

Sept. 28, 1965

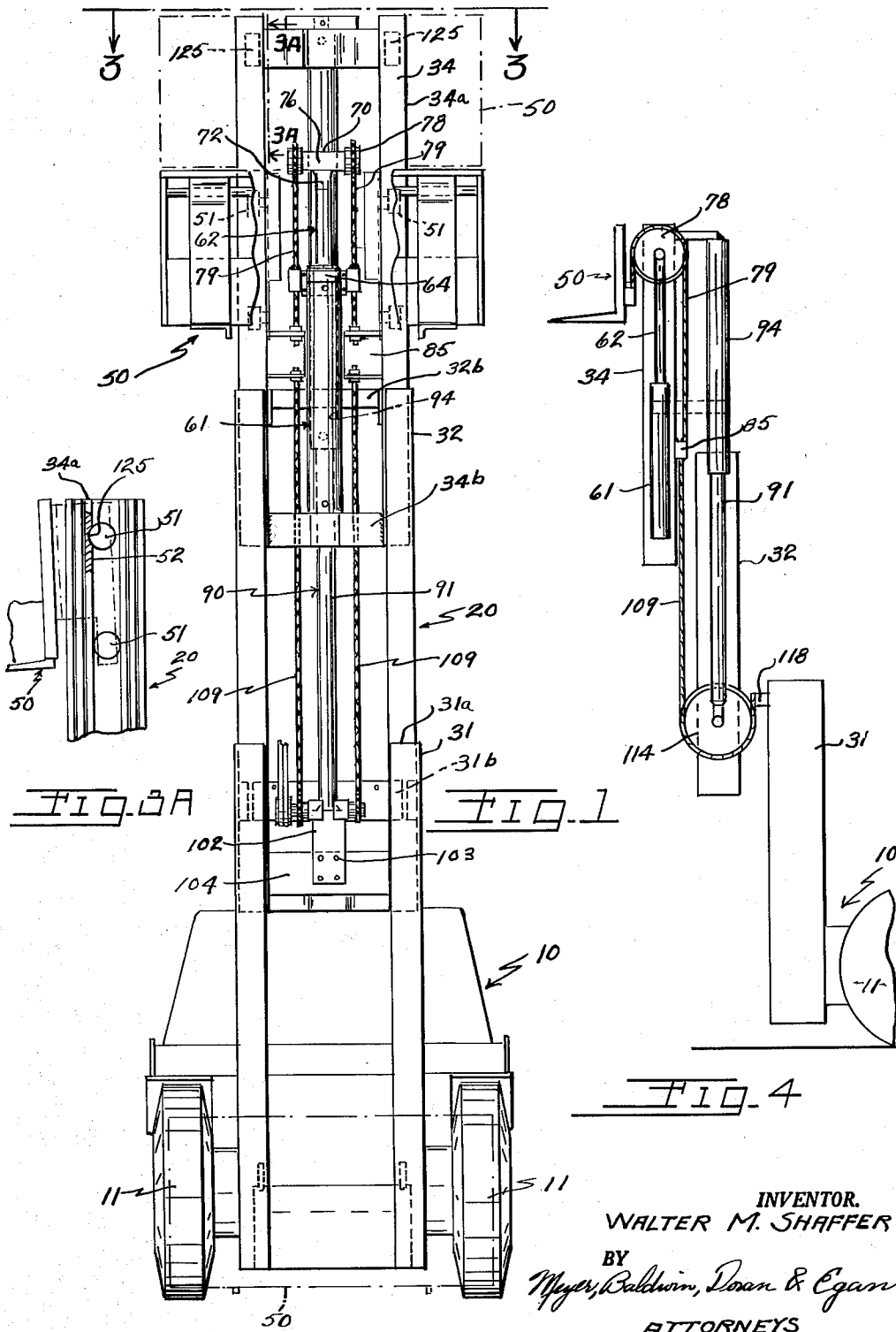
W. M. SHAFFER

3,208,556

MULTIPLE STAGE MASTS FOR LIFT TRUCKS

Filed Feb. 19, 1962

5 Sheets-Sheet 1



INVENTOR.
WALTER M. SHAFFER

BY
Meyer, Baldwin, Dean & Egan
ATTORNEYS

Sept. 28, 1965

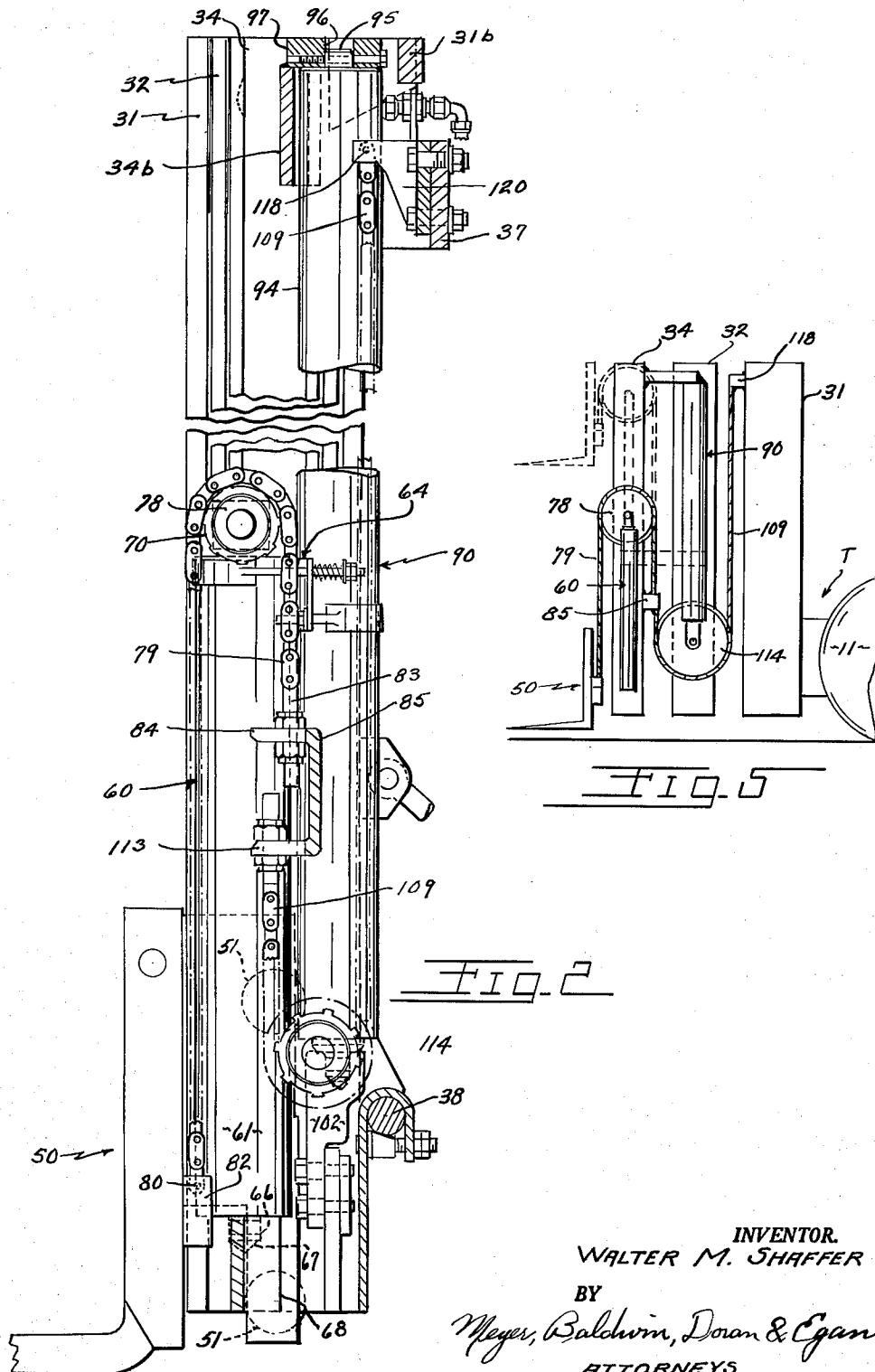
W. M. SHAFFER

3,208,556

MULTIPLE STAGE MASTS FOR LIFT TRUCKS

Filed Feb. 19, 1962

5 Sheets-Sheet 2



Sept. 28, 1965

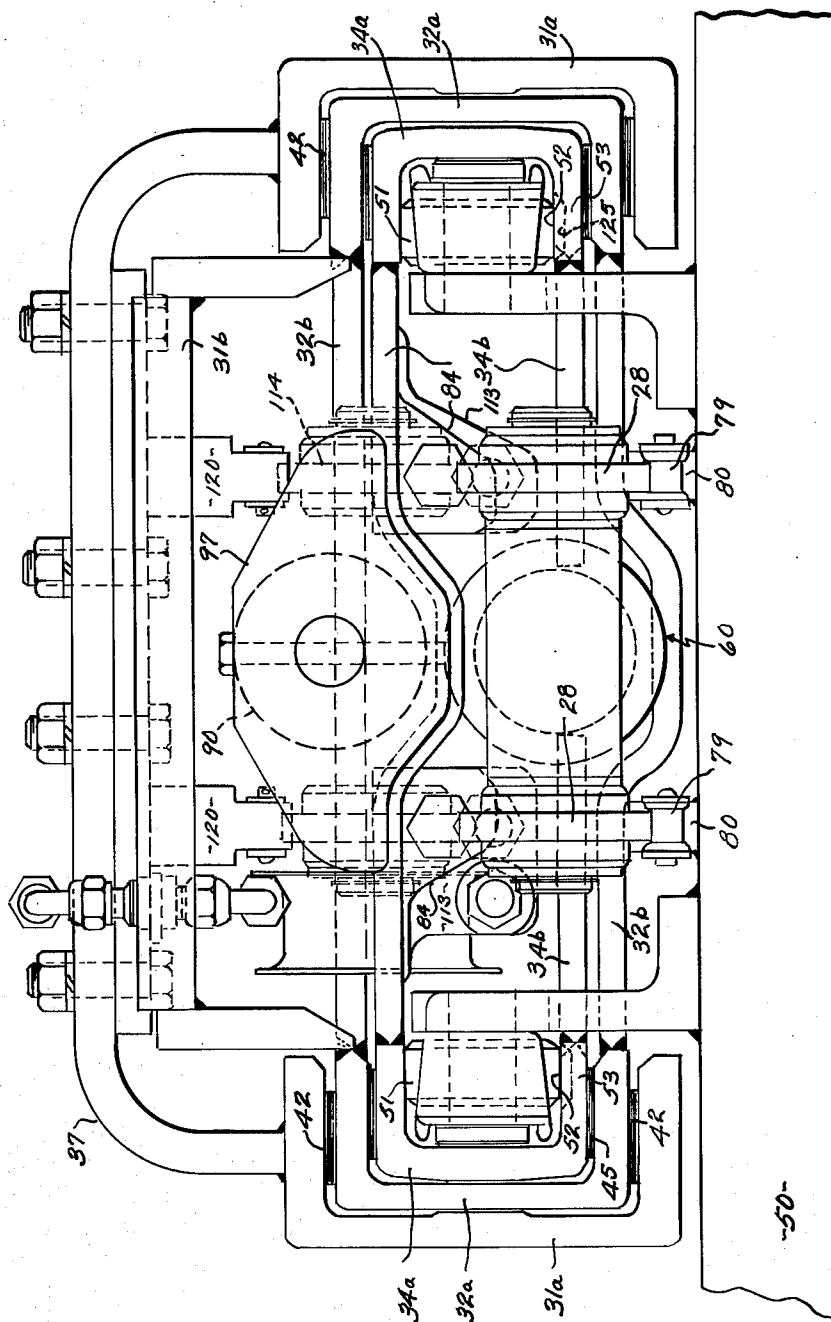
W. M. SHAFFER

3,208,556

MULTIPLE STAGE MASTS FOR LIFT TRUCKS

Filed Feb. 19, 1962

5 Sheets-Sheet 3



INVENTOR
WALTER M. SHAFFER

BY

ATTORNEYS

Sept. 28, 1965

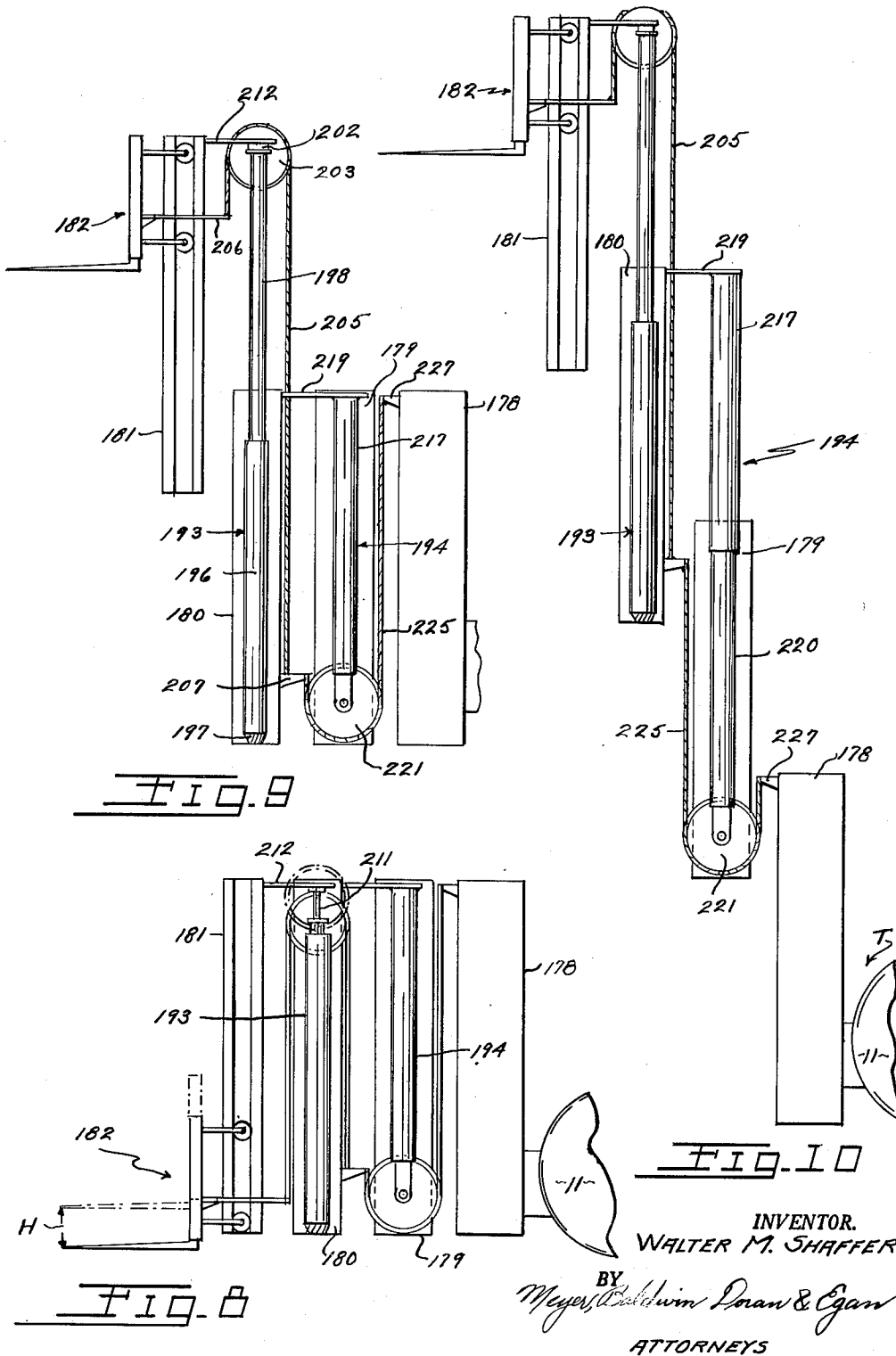
W. M. SHAFFER

3,208,556

MULTIPLE STAGE MASTS FOR LIFT TRUCKS

Filed Feb. 19, 1962

5 Sheets-Sheet 5



1

3,208,556

MULTIPLE STAGE MASTS FOR LIFT TRUCKS
Walter M. Shaffer, Chesterland, Ohio, assignor to Tow-
motor Corporation, Cleveland, Ohio, a corporation of
Ohio

Filed Feb. 19, 1962, Ser. No. 174,182
10 Claims. (Cl. 187—9)

This invention relates generally to industrial lift trucks and more particularly to a new and improved telescopic mast assembly for use with an industrial lift truck.

More specifically, the inventive concept of the present invention is directed to a telescopic type of mast structure for use in an industrial lift truck wherein the mast structure comprises a plurality of partite mast sections disposed in telescopic relation to each other, a load supporting carriage mounted for movement on one of the mast sections and movable therealong by a primary or first hydraulic ram or the like interconnected between said mast assembly and said load carriage; and further wherein the multiple sections of the mast assembly are separately extensible by drive means including a secondary hydraulic ram or the like carried on said mast assembly and interconnected between the sections thereof.

