Aug. 28, 1962 R. S. BOYAJIAN ETAL 3,051,265

FORK TRUCK WITH TRI-LIFT MAST

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10 Sheets-Sheet 1

Fig. 2.

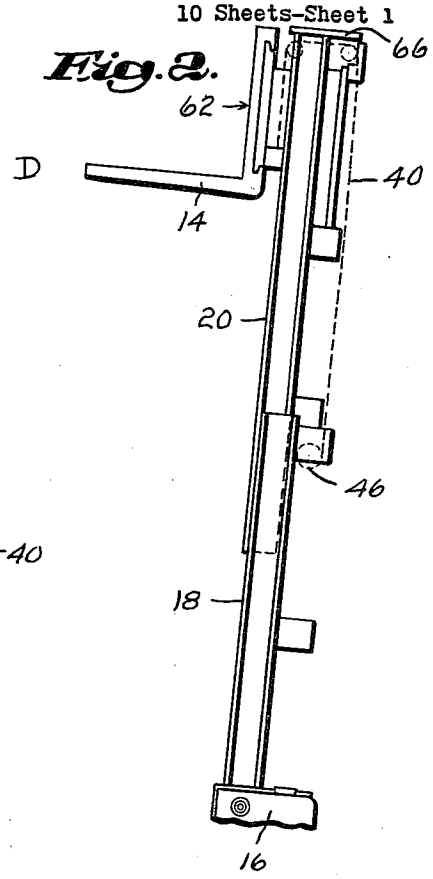


Fig. 1.

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Fig. 3

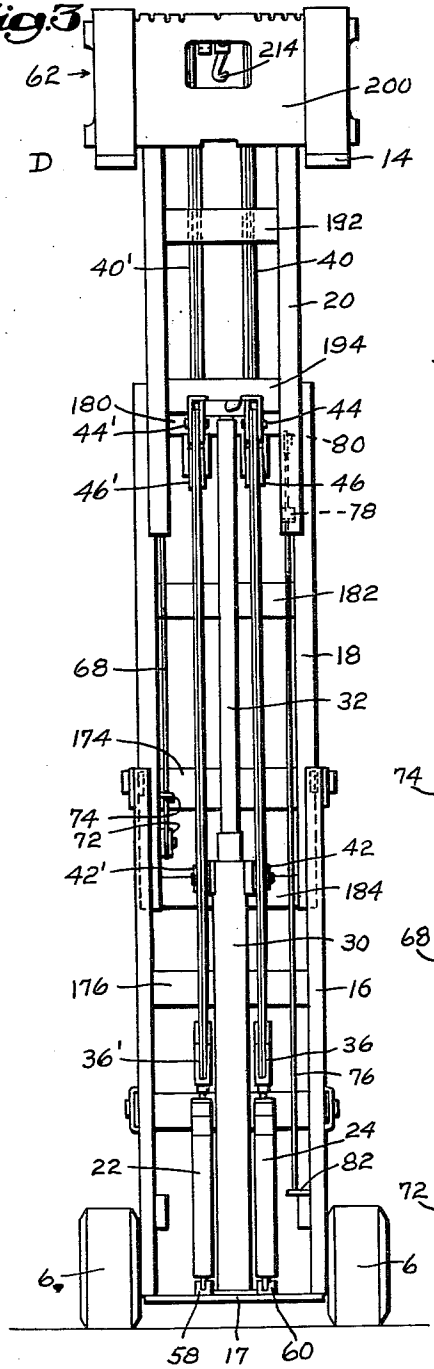


Fig. 8.

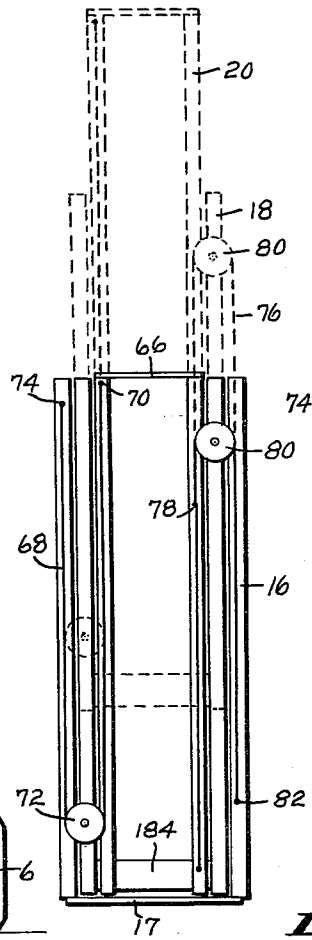
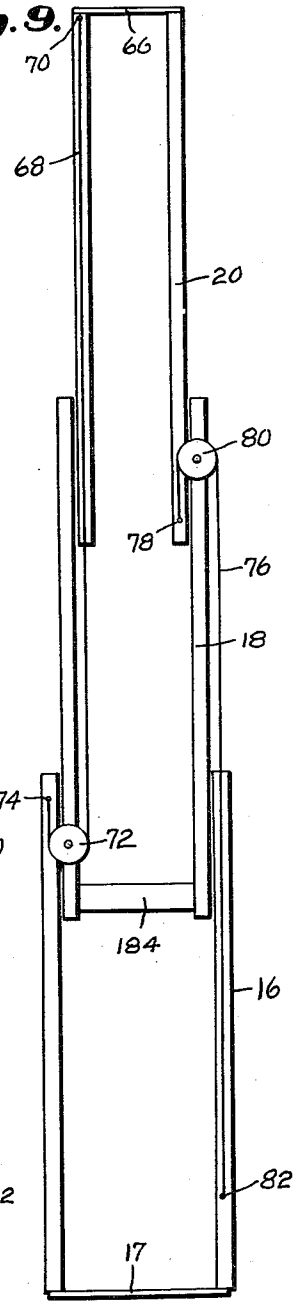


Fig. 9.



