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3,344,940

SYNCHRONIZING MEANS FOR HYDRAULIC CYLINDERS

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4 Sheets-Sheet 1

FIG. 1

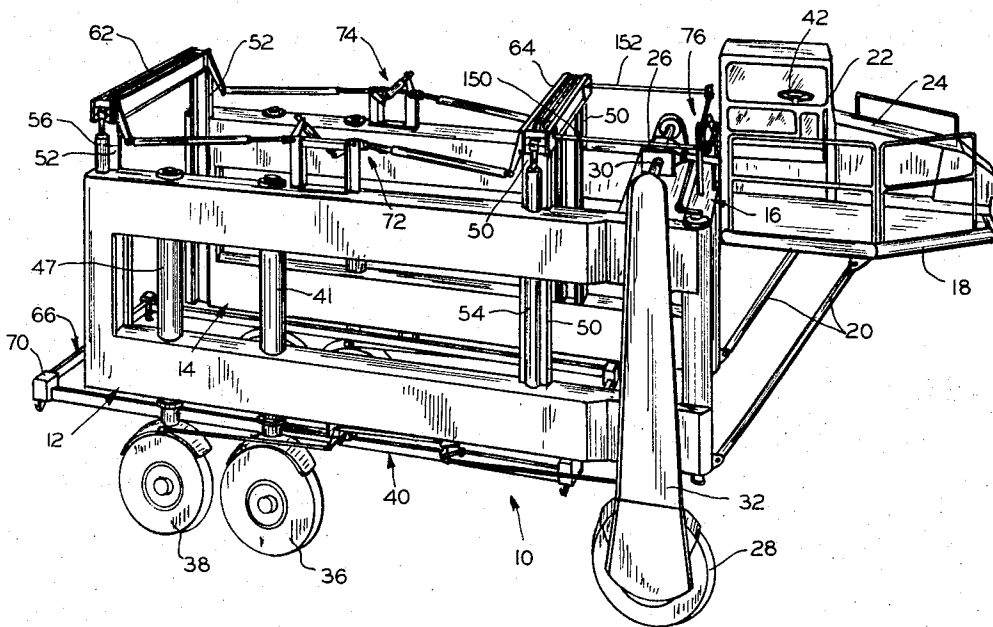
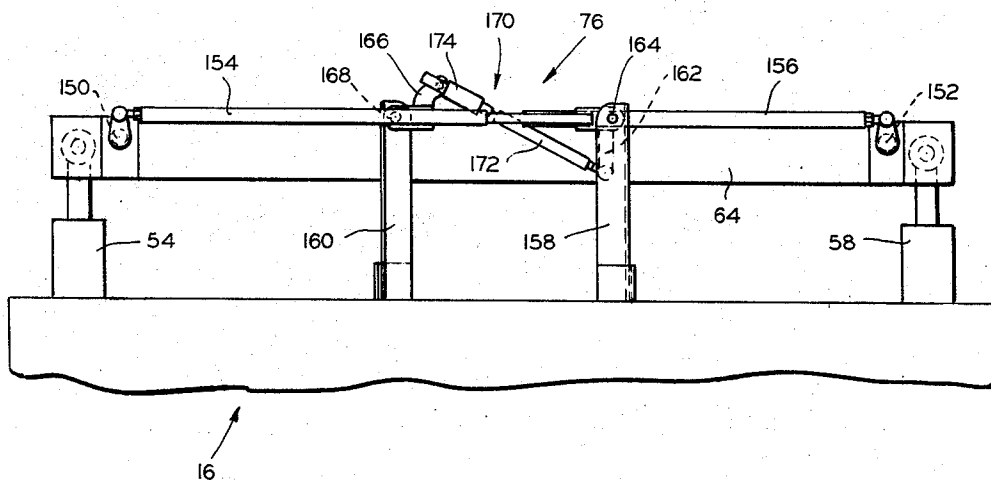