A primary object of the present invention is the provision of a novel and improved mast assembly for use in an industrial lift truck or the like, and wherein said assembly comprises partite mast sections disposed in extensible relation each to the other, a load supporting carriage movably carried on one of said partite sections and primary drive means for moving said load supporting carriage therealong; separate drive means for extending the mast sections of said assembly, and wherein the drive means for said load supporting carriage is separately actuable to raise and/or lower said carriage with said mast sections disposed in any actuated position.

Another object of the present invention is to provide a novel and improved mast assembly for use in an industrial lift truck or the like and which assembly comprises a tripartite type of construction having three identical mast sections disposed in nested relation each to the other, a load supporting carriage mounted for slidable movement along one of said mast sections and primary hydraulic drive means for moving said load carriage therealong; secondary drive means to effect the extension of said tripartite mast assembly and wherein the primary drive means may be actuable with so as to selectively move the load supporting carriage along its supporting mast section without consequent movement of said mast assembly.

Another object of the present invention is to provide a novel and improved mast assembly for use with an industrial lift truck or the like, and which assembly comprises at least four identical mast sections disposed in a nested relation each to the other, load supporting means movably mounted on one of said sections and primary drive means for selectively moving said load supporting means therealong; secondary drive means interconnected between the mast sections of said assembly and effective to provide for the extension thereof, the actuation of said secondary drive means being operable to extend said mast assembly without consequent movement of said load supporting means on its supporting mast section.

Still another object is the provision of a new and improved extensible partite mast assembly as is described hereinabove and wherein the load supporting means is separately movable along substantially the whole length of its supporting mast section to thus obtain a full free lift of said supporting means with said mast assembly in any of its actuated positions.

Another object of the present invention is to provide

2

a new and improved extensible partite mast assembly as above described, and wherein the primary and secondary drive means each include a single acting hydraulic motor actuable to initiate the raising and lowering of the mast sections and the load supporting means of the partite mast assembly.

Still another object of the present invention is to provide a triple stage mast assembly which is substantially more economical in its manufacture and assemblage of component parts to produce a triple "full free" lift than has been heretofore realized.

