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3,494,259

METHOD OF PROVIDING EQUAL FLOW TO HYDRAULIC CYLINDERS

Original Filed Oct. 24, 1967

4 Sheets-Sheet 1

FIG. 1

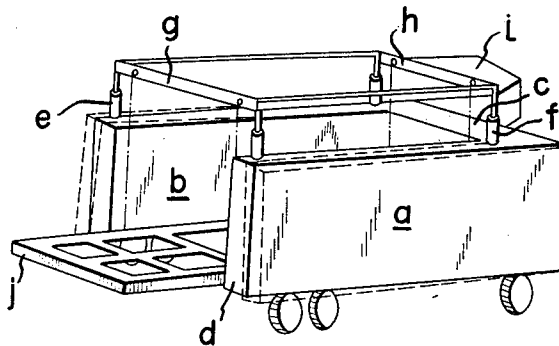
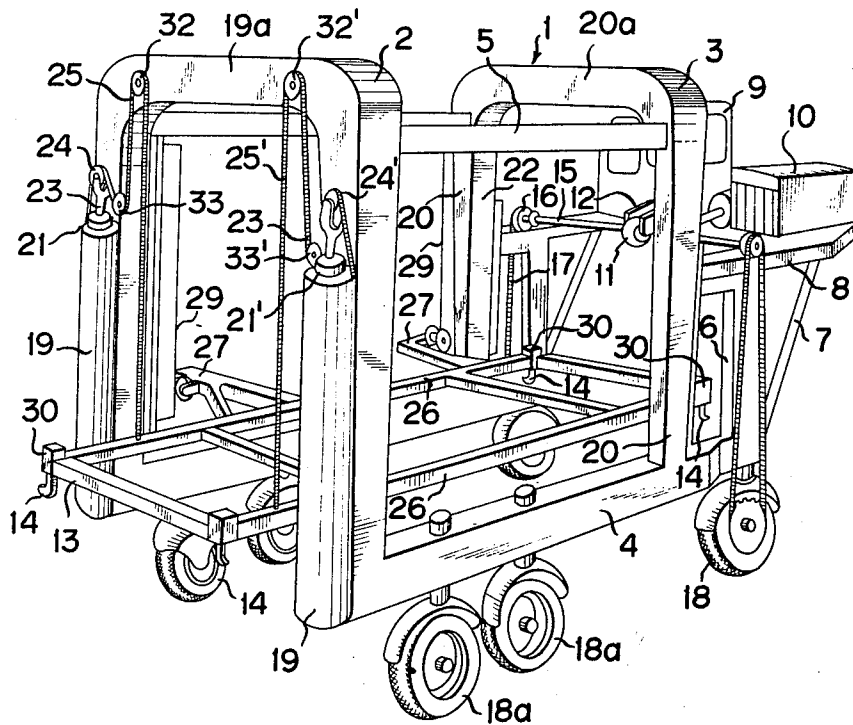


