United States Patent

Monk

[15] **3,703,243**

[45] **Nov. 21, 1972**

[54] STRADDLE CARRIER

[72] Inventor: **John Thomas Monk,** 405 Meadow Moss Drive, Jackson, Miss. 39206

[22] Filed: **Sept. 15, 1970**

[21] Appl. No.: **72,444**

[52] **U.S. Cl.** **214/394**
[51] **Int. Cl.** **B60p 1/02**
[58] **Field of Search** 214/390, 392, 394, 396

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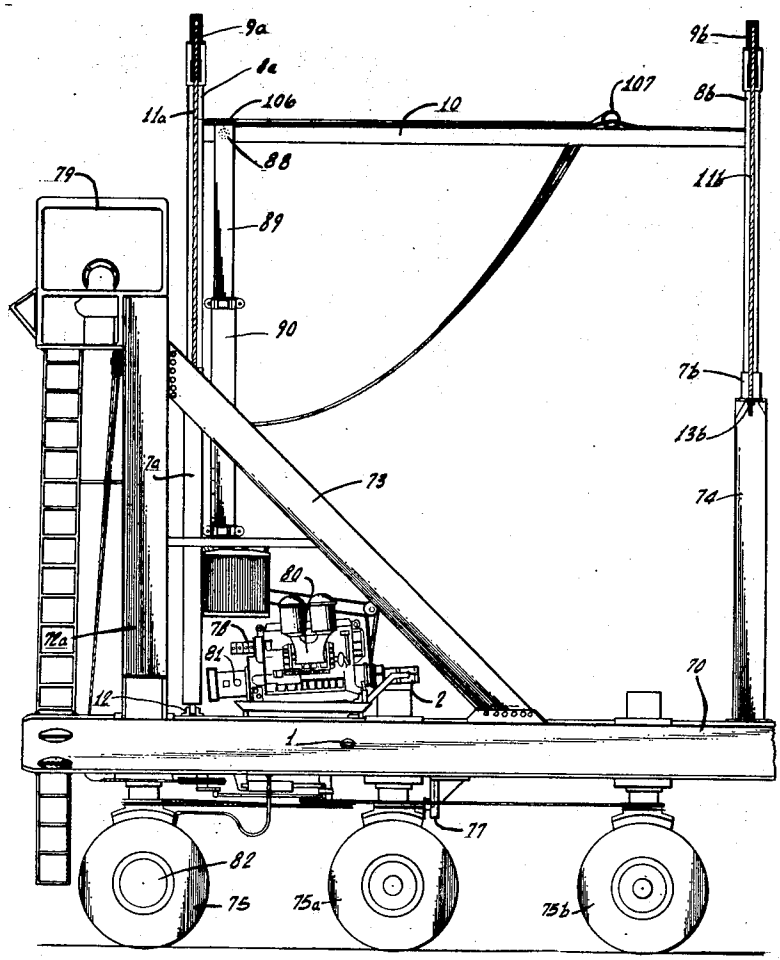
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Primary Examiner—Robert J. Spar
Attorney—Alexander & Dowell

[57] **ABSTRACT**

The straddle carrier has two spaced parallel elongated frame members adapted to straddle a load. A vertically disposed arch member connects the frame members together adjacent one end thereof and diagonally disposed leg members connect the tops of the arch to substantially the mid-points of the frame members. Ground wheels are flexibly mounted on the undersides of the frame members, and means for steering the wheels are provided. A rectangular load lifting beam is disposed between the frame members and arches. Means are provided engaging the four corners of the lifting beam for raising and lowering the lifting beam, means being provided at the four corners of the lifting beam for securing same to a load. Means are also provided for guiding the lifting beam during its ascent and descent. And means are provided for controlling the lifting beam raising and lowering means whereby the four corners of the beam will be simultaneously raised or lowered equal amounts notwithstanding the relative weights on the respective corners, in order to maintain the beam always parallel with the frame members.

17 Claims, 19 Drawing Figures



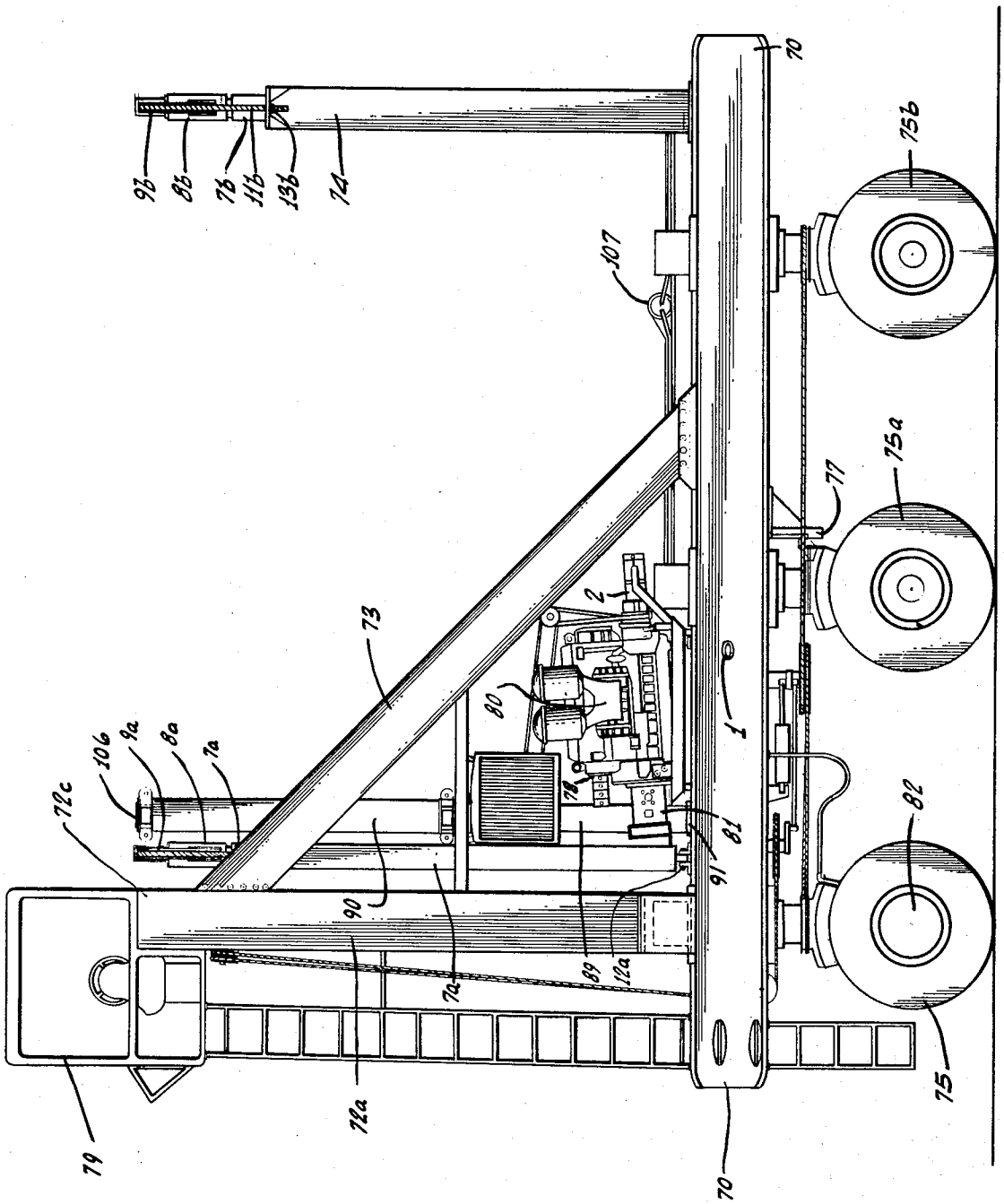


FIG. 1

INVENTOR.
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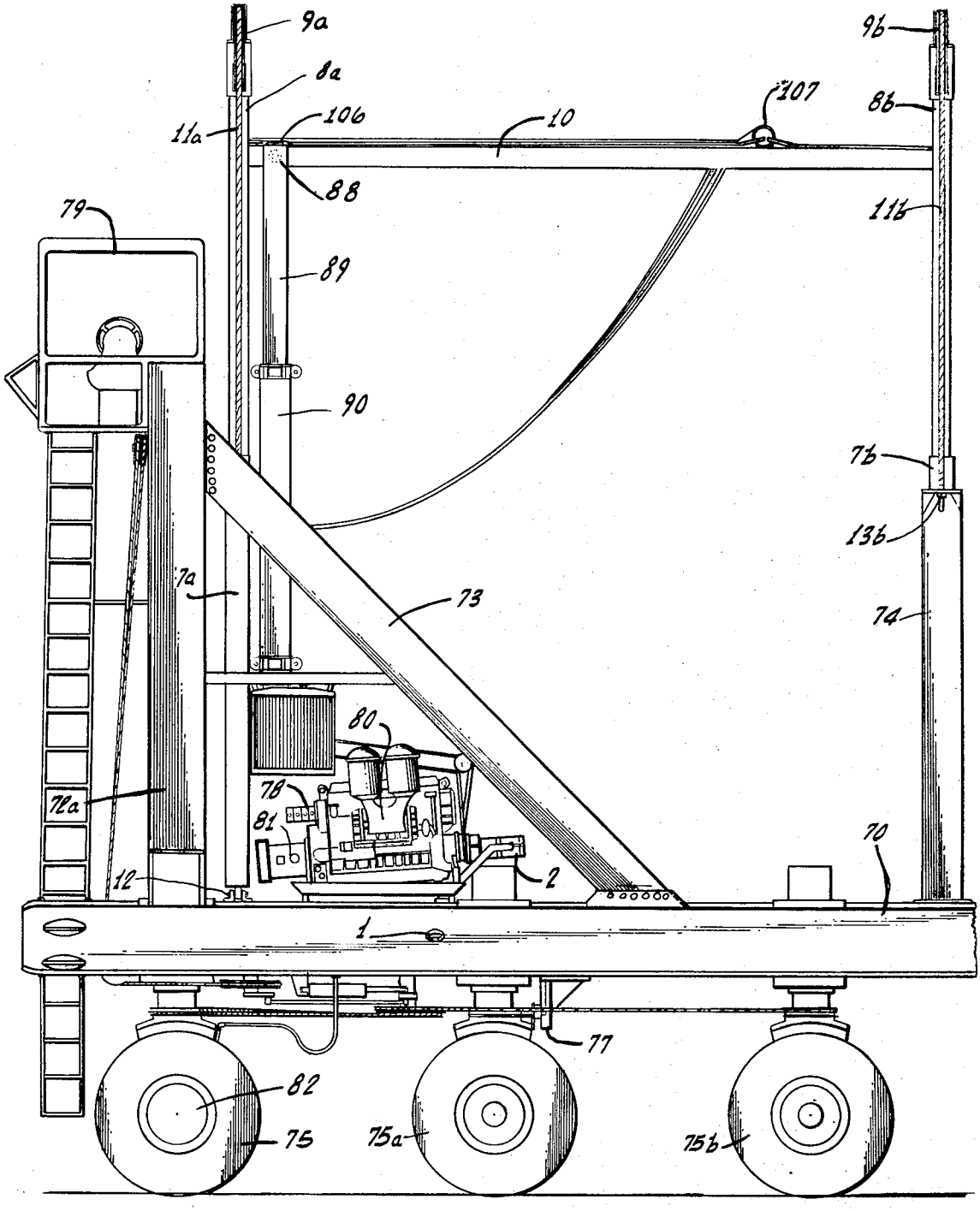


FIG. 2

INVENTOR.