Additional objects and advantages of the mast assembly of the present invention will be realized by one skilled in the art to which it pertains and upon reference to the following disclosure thereof, the inventive concepts of the same being illustrated in several preferred embodiments in the accompanying drawings forming a part of this specification, and wherein:

FIG. 1 is a front view of a lift truck which utilizes an extensible mast assembly embodying the present invention;

FIG. 2 is a vertical section of the mast assembly with the work supporting means located in its lowered position;

FIG. 3 is a plan view looking in the direction of the arrows 3—3 in FIG. 1;

FIG. 3A is a transverse vertical section taken approximately on the line 3A—3A in FIG. 1;

FIG. 4 is a diagrammatic side elevational view of the mast assembly of FIG. 1 shown in a fully extended position and with the mast sections thereof removed from their nested assembly and disposed one in front of the other to more clearly illustrate the interconnection between the same;

FIG. 5 is also a diagrammatic side elevational view of the mast assembly of FIG. 1, but with the mast assembly in its collapsed condition, and with the load supporting carriage thereof shown in full lines in its lowermost position and in dotted lines in its fully raised position with respect to its supporting mast section;

FIG. 6 is a side view of a second embodiment of mast assembly having four mast sections, each of which is also shown removed from its nested arrangement and disposed one in front of the other in a "collapsed mast" position so as to more clearly show the interconnection therebetween;

FIG. 7 is a side view of the mast assembly of FIG. 6 with the mast sections thereof fully extended;

FIG. 8 is a side view of a third embodiment of mast assembly having four mast sections and showing the same in a collapsed mast position;

FIG. 9 is a side view of the mast assembly of FIG. 8 and showing one of the mast sections and load supporting means carried thereon in a raised position; and,

FIG. 10 is a side view of the mast assembly of FIG. 8, and showing the mast sections thereof fully extended.

Briefly, the mast assembly of the present invention is herein shown as especially designed for use with an industrial truck which, as seen in FIG. 1, includes a vehicular body indicated at 10, being preferably of the motorized type as referred to in the art and thus capable of self propulsion, said body being supported on suitable wheels 11 so as to be easily maneuverable.

The mast assembly embodying the present invention is mounted in a generally vertical plane on the front end of the vehicular body 10, and although not herein shown, is preferably intended to be forward and reversibly slightly tiltable to locate the same at a predetermined vertical angle relative to said forward end of the truck assembly as will be understood.

In each of the several embodiments of mast assembly herein illustrated, a load supporting carriage is movably mounted on one of the mast sections thereof so as to ex-

tend forwardly from the vehicle body 10 and thus positioned to provide for the manipulation and transportation of a load placed thereon.

In each of the first and second embodiments of mast assembly, the load supporting carriage is moved along its supporting mast sections by means of primary drive means, hereinafter defined in detail, and the several mast sections of said assembly are similarly actuated between collapsed and fully extended positions by means of secondary drive means.

In the third embodiment of mast assembly the primary drive means is operable to move the load supporting carriage and also its supporting mast section between lowered and raised positions, and the secondary drive means similarly actuates the remaining mast sections between collapsed and extended positions.

With reference now directed to FIGS. 1-5, the embodiment of mast assembly as herein identified in its entirety by the reference numeral 20, is of tripartite construction comprising an outer mast section 31, an intermediate mast section 32 and an inner mast section 34.

As shown particularly in FIGS. 1 and 3, each of the mast sections comprises a pair of U-shaped channel members identified respectively by the reference numerals 31a, 32a and 34a, disposed in parallel spaced relation and rigidly connected together by bracing members 31b, 32b and 34b. The channel members 31a of the outer mast section 31 are interconnected at the upper end thereof by tie bar 37.

Each of the mast sections are also seen to be identical in length and of such configuration so as to be nested one within the other, the outer mast section 31 being pivotally mounted on bar 38 onto the forward end of the vehicular body 10 of the lift truck, the intermediate mast section 32 being slightly smaller in its dimension and nested within the outer mast section and disposed in slightly inwardly spaced relation thereto by means of suitable wear strips 42 so as to be freely slidable longitudinally therealong.

In like manner, the inner mast section 34 is nested within the intermediate mast section 32, being likewise disposed in inwardly spaced relation thereto by means of suitable bearing members 45 so as to be capable of slidable movement longitudinally therealong.

A work supporting carriage as is identified in its entirety by the reference numeral 50 is supported on the inner mast section 34, said carriage mounting spaced pairs of rollers 51 which are disposed so as to be rollably engageable with surface 52 on the side leg 53 of each U-shaped channel 34a of the inner mast section 34 being thus effective to advance the carriage 50 therealong.

As is previously mentioned, the instant embodiment of mast assembly is provided with primary drive means for raising and/or lowering the work supporting carriage 50 within its supporting mast section 34, between its fully raised position as is shown in dotted lines in FIG. 5 and its lowered position as is shown in full lines in said figure.

For this purpose, the present form of primary drive means comprises a suitable hydraulic ram 60 which is mounted on the mast assembly so as to have its piston or plunger 62 facing upwardly therefrom, the cylinder 61 of said ram being firmly attached by means of strap 64 to the ram 90 and hence to the inner mast section 34.

The closed end of the ram cylinder 61 as best seen in FIG. 2 is formed with a boss or projection 66 which, in turn, is disposed within a recess 67 formed in anchor block 68, the latter being attached and preferably mounted on the inner mast section 34 at its lower end.

The ram piston 62 is seen to mount a roller assembly on its free end as identified in its entirety by the reference numeral 70, and which includes as best seen in FIG. 1, a body of somewhat T-shaped configuration, the stem portion 72 of which is disposed within a recess formed in said ram piston so as to extend in longitudinal prolongation upwardly therefrom.

The cross head 76 of the aforesaid body is preferably

formed integrally with the stem 72 thereof, being preferably of square cross section and having a shaft therein formed on each end, the latter in turn, rotatably mounting a guide roller 78.

A pair of flexible members such as link chains 79, are each seen to have one end thereof anchored at 80 to a plate 82 carried on the rearward face of the work carriage 50 adjacent the base of the latter, said link chains extending upwardly therefrom, and passing over the guide rollers 78 and thence extending downwardly and being securely anchored at 83 to the upper rail 84 of bracket 85 carried on the inner mast section 34.

With this assembly, it will now be realized that upon applying hydraulic fluid to the primary cylinder 61 of ram 60, the ram piston 62 will be forced upwardly so as to raise the guide roller assembly 70 therewith which is effective to pull the work supporting carriage 50 upwardly along its supporting mast section 34.

As will also be realized, the velocity at which the work carriage 50 moves upwardly along its supporting inner mast section 34 is substantially twice that of the velocity of the piston 62 as it moves out of its cylinder.

The length of the primary ram 60, as may be best seen in FIG. 1 is preferably at least half as long as its supporting mast section 34 so that when the ram piston 62 thereof is fully extended the guide roller assembly 70 will be positioned closely adjacent the top of the mast inner mast section 34, being thus effective to position the work supporting carriage 50 also at said upper end of said mast section.

This movement of the work supporting carriage 50 is accomplished as will be realized, with the mast assembly in its collapsed condition, and is referred to in the art as the "full free lift" of the work supporting carriage, thus identifying that the carriage is movable throughout substantially the length of the inner mast section 34.