FIG. 2



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4 Sheets-Sheet 2

FIG. 3

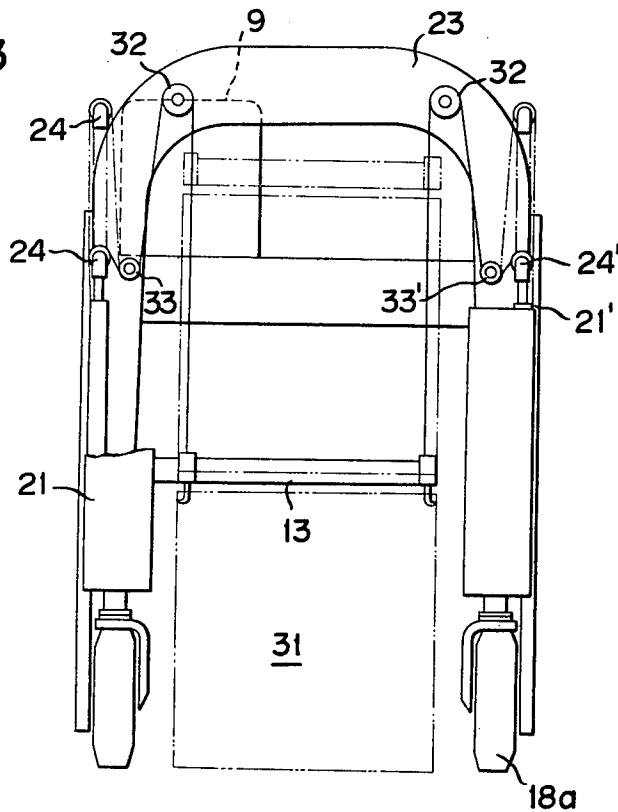
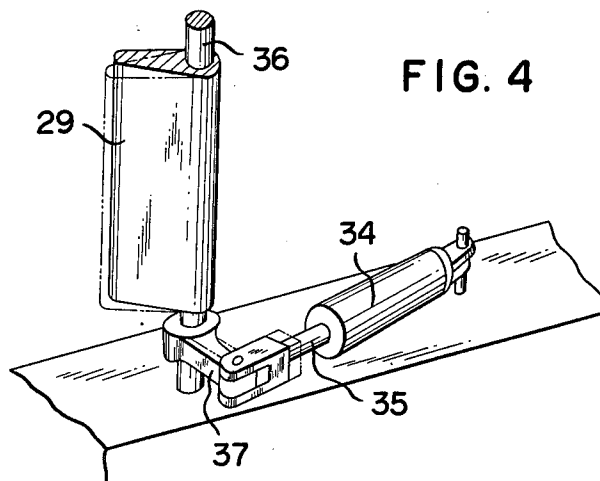


FIG. 4



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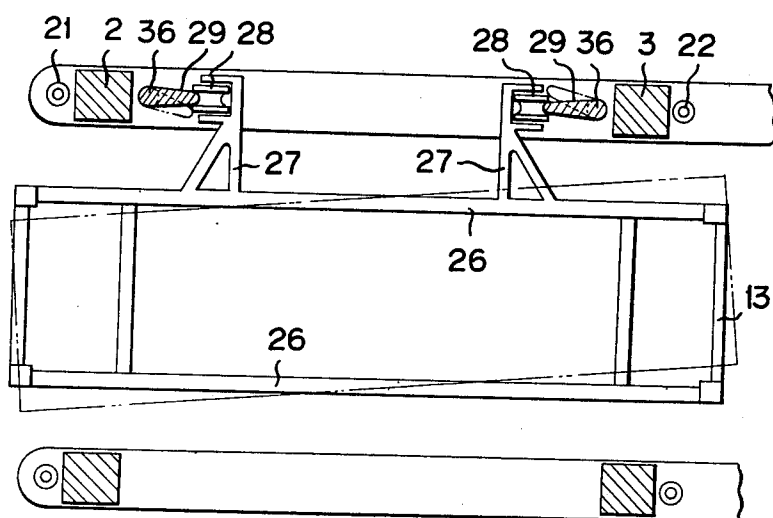
3,494,259

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4 Sheets-Sheet 3

FIG. 5



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4 Sheets-Sheet 4

The schematic diagram illustrates a hydraulic system 38. It features two main actuator assemblies, each housed within a larger container 48. The left assembly contains cylinders 21 and 21' with pistons 23 and 23' respectively. The right assembly contains cylinders 22 and 22' with pistons 24 and 24'. Each cylinder is controlled by a solenoid valve (50 and 50') which directs fluid flow from a common supply line 45 through a manifold 42 (with ports 42a and 42b) to the cylinders. The manifold 42 is connected to a pump 40, which is driven by a motor 39. The pump 40 has two pressure feedback ports, 40a and 40b, connected to pressure sensors (STRN) and a pressure filter (PF). A check valve 41 is located between the manifold 42 and the pump 40. The entire system is labeled 38.

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METHOD OF PROVIDING EQUAL FLOW TO HYDRAULIC CYLINDERS

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Original application Oct. 24, 1967, Ser. No. 677,609.