BY John Thomas Mond

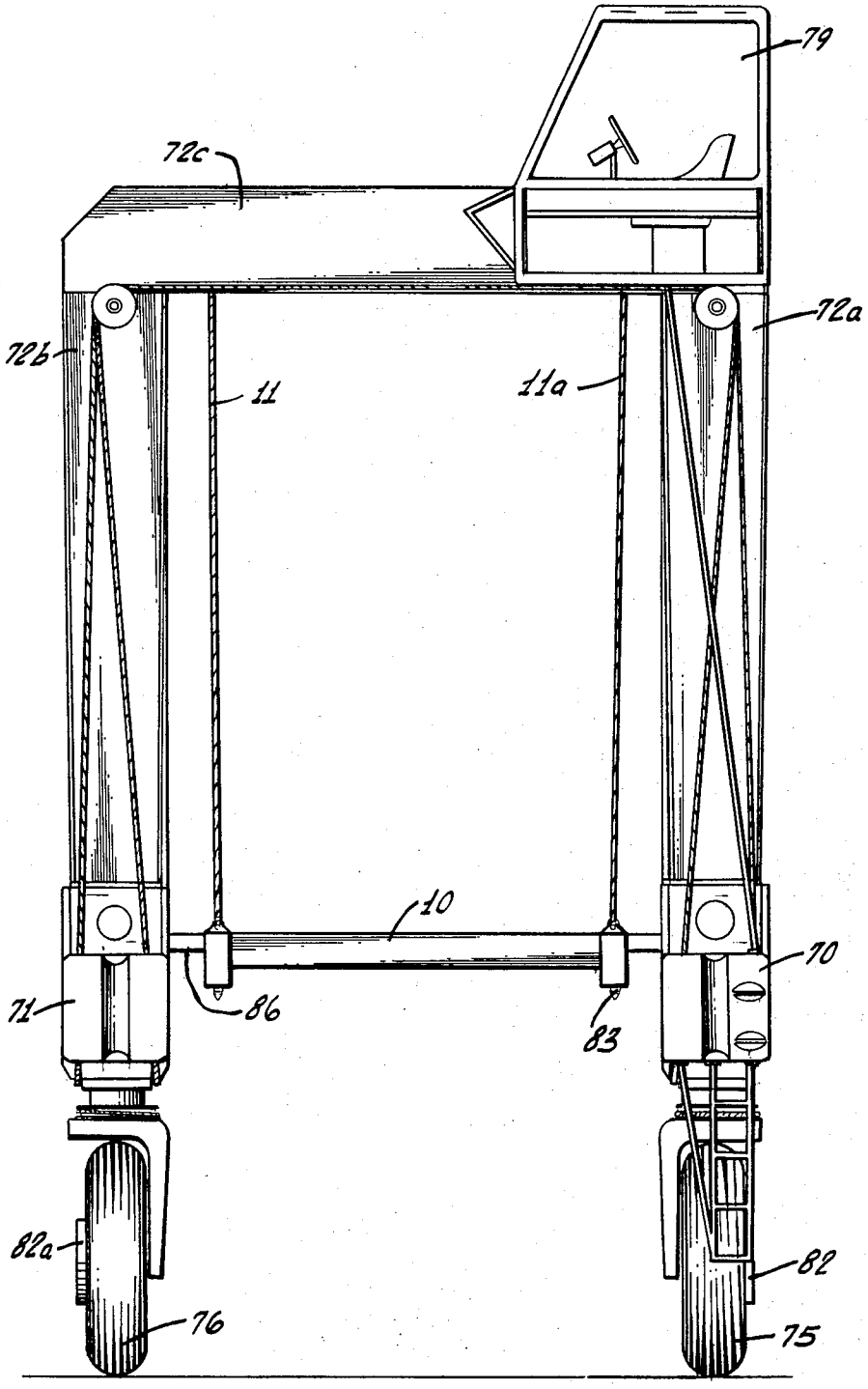


FIG. 3

INVENTOR.
John Thomas Monk

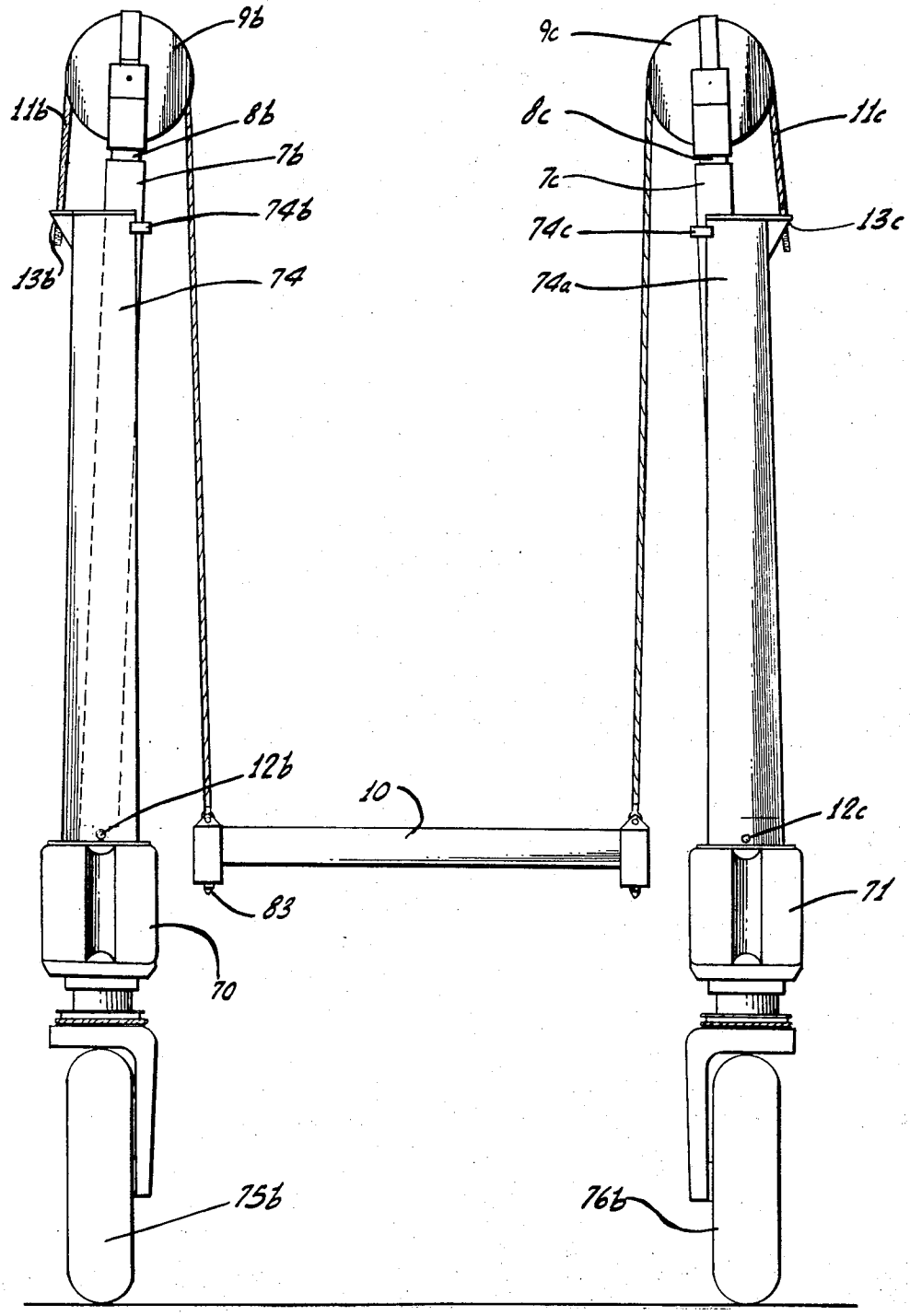


FIG. 3A

INVENTOR.
John Thomas Monk

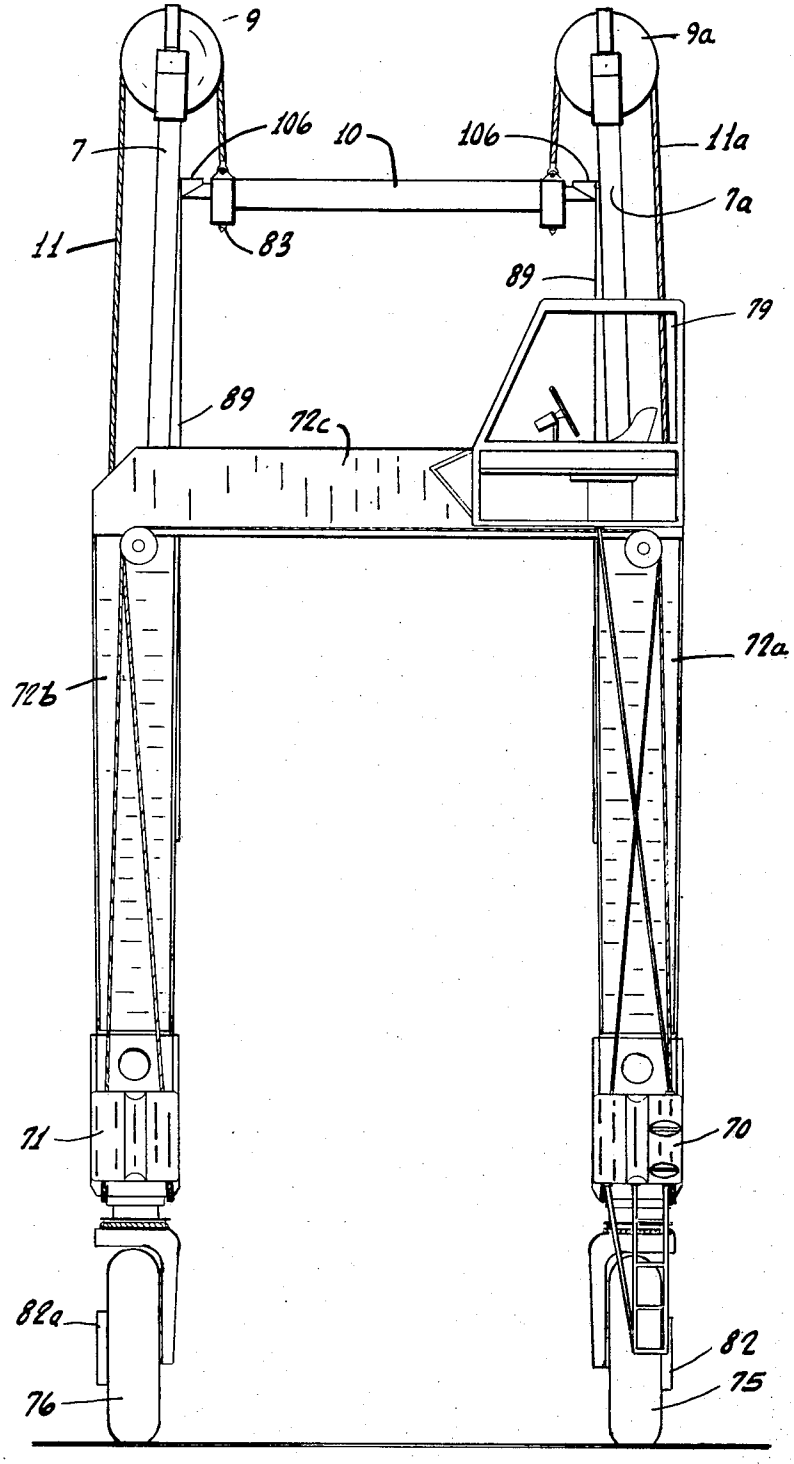


FIG. 4

INVENTOR.
John Thomas Monk