As is likewise previously mentioned, the instant mast assembly is provided with secondary drive means which is intended to provide for the extension of the mast sections of assembly.

To accomplish this, the present form of drive means includes a hydraulic ram 90 which is disposed rearwardly of the primary ram 60 and in such manner as to have its piston rod or plunger 91 facing downwardly toward the base of the mast assembly.

The cylinder 94 of ram 90 is likewise secured by strap 64 to the inner mast section 34 so as to be movable with the latter.

The closed end of the cylinder 94 is seen to be formed with a projection 95 which is disposed within an aperture 96 formed in cross bar 97 attached to the upper end of the inner mast section 34 and extending thereacross.

The piston or plunger 91 of the secondary ram, as best seen in FIG. 1, mounts a roller block 102 on its free end, said block in turn being fastened at 103 to an anchor plate 104 attached to the intermediate mast section 32 and extending across the channel members thereof adjacent the lower end.

In this manner, the closed end of the secondary ram cylinder 94 is thus directly connected to the upper end of inner mast section 34 whereas the movable ram piston or plunger 91 of said cylinder is directly connected to the intermediate mast section 32.

The secondary drive means also includes a pair of flexible members such as link chains 109, each of which is seen to have one end thereof anchored at 112 to the bottom rail 113 of the aforementioned bracket 85 carried on the inner mast section 34, each of said link chains extending downwardly therefrom and around one of a pair of guide rollers 114 rotatably carried on the roller block 102 and thence upwardly therefrom to be securely fastened at 118 to anchor bar 120, the latter being securely attached to the outer mast section 31 closely adjacent the upper end thereof.

With this assembly it will now be apparent that upon the application of hydraulic fluid to the cylinder of the secondary ram 90, said cylinder will be raised upwardly on its piston rod 91, the latter being connected directly to the intermediate mast section 32, which movement is effective to initiate the raising of the inner mast section 34. Simultaneous with this movement, the intermediate mast section 32 will also be raised relative to the outer mast section 31, the velocity of this latter movement being substantially twice the speed of the aforesaid cylinder movement of the hydraulic ram 90 due to the reeving arrangement of the link chains 109 therebetween.

As best seen in FIG. 2, the secondary ram is approximately as long as the mast sections of the aforesaid assembly, being therefore effective upon actuation to extend said assembly a distance equal to at least approximately twice the height of any one of said mast sections.

The primary and secondary rams 60 and 90 respectively, are likewise each preferably of the singleaction type as referred to in the art, being actuatable by hydraulic fluid to raise the work supporting carriage and the several mast sections of the aforesaid assembly, said rams upon being drained of the actuating fluid permitting the said elements to return gravitationally to their lowered and collapsed positions respectively.

Although not herein shown, it is desirable to connect the primary and secondary rams 60 and 90 into a single hydraulic control circuit which may be manually operable at the usual operator's station on the lift truck whereby hydraulic fluid is supplied simultaneously to each of said rams.

In this instance, the primary ram 60 is preferably larger in diameter than the secondary ram 90 whereby it is actuated at a somewhat lower hydraulic pressure than the latter, it being intended that for any one mast assembly, the primary ram 60 is actuatable so as to raise the work supporting carriage in the manner above described to its "full free lift" position prior to the secondary ram 90 being actuated to begin to raise the mast sections of said assembly.

It is likewise intended in determining the optimum design for the instant mast assembly that with the work supporting carriage and the mast sections of the mast assembly having previously been moved to their fully raised and extended positions respectively, that upon permitting the hydraulic fluid to drain from the primary and secondary rams, their respective sizes should be such as to permit the mast sections to move into their "fully collapsed" position prior to the hydraulic pressure being lowered sufficiently in the ram 60 to initiate the lowering movement of the work supporting carriage.

As will also be realized, it is possible to use primary and secondary rams 60 and 90 of equal size and connect the same into separate hydraulic control circuits whereby they may be sequentially controlled individually by the operator to provide the desired sequence of movement for the respective work supporting carriage and mast sections of the said assembly.

In the instant mast assembly, it is desirable that the work supporting carriage 50 having previously been lifted to its "full free lift" position is retained in said position so as to assure that when the mast sections are next subsequently lowered to their "fully collapsed" position the carriage will remain in said "full free lift" position until the mast is "fully collapsed."

For this purpose, the channel members 34a of the inner mast section 34, as may be best seen in FIGS. 3 and 3A are each provided with a recess 125 on the inner surface 52 of its front leg and adjacent its upper end being disposed in vertical alignment with the upper pair of carriage rollers 51.

With this assembly, as the load supporting carriage 50 is raised by the primary hydraulic ram 60 to its "full free lift" position the aforesaid rollers enter into the recesses 125, and the carriage 50 will tilt slightly forwardly ap-

proximately to a position as is shown in FIG. 3A whereby the same is locked or releasably retained in said raised position.

In this manner, upon collapsing the mast sections of the assembly, it is assured that said assembly will be moved to its "fully collapsed" position prior to the weight of the work supporting carriage being effective to initiate its gravitational movement to its lowered position.

With reference now directed to FIGS. 6 and 7, there is herein shown a second embodiment of mast assembly having four identical mast sections 130-133 inclusive which, merely for purposes of clarity are herein shown removed from their normal nested relationship and stacked one in front of the other so as to adequately show the interconnection therebetween.

The work supporting carriage 136, as in the previous embodiment of mast assembly, is intended to be moved longitudinally along substantially the full length of the inner mast section 133, and for this purpose a primary hydraulic ram 140 is seen to be mounted within said inner mast section and to have its piston rod 142 mounting a pair of guide rollers 143, only one of which is herein shown.

The piston rod 142 is preferably hollow so as to accommodate a guide rod 145 which is connectable at 144 to the upper end of the inner mast section being thus operable to guide the movement of said piston rod as the same is propelled out of said ram cylinder.

Suitable flexible members such as a pair of link chains, one of which is shown at 147, each has its one end connectable at 148 to the work supporting carriage 136, each of said chains extending over the aforementioned guide rollers 143 and thence downwardly therefrom to connect at its opposite end to an anchor plate 149 attached to the inner mast section 133, closely adjacent the bottom end thereof.

With this assembly, it will be seen that upon powering the primary ram 140 the work supporting carriage 136 is thus moved upwardly longitudinally along the inner mast section 133 and at a rate approximately twice the velocity of the extension of the ram piston rod 142.

As herein shown, the primary ram 140 is approximately half as long as its supporting mast section 133 whereupon as its piston rod 142 is fully extended it raises the work supporting carriage 136 to its uppermost position as best shown in FIG. 7 closely adjacent the upper end of the inner mast section, said positional movement being also referred to as the "full free lift" of the work supporting carriage.

