest right travel as viewed in FIG. 3, and reverses direction to again being to move to the left progressively increasing the resistance, decreasing the opening of the control valve and resulting in a decrease of speed of the fork travel as the forks approach their fully extended position. One the forks have been fully extended, the moveable tap 254 will again break circuit with the resistance 256, and the force motor 43 will become deenergized, closing the valve 47 to stop the forks in the fully extended position.

To return the forks to the centered position, the operating handle 82 is simply moved in the opposite direction to again initiate manual movement of the forks as previously described. Once manual movement has been initiated and the forks begin their return to the centered position, the handle 82 may again be centered and the forks will continue to move automatically as previously described until they have reached the centered position. When the forks are centered, the tap 254 will again break contact with resistance 256, switch 268 will be mechanically opened and the fork movement will stop. When operating the forks in the automatic mode in the opposite direction so as to return the forks to the lift platform, the position of the latching relay switching contacts will be reversed from that previously described. Thereby in returning the forks in the automatic mode, a circuit is now completed from lead 120, through conductor 250 and its normally closed switches 258 and 259 and now closed latching relay switching contacts 260, 284', through the tap 254, resistance 256, conductor 234 and its force motor 43 and zero speed switch 236, conductor 266 and closed switch 268, conductor 272 and its closed latching relay switching contacts 274, 284 and through conductor 252 to lead 120'.

It will be readily appreciated that any time the operator desires to again take over manual control while the forks are undergoing extension or retraction in automatic, he need only move the operating handle 82 off center to override the automatic operation. Automatic operation will immediately cease when the handle is so moved, since a circuit will again be established between the rheostats 209 and 209' and their taps 208 and 208', energizing either conductors 210 or 211 to "fire" one of the rectifiers 194 or 198. The firing of one of the rectifiers will again energize either relay coils 188, 189 or relay coils 190 and 191 opening either switch 258 or 259 to break the automatic control lead 250. If the operating handle is moved in a direction so as to reverse the direction in which the forks are being automatically moved, the switching con-

tacts of the latching relay will reverse, otherwise the switching contacts will remain in the position which they had previously assumed during the prior automatic operation.

It should be understood that suitable solid state circuitry or components may be employed in place of one or more of the relays disclosed in the above-described electrical control circuit when practicing the principles of our invention.

It will also be understood that the embodiment of the present invention which has been described is merely illustrative of an application of the principles of our invention. Numerous modifications may be made by those skilled in the art without departing from the true spirit and scope of the invention.

What is claimed is:

1. In a load carrier including load supporting lift means and movable article handling means mounted thereon for storing and retrieving articles in a storage installation which includes drive means for manipulating the articles in at least two of three directions including a vertical direction, a direction transverse to the load carrier and a horizontal direction, a control arrangement comprising in combination therewith:

power circuit means for supplying power to said drive means from a power source to manipulate the articles in said two directions,

said power circuit means including power control means for selectively introducing the power to the respective drive means for manipulating the articles in said two directions, at least a pair of electrical control circuits for selectively energizing said power control means to manipulate the articles in said two directions, respectively,

electrical control means in each of said pair of control circuits moveable between a first position in which said power control means are operated to secure power to said drive means and a second position in which said power control means are operated to selectively introduce power to said drive means, and

switching means in said pair of control circuits, said switching means opening both of said control circuits when the electrical control means of either of the circuits are in said first position, whereby manipulation in either of said two directions can only occur when the electrical control means of both of said circuits are each in said second positions.

2. The arrangement of claim 1 wherein said power circuit means comprises a hydraulic circuit and said power control means comprise proportional flow hydraulic valve means, said valve means including motor means in and responsive to the condition of said electrical control circuits respectively.

3. The arrangement of claim 1 wherein said electrical control means of each of said control circuits comprises a gapped rheostat, whereby said electrical control means are moveable to a plurality of said second positions.

4. The arrangement of claim 1 wherein said drive means manipulates the articles in said vertical and horizontal directions and said switching means opens both of said control circuits when the electrical control means of either of the circuits are in said first position, whereby said vertical and horizontal manipulation can only occur when the electrical control means of both of said circuits are each in said second positions.