Divided and this application Mar. 24, 1969, Ser.
No. 809,717

Claims priority, application Japan, Oct. 29, 1966,
41/71,222

Int. Cl. F15b 11/00, 13/00

U.S. Cl. 91—471

6 Claims

ABSTRACT OF THE DISCLOSURE

The hydraulic lift system of a materials handling vehicle is arranged to lift a load uniformly though it may be unevenly distributed. The hydraulic fluid is divided and supplied in equal parts to each of the lifting members for uniform movement of the load in both the lifting and the lowering operations. A method of providing equal flow includes the steps of withdrawing a plurality of supplies of hydraulic fluid from a reservoir, subdividing each supply into equal parts, intermixing an equal part from one supply with an equal part from another supply, and directing the intermixed supplies to each of the hydraulic cylinders.

CROSS REFERENCE TO RELATED APPLICATIONS

This is a division of application Ser. No. 677,609, filed Oct. 24, 1967.

SUMMARY OF THE INVENTION

The present invention is directed to an improved method of operating a materials handling vehicle and, more particularly, to providing an improvement in lifting materials to be transported.

In conventional materials handling vehicles, the vehicle is positioned over the materials to be transported, then the materials are lifted, moved to a predetermined place, and then lowered and released. To perform these operations, the vehicle is generally provided with a vertically extending open space within its frame. However, in known vehicles of this type the following drawbacks have been noted:

(1) To provide the required open space for handling various materials the side and cross frames of the vehicle have been unsubstantial and the ends of the side frame have had the tendency to move relative to one another when the vehicle is turning;

(2) The location of the hydraulic motor for lifting the materials and of the cross support members has often made it difficult for the driver to obtain an unobstructed view of the lifting operation;

(3) The means used for laterally positioning the lifting member has provided further obstacles in the path of the driver's vision; and

(4) The mechanically or hydraulically driven lifting apparatus often has been inadequate and has required excessive down time for repairs.

A primary object of the invention is to provide a method of operating the lifting means of a materials handling vehicle whereby the lifting frame may be maintained in a plane parallel to the surface on which the vehicle is positioned in spite of any uneven distribution of the load.

Another object of the invention is to supply equal quantities of hydraulic fluid to each of the lifting devices in the vehicle.

Therefore, the present invention is directed to a materials handling vehicle having a frame structure pro-

2

viding an open space for receiving and handling the materials to be transported. Preferably, the support frame comprises a pair of spaced end frames of an inverted U-shaped configuration formed by a pair of spaced upright members secured at their upper ends by an integrally attached cross member. Side members secured to the end frames provide additional rigidity without encroaching on the open space within the frame or obstructing the view of the operator. A lifting member is located within the open space in the frame and is adapted to extend generally parallel with the surface on which the vehicle is positioned. The lifting member is arranged to be moved laterally as well as upwardly and downwardly within the open space. Lifting means are mounted on the upright members of the end frames for raising and lowering the lifting member. In addition, control means are provided for the lifting means to assure that the lifting member is maintained in a position substantially parallel to the surface on which the vehicle is positioned during lifting, regardless of any uneven distribution of load upon the lifting member.

For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a perspective view of a somewhat schematic arrangement showing a conventional type of materials handling vehicle used in the prior art;

FIG. 2 is a perspective view of a materials handling vehicle embodying the present invention;

FIG. 3 is a rear view of the vehicle shown in FIG. 2 with a container shown in phantom arranged to be lifted by the vehicle;

FIG. 4 is a partial perspective view of the vehicle illustrating a device for laterally positioning a lifting member;

FIG. 5 is a partial sectional top view of the lower portion of the vehicle shown in FIG. 2; and

FIG. 6 is a schematic arrangement showing a control apparatus for the lifting devices on the vehicle shown in FIG. 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 an arrangement is shown of a conventional materials handling vehicle, as known in the art, comprising a pair of side frames *a*, *b* and a cross frame *c* at one end. In transporting material, as the vehicle turns, the rear ends *d* of the side frames *a*, *b* have a tendency to move either apart or toward one another since there is no means for adequately spacing them and the side frames are not sufficiently rigid to assure that they will remain in proper spaced parallel relationship. The hydraulic lifting cylinders *e* and *f* located at either end of the vehicle and the gate or cross frame members *g* and *h* form obstructions in the line of sight of the operator of the vehicle as he sits in its cab *i*. Additionally, the cross frame *c* is another obstruction which makes it difficult for the operator to see the materials being handled within the open space in the vehicle. Where a motor unit or other apparatus is provided for laterally positioning the lifting frame *j*, this also obstructs the vision of the operator.