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Fig. 4.

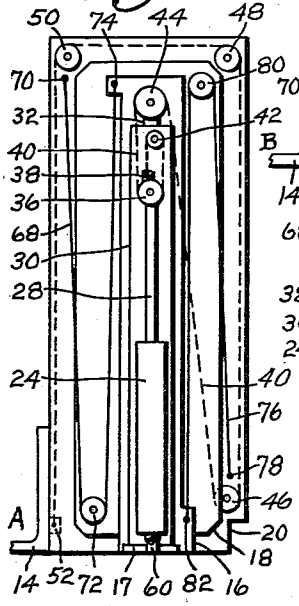


Fig. 5.

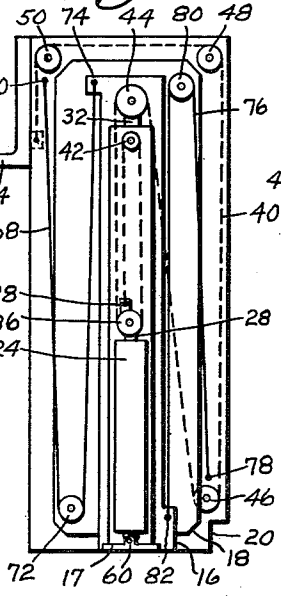


Fig. 6.

Fig. 7.

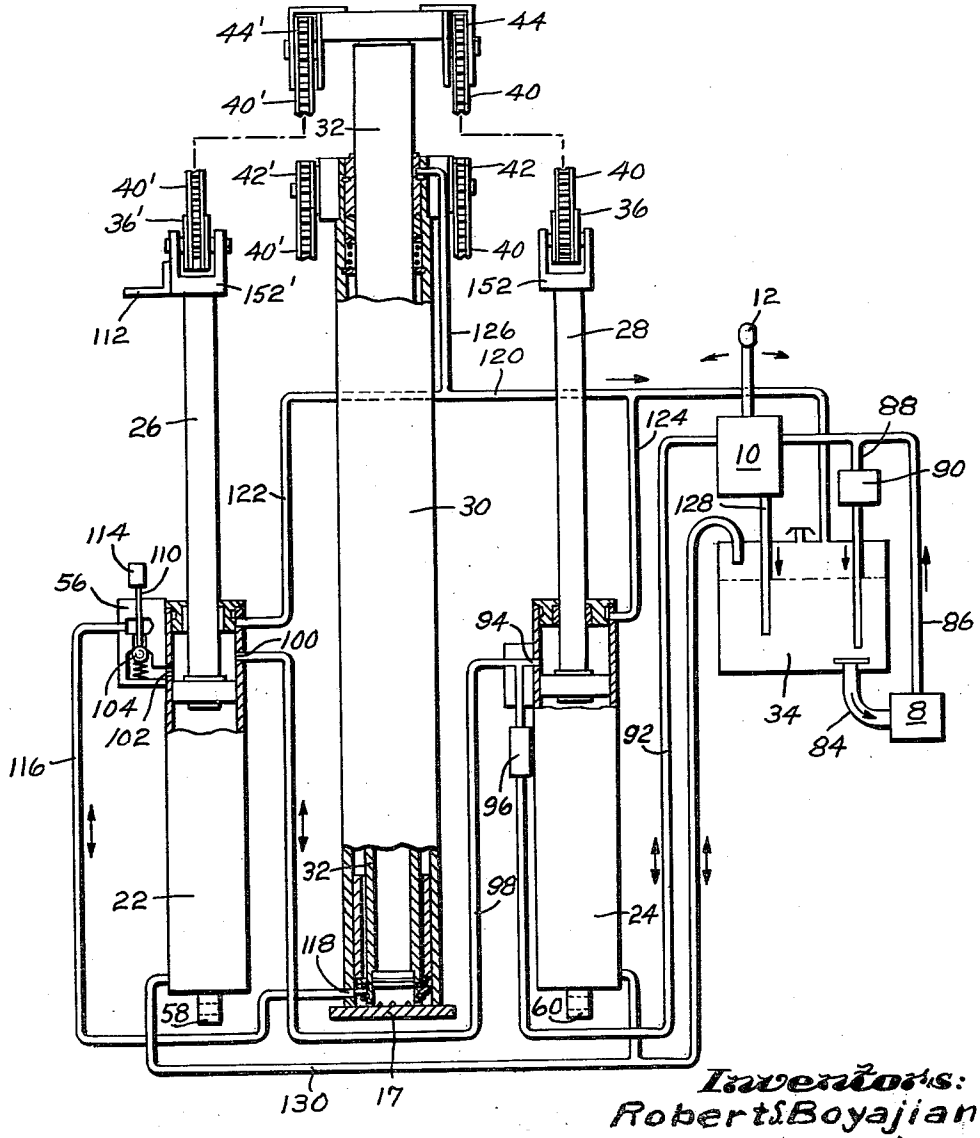
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Fig. 10.