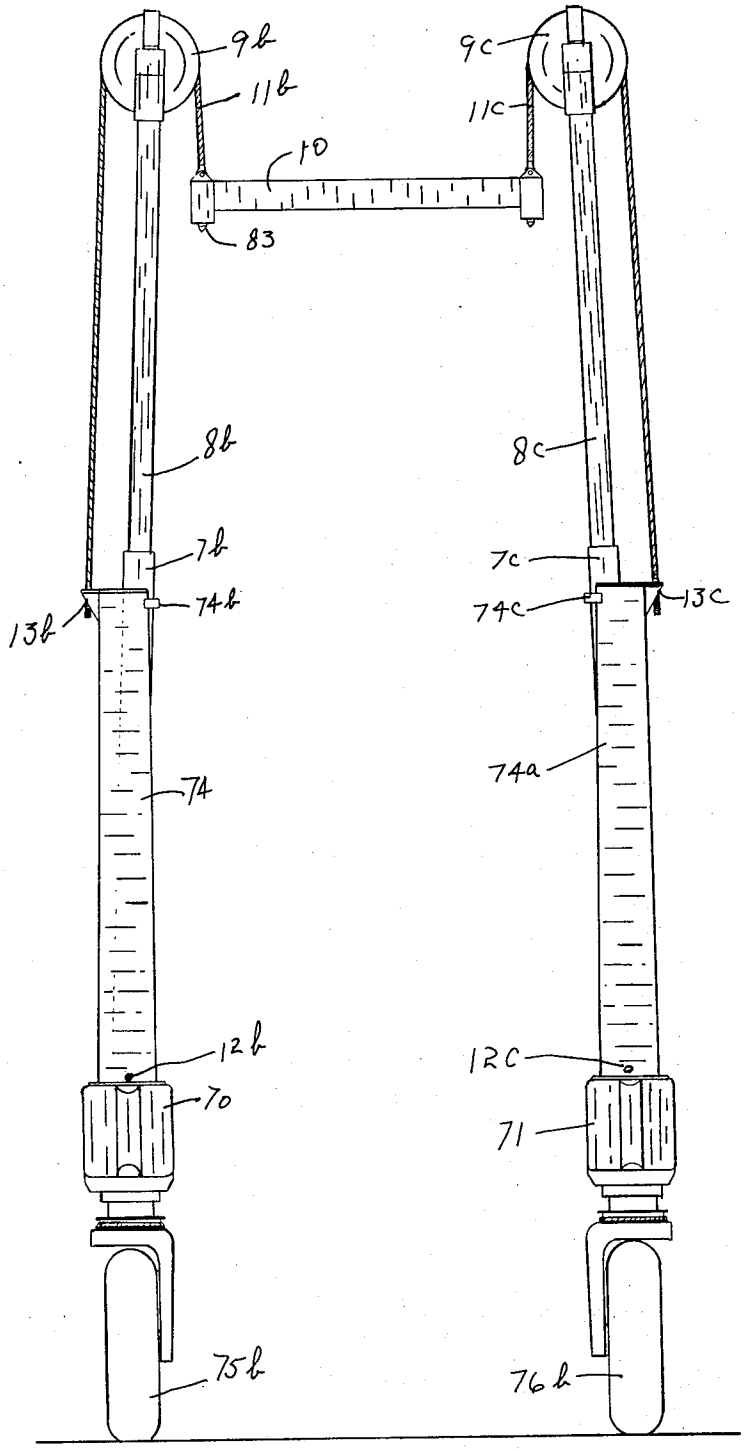


FIG 4A

INVENTOR.
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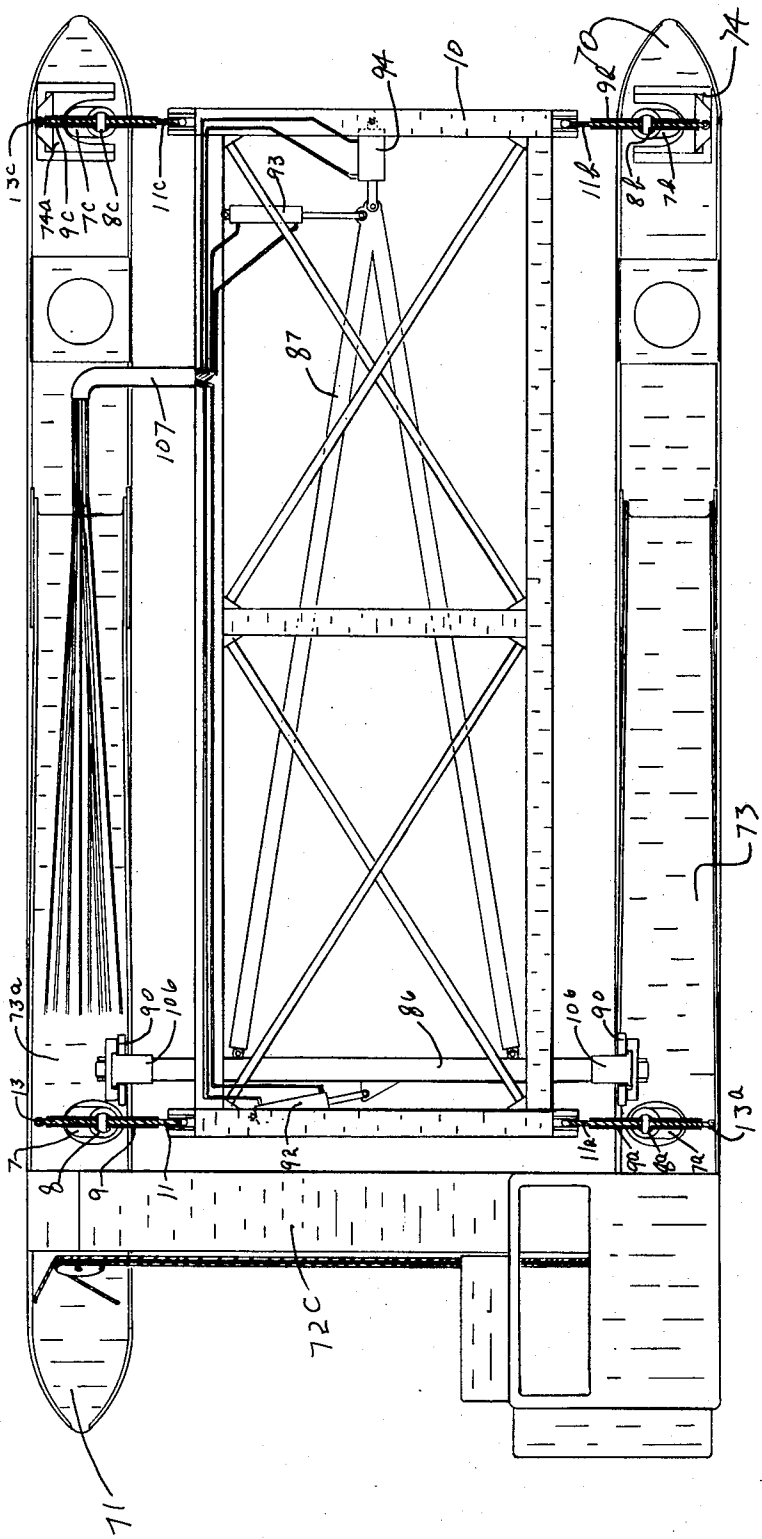


FIG 5

INVENTOR.

John H. Ponce Mora

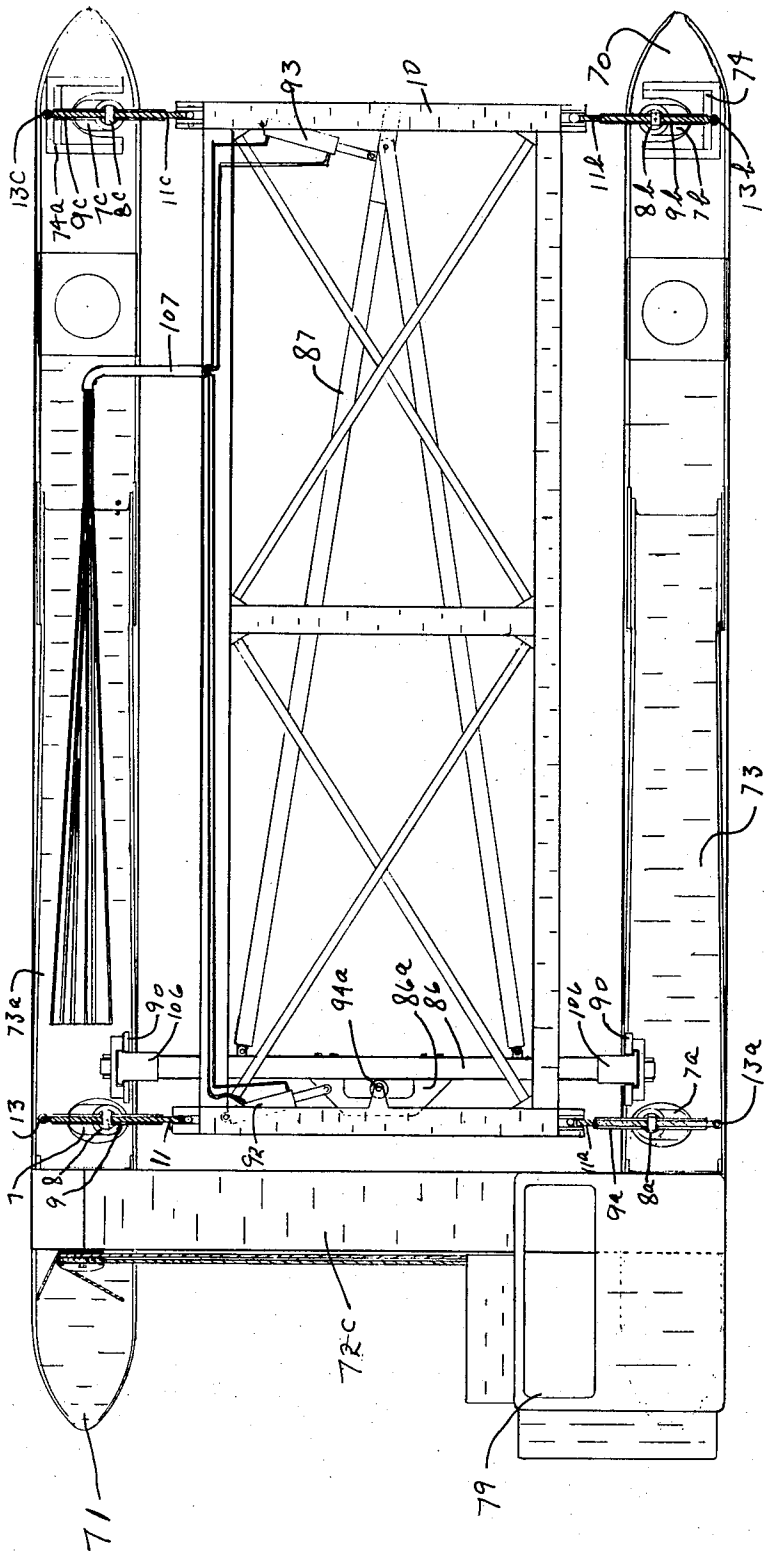


FIG. 5A

INVENTOR.