FIG. 3



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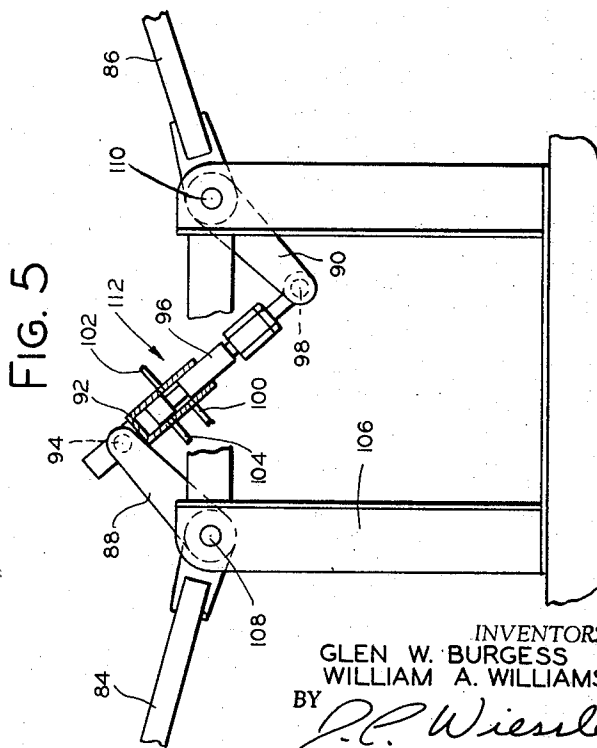
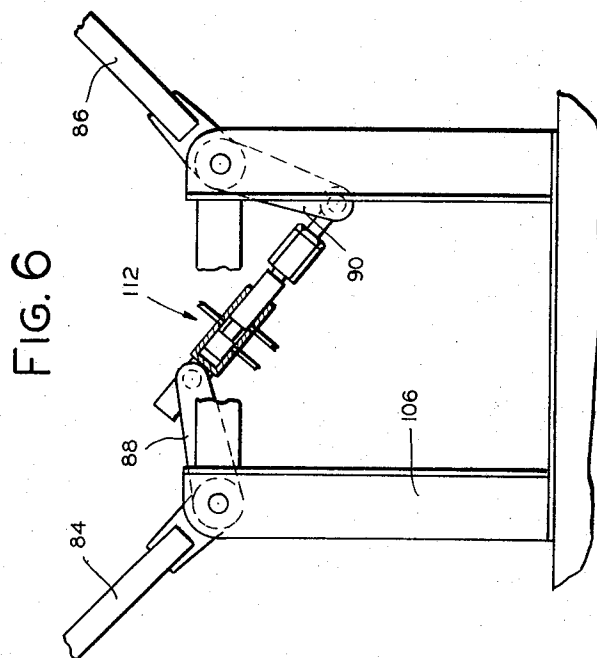
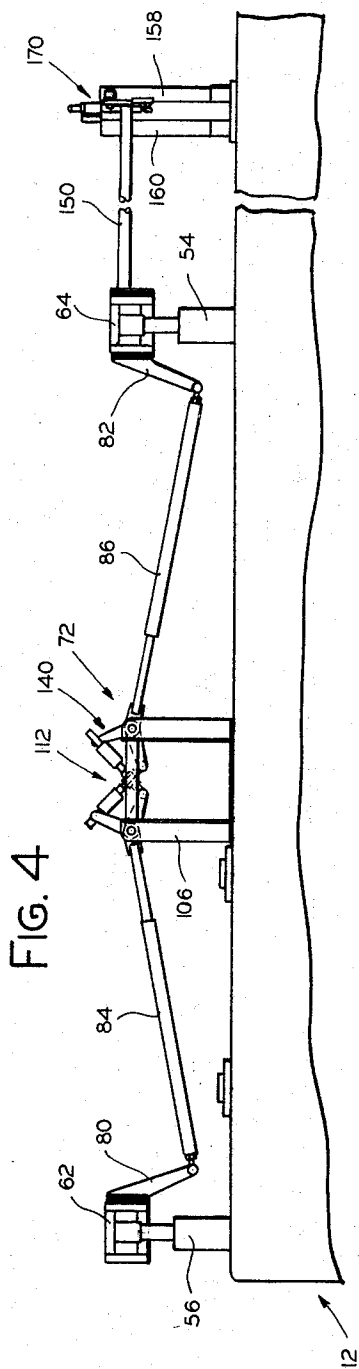
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SYNCHRONIZING MEANS FOR HYDRAULIC CYLINDERS

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4 Sheets-Sheet 2



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SYNCHRONIZING MEANS FOR HYDRAULIC CYLINDERS

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This invention relates to means for synchronizing the operation of a plurality of extensible hydraulic cylinders.

One embodiment of our invention is illustrated in the drawings wherein a plurality of hydraulic load lifting and lowering cylinders are utilized in a straddle carrier type material handling vehicle. With the advent of large van and container handling systems came the need for specialized vehicles adapted to efficiently handle and transport van size containers between major transport facilities such as railroads, overland trucks, cargo airplanes, and marine freighters. The relatively large and heavy loads handled by such vehicles are generally most readily handled by load lifting mechanism which includes extensible hydraulic cylinder means. Such lifting operations require that the load be raised and lowered in an attitude which is continuously substantially parallel to the supporting surface of the vehicle, and it is therefore desirable that synchronizing means be provided for controlling the operation of the lift cylinders in such a manner that said result is effected.

It is a primary object of our invention to provide means for synchronizing the operation of a plurality of extensible hydraulic cylinders.

Another object of the invention is to provide improved means for lifting and lowering loads synchronously.

Another object of the invention is to provide a plurality of extensible hydraulic cylinder means interconnected in such a manner that any tendency of one or more of such cylinder means to advance or retract ahead of the remaining cylinder means will automatically effect a realignment of all the cylinder means so that they extend to retract together.

In carrying out our invention we provide in a hydraulic system linkage mechanism interconnecting the extensible elements of a plurality of hydraulic cylinders and operatively connected to the hydraulic system such that the tendency of one or more cylinders to extend or retract ahead of the remaining cylinders during operation modifies through the operation of said mechanism the flow of hydraulic fluid to various cylinders in such a manner as to realign the relative positions of extension or retraction thereof.