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FORK TRUCK WITH TRI-LIFT MAST

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Fig. 11.

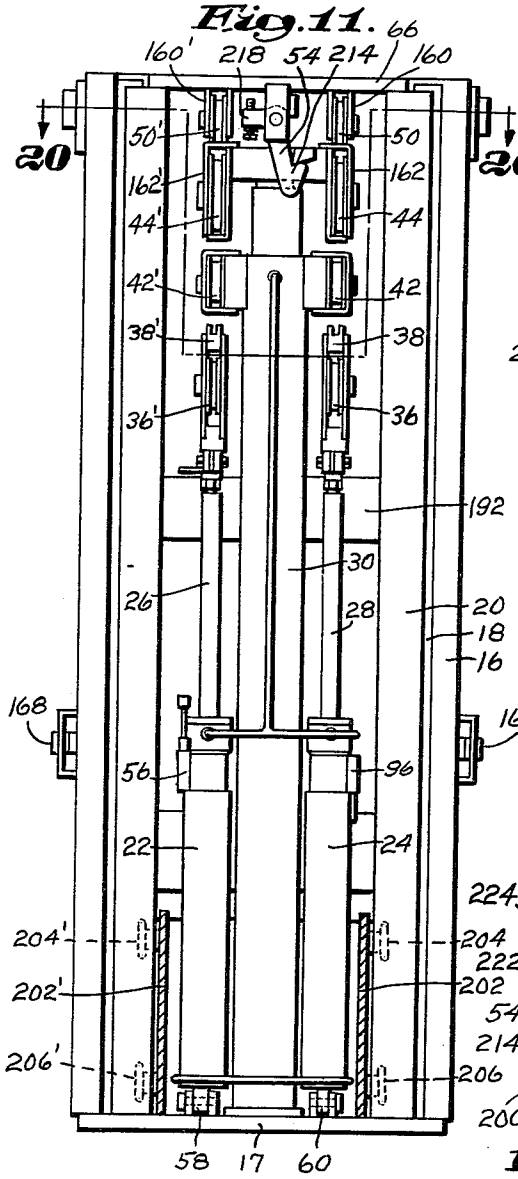


Fig. 12.

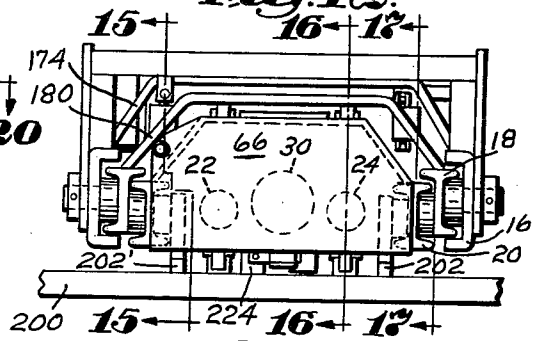


Fig. 13.

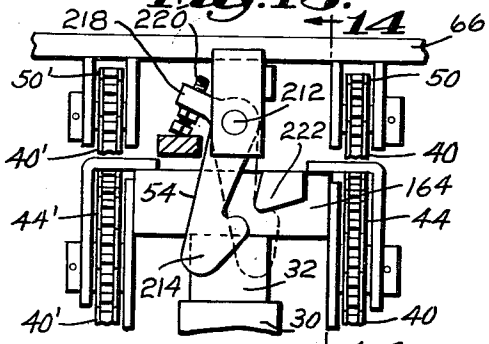
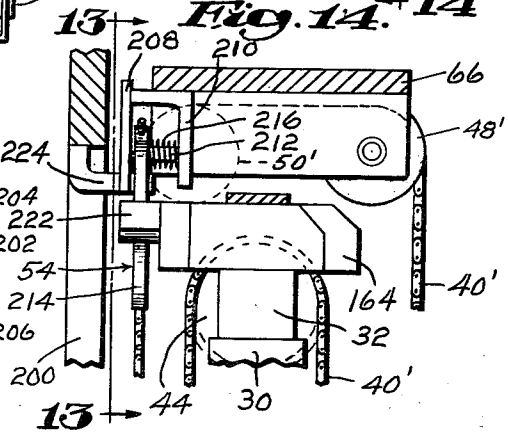


Fig. 14.



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Fig. 15.

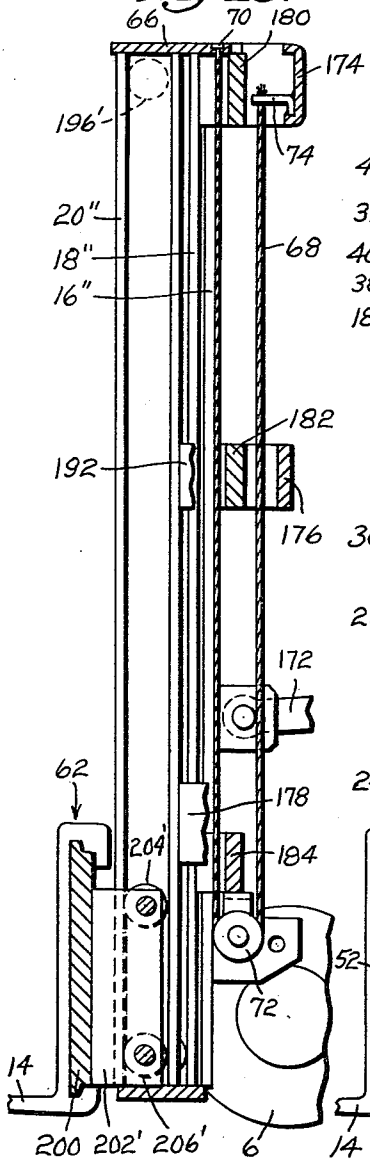


Fig. 16.