John Thomas Monk

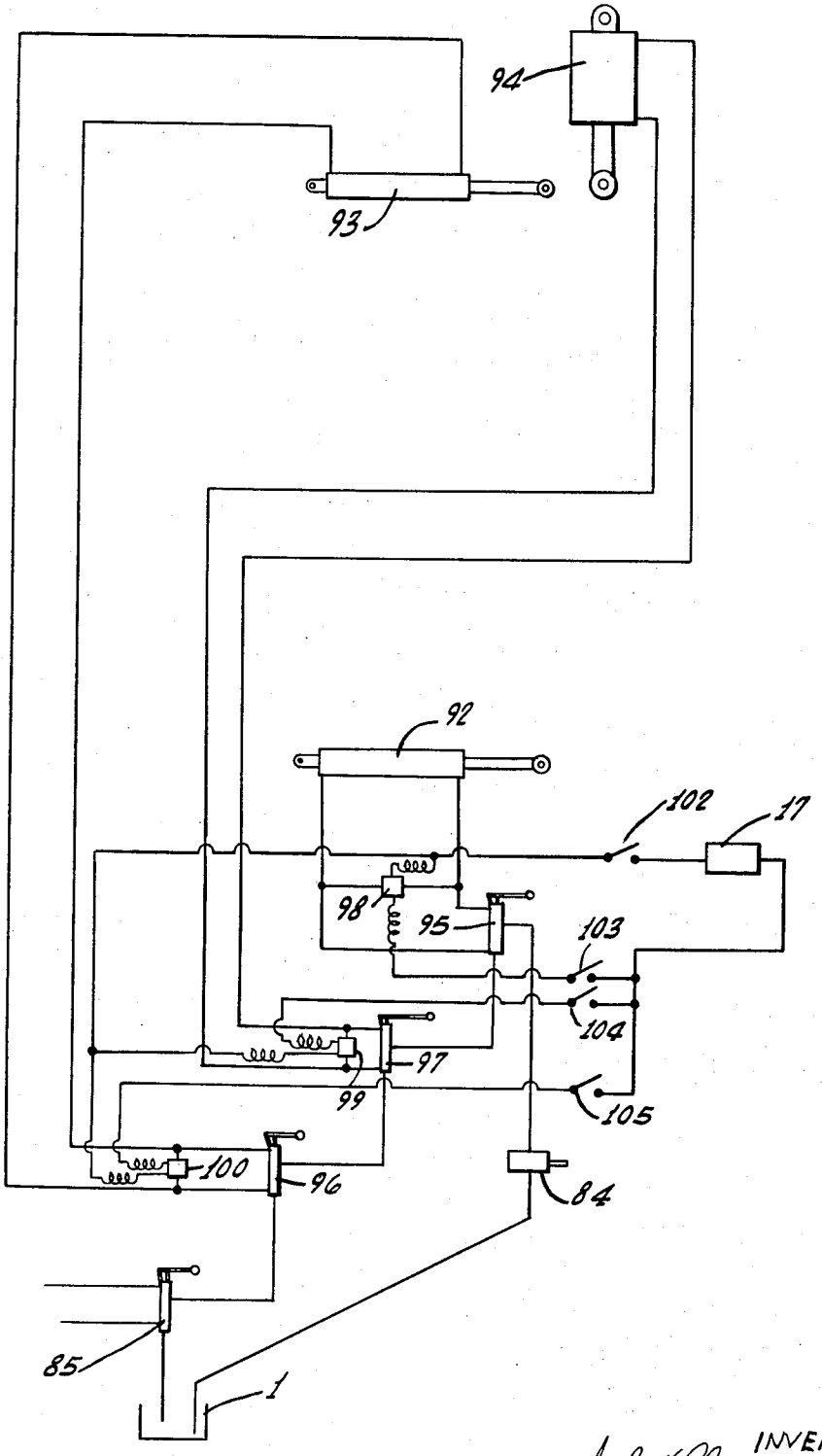


FIG. 6

INVENTOR
John Thomas Monk

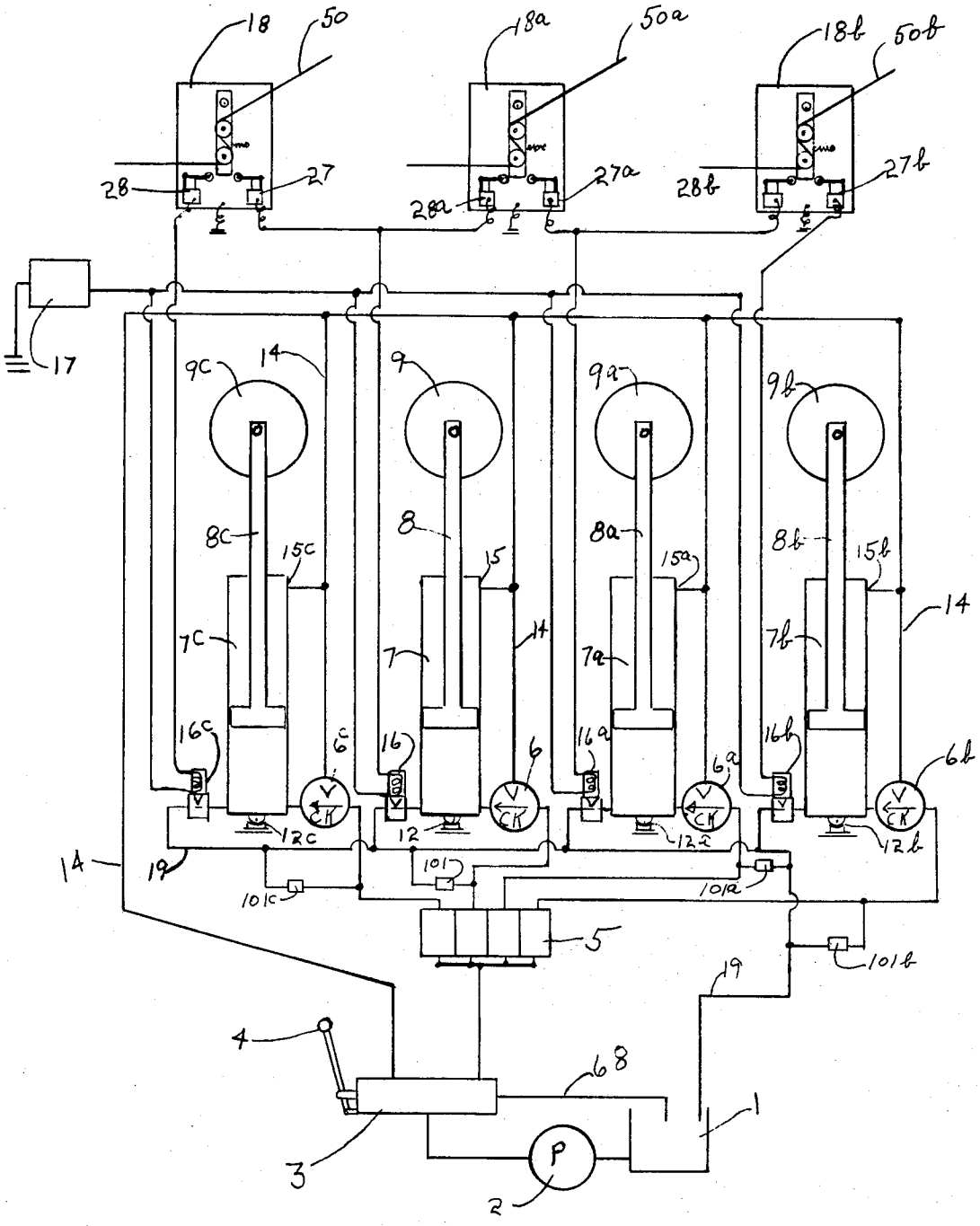


FIG 7

INVENTOR
John Thomas Mork

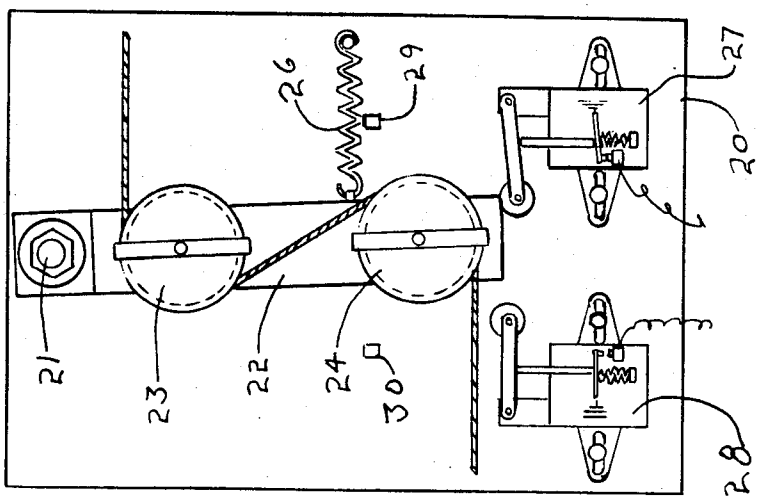
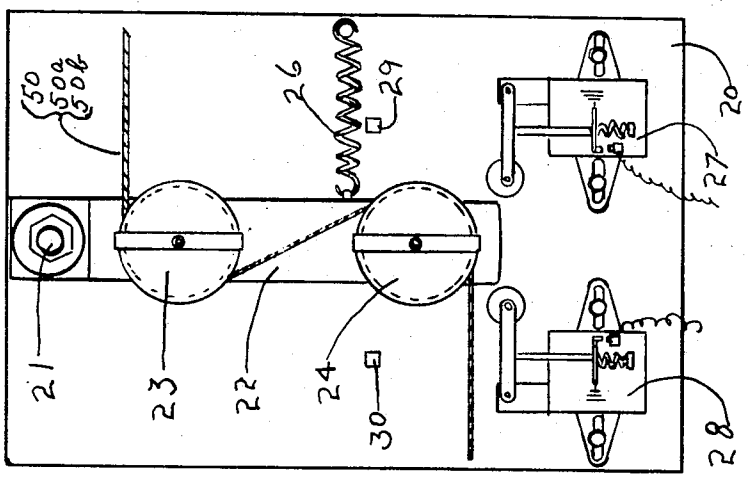