Other objects, features and advantages of the present invention will appear from the following description taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a perspective view of a straddle carrier type material handling vehicle which embodies our invention;

FIGURE 2 is an enlarged partial plan view of the vehicle shown in FIG. 1;

FIGURE 3 is an enlarged partial end view taken from the right side of FIG. 2 showing a portion of the mechanism of the present invention;

FIGURE 4 is a partial view in side elevation taken

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from the lower side of FIG. 2 showing another portion of the mechanism of the invention;

FIGURES 5 and 6 are enlarged broken away views of a portion of the mechanism shown in FIG. 4 illustrating two different operating positions thereof; and

FIGURE 7 is a schematic view of the hydraulic system of the embodiment of the present invention shown in FIGS. 1-6.

Referring now in detail to the drawings, a straddle type van carrier is illustrated generally at numeral 10 having an open bay formed between a pair of longitudinally extending parallel side frame constructions 12 and 14 secured together at the rearward ends by a transverse frame 16 from which is suitably supported a rearwardly extending platform 18 having support rods 20 connecting each side thereof to side frame construction 12 and 14. An operator's station 22 and engine and transmission compartment 24 are located on the platform, the power train components being drivably connected to a differential drive mechanism 26 which is suitably connected to a pair of steering-driving rear wheels 28 by shaft 30 and chain and sprocket mechanism located within a pair of housings 32, one of which is shown. Additional pairs of dirigible wheels 36 and 38 are mounted upon opposite side frames 12 and 14 in tandem relationship. A steering mechanism generally shown at numeral 40 interconnects pairs of wheels 28, 36 and 38 on each side of the carrier and is operated by a steering wheel 42. The construction of the steering mechanism is disclosed and claimed in U.S. Patent No. 3,084,951, granted Apr. 9, 1963. Each of the wheels is resiliently mounted from the respective sides 12 and 14 by means of coil springs, not shown, enclosed within vertically extending wheel mounting fork tubes, such as shown at numerals 41 and 47, which extend through each frame construction in longitudinally spaced relation.

Two pairs of longitudinally spaced telescopic upright constructions 50 and 52 are mounted in opposite end portions of the U-shaped bay formed by the side and end frame assemblies of the vehicle and are adapted to be raised and lowered by means of pairs of adjacent extensible hydraulic hoist motors or cylinder assemblies 54, 56, 58 and 60, which are connected in pairs to the opposite ends of each of a pair of transversely extending lifting arches 62 and 64 located in opposite end portions of the vehicle frame for vertical movement. A lifting frame construction shown generally at numeral 66 in FIG. 2 is suspended in the U-shaped vehicle frame from lifting arches 62 and 64 by means of sprocket and chain mechanism in each lifting arch as illustrated generally at numerals 68. The arrangement is such that actuation vertically of the lifting arches 62 and 64 by the lift cylinders 54, 56, 58 and 60 and pairs of upright assemblies 50 and 52 causes lifting frame 66 to be actuated by the chain and sprocket mechanism 68 at a 2:1 movement ratio relative to movement of the lifting arches. Locking dog assemblies 70 are located in each corner section of the lifting frame 66 for engaging adaptor means located in the upper corner portions of van containers to be engaged by the carrier vehicle within the open bay of the frame.

The carried vehicle described thus far is described in detail and claimed in U.S. Patent No. 3,146,903, granted Sept. 1, 1964. The present invention is not intended to be restricted to any particular type of vehicle, such as is

above-disclosed generally herein primarily for the purpose of setting forth a typical environment in which the present invention may be embodied to advantage. It is unnecessary, therefore, to elaborate further upon the construction of the vehicle per se.

Lifting arch 62 is pivotally connected to the ends of the extensible piston rods of lift cylinders 56 and 60, and lifting arch 64 is similarly connected to the piston rods of lift cylinders 54 and 48. It will be understood that each of the lift cylinders can be mounted in a relation to the vehicle reverse to that disclosed by fixedly mounting the piston rods to the frame of the vehicle and the hydraulic cylinder portions mounted extensibly on the piston rods. In the aforementioned Patent No. 3,146,903 a pair of longitudinally extending torque tubes are disclosed which extend between the end portions of the lifting arches and are connected to sprockets in said arches in such a manner that vertical movement of the arches is coordinated as the pairs of lift cylinders extend and retract. The purpose of these torque tubes is to maintain the lifting arches always at the same elevation relative to the vehicle supporting surface so that the opposite end portions of the lifting frame will be elevated and lowered always at the same rate and in a horizontal plane, assuming that the vehicle supporting surface is horizontal, which is normally the case. The present invention replaces such torque tube construction and more positively assures equal and synchronous vertical movement of the cylinder assemblies 54, 56, 58 and 60.