As will likewise hereinafter be readily apparent, this actuation of the primary ram 140 is accomplished while the mast assembly is in its "fully collapsed" position.

The mast sections 131, 132 and 133 of the instant assembly are each likewise intended to be extendible relative to the outer mast section 130 which as will be understood is fixed to the forward end of the lift truck as identified at T. To accomplish this, a secondary hydraulic ram as is identified at 150, is seen to be carried within the mast section 131 preferably in an inverted position whereby the closed end of its cylinder 151 is connected by bracket 152 to the upper end of the next adjacent mast section 132. The piston rod 153 of said secondary ram 150 is seen to mount a pair of suitable guide rollers 154 one of which is herein shown, the end of said piston rod being likewise anchored to the mast section 131 closely adjacent its base.

A second pair of guide rollers 156 is likewise seen to be carried adjacent the upper end of the mast section 132, and a first pair of flexible members such as link chains 158 are each seen to have one end thereof anchored to the aforementioned plate 149 carried on the mast section 133, said chains thence extending over said guide rollers 156 to have the opposite ends thereof each attached to bracket 160 carried on the mast section 131, adjacent its upper end.

7

In like manner, a second pair of link chains 163 are each connected at one end to plate 164 carried on the outer mast section 130, said chains thence extending downwardly and around the guide rollers 154 carried on the secondary piston rod 153 and upwardly therefrom to be anchored at the opposite ends at 167 to the mast section 132 adjacent its lower end.

With this assembly, it will now be apparent that as the secondary ram 150 is powered, the mast sections 131, 132 and 133 may be raised relative to each other and to the outer mast section 130 to the position as shown in FIG. 7 which position is also referred to as the "fully extended" position for said mast assembly.

It is likewise apparent with the instant double chain reeving arrangement that as the mast section 132 is elevating with respect to the mast section 131, the mast section 133 will likewise elevate at the same rate of speed with respect to mast section 132, and likewise that mast sections 132 and 133 will be elevating at approximately three times the rate that the piston rod 153 of the secondary ram 150 is extended from its cylinder 151.

As in the previous embodiment of mast assembly, it is intended that the primary ram 140 be actuatable at a somewhat lower hydraulic pressure than the secondary ram 150, it having been preferred to have the primary ram operating at a pressure approximately two-thirds of that which would be required to actuate the secondary ram 150.

With this ratio between operating pressures for the primary and hydraulic rams, the desired sequence of movement may be readily obtained. That is to say that with the mast assembly in a "fully collapsed" position as is shown in FIG. 6 and upon actuation of the primary ram 140, the work supporting carriage 136 may be lifted to its "fully raised" position on the mast section 133 prior to any extension of the mast sections.

Conversely, when it is desirable to lower the work supporting carriage and to likewise collapse the mast assembly, the mast sections will first gravitationally move toward their "fully collapsed" position before the pressure has been reduced sufficiently in primary ram 140 to allow the work supporting carriage 136 to initiate its gravitational movement toward its "fully lowered" position as shown in FIG. 6.

And, likewise as in the previous embodiment, this relationship between the primary and secondary hydraulic rams is an important design concept since it is possible to obtain the proper sequence of operation of the mast assembly and the work supporting carriage without the necessity of utilizing latches between the said carriage and its supporting mast section as is oftentimes required in present day constructions.

In FIGS. 8-10 I have herein shown another embodiment of telescopic mast assembly which utilizes four identical mast sections as are herein identified by the reference numerals 178-181 inclusive, and which are likewise intended to be disposed in nested relation each to the other, the mast section 178 being firmly attached to the forward end of the lift truck T so as to extend generally vertically upwardly with respect thereto.

As herein illustrated, the several mast sections of the instant assembly are removed from their normal nested relation and stacked vertically one next to the other to more clearly disclose the reeving interconnection therebetween.

The work supporting carriage as is identified at 182, is intended to have a "free lift" distance H as seen in FIG. 8, and as will be recalled, the "free lift" of the carriage is that distance which the carriage 182 may be raised with the mast assembly in its "collapsed condition" and before the mast sections of said assembly begin to telescope upwardly.

The instant embodiment of mast assembly differs basically from the previously described quadruple mast assembly of FIGS. 6 and 7 in that the primary and secondary hy-

8

draulic rams as are identified herein by the reference numerals 193 and 194, are approximately of equal length, the associated drive means connected therewith being such that the primary hydraulic ram 193 is actuatable to effect the raising and lowering of the work supporting carriage and also its supporting mast section 181, whereas the secondary hydraulic ram 194 is actuatable to effect the extension of the intermediate mast sections 180 and 179 relative to the outer mast section 178.

With reference now directed particularly to FIG. 8, the work supporting carriage 182 is herein seen to be similarly mounted on the inner mast section 181 so as to be rollably movable longitudinally therealong.

The primary hydraulic ram 193 is carried within the intermediate mast section 180 and is seen to have the closed end of its cylinder 196 attached at 197 to the bottom end of said mast section, said ram cylinder extending upwardly therefrom so as to have its piston rod 198 facing upwardly from the base of said assembly. The cylinder 196 of said hydraulic ram is seen to be approximately as long as its accommodating mast section 180.

The end of the piston rod 198 of said ram is seen to mount a cross head 202, which, in turn, rotatably mounts a pair of guide rollers 203, only one of which is herein shown. A pair of flexible members such as link chains 205 are each seen to have one end thereof anchored to carriage plate 206, said link chains extending upwardly and over the guide rollers 203, the opposite ends thereof being firmly anchored to bracket 207 carried on the mast section 180 closely adjacent its base.

The piston rod 198 is preferably hollow so as to freely accommodate a pull down rod 211 therein, the upper end of said pull down rod being securely fastened to plate 212 attached to the upper end of the inner mast section 181.

With the assembly thus far described, it will be seen that upon initial actuation of the primary ram 193, the carriage 182 will be raised from its lowered position as is shown in solid lines in FIG. 8 separately to its "free lift" position as is shown in dotted lines, the vertical distance represented by said "free lift" being identified as is aforementioned by the reference character H.

Thereafter, as the actuation of said ram continues the piston rod 198 carries the cross head 202 upwardly and into engagement with the plate 212 effective to initiate raising the inner mast section 181 simultaneously with the continued movement of said carriage, said movement terminating with the carriage and mast section being elevated to the position shown therefor in FIG. 9.

As will be apparent, the velocity of movement of the carriage 182 is approximately twice the speed at which the piston rod 198 of the primary ram is extended.