FIG. 10



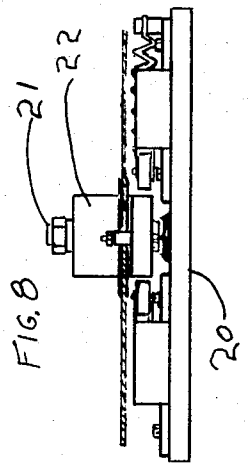


FIG. 8

FIG. 8A

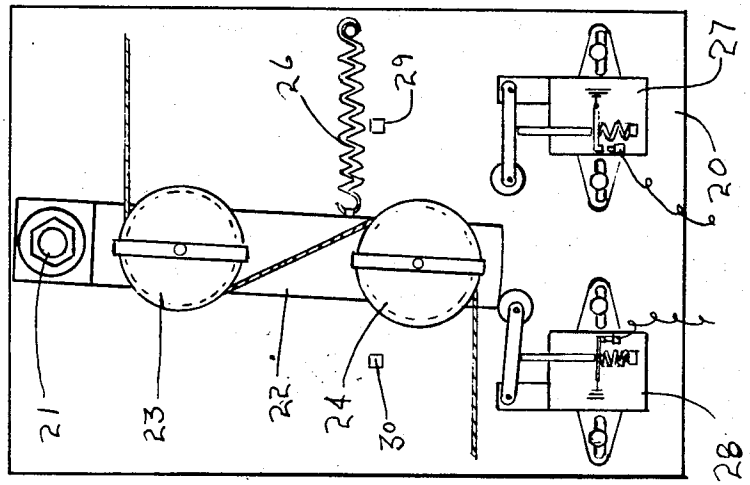


FIG. 9

INVENTOR
John Thomas Monk

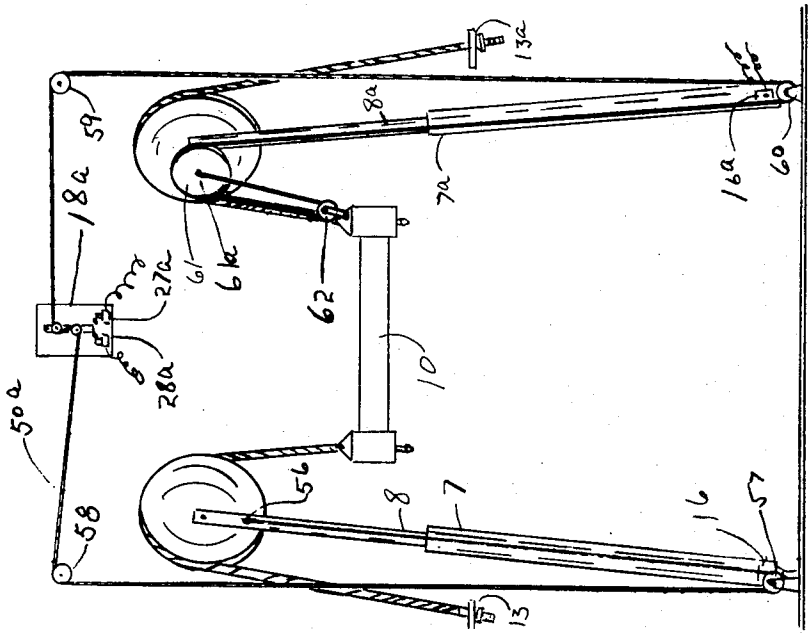


FIG 12

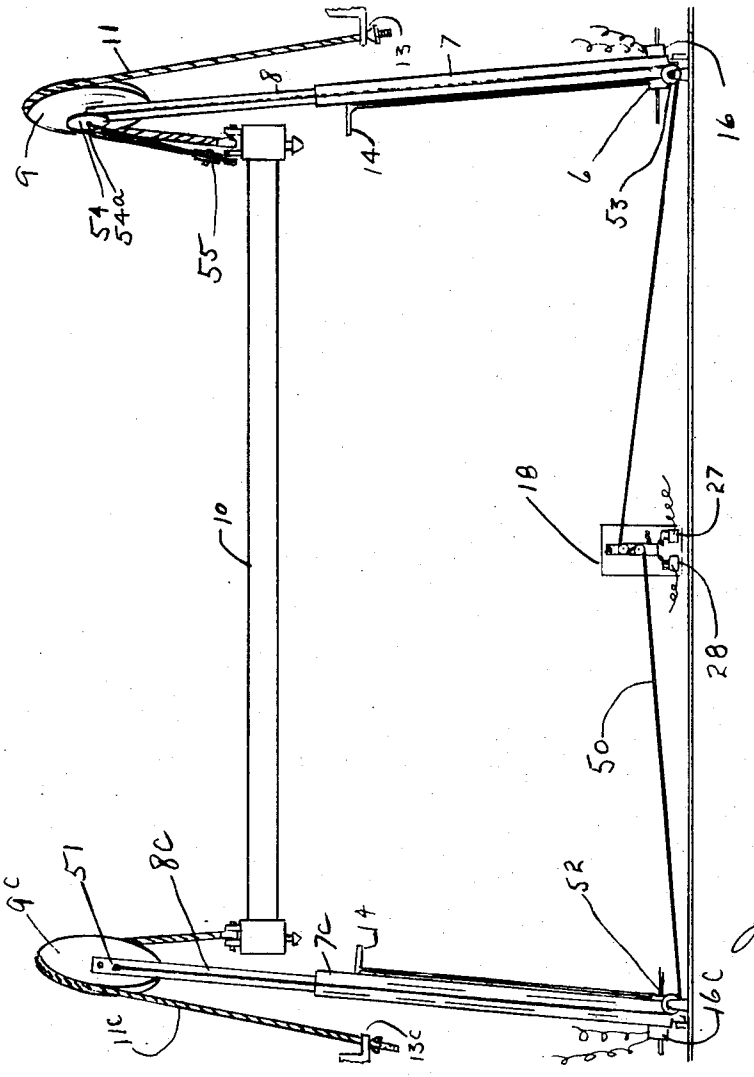


FIG 11

INVENTOR
John Thomas Monk

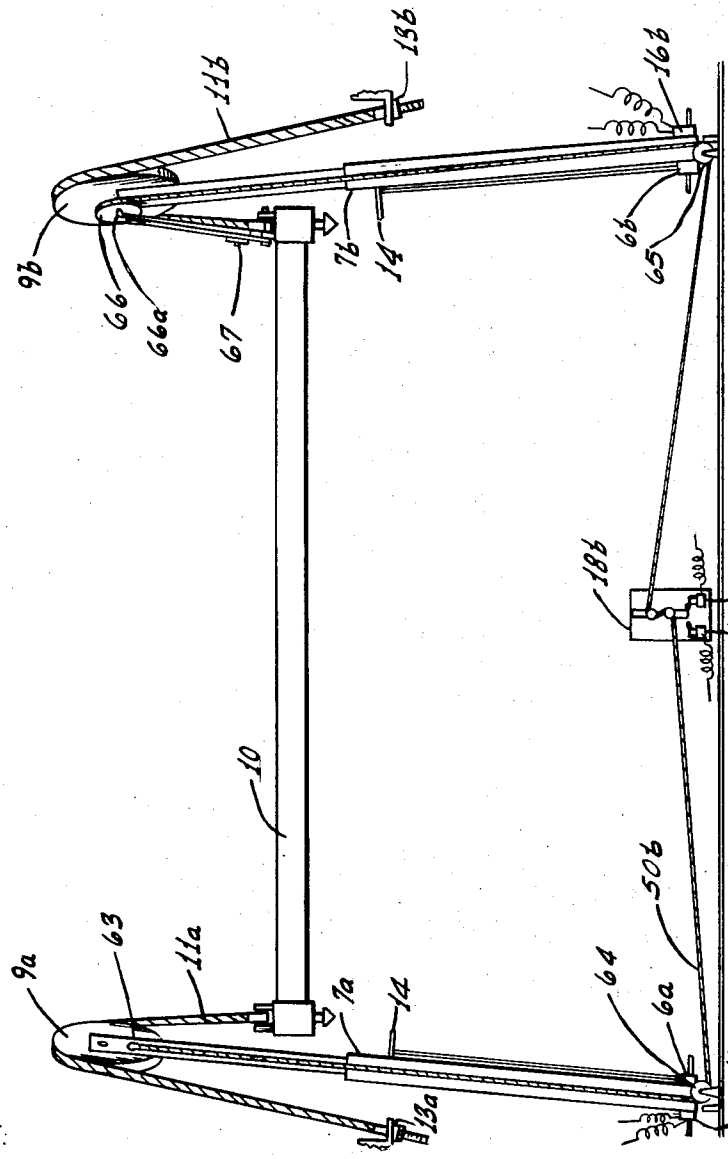


FIG. 13

INVENTOR
John Thomas Monk

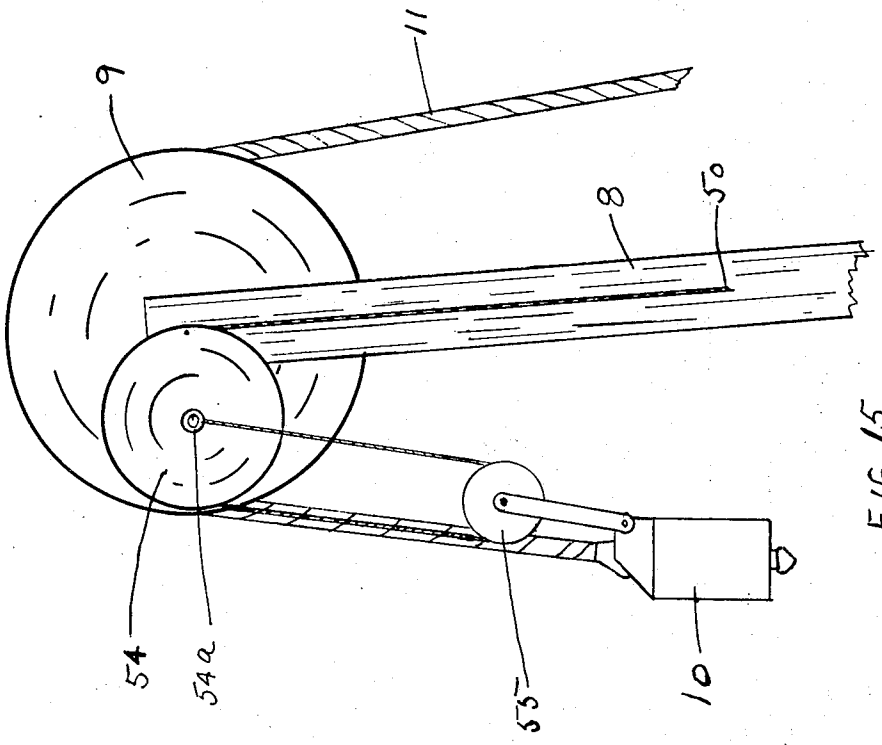


FIG 15

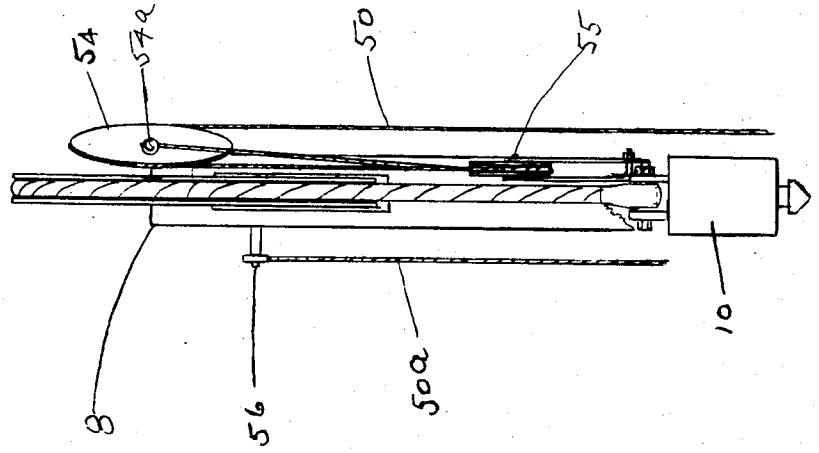


FIG 14

INVENTOR
John Thomas Monk

STRADDLE CARRIER

DESCRIPTION OF INVENTION

This invention relates to straddle carrier type material-handling vehicles so designed that the load to be carried is suspended within the framework of the vehicle, the vehicle may be of such size and proportions as to permit engaging, hoisting, stacking and transporting van-sized containers.

Prior art machines of this type are subject to very high accident rates caused by poor visibility. They have mechanical failures caused by weak frame structures and complicated lift systems.

The principal objects of my invention are to provide a straddle carrier which has excellent visibility and a strong, simple, smooth structure. These objectives are attained in numerous ways, some of which are as follows:

The main frame of my invention consists of spaced parallel elongated frame members which are connected together adjacent one end by means of a vertically disposed structural arch to form a rigid rectangular frame. Said arch carries adjacent its upper end the cab for the driver in which is disposed the steering wheel and various controls for the vehicle. The arch is braced by a diagonal leg connecting the arch adjacent its upper ends to substantially the mid-points of the frame members.

Supporting wheels are flexibly applied to the underside of the frame members, three wheels being provided on each side below each frame member, the center wheels of which are fixed, while the outer wheels are simultaneously actuated regardless of the radius of curvature of any steering course in such manner that the projection of the axles of the outer wheels, both those of the inner frame and outer frame members, will always intersect the projection of the axles of the center wheels at a common point for all radii of curvatures in steering.

Within the vehicle is a container lifting beam comprising an outer member and an inner member, the former being shiftable laterally and longitudinally with respect to the inner member. The ends of the inner member of the lifting beam extend beyond the ends of the outer member and carry at the corners thereof rollers adapted to engage telescoping guides disposed on or adjacent the legs of the arch to guide the lifting beam during its vertical ascent and descent. Adjacent the guides are upwardly disposed fluid cylinders carrying upwardly extensible rams, said cylinders being connected with their respective frame members by self aligning bearings to permit universal movements of the upper ends of the cylinders. The corners of the outer member of the lifting beam are connected to one end of cables extending from said corners up and over pulleys on the upper ends of the respective rams, the other end of the cables being connected to the frame members adjacent the upper end of the cylinders, whereby as the rams of the hydraulic cylinders are extended upwardly by hydraulic pressure the four corners of the lifting beam will be simultaneously raised or lowered to thereby raise or lower a van-sized container or the like which is attached at its four corners to the underside of the lifting beam at the four corners thereof by conventional coupling members. Means are provided for simultaneously actuating the cylinders to raise or lower

the lifting beam and the van-sized container attached thereto within the frame of the vehicle, said means including a fluid circuit so arranged that the said corners of the lifting beam are simultaneously raised or lowered equal amounts notwithstanding the relative weights on said respective corners, so as to maintain the van-sized container at all times parallel with the machine frame.

Heretofore, straddle carriers have been provided in which the frame is of general horizontal U-shape, i.e., in a horizontal plane, the frame being open at one end only, the same having a connecting arch at one end only, but it has been found that the stresses imposed are on such long moments that it is very difficult to prevent frame breakage in the center section of the arch; and in order to help this situation the lift cylinders on such prior art machines have been rigidly mounted on the frame and were connected at their upper ends with a cross member; but it has been found that this imposes severe bending loads on the lift cylinders, and results in broken cylinders and severe wear on the piston and sealing leathers.

Another object of my invention is to provide rigid rectangular frame having a connecting arch near one end, of such strength as to require no other connection, the outer rounded ends of the frame members acting as guides for the container as it passes between the frame members. In my design the lift cylinders being connected with the frame members by universal joints, leaves the lift cylinders free of all outside bending stresses and they support only the load.

Heretofore, such prior art machines have been provided in which the lift cylinders have been connected together with a cross member from which the lifting beam is suspended; but in my design the lifting beam is suspended directly from the lift cylinders. This removes another obstruction to vision.

Heretofore, in such prior art machines the vertical guide tracks for the lifting beam having been attached directly to the cross members which connect the lift cylinders and the guide tracks move up or down with the cross member. Further, the tracks are restrained by guide bars in the side frame members and are subjected to loads imposed by the frames.

Another object of my invention, however, is to provide a construction in which the vertical guide tracks are stationary until such time as the lifting beam rises to the tops of the arch, after which the guide tracks are raised by the guide rollers on the ends of the lifting beam engaging plates at the tops of the tracks. When the beam is lowered, the tracks descent until they reach the starting point, at which place they stop, but the lifting beam is free to continue its downward movement without further movement of the guide tracks. No stresses can be transferred from the frame to the guide tracks.

Heretofore in such prior art machines, the lifting beam itself is usually suspended some distance from the point where it attaches to the load. Hence a cantilever or bending load is imposed on the lifting beam. However, a further object of my invention is to provide an arrangement in which the lifting cables for the lifting beam attach directly over the point where the load itself is lifted; therefore my lifting beam supports nothing, but merely acts as a spacer to keep the lifting hooks or twist locks in proper relation to one another.

Heretofore in such prior art machines the engine, transmission and all drive components were disposed on the platform above the front arch with the operator, but is has been found that such machines are top heavy and unstable. Moreover, visibility is very poor and a crane or elevated platform is needed to do many minor repairs.

A further object of my invention is to provide a design which removes all power components from high elevations and places them low in the structure where they contribute to stability, and are low enough to be reached from a ladder, or may be removed by use of a small fork-lift, common everywhere. In my design there are no members connecting the lift cylinders to interfere with theoperator's vision, and no power train components surround the operator. Furthermore, there are no horizontally extending frame members in the upper side frames to further restrict vision.

In such prior art machines a long chain drive is used for each drive wheel, reaching from the power platform to the drive wheel, which chain limits the amount the drive wheels can "cut", or steer, and for that reason they must resort to uneven spacing of the support wheels, involving severe steering angles on those furthest from the drive wheels. It has been found that in order to secure an acceptable turning radius, the machine must have a short wheelbase. This results in instability in a fore-and-aft direction. The projecting chain and guard are frequently damaged in collision accidents.

A still further object of my invention therefore is to provide a design which uses hydraulic or hydrostatic power which is transmitted to the drive wheels through flexible hose. For that reason the steering angles can be whatever the designer fancies up to and including a 90° "cut." This makes it possible to space the wheels evenly on the machine, which in turn makes it unnecessary to steer the center wheels and hence provides simpler steering. Since the steering angles can be greater, it is no longer necessary to keep the wheelbase short and therefore it may be made longer with improvement in fore-and-aft stability. As in my design there are no chains and guards to knock off, another set of problems are eliminated.

Other minor object will be hereinafter set forth.

I will explain the invention with reference to the accompanying drawings, which illustrate several practical embodiments thereof, to enable others familiar with the art to adopt and use the same; and will summarize in the claims the novel features of construction, and novel combination of parts, for which protection is desired.

In said drawings:

FIG. 1 is a side elevation of my novel straddle carrier showing the lifting beam in the lowered position.

FIG. 2 is a side view similar to FIG. 1, but showing the lifting beam in elevated position.

FIG. 3 is an end elevation of the carrier shown in FIG. 1 showing at said end the arch and cab mounted thereon.

FIG. 3A is an end elevation of the carrier shown in FIG. 1, showing the end opposite from that shown in FIG. 3, and showing the relation between the beam frame and lift cylinders, and showing that the cylinders lean inwardly.

FIG. 4 is an end elevation of the carrier shown in FIG. 2, but showing the lifting beam elevated.