To this end, we provide a longitudinally extending linkage and valve mechanism 72 supported from the top of side frame 12 and operatively connected to the adjacent end portions of lifting arches 62 and 64 and to cylinder assemblies 54 and 56. A similar linkage and valve mechanism 74 is supported from the opposite side frame 14 and is operatively connected to the opposite end portions of lifting arches 62 and 64 and to lift cylinder assemblies 58 and 60. A transversely extending linkage and cylinder assembly 76 is supported from the upper rear end portions of side frame assemblies 12 and 14 and is operatively connected to the opposite end portions of lifting arch 64 and to lift cylinder assemblies 54 and 58.

Referring first to the linkage and valve assembly 72, diagonally extending brackets 80 and 82 are secured to the opposed one end portions of lift arches 62 and 64, at the ends of which brackets are connected longitudinally extending telescopic link members 84 and 86 having bell cranks 88 and 90 connected to the respective adjacent ends thereof. A valve sleeve 92 is pivotally connected at 94 to the operating end of bell crank 88, and a valve spool 96 is pivotally connected at 98 to the operating end of bell crank 90, said valve sleeve and valve spool being in registry to provide under circumstances to be desired controlled communication between hydraulic lines 100 and 102 or 104 and 102. A four-sided mounting bracket 106 is secured to the upper portion of side frame 12 approximately mid-way between lift cylinders 54 and 56, the fulcrum of bell crank 88 being pivotally mounted at 108 so that the operating leg 88 of the bell crank normally extends diagonally upwardly therefrom as shown, and the fulcrum of bell crank 90 being pivotally mounted at 110 so that the operating leg 90 of the bell crank normally extends diagonally downwardly from the pivot 110, the valve assembly 112 extending in a diagonal direction longitudinally of the side frame 12 between pivots 94 and 98.

Linkage and valve assembly 74 is mounted on side frame 14 and to the opposite ends of lifting arches 62 and 64 in a manner similar to the mounting of linkage and valve assembly 72 except that the valve assembly 140 thereof, as shown, normally and preferably extends diagonally in a direction opposed to the direction of valve assembly 112, as shown in FIGS. 1 and 4. Assembly 74 comprises a pair of longitudinally extending telescopic linkage members 116 and 118 pivotally connected at the

one ends thereof to diagonally downwardly extending brackets 120 and 122 which are secured to the opposite ends of lifting arches 62 and 64, respectively, said telescopic link 116 having a bell crank 124 connected to its inner end and pivotally mounted at 126 to the one upper corner of a four-sided bracket 128 which is secured to side frame 14 approximately mid-way between lifting arches 62 and 64, and telescopic link 118 having a bell crank 130 connected to its inner end and pivoted from the upper opposite corner of bracket 128. The operating legs of bell cranks 124 and 130 are pivotally connected at 132 and 134 to a valve spool 136 and a valve sleeve 138, respectively, of valve assembly 140 having hydraulic lines 142, 144 and 146 connected to ports in the valve sleeve, said valve assembly 140 being similar to valve assembly 112 but having its connections to link members 116 and 118 reversed from the connections of link members 84 and 86 to valve assembly 112 so that said valve assembly 140 extends in a direction normally diagonally opposed to the position of valve assembly 112, as mentioned above. The opposed diagonal arrangement of valve assemblies 112 and 140 is for the purpose of permitting interchangeability of parts, and said valve assemblies may, if desired, be constructed as right and left hand units and mounted to extend diagonally in the same direction.

Mechanism 76, which extends transversely of the vehicle at a location immediately forwardly of platform 18, is operatively connected to lift cylinders 54 and 58 by means of a pair of transversely spaced and longitudinally extending rods 150 and 152 which are fixedly secured at their one ends to opposite end portions of lifting arch 64, and are pivotally secured at their opposite ends to telescopic link members 154 and 156, respectively. To effect the desired compensating action of mechanism 76 during elevation of the lift cylinder assemblies, it has been found desirable to use an effective length of links 154 and 156 which is substantially equal to the effective length of the telescopic links associated with assemblies 72 and 74 on each side of the vehicle. Since the width of the vehicle is substantially less than the longitudinal distance between lifting arches 62 and 64, as best seen in FIG. 2, the desired result is accomplished by extending the links 154 and 156 to points of pivotal connection with the remote ones of a pair of transversely and longitudinally spaced upstanding brackets 158 and 160, so that link 154 is adapted to operate a bell crank 162 which is pivotally connected to bracket 158 at 164, while link 156 is adapted to operate a bell crank 166 which is pivotally connected to bracket 160 and 168. The operating ends of bell cranks 162 and 166 are pivotally connected to opposite elements of a control valve assembly 170 in a manner similar to that above-described with respect to valve assemblies 112 and 140; i.e., a valve spool 172 is pivotally connected to the end of bell crank 162, and a valve sleeve which has a sliding connection with the valve spool is pivotally connected to the one end of bell crank 166, valve assembly 170 extending diagonally transversely of the vehicle as best shown in FIG. 3. Hydraulic conduits 176, 178 and 180 are connected to ports in valve sleeve 174 for a purpose to be described.