In a materials handling vehicle 1, shown in FIGS. 2 to 6, a vertically extending open space is formed within the frame construction of the vehicle. The vehicle frame is comprised of two spaced end frames 2 and 3 having

generally inverted U-shaped configuration. The end frames 2 and 3 are interconnected by longitudinally extending lower beams 4 and upper beams 5. The lower and upper beams do not encroach on the vertical open space within the frame. The end frames 2 and 3 are formed of upright members 19 and 20 and cross members 19a and 20a, respectively. Since the end frame is formed of an integral construction, it is sufficiently rigid to withstand the various forces exerted on it in the lifting operation and in the movement of the vehicle. Moreover, since there are no cross members below the upper members 19a, 20a, there is no obstruction in the open space within the frame for the vertical movement of materials to be transported.

Extending upwardly from the lower beams 4, outwardly from the uprights 20 of the end frame 3, are a pair of vertical support members 6 and knee brace members 7 which support a horizontally arranged plate 8. A cab 9 for the operator of the vehicle is located on the plate 8 along with a motor 10 and a differential gear 11 for driving the vehicle. A cantilever support member 12 extends from the plate toward the end frame 3 and supports the differential gear 11. It will be noted that there is no cross member of the vehicle disposed in the path of the differential gear. With this arrangement, the operator has an unobstructed view from his cab into the open space within the frame of the vehicle wherein the materials lifting device is located. The operator is able to view the entire lifting frame 13 as well as the hooks 14 which are located at its corners.

The differential gear 11 is mounted on a shaft 15 and drives sprocket wheels 16 at the outer ends of the shaft which, in turn, transmit the driving motion through chains 17 downwardly to driving wheels 18 located at the lower end of the frame. Other wheels 18a for the vehicle are secured to the lower beam 4 and are located between the end frames 2, 3. The driving mechanism just described does not form an essential part of the present invention, accordingly, further detailed explanation of its construction is not set forth.

Each end of the vehicle has a pair of double acting hydraulic piston cylinders 21, 21' and 22, 22', a separate cylinder is positioned on each of the uprights 19, 20 of the end frames 2, 3. As shown in FIG. 2, the cylinders 21, 21' have vertically movable pistons 23, 23' provided with wheels 24, 24' on the upper ends of the piston arms. Chains 25, 25' are secured to the hydraulic cylinders and extend over the wheels 24, 24'.

Within the vertically extending open space in the frame, a lifting member or open frame body 13 is positioned substantially parallel to the surface on which the vehicle rests. At each of its ends, the lifting member 13 is attached to the chains 25, 25' extending downwardly from the cross member 19a of the end frame. The support of lifting chains 25, 25' extend vertically upward from the lifting member and pass over wheels 32, 32' located on the cross member 19a, of the end frame and then pass downwardly around another wheel 33, 33' mounted on the uprights 19, 19' of the end frame 2. From the wheels 33, 33', which are located below the wheels 24, 24' in their lowermost position in the hydraulic cylinders 21, 21', the chains pass upwardly over the wheel 24, 24' and then, as mentioned previously, are secured to the body of the hydraulic cylinder 21, 21'. A similar lifting chain arrangement (not shown) is provided for the opposite end of the lifting member 13. With this chain and wheel arrangement, the lifting member 13 is designed to move vertically at the rate of 2 to 1 compared with the movement of the piston within the hydraulic cylinder.

In the hydraulic system, a hydraulic fluid equalizer is provided, as will be explained subsequently, to assure an equal feed of hydraulic fluid to each of the hydraulic cylinders mounted on the vehicle. Due to the manner in which the hydraulic fluid is fed to each of the cylinders, the lifting member 13 will be moved upwardly and down-

wardly in a plane substantially parallel to the plane in which the vehicle is positioned.

As can be seen in FIGS. 2 and 5, a pair of spaced support brackets 27 extend laterally outward from one of the longitudinally extending members 26 of the lifting member or frame 13. Near the outer end of each bracket a grooved wheel 28 is positioned. Mounted on the vehicle frame are a pair of vertically extending guide rails 29 with which the grooved wheels are engaged.