As is previously mentioned, the instant mast assembly is also seen to include a secondary hydraulic ram as identified in its entirety by the reference numeral 194 and which likewise is seen to be disposed in an inverted position and carried within the intermediate mast section 179.

The closed end of the cylinder 217 of the secondary ram is connected by plate 219 to the upper end of the mast section 180, whereas its piston rod 220 is affixed to the bottom of the mast section 179 and likewise rotatably mounts a pair of guide rollers 221, only one of which is herein shown.

A pair of link chains 225 are each seen to have one end connected to the aforementioned bracket 207 carried on mast section 180 thence extending downwardly and around the guide rollers 221 and connecting to bracket 227 fastened to the upper end of the outer mast section 178.

With this assembly, it will be realized that upon actuation of the secondary ram 194 the mast sections 180 and 179 will be extended upwardly relative to the fixed outer mast section 178, carrying likewise the inner mast section 181 and carriage 182 therewith.

9

The elevation of said mast sections 179 and 180 as will be understood is at approximately twice the velocity as the extension of the piston rod 220 of said ram 194.

As in the previous embodiments of mast assembly, it is also desired that the primary and secondary hydraulic rams 193 and 194 respectively are connected in a single control circuit (not herein shown) and actuatable from a single hydraulic fluid source.

In this assembly, it is further desired that the primary and secondary hydraulic rams 193 and 194 be of such relative size as to enable the primary ram to initiate the propulsion of its piston rod at a slightly lower pressure level than that of the secondary ram 194. In like manner, inasmuch as the primary hydraulic ram is operable at a lower pressure level than the secondary hydraulic ram 194, the latter will initially permit the mast assembly to gravitationally move to its "fully collapsed" position as shown in FIG. 9 prior to the pressure in said control circuit being reduced sufficiently in the primary ram 193 whereby the carriage 182 and supported mast section 181 may gravitationally initiate their movement to their respective lowered positions as is shown in FIG. 8.

Having thus described in detail several preferred embodiments of mast assembly incorporating the inventive concepts of the present invention therein, it will be realized that the same is susceptible to various modifications, arrangements and combinations of parts thereof without departing from the aforesaid concepts as are defined in the appended claims.

What is claimed is:

1. A mast assembly for a lift truck comprising, first, second and third mast sections, said sections being substantially the same length and disposed in nestable relation each to the other, said first mast section being attached to the lift truck and extending generally vertically therefrom, said second mast section mounted for movement longitudinally along said first mast section, said third mast section being mounted for movement longitudinally along said second mast section, a load carriage mounted for movement along said third mast section, a hoist assembly comprising a first hoist cylinder having a piston rod, said first hoist cylinder and piston rod having a length approximately equal to one-half the length of one of said mast sections, said first hoist cylinder being attached to said third mast section so as to be movable therewith, a second hoist cylinder having a piston rod, said second hoist cylinder and piston rod having a length approximately equal to the length of one of said mast sections, said second hoist cylinder being attached to said third mast section and the piston rod of said secondary cylinder being attached to said second mast section, guide means mounted on said piston rods, a primary flexible member extending around the guide means on the piston rod of said first hoist cylinder and having one end connected to said load carriage and its opposite end to said third mast section, a secondary flexible member extending around the guide means on the piston rod of said second hoist cylinder and having one end connected to said third mast section and its opposite end to said first mast section, whereupon actuation of said first hoist cylinder is effective to move the carriage along said third mast section and actuation of said second hoist cylinder is effective to move said second and third mast sections relatively to each other and longitudinally along said first mast section.

2. In a mast assembly as is defined in claim 1 and wherein the primary flexible member has its opposite end connected to the third mast section adjacent its lower end.

3. In a mast assembly as is defined in claim 1 and wherein the opposite end of the secondary flexible member is connected to the upper end of the first mast section.

4. A mast assembly for a lift truck comprising, first, second and third mast sections, said sections being substantially the same length and disposed in nestable rela-

10

tion each to the other, said first mast section being attached to the lift truck and extending generally vertically therefrom, said second mast section mounted for movement longitudinally along said first mast section, said third mast section being mounted for movement longitudinally along said second mast section, a load carriage mounted for movement along said third mast section, a hoist assembly comprising a first hydraulic hoist cylinder having a piston rod, said first hoist cylinder and piston rod having a length approximately equal to one-half the length of one of said mast sections, said first hoist cylinder being attached to said third mast section so as to be movable therewith, a second hydraulic hoist cylinder having a piston rod, said second hoist cylinder and piston rod having a length approximately equal to the length of one of said mast sections, said second hoist cylinder being attached to said third mast section and the piston rod of said secondary cylinder being attached to said second mast section, guide means mounted on said piston rods, a primary flexible member extending around the guide means on the piston rod of said first hoist cylinder and having one end connected to said load carriage and its opposite end to said third mast section, a secondary flexible member extending around the guide means on the piston rod of said second hoist cylinder and having one end connected to said third mast section and its opposite end to said first mast section, said first and second hoist cylinders being of such relative size whereby said first cylinder is actuatable at a lower hydraulic pressure as hydraulic fluid is applied simultaneously to both cylinders effective to progressively increase the hydraulic pressure therein, whereupon said carriage is first moved to a raised position along said third mast section, said second cylinder being subsequently actuated at a higher hydraulic pressure to move said second and third mast sections relative to each other from a fully nested position and along said first mast section, said second cylinder being first reversibly operable as said hydraulic pressure is subsequently progressively decreased in said cylinders whereby said second and third mast sections are returned to said fully nested position, and said first cylinder is reversibly operable subsequently to said second cylinder to lower said carriage.

5. A mast assembly for a lift truck comprising, first, second and third mast sections, said sections being substantially the same length and disposed in nestable relation each to the other, said first mast section being attached to the lift truck and extending generally vertically therefrom, said second mast section mounted for movement longitudinally along said first mast section, said third mast section being mounted for movement longitudinally along said second mast section, a load carriage mounted for movement along said third mast section, a hoist assembly comprising a first hydraulic hoist cylinder having a piston rod, said first hoist cylinder being attached to said third mast section so as to be movable therewith, a second hydraulic hoist cylinder having a piston rod, said second hoist cylinder being attached to said third mast section and the piston rod of said secondary cylinder being attached to said second mast section, guide means mounted on said piston rods, a primary flexible member extending around the guide means on the piston rod of said first hoist cylinder and having one end connected to said load carriage and its opposite end to said third mast section, a secondary flexible member extending around the guide means on the piston rod of said second hoist cylinder and having one end connected to said third mast section and its opposite end to said first mast section, said first and second hoist cylinders being of such relative size whereby said first cylinder is actuatable at a lower hydraulic pressure as hydraulic fluid is applied simultaneously to both cylinders effective to progressively increase the hydraulic pressure therein, whereupon said carriage is first moved to a raised position along said third mast section, said second cylinder being subsequent-

ly actuated at a higher hydraulic pressure to move said second and third mast sections relative to each other from a fully nested position and along said first mast section, said second cylinder being first reversibly operable as said hydraulic pressure is subsequently progressively decreased in said cylinders whereby said second and third mast sections are returned to said fully nested position, and said first cylinder is reversibly operable subsequently to said second cylinder to lower said carriage.