Referring now specifically to FIG. 7, the above-mentioned control valve assemblies 112, 140 and 170 are connected to the main hydraulic system of the vehicle which includes a fluid supply pump 190, a double-acting manual control valve 192 connected to the pump by a conduit 194, a flow divider 196 connected to the control valve by a conduit 198, and double-acting lift cylinder assemblies 54, 56, 58 and 60 which are connected to flow divider 196 at the head ends thereof by a plurality of conduits including aforementioned conduits 104, 144, 176 and 178, the plurality of conduits being adapted to supply approximately equal volumes of pressure fluid to the head ends of said lift cylinder assemblies by way of control valve 192 and flow divider 196. Conduit 104 is connected to the head end of cylinder 56 by way of a

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line 200 and a check valve 202; conduit 178 is connected to the head end of cylinder 54 by way of line 204 and a check valve 206; conduit 176 is connected to the head end of cylinder 58 by way of a line 208 and a check valve 210; and conduit 144 is connected to the head end of cylinder 60 by way of line 212 and a check valve 214. The pump 190 is connected to a sump 216 by a conduit 218, and a return conduit 220 connects control valve 192 to sump 216. Sump 216 also receives any fluid which flows through control valves 112, 140 and 170 by way of conduits 102, 146 and 180, and a conduit 222 which interconnects said latter conduits with sump 216. A conduit 224 is connected to valve 192 and to rod ends of the lift cylinders by way of conduits 226, 228, 230 and 232. The dotted lines 234, 236, 238 and 240 are connected to the check valves 202, 206, 210 and 214, respectively, and represent pilot operated means responsive to pressure fluid in conduits 226, 228, 230 and 232 during powered downward movement of the lift cylinders for opening the various check valves to permit a return flow of hydraulic fluids from the head ends of the lift cylinders through the various check valves and conduits to flow divider 196, which is a reversible flow divider, and thence through line 198, control valve 192 and conduit 220 to sump 216. Pilot operated check valves of the type illustrated diagrammatically in FIG. 7 are readily available commercially, and need not be disclosed in detail here. Control valve 192 represents a well-known type of three-position, manually operated valve having a neutral position in which no fluid can flow therethrough, which is the position shown in the drawing, and first and second operating positions for directing pressure fluid selectively to the head ends or rod ends of the lift cylinders, as well as to control valves 112, 140, 170.

In operation, the vehicle is driven forwardly toward a container or other article to be engaged with the lifting frame 66 elevated in the lifting arches 62 and 64 so as to clear the upper surface of the container or other article. The carrier vehicle which embodies our invention is capable of engaging at ground level by means of lifting frame 66 a van container, for example, by means of locking dogs 70, elevating the container to carrying position within the open bay of the vehicle, and transporting same to a desired location for deposit either at ground level or on top of a loading dock, railroad flat car or flat bed trailer, or on top of a first tier of van containers which may be located upon the ground, loading dock, or the like.

During such lifting movement, as well as lowering movement of containers which may be initially engaged from an elevated position, it is important to insure synchronized vertical movement of the lifting arches 62 and 64 both with respect to each other, and with respect to opposite ends of each lifting arch, as will be apparent to persons skilled in the art. This requires synchronized vertical movement of all four lift cylinders assemblies 54, 56, 58 and 60. For example, if a container is more heavily loaded at the forward end of the lifting frame 66, lift cylinders 56 and 60 will carry more than one-half of the load, which will tend to cause lift cylinders 54 and 58 to actuate lifting arch 64 and the rear end of the lifting frame ahead of lifting arch 62 and the forward end of the lifting frame. The present invention compensates for any tendency of one or more of the lift cylinders to lift or lower at a faster rate than the remaining lift cylinders, so that irrespective of unequal distribution of a load in a container, or for any other reason which tends to cause one or more of the lift cylinders to lift or lower ahead of the other cylinders, the entire container or other load will be raised or lowered in the open bay of the vehicle in an attitude which is substantially continuously parallel to the vehicle supporting surface.

The foregoing desirable results are obtained as follows: Whenever during lifting or lowering movements of a load the four lift cylinders are properly synchronized,

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i.e., all extended an equal amount, all of the control valves 112, 140 and 170 are and remain in a neutral position as shown in FIG. 7 wherein the valve spools 96, 136 and 172 of the respective valves close the lower pair of valve ports in the respective sleeves 92, 138 and 174 so that no fluid is permitted to flow through any of conduits 100, 104, 142, 144, 176, or 178 to sump 216 by way of conduit 222. Assuming a condition of operation in which all of the lift cylinders continue to extend at the same rate so that compensation is not required by the linkage device which control valves 112, 140 and 170, all of said valves remain in the neutral position illustrated in FIG. 7 throughout such elevation and no hydraulic fluid flows at any time through any of said control valves to sump 216. During such elevation control valve 192 is positioned so that the output of pump 190 is directed to the head ends of the lift cylinders by way of conduit 198, flow divider 196, and the various conduits which connect said flow divider to check valves 202, 206, 210 and 214. Extension of the lift cylinders causes fluid to be exhausted from the rod ends thereof to the sump 216 by way of conduits 226, 228, 230 and 232, conduit 224, valve 192 and conduit 220. During such elevation fluid at pump discharge pressure is present in lines 100, 104, 142, 144, 176 and 178 to ports of the control valves 112, 140 and 170, but inasmuch as under the assumed condition of operation all such valves are in a neutral position no fluid can flow through any of said valves to sump 216.