5. The arrangement of claim 1 including drive means, power circuit means, power control means and a third electrical control circuit and control means for manipulating the articles in each of said three directions, manipulation prevention means for preventing operation of said power control means from introducing power to the drive means for manipulating said load in the horizontal when said drive means is in a transverse position other than centered on said load carrier and for preventing operation of said power control means to move said drive means transverse of said load carrier when said load carrier is in motion in the horizontal direction.

6. The arrangement of claim 5 wherein said manipulation prevention means includes switch means in at least one of the transverse and horizontal electrical control circuits.

7. The arrangement of claim 6 wherein said switch means comprises a speed responsive switch in said transverse circuit which breaks the circuit to said power control means when said load carrier is in motion in the horizontal direction.

8. The arrangement of claim 6 wherein said switch means comprises a pair of switches one of said switches being in said transverse control circuit and the other of said switches being in said horizontal control circuit, said switch in said transverse circuit being operable in response to transverse movement of said drive means to close when said transverse drive means is centered on the load carrier and to open when said transverse drive means is not centered on the load carrier, coupling means coupling said pair of switches together for simultaneous operation, whereby when the switch in said transverse control circuit closes the switch in said horizontal control circuit is opened.

9. The arrangement of claim 1 wherein said pair of control circuits include means for independently varying the speed of said vertical and horizontal drive means.

10. The arrangement of claim 1 wherein the control circuit for controlling manipulation in said transverse direction includes means for manually moving and controlling said drive means in the transverse direction between an extended and a centered position relative to the load carrier and means for automatically continuing said transverse movement once movement has been initiated manually.

11. The arrangement of claim 10 wherein said manual means includes means to override said automatic means.

12. The arrangement of claim 1 wherein the control circuit for controlling manipulation in said transverse direction includes speed varying means for gradually slowing the speed of said drive means in the transverse direction, as the drive means approaches either a fully extended position or a position in which said drive means is centered on the load carrier, and for stopping said drive means when said drive means reaches either of said positions.

13. The arrangement of claim 1 wherein the control circuit for controlling manipulation in said horizontal direction includes speed varying means for automatically slowing and stopping movement of the load carrier in the horizontal direction when said load carrier approaches the end of its horizontal run.

14. In a load carrier for storing and retrieving articles in a storage installation which includes a fluid powered fork means on a lift platform for moving the articles transversely between a centered position on the load carrier and an extended position and fluid-powered drive means for moving the load carrier horizontally, a control arrangement comprising in combination therewith:

at least a pair of proportional fluid control valves for selectively controlling the supply of power fluid to said fork means and said drive means respectively,

motor means on each of said valves for variably opening said valves to vary the power fluid supplied to said fork means and said load carrier drive means,

an electrical control circuit for controlling the operation of said motor means, said motor means being located in said control circuit,

variable resistance means in said control circuit for variably and independently operating said motor means of each valve to vary the flow of the power fluid to said fork means and said drive means respectively, and

movement prevention means in said control circuit for preventing movement of said fork means out of its centered position when said load carrier is in motion and for preventing movement of said load carrier when said fork means are not centered.

15. The arrangement of claim 14 wherein said control circuit includes means for manually moving said fork means and means for automatically moving said fork means once movement has been initiated manually.

16. The arrangement of claim 15 wherein said manual means is capable of overriding said automatic means.

17. In a load carrier for transporting articles in a storage installation, said load carrier including load supporting lift means mounted thereon for manipulating the articles vertically relative to the load carrier and means for operating the load carrier horizontally, comprising in combination 5 therewith:
first manual operating means for selectively manually operating said load supporting lift means for manipulating the articles vertically of the load carrier, 10
second manual operating means for selectively operating the load carrier horizontally, and 10
first and second manual switching means operatively as-

sociated with each of said first and second manual operating means respectively, said first manual operating means being operative to manipulate the load supporting lift means vertically relative to the load carrier only when said second manual switching means is manually operated simultaneously therewith, and said second manual operating means being operative to manipulate the load carrier horizontally only when said first manual switching means is manually operated simultaneously therewith, whereby both hands of the personnel operator are occupied during said manipulations.

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