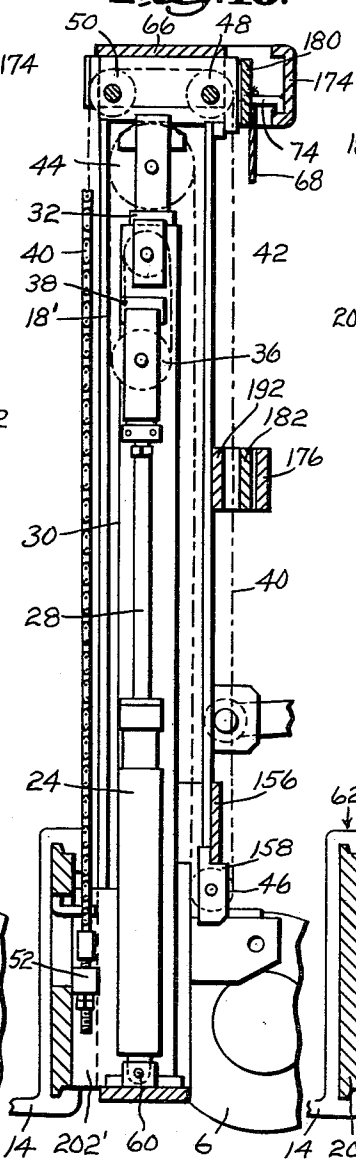
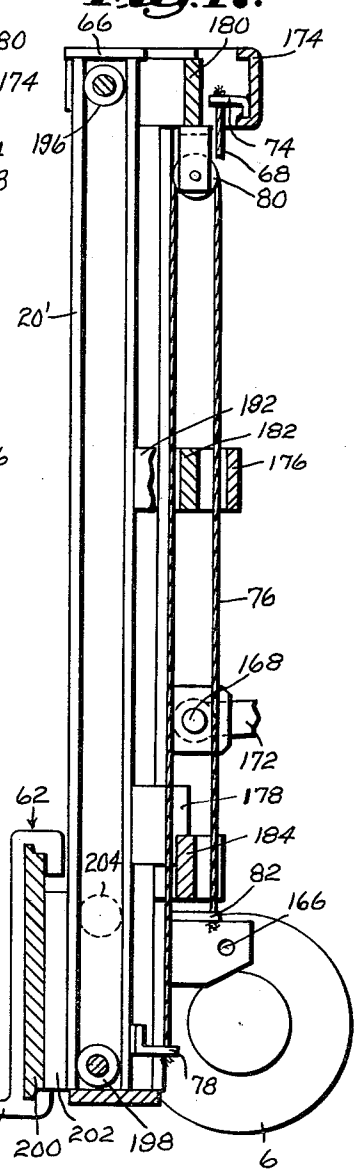


Fig. 17.



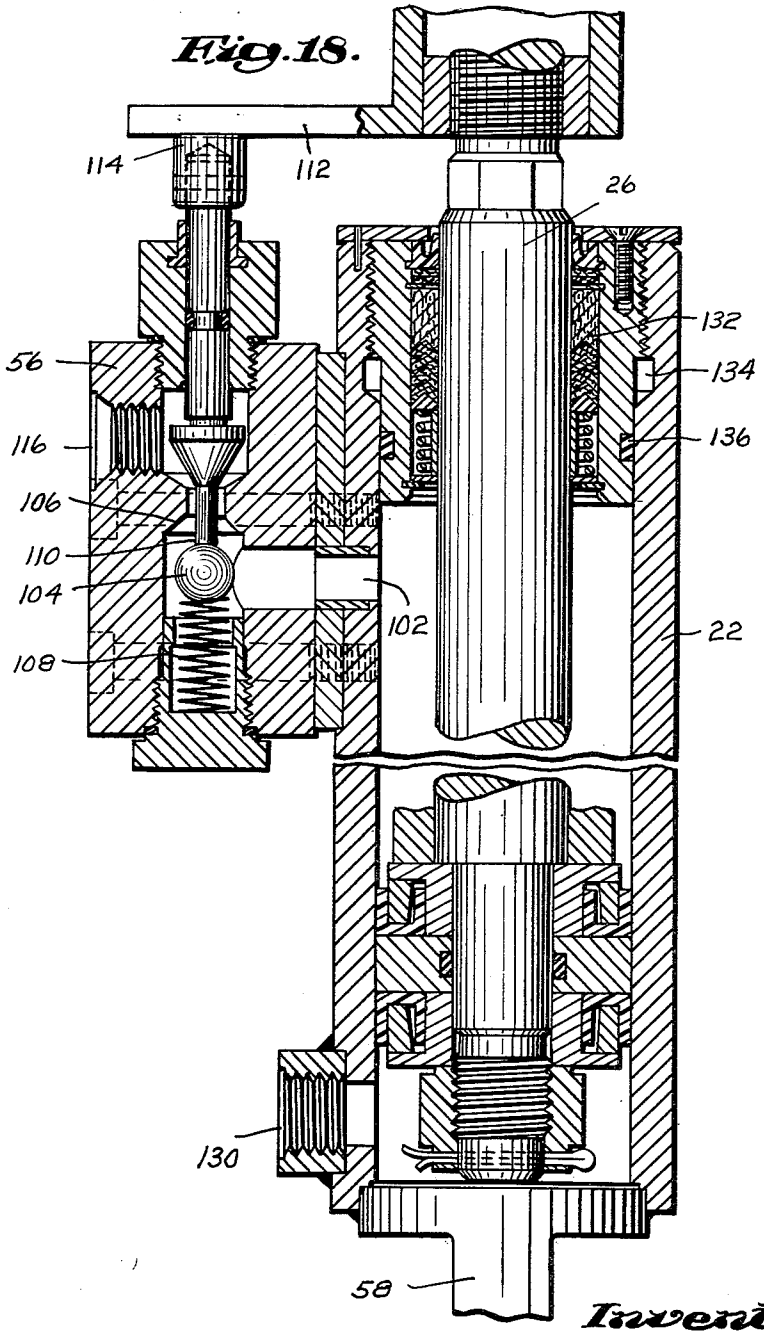
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FORK TRUCK WITH TRI-LIFT MAST