The lift cylinders may be lowered by actuating valve 192 to a second operating position wherein conduits 194 and 224 are connected to each other, and conduits 198 and 220 are similarly connected, whereby the discharge of pump 190 is directed to the rod ends of the lift cylinders by way of conduit 224 and branch conduits 226, 228, 230 and 232, such discharge pressure fluid being also vented to the pilot operated check valves of the various lift cylinders by way of lines 234, 236, 238 and 240 whereby the check valves open to permit the exhausting of fluid from the head ends of the lift cylinders to sump 216 by way of conduits 104, 144, 176 and 178, reversible flow divider 196, conduit 198, valve 192 and conduit 220. Again, if no compensation is required by control valves 112, 140 and 170 such valves remain in neutral position throughout such lowering operation.

Referring to FIGS. 4-6, it will be noted that during such load lifting and lowering operations as aforesaid, the ends of telescopic links 84 and 86 which are connected to brackets 80 and 82 are elevated with lifting arches 62 and 64, and thus cause bell cranks 88 and 90 to pivot about their connections to bracket assembly 106 at 108 and 110. FIG. 4 illustrates the relative positions of the linkage and bell crank mechanism when the lift cylinders are fully retracted, FIG. 5 shows said relative positions when the lift cylinders are partially extended, and FIG. 6 when the lift cylinders are at maximum extension. If no compensation is required of control valve 112 during lift cylinder extension, valve sleeve 92 and spool 96 are actuated together at the same rate by bell cranks 88 and 90 so that the lower pair of valve sleeve ports are never uncovered during movement of the linkage mechanism from the position shown in FIG. 4 to that shown in FIG. 6. Similarly with respect to the operation of control valve 140 of the compensating mechanism 74, and of valve 170 of compensating mechanism 76.

Assuming now that lift cylinder 56 supports a greater load than any of lift cylinders 54, 58 or 60, it will be seen that extension of cylinder 56 will tend to lag that of the remaining lift cylinders. As a result, bell crank 90 will rotate more rapidly than bell crank 88 which causes valve spool 96 to assume the position shown in FIG. 5 which permits communication between conduits 100 and 102, thus by-passing fluid through conduits 100, 102 and 222 to effect decrease in the rate of extension of cylinder 54 until cylinder 56 extends to overtake cylinder 54, at which time valve 112 closes. The temporary decrease in the rate

of extension of cylinder 54 effects the rate of extension of cylinder 58 by operating control valve 170 to by-pass fluid from cylinder 58 to sump 216 by way of conduits 176, 180 and 222, which in turn causes the rate of extension of cylinder 60 to be modified by causing valve 140 to open to by-pass fluid from cylinder 60 to sump 216 by way of conduits 144, 146 and 222.

Compensation is effected during load lowering operations in a manner similar to the above. In this instance assume that the rate of retraction of cylinder 56 lags that of the remaining cylinders, which causes bell crank 88 to rotate less rapidly than bell crank 90 during movement of the bell cranks from the position shown in FIG. 6 toward the position shown in FIG. 4. Such slower rate of retraction from the FIG. 6 position effects a movement of valve spool 96 inwardly of valve sleeve 92 from the neutral position of FIG. 6 so that conduit 104 is permitted to communicate with conduit 102, thus effecting a by-passing of exhaust fluid flowing through check valve 202 by way of conduits 104, 102 and 222, which action causes an increase in the rate of retraction of cylinder 56 until sleeve 92 has been actuated to return the valve 112 to a neutral position, at which time cylinder 56 is again synchronized with cylinder 54.

It will now be understood by persons skilled in the art that the synchronizing mechanism above-described is capable of compensating for the misalignment of any combination of lift cylinders 54, 56, 58 and 60 during elevation and retraction thereof, and that the desired result of maintaining at all times all such cylinders in substantial alignment is thus effected.

Although only one embodiment of our invention has been described herein, this disclosure is merely for purpose of illustration and not as a limitation of the scope of the invention. It is therefore to be expressly understood that the invention is not limited to the specific embodiment shown, but may be used in various other ways, and that various modifications may be made to suit different requirements, and that other changes, substitutions, additions and omissions may be made in the construction, arrangement and manner of operation of the parts without necessarily departing from the scope of the invention as defined in the following claims.