As shown in FIG. 4, a double-acting piston 34 having a piston rod 35 is connected through an arm 37 to the shaft 36 on which the laterally movable guide rail 29 is mounted. By displacement of the piston arm, the shaft 36 is rotated and the end of the rail in contact with the grooved wheel 28 can be moved laterally either outwardly from or inwardly toward the frame of the vehicle.

At each corner of the lifting member 13, a box member 30 is provided with a hook 14 depending downwardly from the lifting member. In FIG. 3, a container 31 is shown in phantom and the hooks 14 are designed to engage a recess component (not shown) provided in the top corners of the container 31. The construction of the hook for such a use is well known and further description is not considered essential to the disclosure of the present invention.

When the lifting member 13 and any load attached to it are raised or lowered, the member is lifted by the chains 25, 25' and is guided in its vertical path with a low frictional resistance by the rollers or grooved wheels 28 and the vertical guide rails 29 provided on one side of the lifting member.

In its normal position within the vehicle, the lifting member 13 is symmetrically arranged with respect to the sides of the vehicle, as shown in full line in FIG. 5. If, in a lifting operation, the vehicle 1 is symmetrically arranged with respect to the container 31 to be lifted, then the lifting member 13 is lowered on the lifting chains until its hooks 14 engage the recessed components on the container. However, if the vehicle is not symmetrically arranged with respect to the container 31, as is often the case, then the position of the lifting member 13 can be adjusted in the horizontal plane by means of controls located in the cab 9 of the vehicle. By means of these controls, the vertical guide rails 29 can be displaced laterally so that the hooks are properly positioned over the container. An example is shown in FIG. 5 where the right-hand guide rail is moved outwardly (see the dashed lines), and the left-hand guide rail is moved inwardly whereby the lifting frame assumes an oblique position with respect to the sides of the vehicle.

In addition to affording the correct positioning of the lifting member over a container to be transported, as shown in FIG. 5, the means for laterally moving the lifting member may also be employed when the container is in a lifted position for placement on another container or for proper placement in a new location. Further, the control means for operating the piston cylinder 34, which moves the vertical guide rails, can be employed to lock the position of the lifting member 13 so that it does not move during the transporting operation.

During the lifting operation, the pistons within the hydraulic cylinders are uniformly set in motion using a hydraulic fluid quantity equalizer. If the center of gravity of the container 31 or other materials to be lifted are displaced closer to one end of the vehicle, than to the other, then the pistons on one end would be subjected to more load than those at the other end. Even in such a case, however, the hydraulic fluid is fed equally to each of the cylinders by means of a divider valve arrangement so that all four pistons have the same relative motion. Moreover, the hydraulic fluid quantity equalizer apparatus contains means whereby a single hydraulic cylinder can be operated by the driver of the vehicle.

In FIG. 6, the arrangement of the hydraulic fluid quantity equalizer apparatus is illustrated. A container 38 forms

5

a reservoir of hydraulic fluid for the operation of the lifting member 13. From the reservoir 38, the hydraulic fluid is taken into the equalizer apparatus by means of two pair of strainers 39 and oil pumps 40. The number of pumps employed is dependent upon the hydraulic fluid quantity required for the apparatus and the capacity of the pumps. Branch pipes 40a, 40'a extend from each of the pumps 40 and combine in a single delivery pipe 40b, 40'b which extends to a flow divider valve 41, 41'. The hydraulic fluid leaves the flow divider valve 41, 41' through two outlets and the quantity of hydraulic fluid is equal at each outlet. Accordingly, even if a difference in pressure exists within the discharge passages from the outlets, the quantity of hydraulic fluid fed from the valve is equal. Downstream of each of the flow divider valves 41, 41' is a four way valve 42, 42'. These four way valves 42, 42' control the movement of the pistons 23, 23' in the two cylinders 21, 21', respectively, at one end of the vehicle while the other valve 42' controls the movement of the pistons 24, 24' in the other cylinders 22, 22', respectively, at the opposite end of the vehicle. The four way valves 42, 42' normally are controlled by the operator from the vehicle cab.