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Fig. 18.



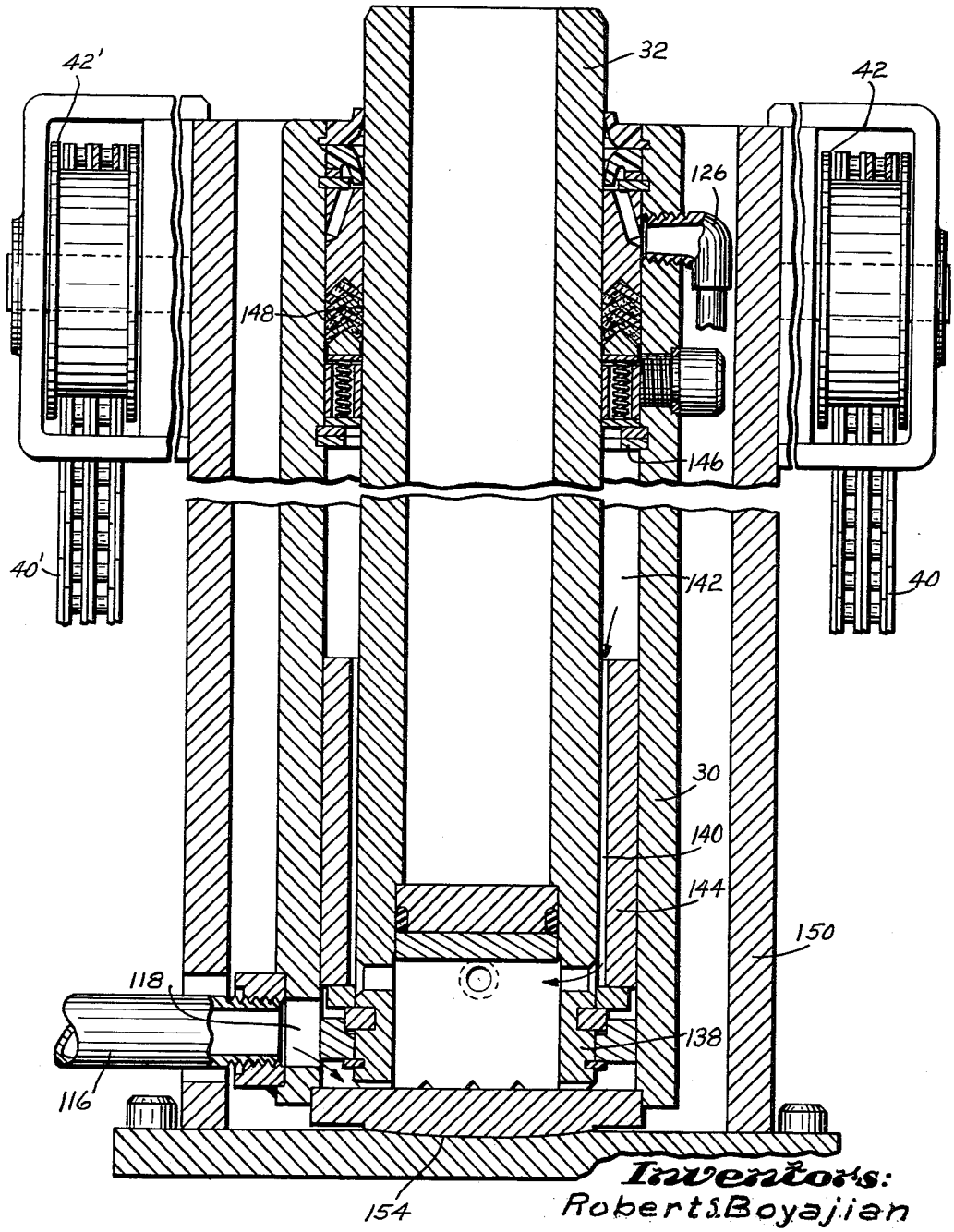
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FORK TRUCK WITH TRI-LIFT MAST

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Fig. 19.