We claim:

1. In a material handling vehicle having at least four upright hydraulic cylinder means mounted in space and substantially parallel relation to each other both longitudinally and transversely of the vehicle, extensible members associated with said cylinder means for elevating load-lifting means of the vehicle, means operatively connecting at least some of said extensible members to each other, said latter means including a device connected to each of said extensible members and to a portion of the vehicle intermediate each of the longitudinally spaced pairs of said cylinder means, each of said devices being movable during extension of the respective extensible members, valve means connecting adjacent ends of the respective pairs of said devices, fluid pressure supply means connected to said cylinder means for actuating said extensible members, said valve means being mounted to be actuated by said devices in pivotal movement during extension of said extensible members.

2. A vehicle as claimed in claim 1, wherein said valve means includes a pair of valve elements connected to different ones of said devices for normal pivotal movement while maintaining a fixed fluid flow relationship during synchronized extension of said extensible members, and operable whenever said extensible members tend to extend at different rates to adjust the volume of fluid flowing to one of said cylinder assemblies.

3. A device for synchronizing the operation of the extensible members of a pair of fluid cylinder assemblies located in spaced and substantially parallel relation to each other, comprising fluid-mechanical means operably connecting said extensible members to each other respon-

sive to the movement of said extensible members, and fluid pressure supply means connected to said cylinder assemblies for actuating said extensible members, said fluid-mechanical means including link means connected to each of said extensible members, a ported valve element connected to a first one of said link means and a second valve element connected to a second one of said link means, said ported and second valve elements comprising a single valve means in which said valve elements are actuatable by said first and second link means for controlling fluid flow through said ported valve element; said valve elements being operatively connected to said cylinder assemblies for adjusting the volume of fluid flowing to said cylinder assemblies to synchronize the movement of said extensible members.

4. A device as claimed in claim 3 wherein each of said link means is extensible and is connected at one end to a respective extensible member and at the other end to one of said valve elements, said valve elements being located intermediate said cylinder assemblies.

5. A device as claimed in claim 4 wherein said valve elements are pivotally connected to the respective adjacent ends of said link means and said link means are pivotally connected at the opposite ends to the respective extensible members, said latter members being extensible relative to the position of said valve elements.

6. A device as claimed in claim 3 wherein during synchronized extension of said extensible members said valve elements are maintained in a fixed valving relationship to each other, and during non-synchronized movement of said extensible members said valve elements are displaced in relation to each other by said link means so as to adjust the volume of fluid flowing to said cylinder assemblies for resynchronizing the movement of said extensible members.

7. A device as claimed in claim 5 wherein during synchronized extension of said extensible members said valve elements are maintained in a fixed valving relationship to each other, and during non-synchronized movement of said extensible members said valve elements are displaced in relation to each other by said link means so as to adjust the volume of fluid flowing to said cylinder assemblies for resynchronizing the movement of said extensible members.

8. A device as claimed in claim 3 wherein said second valve element is in normally closed fluid flow relation to said ported valve element, said second valve element being displaced by said link means relative to said ported valve element upon extension of one extensible member in advance of the other extensible member, whereby to by-pass fluid flow from one cylinder assembly to resynchronize the extensible members.

9. A device as claimed in claim 3 wherein each link means includes a telescopic link and a bell crank operated thereby and connected to one of said valve elements.

10. A device synchronizing the operation of the extensible members of two pairs of fluid cylinder assemblies, the cylinders of each pair being in longitudinally spaced and substantially parallel relation and the respective pairs being in transversely spaced and substantially parallel relation to each other, the device comprising fluid-mechanical means operably connecting the extensible members of each said pair of cylinder assemblies and also operably connecting the extensible members of one transversely spaced pair of cylinder assemblies, said fluid-mechanical means being responsive to the movements of said extensible members, and fluid pressure supply means connected to said cylinder assemblies for actuating said extensible members, said fluid-mechanical means including a pair of link means connected to each respective pair of said extensible members, a ported valve element connected to one link of each pair of said link means and a second valve element connected to the other link of each said pair of link means and cooperating with said ported valve element for controlling fluid flow through

said ported valve element for adjusting the fluid flow to said cylinder assemblies to synchronize the movement of said extensible members.

11. A device for synchronizing the operation of the extensible members of a plurality of fluid cylinder assemblies located in spaced and substantially parallel relation to each other, comprising fixed mounting means intermediate the fluid cylinder assemblies, linkage means connected adjacent the remote ends thereof to each extensible member for movement therewith and extending from said remote ends toward one another, the adjacent opposite ends thereof being pivotally connected to said mounting means, fluid pressure supply means connected to said cylinder assemblies for actuating said extensible members, and means interconnecting the said adjacent ends of said linkage means including a pair of valve elements connected to different ones of said linkage means and controlled by said linkage means during extension of said extensible members and operatively connected to said cylinder assemblies for by-passing fluid from one of said assemblies whenever the extensible member of said one assembly tends to extend ahead of the extensible member of the other cylinder assembly.