6. A mast assembly for a lift truck comprising, first, second, third and fourth mast sections, said sections being substantially of equal length and disposed in nestable relation each to the other, said first mast section being attached to the lift truck and extending generally vertically therefrom, said second mast section mounted for movement longitudinally along said first mast section, said third mast section being mounted for movement longitudinally along said second mast section, said fourth mast section being mounted for movement longitudinally along said third mast section, a load carriage mounted for movement along said fourth mast section, a hoist assembly comprising a first hoist cylinder attached to and carried within the third mast section and having a piston rod, a second hoist cylinder attached to said third mast section and having a piston rod connected to the second mast section, guide means mounted on said piston rods, a primary flexible member extending around the guide means on the piston rod of said first hoist cylinder and having one end connected to said load carriage and its opposite end to said third mast section, a secondary flexible member extending around the guide means on the piston rod of said second hoist cylinder and having one end connected to said third mast section and its opposite end to said first mast section, said first and second hoist cylinders being of such relative size whereby said first cylinder is actuatable at a lower hydraulic pressure as hydraulic fluid is applied to both cylinders effective to progressively increase the hydraulic pressure therein, whereupon said carriage is first moved to a raised position along said fourth mast section and subsequently said fourth mast section is moved with said carriage to an extended position with said other mast sections remaining in a nested relation to each other, said second cylinder being subsequently actuated at a higher hydraulic pressure to move said second and third mast sections from a fully nested position relative to each other and along said first mast section, said second cylinder being first reversibly operable as said hydraulic pressure is subsequently progressively decreased in said cylinders whereby said second and third mast sections are returned to said fully nested position, and said first cylinder is reversibly operable subsequently to said second cylinder to lower said carriage.

7. In a mast assembly as is defined in claim 6 and wherein means on said fourth mast section are engageable with said carriage to releasably retain the latter in said raised position.

8. A mast assembly for a lift truck comprising, first, second, third and fourth mast sections, said sections being substantially of equal length and disposed in nestable relation each to the other, said first mast section being attached to the lift truck and extending generally vertically therefrom, said second mast section mounted for movement longitudinally along said first mast section, said third mast section being mounted for movement longitudinally along said second mast section, said fourth mast section being mounted for movement longitudinally along said third mast section, a load carriage mounted for movement along said fourth mast section, a hoist assembly comprising a first hoist cylinder attached to and carried within said fourth mast section and having a piston rod, said first hoist cylinder and piston rod having a length approximately equal to one-half the length of one of said mast sections, a second hoist cylinder carried

within said second mast section and having a piston rod, said second hoist cylinder and piston rod having a length approximately equal to the length of one of said mast sections, one end of said second hoist cylinder being attached to said third mast section and its piston rod being connected to said second mast section, guide means mounted on said piston rods, guide means mounted on said third mast section, a primary flexible member extending around the guide means on the piston rod of said first hoist cylinder and having one end connected to said load carriage and its opposite end to said fourth mast section, a secondary flexible member extending around the guide means on the piston rod of said second hoist cylinder and having one end connected to said third mast section and its opposite end to said first mast section, a third flexible member extending around the guide means on said third mast section and having one end connected to said fourth mast section and its opposite end to said second mast section, said first and second hoist cylinders being of such relative size whereby said first cylinder is actuatable at a lower hydraulic pressure as hydraulic fluid is applied to both cylinders effective to progressively increase the hydraulic pressure therein, whereupon said carriage is first moved to a raised position along said fourth mast section, said second cylinder being subsequently actuated at a higher hydraulic pressure to move said second and third mast sections from a fully nested position relative to each other and along said first mast section, said second cylinder being first reversibly operable as said hydraulic pressure is subsequently progressively decreased in said cylinders whereby said second and third mast sections are returned to said fully nested position, and said first cylinder is reversibly operable subsequently to said second cylinder to lower said carriage.

9. A mast assembly for a lift truck comprising, first, second, third and fourth mast sections, said sections being substantially of equal length and disposed in nestable relation each to the other; said first mast section being attached to the lift truck and extending generally vertically therefrom, said second mast section mounted for movement longitudinally along said first mast section, said third mast section being mounted for movement longitudinally along said second mast section, said fourth mast section being mounted for movement longitudinally along said third mast section, a load carriage mounted for movement along said fourth mast section, a hoist assembly comprising a first hoist cylinder attached to and carried within said third mast section and having a piston rod connected with said fourth mast section, said first hoist cylinder and piston rod having a length approximately equal to the length of said third mast section, a second hoist cylinder carried within said second mast section and having a piston rod, said second hoist cylinder being attached to said third mast section and its piston rod connected to said second mast section, said second hoist cylinder and piston rod having a length approximately equal to the length of said second mast section, guide means mounted on said piston rods, a primary flexible member extending around the guide means on the piston rod of said first hoist cylinder and having one end connected to said load carriage and its opposite end connected to said third mast section, a secondary flexible member extending around the guide means on the piston rod of said second hoist cylinder and having one end connected to said third mast section and its opposite end to said first mast section, the actuation of said first hoist cylinder being effective to move the carriage along said fourth mast section and to move the fourth mast section along said third mast section, and the actuation of said second hoist cylinder being effective to move said second and third mast sections relative to each other and longitudinally along said first mast section.

10. In a mast assembly as is defined in claim 9 and wherein means on said fourth mast section are engageable

with said carriage to releasably retain the latter in said raised position.

References Cited by the Examiner

UNITED STATES PATENTS

1,676,449	7/28	Lederer	-----	187—11	X
2,480,066	8/49	Weaver	-----	187—9	
2,518,251	8/50	Quayle	-----	187—9	
2,595,120	4/52	Barnes	-----	187—9	

5

2,670,811	3/54	Shaffer	-----	187—9
2,701,031	2/55	Brumbaugh	-----	187—9
2,877,868	3/59	Gunning	-----	187—9
2,918,143	12/59	Shaffer	-----	187—9
3,007,547	11/61	Paradise	-----	187—9
3,061,045	10/62	Gunning	-----	187—9

SAMUEL F. COLEMAN, *Primary Examiner*.
ANDRES H. NIELSEN, LOUIS J. DEMBO, *Examiners*.