A conduit 43 is connected to the lefthand outlet of the valve 41 and extends to the four way valve 42 and similarly, a conduit 46 extends from the righthand outlet of the valve 41' to the four way valve 42'. From the other or righthand outlet of the flow divider valve 41, a conduit 45 extends to the conduit 46 and similarly from the lefthand outlet of the flow divider valve 41' another conduit 44 extends into connection with the conduit 43. Accordingly, due to the arrangements of the flow divider valves 41, 41', the quantity of hydraulic fluid flowing through the passages 43 and 45 from one of the valves is equal to that flowing through the conduits 44, 46 from the other valve, regardless of any difference in pressure in these conduits. Because of this conduit arrangement, the quantity of hydraulic fluid entering each of the four way valves 42, 42' is equal.

The four way valves 42, 42' have three positions for controlling the pistons in the hydraulic cylinders. When the piston is to remain stationary, the hydraulic fluid flowing from the divider valves 41, 41' through the passage ways 43, 46 to the four way valves 42, 42' is bypassed through the lines 43a, 46a to the reservoir 38. With the flow bypassed, there is no passage of hydraulic fluid into the cylinders and the position of the piston remains unchanged. If the pistons 23, 23', 24, 24' are to be moved upwardly the hydraulic fluid from the four way valves 42, 42' is fed into the lines 42a, 42'a and passes upwardly through another flow divider valve 47, 47' into the cylinders. At the same time, the hydraulic fluid on the opposite side of each piston flows out through the upper end of the cylinder and passes through a conduit 48 for its return into the four way valve.

If the pistons in the cylinders are to be moved downwardly, then the hydraulic fluid passed through the conduits 42b, 42'b into the passage ways 48, 48' and thence into the upper ends of the cylinders, and the oil or hydraulic fluid contained at the opposite side of each piston is forced out through the lines 47a, 47b and returns to the four way valve in a manner to be described subsequently.

In the path of flow of the hydraulic fluid from the four way valve 42 to the lower ends of the cylinders 21, 21', it passes through the flow divider valve 47 which separates the fluid into two halves for passage through the lines 47a, 47b to the cylinders 21, 21'.

Accordingly, an equal amount of hydraulic fluid is delivered to each of the cylinders 21, 21'. A similar flow divider valve 47' is provided for the fluid passing from the four way valve 42' to the cylinders 22, 22' and the hydraulic fluid delivered to each of these cylinders is equal. Due to the arrangement of the hydraulic fluid equalizer apparatus passing first through the flow divider valves 41,

6

41' and then through the flow divider valves 47, 47' an equal quantity of fluid is fed into each of the four cylinders and the pistons can therefore be moved upwardly within the cylinders at the same speed.

Though flow divider valves 47, 47' are provided in the path of flow of the hydraulic fluid from the four way valves to the lower ends of the cylinder 21, 21', 22, 22' there is no such divider valve in the path of the hydraulic fluid to the upper ends of the cylinders. Accordingly, the flow through the cylinders has to be controlled to assure proper operation. For controlling the flow of the fluid through the cylinders when the piston is being moved downwardly, the hydraulic fluid instead of flowing through the flow divider valves 47, 47' is blocked by the check valves 49, 49' and passes through bypass conduits 50, 50' and flow limiting valves 51, 51' and then through the conduits 52, 52' into the four way valves. In normal operation, the flow limiting valves 51 are closed by means of springs to prevent any passage of hydraulic fluid through them. If, however, the hydraulic fluid pressure is applied to the upper sides of the pistons 23, 23', then this pressure plus a pressure due to the weight of the piston exerts a pressure in the conduits 50, 50' which is sufficiently high to overcome the spring action within the flow limiting valve 51, 51'. As a result, a small piston (not shown) within the valve is shifted and the hydraulic fluid is fed to the four way valve through the conduit 52. The position of the small piston within the flow limiting valves 51, 51' is designed so that the passage of hydraulic fluid may be regulated whereby the quantity of the fluid flowing through the valve 51, 51' is dependent on the cross sectional area of the valve opening and in this way, the four pistons may be moved at the same speed regardless of the load which is being supported. Therefore, the pistons within the cylinders may be moved upwardly or downwardly in a uniform fashion by employing the flow divider valves 47, 47' or the flow limiting valves 51, 51' depending on the direction of travel.