FIG. 4A is an end elevation of the carrier opposite from that shown in FIG. 4, but showing the lifting beam elevated, and also showing that the cylinders lean inwardly.

FIG. 5 is a top plan view of the carrier.

FIG. 5A is a top plan view of the carrier but showing an alternate beam shift, omitting the fore-and-aft cylinder.

FIG. 6 shows a schematic plan of the beam shift hydraulic system.

FIG. 7 shows a schematic plan of the beam lift and leveling system, and also showing the electrical circuit for same.

FIG. 8 shows a plan of the sensor device in neutral.

FIG. 8A shows an end elevation of the device shown in FIG. 8.

FIG. 9 shows a plan elevation of the sensor of FIG. 8 in the increased tension position.

FIG. 10 shoes a plan elevation of the sensor of FIG. 8 in the decreased tension position.

FIG. 11 shows in schematic elevation how the sensor cable 50 is attached to the beam and cylinders in order to sense differences in cylinder extensions.

FIG. 12 shows the same as FIG. 11 but for cable 50*a*.

FIG. 13 shows the same as FIG. 12 but for cable 50*b*.

FIG. 14 shows a detail.

FIG. 15 shows a detail.

The rectangular main frame of the vehicle as shown in FIGS. 1, 2, 3, 3A, 4, 4A and 5 is comprised of two spaced parallel elongated frame members 70 and 71 formed of structural plates and angle bars, or of square tubing, connected to one another adjacent to one end only thereof by an arch 72 formed of structural plates and angle bars, said arch 72 being of substantial construction and serving to keep the main frame members 70 and 71 in proper spaced relation with one another, and to provide clearance for the frame to straddle a load to be handled from either end thereof. Said arch 72 is comprised of vertical legs 72*a* and 72*b*, diagonal legs 73 and 73*a*, the lower ends of which rest upon and are secured to main frame members 70 and 71. The upper ends of said legs 72*a*, 72*b*, 73*a* and 73 are connected by a horizontal beam 72*c* formed of high strength structural bars and angles. The whole arch assembly will be referred to in this description simply as arch 72.

The main frames 70 and 71 are each supported by two or more flexibly mounted wheels. They are here shown FIG. 1 and 2 supported by three equally spaced wheels 75, 75*a* and 75*b*, under frame member 70; and wheels 76, 76*a*, 76*b*, under frame member 71. The wheels are attached to the frame 70, 71 with trunnions which allow vertical movement as well as rotative movement about the vertical axis of the trunnions. The center wheels (when used) 75*a* and 76*a* are attached to frame members 70 and 71 respectively with linkages 77, 77*a* which prevent their rotation about the vertical axes of the trunnions, and thus cause wheels 75*a* and 76*a* to remain always parallel with the axis of the main frames 70 and 71 respectively. The wheels 75 and 75*b* are connected with a linkage system in such a way as to cause them to steer equal but opposite angles. The wheels 76 and 76*b* are connected with a linkage system

in such a way as to cause them to steer equal but opposite angles. Wheels **75** and **75***b* are connected to wheels **76** and **76***b* with a linkage system in such a way as to cause them to turn about a common point whenever the machine is traveling in any way but a straight line direction. The force to operate the steering mechanism is supplied by an engine driven hydraulic pump **78**. The steering is controlled by an operator-controlled valve connected to a steering wheel mounted in cab **79**.

The operator is housed in the cab **79** mounted on the front face of cross beam **72***c* of the arch **72**, in such a manner as to give the best visibility possible. All controls for driving or hoisting are also located in cab **79**.

The engine **80** for hoisting and propulsion is mounted on frame member **70** near the arch **72** as shown in FIGS. **1** and **2**. The engine **80** has several hydraulic pumps mounted upon it which furnish the power to operate various functions of the vehicle. The engine **80** provides the power for propulsion of the vehicle by means of a variable displacement hydraulic pump **81** mounted thereon and connected to hydraulic motors **82** and **82***a* in two (or more) of the wheel hubs by means of suitable pipe and hose connections.

The frame of the vehicle also supports the lift mechanism and guidance system for the load to be lifted. The various systems and devices used to lift and control the load lifted will be described in detail in subsequent paragraphs. In general it comprises four free hydraulic cylinders **7**, **7***a*, **7***b*, **7***c*, FIGS. **1**, **2**, **5** and **5A**, supported on the main frame members **70** and **71** by use of self aligning bearings **12**. The cylinders **7** and **7***a* and their rams **8**, **8***a*, project through openings in the diagonal legs **73** and **73***a* near their upper ends as shown in FIGS. **5** and **5A**, and are loosely confined therein. The cylinders **7***b* and **7***c* and their rams **8***b* and **8***c* respectively are mounted in columns **74** and **74***a*, FIGS. **3A**, **4A** and **5A**. The columns **74** and **74***a* serve to protect the cylinders **7***b*, **7***c* and rams **8***b*, **8***c* from collision damage, and also to provide anchor points **13***b* and **13***c* for cables **11***b* and **11***c*. Supports **74***b* and **74***c* prevent cylinders **7***b* and **7***c* from falling inwardly under no-load conditions.

The lift mechanism described herein is intended to lift or lower an object or adapter beam by use of double acting hydraulic cylinders and rams. Each ram has a sheave attached directly to its exposed upper end and is not directly connected without another ram. The cylinders and rams do not stand vertical or parallel, but lean inwardly at their upper ends as shown in FIGS. **3A** and **4A**. All of the lift cylinders are identical in components and operation.

Hydraulic fluid is carried in tank **1**, FIGS. **1** and **7**, pumped by engine driven pump **2** to operator controlled valve **3**. When valve **3** is in neutral or "hold" position, fluid circulates through valve **3** and back to tank **1**. The other connections are closed. The valve **3** is an open-center type designed to be used with double acting cylinders. When pressure from pump **2** is applied to one outlet port the other communicates with the tank through line **68**. When lever **4** is actuated to the "UP" position, fluid from pump **2** flows through valve **3** to the flow divider **5** where it is divided into four approximately equal parts, each being routed to the pilot operated check valves **6**, **6***a*, **6***b*, **6***c* on the lower end of its respective cylinder **7**, **7***a*, **7***b*, **7***c* thereby extending the related ram **8**, **8***a*, **8***b*, **8***c*, which carries sheave **9**, **9***a*, **9***b*, **9***c*, upwardly, and raises the lifting beam **10** through the action of tensile member **11**, **11***a*, **11** *b*, **11***c*, FIGS. **2**, **3**, **4** and **4a**. Tensile members **11**, **11***a*, **11***b*, **11***c* are attached to the beam **10** each to one end thereof and to the frame structure of the machine at the other end **13**, **13***a*, **13***b*, **13***c* (FIG. **5A**) adjacent the upper end of the corresponding cylinder **7**, **7***a*, **7***b* and **7***c*. A pressure relief valve **101**, **101***a*, **101***b*, **101***c* (FIG. **7**) limits the maximum pressure which can be supplied to check valves **6**, **6***a*, **6***b*, **6***c*, respectively by the flow divider **5**. Excess pressure is dissipated through line **19** to tank **1**.

The cylinders **7**, **7***a*, **7***b*, **7***c* are attached to the frames **70**, **71** of the machine only at their bases, and each is supported on a self-aligning bearing **12** (FIGS. **1** and **2**) in such a manner as to allow the movement of its upper end in all planes. The cylinders **7**, **7***a*, **7***b*, **7***c*, and rams **8**, **8***a*, **8***b*, **8***c*, are thus free to equalize the forces acting on lifting beam **10** and anchors **13**, **13***a*, **13***b*, **13***c* through the tensile members **11**, **11***a*, **11***b*, **11***c*, without being subjected to any bending loads.

When the operator moves the control **4** (FIG. **7**) to the "Down" position, fluid flows through valve **3** through line **14** to cylinders **7**, **7***a*, **7***b*, **7***c*, at points **15**, **15***a*, **15***b*, **15***c*, respectively, and to the pilot pistons in valves **6**, **6***a*, **6***b*, **6***c* causing same to open. Fluid may then escape from beneath the rams **8**, **8***a*, **8***b* and **8***c* and through valves **6**, **6***a*, **6***b*, **6***c*, and back to the tank **1** by way of flow divider **5** and valve **3**. Unless pressure is exerted on the pilot pistons in valves **6**, **6***a*, **6***b*, **6***c* the valves will close and stop downward movement of the rams **8**, **8***a*, **8***b*, **8***c*. If the downward movement of ram **8**, **8***a*, **8***b*, **8***c* requires more fluid than is supplied by the engine driven pump **2**, the pressure will fall in line **14** and the pilot pistons in valves **6**, **6***a*, **6***b*, **6***c* will close. Pressure applied at the upper side of the ram pistons at points **15**, **15***a*, **15***b*, **15***c*, forces the rams downwardly. If the load on sheaves **9**, **9***a*, **9***b*, **9***c* cause it to descend faster than fluid is supplied to points **15**, **15***a*, **15***b*, **15***c*, the pressure in line **14** will become too low to hold the pilot check valves open in valves **6**, **6***a*, **6***b*, **6***c*, and the ram will stop. Thus it is possible for the operator to control the speed of both ascent and descent of the lifting beam **10** by controlling the speed of the engine and hence the volume of fluid delivered by pump **2**.

In order to insure that all rams will be displaced approximately equal amounts despite variations of load and internal leakage, it is necessary to further refine or trim the system. Therefore, means of sensing uneven extensions of the rams **8**, **8***a*, **8***b*, and **8***c*, is devised. A system (FIGS. **11**, **12**, **13**) of cables pulleys, sensors (FIG. **8**), and solenoid valves (FIGS. **7**, **11**, **12** and **13**, is used to accomplish this end.

The sensor (FIGS. **8**, **9**, **10**) is intended to sense changes in the tension of the cable **50** threaded through it and to translate said information into an electrical signal. Base **20** (FIG. **8**) has an axle **21** upon which lever **22** is mounted. Said lever is supported by bearings between axle **21** and base **20** so that the lever **22** may move in a plane parallel to the base **20**. Mounted on lever **22** are pulleys or sheaves **23** and **24** which are free to rotate on their respective axles. Two "Micro" switches **27** and **28** are mounted on the base **20** in a

position which will allow the free end of the lever **22** to operate the linkage in switches **27** and **28** and cause the contacts to close or open as the lever is moved along its arc. Means are provided to alter the position of these switches **27** and **28** in relation to lever **22** so that the sensitivity of the device may be controlled. Two lugs **29** and **30** are attached to base **20** in such a way as to prevent lever **22** from traveling far enough to overrun the actuating linkage for switches **27** and **28**. In FIG. **8** the device is shown in neutral or no-signal position. In this view the cable **50** tension has been adjusted so that spring **26** has been overcome enough to allow lever **22** to rest in the mid-point of its travel. The switches **27** and **28** are positioned so that their linkage is approximately equidistant from the free end of lever **22**. This condition will be referred to as the neutral position. The switches themselves could either be closed or open depending on the requirements of the application. In this illustration all switches will be of the "normally open" type. If normally closed type are used the flow of current would be interrupted in FIGS. **9** and **10**. FIG. **9** shows what happens when the tension on cable **50** is increased enough to further overcome spring **26** and thus cause the lever **22** to depress the linkage of switch **28** thereby closing the related circuit. FIG. **10** shows what happens when the tension on cable **50** is decreased enough to allow the spring **26** to retract lever **22** causing it to depress the linkage in switch **27** and thereby close related circuit.

FIGS. **7** and **11** show that at the base of each cylinder **7**, **7***c* and communicating with the hydraulic fluid within same, there is mounted a respective solenoid controlled valve **16**, **16***c*, of the "normally closed" type. Fluid passing through the valves **16**, **16***c* is returned to the tank **1** by line **19**. This solenoid valve has one end of its coil attached to an electric power source **17** such as a storage battery, the other end of the coil being attached to the corresponding switch in sensor **18**. It can be seen in FIG. **7** that switch **28** is connected to solenoid **16***c*, also that switch **27** is connected to solenoid **16**.

In FIGS. **11**, **14** and **15**, cable **50** is attached to ram **8***c* at point **51**, and is threaded under sheave **52** and thence through sensor **18** and under sheave **53**, and over sheave **54** which is attached to ram **8**, and under sheave **55** which is attached to lifting beam **10** with its outer end attached to ram **8** at point **54***a*. As the lifting beam **10** is elevated cable **50** is paid out between sheaves **55** and **54** twice as fast as the increase in distance between sheaves **54** and **53**. Therefore the tension on cable **50** will remain constant as long as rams **8** and **8***c* extend or retract an equal amount, and the sensor **18** will remain in neutral, as in FIG. **8**.