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FORK TRUCK WITH TRI-LIFT MAST

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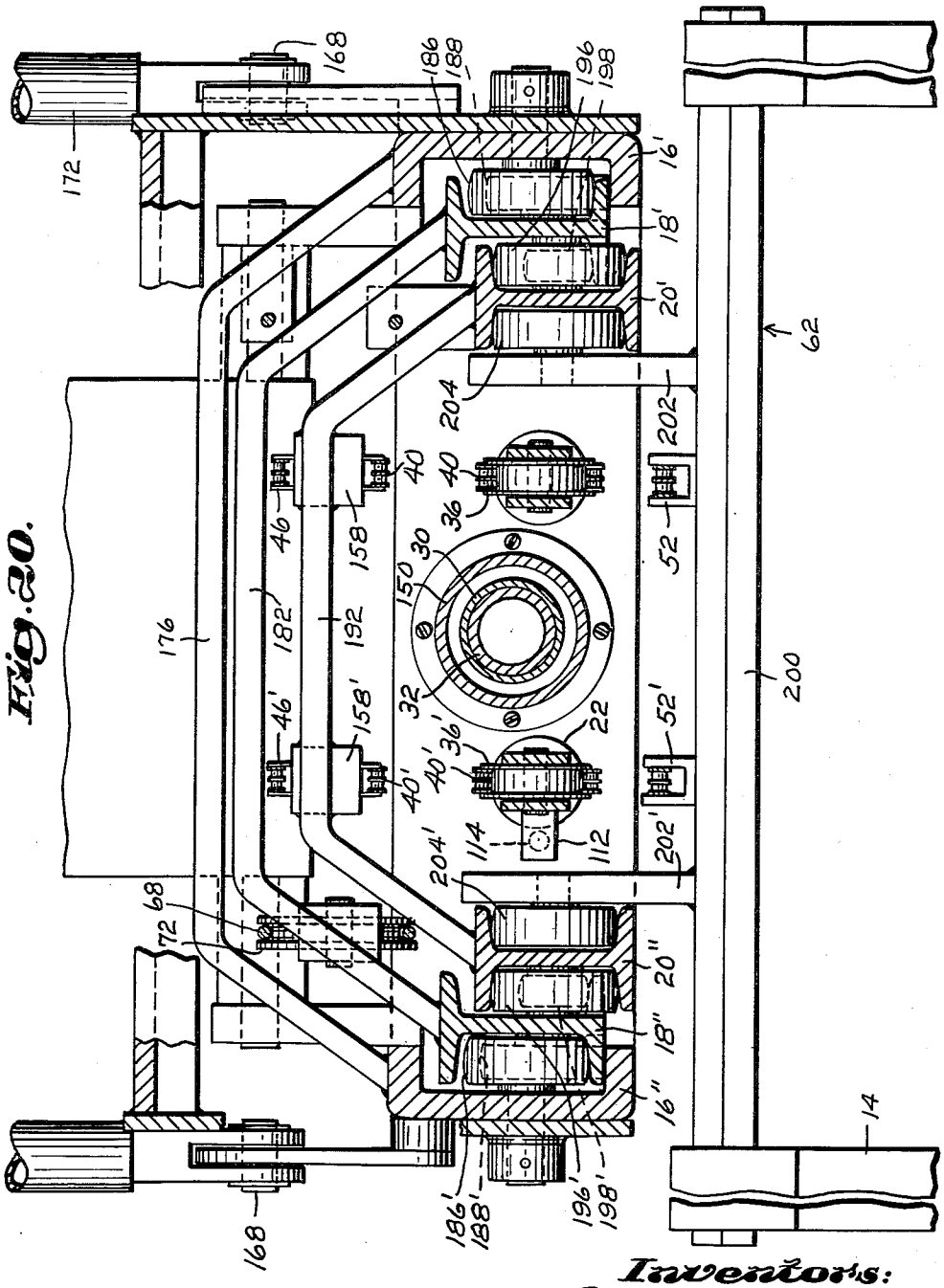


Fig. 20.

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Fig. 21.

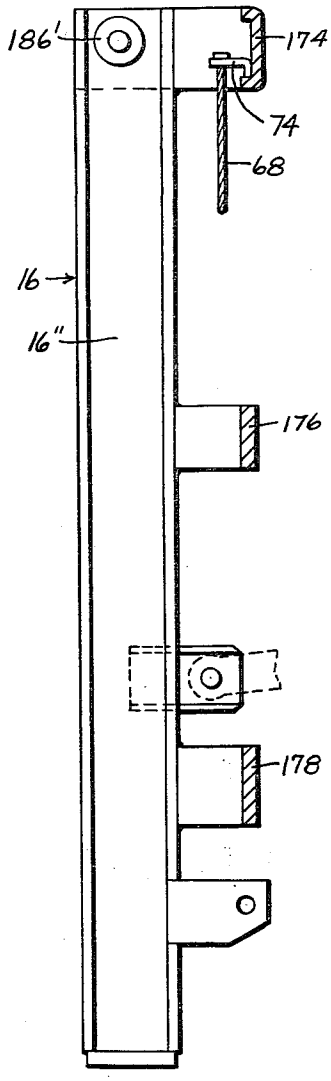


Fig. 22.