There may be instances where less than the full number of four cylinders are to be used and in such a case, the circuit illustrated in FIG. 6 operates in the following manner. For purpose of explanation it will be assumed that cylinder 21 is the only one to be used. The operator sets the four way valve 42 in the desired position and also actuates one of a series of buttons (not shown) for the flow limiting valve 51. Four of these buttons are provided in the cab of the vehicle and are connected to the four flow limiting valves, respectively. An electric current is supplied to each of the valves when its corresponding button is actuated and solenoid is operated which withdraws the small piston which limits the flow through the valve. In this way, the hydraulic fluid passage in the bypass about the flow divider valve 47 is opened.

Since only the cylinder 21 is to be used, the flow of hydraulic fluid is opened between the lower end of the cylinder and the four way valve 42. Further, the passage or conduit 48 extending from the upper end of the cylinder 21 to the four way valve is also opened for passage of the hydraulic fluid therethrough. However, the cylinder 21' which receives hydraulic fluid from the same four way valve is subjected to resistance to flow in its return passage by means of the divider valve 47, the flow limiting valve 41 and the check valve 49. Because of this arrangement, the hydraulic fluid which is discharged from the four way valve only enters the cylinder 21 and directs the piston in the desired direction.

It is to be understood that the present invention is not limited to the various embodiments illustrated and various modifications may be possible within the scope of the invention.

In view of the foregoing, it will be appreciated that the present invention as compared with the conventional apparatus shown in FIG. 1 has the following advantages:

(1) As the integral end frame members are connected to each other by means of both upper and lower beams,

the vehicle body is strong in construction; and because of this construction, any deformation or relative movement of its side members at the rear of the vehicle is limited to a point where it is not in any way a problem in the operation of the vehicle. This construction is particularly useful for the design of large sized materials handling vehicles.

(2) The position of the lifting cylinders on the upright members of the frame provide an unobstructed path of view for the operator in handling materials.

(3) Since the hydraulic fluid quantity equalizer apparatus moves the pistons equally, the location of the lifting member is maintained in a plane parallel with the surface in which the vehicle is positioned and smooth operation is achieved during the transportation of the materials.

What is claimed is:

1. A method of providing equal flow of hydraulic fluid from a reservoir to a plurality of hydraulic fluid piston cylinders comprising the steps of withdrawing a plurality of supplies of hydraulic fluid from the reservoir, subdividing each supply of hydraulic fluid into equal parts, intermixing an equal part from one supply with equal parts from the other supplies and selectively directing equal quantities of the intermixed supplies to each of the hydraulic cylinders.

2. A method, as set forth in claim 1, wherein the step of selectively directing equal quantities comprises dividing each intermixed supply into equal parts and supplying each equal part to a different hydraulic cylinder.

3. A method of providing equal flow of hydraulic fluid from a reservoir to a plurality of double acting hydraulic fluid piston cylinders comprising the steps of withdrawing a plurality of supplies of hydraulic fluid from the reservoir, combining the supplies of hydraulic fluid into two sources, subdividing each source of hydraulic fluid into two equal parts, intermixing one equal part from one source with an equal part from the other source, and selectively directing equal quantities of the intermixed sources to each of the hydraulic cylinders.

4. A method, as set forth in claim 3, and comprising the step of withdrawing hydraulic fluid from the cylinder on the opposite side of the piston from the supply to the cylinder.

5. A method, as set forth in claim 3, wherein the step of selectively directing equal quantities comprises dividing the intermixed sources into two equal parts, and supplying each equal part to a different cylinder and withdrawing hydraulic fluid from the cylinder on the opposite sides of the piston from that receiving the equal parts for effecting the displacement of the piston within the cylinder.

6. A method, as set forth in claim 3, wherein the step of selectively directing equal quantities comprises affording a supply of intermixed hydraulic fluid to each of the cylinders on one side of the piston, regulating the withdrawal of equal amounts of hydraulic fluid from the cylinder on the other side of the piston for affording equal quantities of hydraulic fluid into each of the cylinders.

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