12. A hydraulic system comprising a plurality of load-lifting upright hydraulic cylinder assemblies having extensible members responsive to fluid pressure, said cylinder assemblies being mounted in predetermined spaced and substantially parallel relation to each other, load-lifting means connected to the extensible members for elevation therewith, a supply means for providing a volume of pressure fluid to said cylinder assemblies for actuating said extensible members, and means controlling the volume of pressure fluid to said cylinder assemblies to control the extension of said extensible members including normally closed valve means and mechanical means controlling said valve means, said valve means including a pair of cooperating valve members each one of which is connected by said mechanical means to a different one of said extensible members, said cooperating valve members maintaining a normally closed flow position during synchronized movement of said extensible members while being actuated by said mechanical means, and said valve members being additionally actuated by said mechanical means to by-pass fluid from any cylinder assembly the extensible member of which tends to extend ahead of the extensible member of another cylinder assembly.

13. A device for synchronizing the operation of the extensible members of a pair of fluid cylinder assemblies located in spaced and substantially parallel relation to each other, comprising fluid-mechanical means operably connecting said extensible members to each other responsive to the movement of said extensible members, and fluid pressure supply means connected to said cylinder assemblies for actuating said extensible members, said fluid-mechanical means including valve means for adjusting the volume of fluid flowing to said cylinder assemblies to synchronize the movement of said extensible members and mechanical means operatively connecting different cooperating elements of said valve means to different ones of said extensible members, said mechanical means being connected to said extensible members and said valve elements in such a manner as to actuate said valve means pivotally during extension of said extensible members while maintaining said valve elements in a fixed relative position to each other during synchronized movement of said extensible members.

14. A device as claimed in claim 13 wherein said valve elements are displaced one relative to the other during non-synchronized movement of said extensible members for controlling the flow to said cylinder assemblies so as to resynchronize said extensible members.

15. In a material handling vehicle having at least four upright hydraulic cylinder assemblies, one pair being mounted in longitudinally spaced and substantially

parallel relation on each side of the vehicle, and load-lifting mechanism located intermediate said pairs of cylinder assemblies and elevatable thereby, an extensible member associated with each cylinder assembly, fluid pressure supply means connected to said cylinder assemblies for actuating said members in extension, therefrom, and control means operatively connecting the extensible members of each of said pairs of cylinder assemblies, movable with said extensible members and operable to control the volume of pressure fluid communicated to the cylinder assemblies of each said pair in such a manner that the extensible members of each said pair elevate at substantially the same rate irrespective of variations in the load carried by different ones of each said pair, said control means including telescopic link means, bell crank means operated thereby and valve means operated by said bell crank means to by-pass fluid from a cylinder assembly when the extensible member thereof tends to extend ahead of the extensible member of another cylinder assembly.

16. In a material handling vehicle having at least four upright hydraulic cylinder assemblies, one pair being mounted in longitudinally spaced and substantially parallel relation on each side of the vehicle, and load-lifting mechanism located intermediate said pairs of cylinder assemblies and elevatable thereby, an extensible member associated with each cylinder assembly, fluid pressure supply means connected to said cylinder assemblies for actuating said members in extension therefrom, and control means operatively connecting the extensible members of each of said pairs of cylinder assemblies, movable with said extensible members and operative to control the volume of pressure fluid communicated to the cylinder assemblies of each said pair in such a manner that the extensible members of each pair elevate at substantially the same rate irrespective of variations in the load carried by different ones of each said pair, said control means including a pair of valve elements cooperable to control the volume of said pressure fluid which is communicated to the cylinder assemblies and mounted for pivotal movement during extension of said extensible members, said valve elements being also mounted for longitudinal movement one relative to the other.

17. In a material handling vehicle having at least one pair of upright hydraulic cylinder assemblies mounted in longitudinally spaced relation on the vehicle and load-lifting mechanism supported by said cylinder assemblies and elevatable thereby, an extensible member associated with each cylinder assembly, fluid pressure supply means connected to said cylinder assemblies for actuating said members in extension, and control means operatively connecting the extensible members of said cylinder assemblies and operable to control the volume of pressure fluid communicated to the cylinder assemblies so that the extensible members thereof elevate substantially the same rate irrespective of variations in the load carried by different ones of the extensible members, said control means comprising fixed mounting means located intermediate the cylinder assemblies, means pivotally connected to each extensible member and to the mounting means and extensible during extension of said extensible members, and valve means operatively connected to the adjacent ends of said extension means which are connected to said mounting means, said valve means being actuatable by said extension means during extension of said extensible members in both pivotal and relative longitudinal movement for controlling said cylinder assemblies.

18. A vehicle as claimed in claim 17 wherein said valve means is pivotable in closed fluid flow relation during synchronized movement of said extensible members, and is actuatable to by-pass fluid flow from one of said cylinder assemblies during non-synchronized movement thereof in relation to the other cylinder assembly.

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19. A vehicle as claimed in claim 17 wherein a second pair of upright cylinder assemblies are located similarly to the first said pair thereof on the opposite side of the vehicle and are operable together with said first pair for elevating said load-lifting mechanism, and separate control means similar to said first-mentioned control means operatively connecting the extensible members of each of said second pair of cylinder assemblies, and third control means similar to said first-mentioned control means operatively connecting the extensible members of one each of said first and second pairs of cylinder assemblies.

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