If ram **8***c* extends more than ram **8**, the tension on cable **50** will be increased and this will be detected by sensor **18** (FIG. **9**). The increase in tension will cause the switch **28** to close and thus energize the solenoid valve **16***c* (FIG. **7**), opening the said valve and allowing fluid to escape from cylinder **7***c*. This will allow ram **8***c* to descend until the cable tension decreases enough to allow sensor **18** to return to neutral position, as in FIG. **8**, thus breaking the circuit and allowing valve **16***c* to close again.

If ram **8** extends more than ram **8***c* the tension on cable **50** will decrease and this will be detected by sensor **18** (FIG. **9**). This decrease will cause switch **27** to close and thus energize the solenoid valve **16** (FIG. **7**), opening the said valve and allowing fluid to escape from cylinder **7**. This will allow ram **8** to descend until the cable tension increases enough to allow sensor **18** to return to neutral as in FIG. **8**, thus breaking the circuit and allowing valve **16** to close again.

The system shown in FIGS. **7**, **11**, **14** and **15** will cause rams **8** and **8***c* to maintain the same amount of extension as long as electrical energy is supplied. Since it provides an independent means for the escape of fluid from beneath the rams **8** and **8***c* it will operate whether the rams are ascending, descending, or stationary.

In FIGS. **7** and **12** at the base of each cylinder **7**, **7***a* and communicating with the hydraulic fluid within same, is mounted a respective solenoid controlled valve **16**, **16***a* of the "normally closed" type. Fluid passing through the valve **16**, **16***a* is returned to the tank **1** by way of line **19**. This solenoid valve has one end of its coil attached to an electric power source **17** such as a storage battery, the other end of its coil being attached to the corresponding switch in sensor **18***a*. It can be seen in FIG. **7** that the switch **28***a* is connected to solenoid **16**. Also that switch **27***a* is connected to solenoid **16***a*.

In FIG. **12**, cable **50***a* is attached to ram **8** at point **56** and is threaded through sheaves **57**, **58**, sensor **18***a*, through sheaves **59**, **60**, through sheave **61** which is attached to ram **8***a*, through sheave **62** which is attached to lifting beam **10** and is attached to ram **8***a* at point **61***a*. As the lifting beam **10** is elevated, cable **50***a* is paid out between sheaves **61** and **62** twice as fast as the increase in distance between sheaves **60** and **61**, therefore the tension on cable **50***a* will remain constant as long as rams **8** and **8***a* extend or retract an equal amount, and the sensor **18***a* will remain in neutral as in FIG. **8**.

If ram **8** extends more than ram **8***a*, the tension on cable **50***a* will be increased and will be detected by sensor **18***a* (FIG. **9**). The increase in tension will cause the switch **28***a* (FIG. **7**) to close, and thus energize the solenoid valve **16**, opening the said valve and allowing fluid to escape from cylinder **7**. This will allow the ram **8** to descend until the tension on cable **50***a* decreases enough to allow sensor **18***a* to return to neutral position (FIG. **8**). This will break the circuit allowing valve **16** to close.

If ram **8***a* extends more than ram **8** the tension on cable **50***a* will decrease and this will be detected by sensor **18***a* (FIG. **10**). This decrease will cause switch **27***a* to close and thus energize solenoid valve **16***a* (FIG. **7**), opening the valve and allowing fluid to escape from cylinder **7***a*. This will cause ram **8***a* to descend until the cable **50***a* tension increases enough to allow sensor **18***a* to return to neutral (FIG. **8**). This will break the circuit allowing valve **16** to close.

The system shown in FIG. **12** will cause rams **8** and **8***a* to maintain the same amount of extension as long as electrical energy is supplied. Since it provides an independent means for the escape of fluid from beneath rams **8** and **8***a* it will operate whether the rams are ascending, descending or stationary.

In FIGS. **7** and **13** at the base of each cylinder **7***a*, **7***b* and communicating with the hydraulic fluid within

same, is mounted a solenoid controlled valve **16***a*, **16***b*. This valve is of the "normally closed" type. Fluid passing through valve **16***a*, **16***b*, is returned to the tank **1** by way of line **19**. This solenoid valve has one end of its coil attached to an electric power source **17** such as a storage battery, the other end of the coil is attached to the corresponding switch in sensor **18***b*. It can be seen in FIG. **7** that switch **28***b* is connected to solenoid valve **16***a*, also that switch **27***b* is connected to solenoid valve **16***b*.

In FIG. **13**, cable **50***b* is attached to ram **8***a* at point **63** and is threaded through sheave **64**, sensor **18***b*, through sheave **65**, through sheave **66** which is attached to ram **8***b*, through sheave **67** which is attached to lifting beam **10**, and cable **50***b* is attached to ram **8***b* at point **66***a*. As the lifting beam **10** is elevated cable **50***b* is paid out between sheaves **66** and **67** twice as fast as the increase in distance between sheaves **65** and **66**; therefore the tension on cable **50***b* will remain constant as long as rams **8***a* and **8***b* extend or retract an equal amount, and the sensor **18***b* will remain in neutral as in FIG. **8**.

If ram **8***a* extends more than ram **8***b* the tension on cable **50***b* will be increased and will be detected by sensor **18***b* (FIG. **9**). The increase in tension will cause the switch **28***b* to close and thus energize the solenoid valve **16***a* (FIG. **7**) opening the said valve and allowing fluid to escape from cylinder **7***a*. This will allow the ram **8***a* to descend until the tension on cable **50***b* decreases enough to allow the sensor **18***b* to return to neutral position (FIG. **8**). This will break the circuit allowing solenoid valve **16***a* to close.

If ram **8***b* extends more than ram **8***a*, the tension on cable **50***b* will decrease and this will be detected by sensor **18***b* (FIG. **10**). This decrease will cause the switch **27***b* to close and thus energize solenoid valve **16***b* (FIG. **7**) opening the said valve and allowing fluid to escape from cylinder **7***b*. This will cause ram **8***b* to descend until the cable tension increases enough to allow sensor **18***b* to return to neutral, as in FIG. **8**. This will break the circuit allowing valve **16***b* to close.

The system shown in FIG. **13** will cause the rams **8***a* and **8***b* to maintain the same amount of extension as long as electrical energy is supplied. Since it provides an independent means for the escape of fluid from beneath the rams **8***a* and **8***b* it will operate whether the rams are ascending, descending or stationary.

The application of the lift and leveling circuits to the lifting and transporting of containers or other loads is accomplished by a rectangular frame **10** suspended within the main frame of the vehicle by cables **11**, **11***a*, **11***b*, **11***c*, FIGS. **2**, **3** and **5**. The lifting beam **10** may have any of several methods for attaching it to a load. It is shown here equipped with a twist lock type of mechanism **83** (FIG. **3**) which has become a standard in the containerized freight industry. Such twist lock mechanism is disclosed in U.S. Pat. No. 2,963,310 issued Dec. 9, 1960. It is engaged by being inserted into a suitable socket which is integral with the load, and is then rotated about **90** degrees within the socket. It will thus support the attached load until it is disengaged by the operator. In this machine the force required to lock and unlock is supplied by an hydraulic cylinder on the frame **10** (not shown). The operator controls the application of this force by a control valve **85** (FIG. **6**) located in the operator's cab **79**. The hydraulic pump **84** (FIG. **6**) to operate this circuit is located on the engine **80** and may serve as a source of power for several other functions.

Near the end of the lifting beam **10** (FIG. **5**) adjacent the arch **72** is located a guide bar **86** disposed across lifting beam **10** and projecting beyond it at both sides. The guide bar **86** is carried in a slotted opening in the lifting beam **10** so that it may move either fore and aft or laterally with relation to the lifting beam **10**. The guide bar **86** has a roller **88** (FIG. **2**) attached to each end. These rollers **88** move vertically in tracks **89**, which are mounted on the arch diagonal legs **73** and **73***a*, by use of track guides **90** (FIGS. **1**,**2**, **5** and **5***a*) disposed thereon near the top of diagonal legs **73** and **73***a*. The tracks **89** can be moved vertically in these guides **90**. They rest in sockets fitting **91** (FIG. **1**) on main frames **70** and **71**. As long as the guide bar **86** operates below the tops of the arch **72** (FIGS. **1** and **3**) no movement of tracks **89** occurs. When the guide bar **86** is elevated above this point, as in FIGS. **2** and **4** however caps **106** (FIGS. **1**, **2** and **4**) at the tops of the tracks **89** are engaged by the guide bar **86** and the tracks **89** are elevated with it. As the beam **10** with guide bar **86** is lowered, the tracks **89** descend with it until their lower ends rest in socket fittings **91** on the main lower frame members **70** and **71**. From this point downward travel is guided by rollers **88** descending in the tracks **89**.

The guide bar **86** has a lateral extension **87** in the form of an A-frame attached to it which extends to the opposite end of the lifting beam **10**, as shown in FIG. **5**. The guide bar **86** and A-frame **87** are caused to maintain the same lateral and fore and aft position in relation to the main frame of the machine by the actions of the tracks **89**. They thus serve as a base for the lateral control of the lifting beam **10**.

The guide bar **86** and A-frame **87** and the lifting beam **10** are connected near each end by double-acting hydraulic cylinders **92** and **93**, as shown in FIG. **5** and FIG. **6**. Cylinders **92** and **93** are arranged so as to impart relative movement to lifting beam **10** in a lateral direction (crosswise of the machine), and a cylinder **94** is arranged to impart relative movement to lifting beam **10** in a fore-and-aft direction. The cylinders **92**, **93** and **94** have independent separate controls **95** and **96** and **97** (FIG. **6**) in the operator's cab **79**. Thus it is possible for the operator to move either end of the lifting beam **10** in a lateral direction, or to move the lifting beam **10** fore-and-aft with relation to the guide bar **86** and A-frame **87**, and hence to the rest of the vehicle. He can also cause any combination of the two movements to occur.

The beam shift controls (FIG. **6**) are in the form of an hydraulic control valve which has a "hold" or "no flow" position when the valve is in neutral. Thus the shift cylinders will hold the beam **10** in whatever position the operator desires. Each valve **95** and **96** is connected to its respective cylinder by two hydraulic conduits. The braking and acceleration loads imposed on lifting beam **10** are transferred to the guide bar **86** through cylinder **94** and A-frame **87**.

Because the hydrostatic drive employed in this machine allows precision control in a fore-and-aft direction, it is likely that some operators will not feel

that the use of a fore-and-aft control is justified. For that reason an alternate beam design is shown in FIG. 5*a*. The fore-and-aft cylinder **94** and all attendant parts, i.e., valve **97**, circuits **104** etc., which are shown in FIG. **6**, are eliminated. In this modification the guide bar **86** has a bracket **86***a* (FIG. 5*a*) attached to one face to form a slot or track in which roller **94***a* is contained. Roller **94***a* is attached rigidly to lifting beam **10** and so fixes the position of lifting beam **10** in a fore-and-aft direction. Lifting beam **10** is still free to move laterally at either end subject to the actions of cylinders **92** and **93** and their related controls.

Each pair of conduits leading from a beam control valve is interconnected by a "normally closed" valve **98, 99, 100** (FIG. **6**). So long as these valves are closed they perform no function or in any way influence the action of their related hydraulic cylinders. When they are open they will allow hydraulic fluid to flow from one end of their respective cylinders to the other. The lifting beam **10** is thus free to respond to outside forces applied to it or to "float." The controls for these "-float" valves are located near the operator in the cab **79**, and may be operated by a single control **102** (FIG. **6**).

In FIG. **6** it can be seen that an electric power source **17** such as a storage battery is connected to valves **98, 99** and **100** in such a manner that a single switch **102** may energize all simultaneously, and thus allow the beam **10** to "float." In addition each has a switch **103, 104** and **105**, respectively, so that one or more may be rendered inoperative by the operator of the machine and thus allow the operator to exclude the float control on any particular cylinder.

In operation the function of the "float" control is as follows: The operator will drive the straddle carrier over the load to be transported. He will lower the lifting beam **10** over the load container guiding it by use of the shift cylinder controls until the tapered ends of the locks **83** are starting in the corner sockets in the load container at which time he will operate the "float" control. When the lifting beam **10** has settled into position the operator will operate the "locking" control **85** (FIG. **6**). When he has locked the lifting beam **10** and the load container together he will then operate the hoist or lift control **4** (FIG. **7**) and the "float" control **102** (FIG. **6**). This will allow the lifting beam **10** and the load container to center in the machine frame due to the pendulum effect of the four diverging lift cables **11, 11***a*, **11***b* and **11***c*. When this happens the operator will release the "float" control **102** and hoist the load container to the desired height. The position of the lifting beam **10** and the load will be maintained by the beam shift cylinders **92, 93, 94**, while transporting the load. When the point has been reached where the load container is to be deposited, the operator lowers the lifting beam **10** and attached load, guided by the normal use of the beam shift cylinders **92, 93, 94**. He unlocks the beam **10** from the load container, then operates the "float" control **102** and the lift or hoist control **4**, and the beam **10** is raised and returns to center, or neutral position. The operator releases the "-float" control **102** and then hoists the lifting beam **10** to the desired height. When he next drives astride a load or container he will have approximately the same amount of range to shift the beam in all directions. He will therefore be able to correct for errors in parking, in relation to the load, equal amounts in all planes. By proper use of the various controls the whole operation will be greatly expedited. When the operator is transporting a container over another he must use the side of the transported container for a guide or sighting plane to maneuver the machine. Since the container is centered in the frame of the straddle carrier there is less likelihood of collision damage.