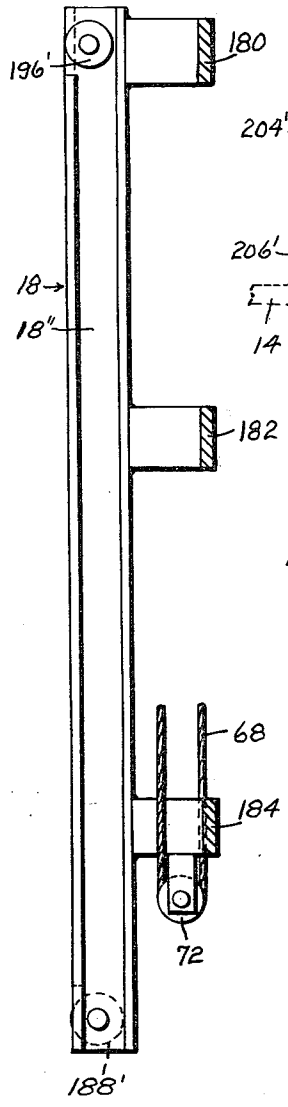
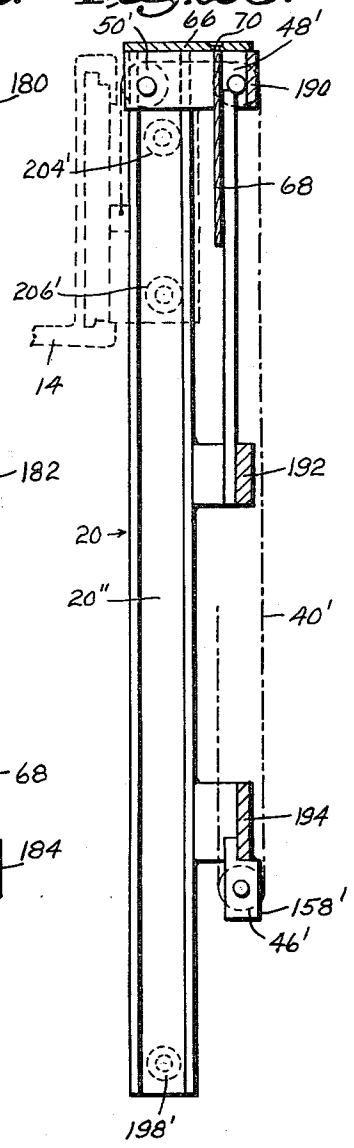


Fig. 23.



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United States Patent Office

3,051,265

Patented Aug. 28, 1962

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FORK TRUCK WITH TRI-LIFT MAST

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Filed June 6, 1960, Ser. No. 34,086
10 Claims. (Cl. 187—9)

This invention relates to fork trucks of the telescoping mast type now in use in industry. The invention is particularly concerned with the provision of a three-part telescoping mast which makes it possible to lift articles to a greater height than is possible with a two-part mast having the same initial collapsed height. A low collapsed mast height is an advantage in many instances where the truck must pass through low doorways or under low overhanging equipment. At the same time, the ability to lift the load to a high level is an essential requirement.

A further object of the invention is to provide a tri-lift or three-part mast having means for achieving full free lift of the fork or carriage for a distance equal to the height of the collapsed masts before there is any extension of the masts themselves.

Another object of the invention is to provide hydraulic means which will provide fluid under a constant pressure acting on the pistons and cylinders of the fork and mast lifting means in such manner that the rate of upward travel of the fork through the period of full free lift and thence on upwardly as the masts are extended will be at a constant speed.

The constant speed movement of the fork under conditions of constant fluid pressure is achieved in the present instance by the utilization of two sets of hydraulic cylinders acting in sequence. One set of cylinders comprises a pair of pull cylinders which act to move the fork upwardly through the full free lift part of its movement at a one-to-three ratio. The other set comprises a single push cylinder. The push cylinder, functioning upon the completion of the movement of the pull cylinders, moves the fork and inner mast upwardly at a ratio of one-to-two and at the same time causes simultaneous and proportional extension of the telescoped intermediate and inner masts. In shifting from the one-to-three ratio to the one-to-two ratio, means is provided whereby the constant pressure fluid will cause the fork to move upwardly through its entire travel at a constant rate. This is important in the safe handling of merchandise. Likewise, valve means in the fluid lines controls the descent at a constant rate.

Another object of the invention is to provide a lift truck having a three-part mast in which the intermediate section is raised and lowered by means associated solely with the fixed and inner masts. The construction insures that the extent of the overlap of the intermediate mast with the fixed and inner masts will at all times be equal though decreasing as the masts rise, thereby providing maximum strength and rigidity of the system throughout the entire extent of the upward movement of the fork.

These and other objects of the invention will become more apparent as the description proceeds with the aid of the accompanying drawings in which

FIG. 1 is a side elevation of the lift truck and the three-part mast, the solid lines representing the mast as it is in collapsed position and the dotted lines showing the intermediate and inner masts partially extended.

FIG. 2 is a fragmentary view of the upper part of FIG. 1 showing the intermediate and inner masts fully extended with the fork in maximum raised position.

FIG. 3 is a front elevation of FIG. 2 including the main mast section shown in FIG. 1.

FIGS. 4, 5, 6 and 7 show in schematic form the basic elements of the construction and the manner in which they function to cause the upward movement of the fork through its initial full free lift (see FIG. 5), an intermediate condition in which the intermediate and inner masts are partially extended (see FIG. 6) and the fully extended condition (see FIG. 7).