The hydraulic force for these controls is supplied by the same engine pump **84** used to operate the load and lifting beam locking and unlocking mechanism.

The flexible conduits used to connect the operator controlled valves to the shift cylinders and twist locks on beam **10** are attached to the diagonal leg **73a** near its upper end, and routed through a tubular support **107** on beam **10** FIGS. **2, 5, 5A**. The conduits are supported by the diagonal leg **73***a* when beam **10** is in its lowest position, and as the beam is elevated the resulting slack is prevented from falling off the diagonal **73***a* by the flanges of that member.

I claim:

1. A straddle carrier consisting of a pair of spaced parallel elongated frame members adapted to straddle a load; a single vertically disposed arch member connecting said frame members together adjacent one end thereof; diagonally disposed leg members connecting the top of the arch member to said frame members intermediate the ends thereof forming an open ended vertically unobstructed bay between said frame members rearwardly of said arch member; ground wheels flexibly and steerably mounted on the undersides of the frame members; means for driving certain of said wheels; a rectangular load lifting beam disposed between the frame members; extensible upright support means spaced along each frame member, and flexible lifting means guided over the upper end of each support means and engaging the four corners of the lifting beam for raising and lowering the lifting beam; means at the four corners of the lifting beam for securing the same to a load; means adjacent the arch member for guiding the lifting beam during its ascent and descent; and means controlling the lifting beam raising and lowering means whereby the four corners of said beam will be simultaneously raised or lowered equal amounts notwithstanding the relative weights on said respective corners in order to maintain the beam always parallel with the said frame members.

2. In a carrier as set forth in claim **1**, said driving means comprising drive motors mounted in the hubs of one end wheel of each frame member; an engine driven variable displacement pump mounted on one frame member, flexible piping connecting the pump with said motors respectively; a cab mounted on the outer face of the top of said arch member; and means in said cab for controlling said pump.

3. In a carrier as set forth in claim **1**, said load lifting beam comprising a rectangular frame; a transverse guide bar extending through slotted openings in the lifting beam so as to be shiftable fore-and-aft and laterally with respect to the lifting beams; rollers carried by the ends of the guide bar; said guide bar being disposed near the end of the lifting beam adjacent to the arch member; an A-frame extending from the guide bar within the lifting frame and having its apex terminating

adjacent the opposite end of the lifting beam; a double-acting hydraulic cylinder connecting the said opposite end of the lifting beam to the apex of the A-frame and adapted to impart relative movement of the A-frame and lifting beam in a fore-and-aft direction; other double-acting hydraulic cylinders connecting the guide bar and the adjacent end of the lifting beam adapted to impart relative movement of the A-frame and lifting beam in a lateral direction; a cab mounted on the outer face of the top of said arch member; and means in said cab for controlling said cylinders.

4. In a carrier as set forth in claim 3, a lifting beam control comprising an hydraulic circuit including a tank, a pump, said first and other double-acting hydraulic cylinders, and normally closed hydraulic valves adapted when open to allow fluid to flow from one end of their respective double-acting hydraulic cylinders to the other end, and when closed to hold the lifting beam in adjusted position.

5. In a carrier as set forth in claim 4, said normally closed hydraulic valves having controls, an electric circuit including the controls of the normally closed hydraulic valves, and a single switch which when closed will cause the said controls to be energized simultaneously, thereby allowing the lifting beam to "float", and when open will allow the said controls to be operated individually.

6. In a carrier as set forth in claim 1, said load lifting beam comprising a rectangular frame; a transverse guide bar extending through slotted openings in the lifting beam so as to be shiftable laterally with respect to the lifting beams; rollers carried by the ends of the guide bar; said guide bar being disposed near the end of the lifting beam adjacent to the arch member; an A-frame extending from the guide bar within the lifting frame and having its apex terminating adjacent the opposite end of the lifting beam; double-acting hydraulic cylinders connecting the lifting beam to the apex of the A-frame and to the transverse guide respectively adapted to impart relative movement of the A-frame and transverse guide in a lateral direction; a cab mounted on the outer face of the top of said arch member; and means in said cab for controlling said cylinders.

7. In a carrier as set forth in claim 1, said means for guiding said lifting beam comprising telescoping tracks on the arch diagonal leg members receiving rollers on the lifting beam, said tracks being movable vertically in guides disposed adjacent the tops of the leg members, said tracks being of such height that as long as the lifting beam is operating below the top of the arch member no movement of the tracks will occur, but when the lifting beam is elevated above the arch member the rollers will engage caps at the tops of the tracks and will elevate the tracks in their guides with the lifting beam; and sockets on the carrier frame members below the tracks normally receiving the lower ends of the tracks.

8. In a carrier as set forth in claim 1, said lifting beam raising and lowering means comprising independent free double-acting hydraulic cylinders having their lower ends connected by self-aligning bearings to the frame members adjacent the corners of the lifting beam; said cylinders adjacent the arch member being loosely confined in and extending freely through openings therefor in the upper ends of the diagonal brace members; channel-shaped columns extending upwardly from the frame members at the end opposite from the arch member, said channels loosely confining the said cylinders at the end of the frame members opposite from the arch member, and having straps across their upper ends for preventing the related cylinders from falling inwardly under no-load conditions; upwardly movable rams in said cylinders respectively; pulleys mounted on the upper ends of the rams respectively; cables connected with the four corners of the lifting beam respectively and extending over said pulleys with their outer ends adjustably secured to anchors on the brace members and said columns respectively, whereby as the rams are simultaneously activated the corners of the lifting beam will be simultaneously correspondingly vertically moved; said cylinders and rams normally leaning inwardly at their upper ends, and being free to equalize the forces acting on the lifting beam and anchors through said cables without subjection to any bending loads.

9. In a carrier as set forth in claim 1, said controlling means comprising a fluid circuit including a fluid tank, a pump, an operator-controlled valve, and a flow divider; said divider dividing the fluid delivered thereto into four substantially equal parts each of which parts is delivered to a related check valve at the lowe end of its related flexibly mounted hydraulic cylinder to move its related ram; said check valves having pilot pistons therein adapted to open when fluid is passing thereto, said fluid escaping through said check valves and passing back to the tank, and said pistons closing when no fluid pressure is exerted thereon, thereby stopping movement of the related ram; said check valves discharging into the upper and lower ends of the hydraulic cylinders, electric control means for maintaining equal ram extension when ascending, descending or when stationary; whereby the operator may control the speed of ascent and descent of the lifting beam by controlling the speed of the pump.

10. In combination with a carrier as set forth in claim 9, means for sensing uneven extensions of the rams due to variations in load on the four corners of the lifting beam, comprising cables each having one end connected to a ram respectively, said cable being threaded through a sheave at the base of the related cylinder through a sensor, through a second sheave at the base of an adjacent cylinder, over a third sheave at the top of the ram of the adjacent cylinder, and under a fourth sheave attached to the adjacent corner of the lifting beam, its other end being attached to the ram of the adjacent cylinder, whereby as the lifting beam is elevated the cable will be paid out between the fourth and third sheaves twice as fast as the increase in distance between the third and second sheaves, the tension on the cable remaining constant as long as the rams extend equal amounts, but if one ram should extend more than the other, the variation in tension on the cable will be detected by the sensor and the related valve will open allowing fluid to escape from the related cylinder, allowing the related ram to move until the cable tension changes thereby permitting the sensor to return to neutral position.

11. In a carrier as set forth in claim 10, said sensor comprising a base, a swingable lever pivoted at one end

on the base, a pair of spaced pulleys journaled on the lever; said cable passing under one pulley, between and over the other pulley; microswitches on the base disposed at opposite sides of the lever one of which is adapted to be actuated as the lever is swung from central neutral position by variation in tension in the cable to a position over said one microswitch; spring means normally urging the lever to overcome the cable tension; said valves being solenoid controlled valves; and an electric circuit including a battery, said valves, and said microswitches.

12. In a wheeled vehicle, a load lifting beam comprising a rectangular frame; a transverse guide bar extending through slotted openings in the lifting beam so as to be shiftable fore-and-aft and laterally with respect to the lifting beams; rollers carried by the ends of the guide bar; said guide bar being disposed near one end of the lifting beam; an A-frame extending from the guide bar within the lifting frame and having its apex terminating adjacent the opposite end of the lifting beam; means for guiding said lifting beam; means for raising and lowering the lifting beam; a double-acting hydraulic cylinder connecting the said opposite end of the lifting beam to the apex of the A-frame and adapted to impart relative movement of the A-frame and lifting beam in a fore-and-aft direction; other double-acting hydraulic cylinders connecting the guide bar and the adjacent end of the lifting beam adapted to impart relative movement of the A-frame and lifting beam in a lateral direction; and means for controlling said cylinders.

13. In a vehicle as set forth in claim 12, said means for guiding said lifting beam comprising telescoping tracks on vehicle receiving said rollers, said tracks being movable vertically in guides and being of such height that as long as the lifting beam is operating below the tops of the tracks no moment of the tracks will occur, but when the lifting beam is elevated above the tops of the tracks the rollers will engage caps at the tops of the tracks and will elevate the tracks in their guides with the lifting beam; and sockets on the carrier vehicle below the tracks normally receiving the lower ends of the tracks.

14. In a vehicle as set forth in claim 12, said lifting beam raising and lowering means comprising independent upwardly disposed free double-acting hydraulic cylinders having their lower ends connected by self-aligning bearings to the vehicle adjacent the corners of the lifting beam; said cylinders at one end of the vehicle being loosely confined in and extending freely through openings therefor in the upper end of the vehicle frame; channel-shaped columns extending upwardly from the vehicle at the opposite end of the lifting beam, said channels loosely confining the said cylinders at the said end of the vehicle, and having straps across their upper ends for preventing the related cylinders from falling inwardly under no-load conditions; upwardly movable rams in said cylinders respectively; pulleys mounted on the upper ends of the rams respectively, cables connected with the four corners of the lifting beam respectively and extending over said pulleys with their outer ends adjustably secured to anchors on the frame and the said columns respectively, whereby as the rams are simultaneously activated the corners of the lifting beam will be simultaneously correspondingly vertically moved; said cylinders and rams normally leaning inwardly at their upper ends, and being free to equalize the forces acting on the lifting beam and anchors through said cables without being subjected to any bending loads.

15. In a vehicle as set forth in claim 12, said controlling means comprising a fluid circuit including a fluid tank, a pump, an operator-controlled valve, and a flow divider, said divider dividing the fluid delivered thereto into four substantially equal parts, each of which parts is delivered to a related check valve at the lower end of its related hydraulic cylinder to move its related ram; said check valves having pilot pistons therein adapted to open when fluid is passing thereto, said fluid escaping through said check valves and passing back to the tank, and said pistons closing when no fluid pressure is exerted thereon, thereby stopping movement of the related ram; said check valves discharging into the upper and lower ends of the hydraulic cylinders whereby the operator may control the speed of ascent and descent of the lifting beam by controlling the speed of the pump.

16. In combination with a vehicle as set forth in claim 15, means for sensing uneven extensions of the rams due to variations in load on the four corners of the lifting beam, comprising cables each having one end connected to a ram respectively, said cable being threaded through a sheave at the base of the related cylinder through a sensor, through a second sheave at the base of an adjacent cylinder, over a third sheave at the top of the ram of the adjacent cylinder, and under a fourth sheave attached to the adjacent corner of the lifting beam, its other end being attached to the ram of the adjacent cylinder, whereby as the lifting beam is elevated the cable will be paid out between the fourth and third sheaves twice as fast as the increase in distance between the third and second sheaves, whereby the tension on the cable will remain constant as long as the rams extend an equal amount, but if one ram should extend more than the other, the changed tension on the cable will be detected by the sensor and the related valve will open allowing fluid to escape from the related cylinder, allowing the related ram to move until the cable tension changes, thereby permitting the sensor to return to neutral position.

17. In a vehicle as set forth in claim 16, said sensor comprising a base, a swingable lever pivoted at its top on the pair of spaced pulleys journaled on the lever; said cable passing under one pulley, between the over the other pulley; microswitches on the base disposed at opposite sides of the lever adapted to be actuated as the lever is swung from central neutral position by changed tension in the cable to a position over a microswitch; a spring normally urging the lever to overcome cable tension; said valves being solenoid controlled valves; and an electric circuit including a battery, said valves, and said microswitches.

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