FIGS. 8 and 9 are simplified views of the masts looking from the front showing the relationship between the fixed, intermediate and inner masts as they move from collapsed to fully extended position. FIGS. 8 and 9 correspond generally with the views of FIGS. 1 and 2.

FIG. 10 is a diagram of the hydraulic system showing in schematic form the pump and the hydraulic piping leading therefrom to the two laterally disposed pull cylinders which function to lift the fork through its full free lift motion and the centrally located push cylinder which acts to cause the subsequent upward movement of the intermediate and inner masts and the fork which moves directly with the inner mast.

FIG. 11 is a front view of the masts and cylinders, all in collapsed condition showing the aligned pulleys but with the chain hoist omitted for clarity. The latch that acts to hold the inner mast down during the full free lift movement of the fork is shown in engaged position.

FIG. 12 is a plan view of FIG. 11.

FIG. 13 is an enlarged view of the upper central portion of FIG. 11 showing the hold-down latch shifted to unlatched position.

FIG. 13 is an enlarged view of the upper central portion of FIG. 11 showing the hold-down latch shifted to unlatched position.

FIG. 14 is a section taken on the line 14—14 of FIG. 13.

FIGS. 15, 16 and 17 are vertical sectional views showing the mast elements in collapsed position with the fork also at lowermost position. FIG. 15 is taken on the line 15—15 of FIG. 12. FIG. 16 is taken on the line 16—16 of FIG. 12. FIG. 17 is taken on the line 17—17 of FIG. 12.

FIG. 18 is an enlarged vertical sectional view of one of the pull cylinders with the piston in down position. The mechanical sequence valve at the left has just been opened.

FIG. 19 is a vertical sectional view of the push cylinder broken away in part with the ram plunger in down position.

FIG. 20 is an enlarged horizontal section taken on the line 20—20 of FIG. 11 showing in detail the relationship of the fixed, intermediate and inner masts.

FIGS. 21, 22 and 23 are side elevations of the fixed, intermediate and inner masts respectively showing the connection therebetween which results in the intermediate mast moving as the inner mast is actuated by upward movement of the push cylinder.

General Description

The general character of the invention can be seen from FIGS. 1, 2 and 3 in which there is shown a conventional truck 2 which includes in the body 4 a group of storage batteries, an electric motor for driving the truck through actuation of the motor driven wheels 6 and an electrically driven hydraulic pump 8. The pump 8 (shown schematically in FIG. 10), acting through suitable means under the control of a manually operated valve 10 having a handle 12, causes the vertical movement of a fork 14 from position A through its full free lift to position B (see FIG. 1). Thereafter, the pump 8 causes the vertical extension above the main mast 16 of the intermediate and

inner masts 18 and 20 respectively (see FIGS. 1, 2 and 3) and movement of fork 14 to positions C and D. The movement of fork 14 from position A to position B is the extent of the full free lift of the fork. That is to say, when the fork has reached position B, it has traveled the full length of the collapsed masts and there has been thus far no upward movement of either the intermediate or inner masts. Movement from position A to position B of the fork 14 is caused by the functioning of two pull cylinders 22 and 24 shown in FIGS. 3, 10 and 11. When the pistons 26 and 28 in these two cylinders have completed their downward movement, the fork 14 will be at position B. Immediately thereafter the push cylinder 30 takes over and the upward movement of the ram plunger 32 causes the intermediate and inner masts 18 and 20 to move upward at a one-to-two ratio until the masts have become fully extended, as shown in FIGS. 2 and 3, with the fork 14 at its maximum upward position D.

When the handle 12 of the control valve 10 is moved to the lowering position, the oil in the push cylinder 30 bleeds back to the oil reservoir 34 permitting the ram plunger 32 to descend under the weight of the fork and the inner and intermediate masts. When the inner and intermediate masts have reached their lowermost positions and are nested within the main mast, the fork 14 will then be at position B shown in FIG. 1. The weight of the fork is sufficient to lift the pistons 26 and 28 of the two pull cylinders 22 and 24 so that descent of fork 14 continues until it reaches its lowermost position A.

A better understanding of the mode of operation may be obtained from a study of FIGS. 4 to 7 inclusive. In these figures, the various structural elements are shown only schematically and are not representative of their actual configuration. After the mode of operation has been explained by reference to these figures, it is thought that the actual structure shown in the other figures may be more easily comprehended. In FIG. 3, which is a true front view of the mast in extended position, both pull cylinders 22 and 24 are shown, whereas in FIGS. 4 to 7 only one pull cylinder 24 is disclosed. This is believed to suffice for illustration since the two cylinders work in conjunction and together provide the necessary lift.

In FIG. 4, pull cylinder 24 is shown. This has its piston 28 in up position. On the upper end of the piston is a pulley 36. Also on the upper end of piston 28 is a chain connection 38 to which is affixed a chain 40, the chain being indicated in dotted line. Chain 40 passes upwardly around and down over a pulley 42 that is fixed vertically, being attached to the upper end of the push cylinder 30. The chain then travels downwardly around pulley 36, up and then around and down over pulley 44 which is on ram plunger 32 of the push cylinder 30. The chain 40 continues down to the bottom of the masts where it passes around pulley 46 that is secured to the lower end of inner mast 20. The chain then runs up to the top of the inner mast to pass over a pair of spaced pulleys 48 and 50 mounted on the inner mast, thence downwardly to terminate at a lug 52 secured on the back side of the carriage of fork 14.

FIG. 5 shows the first step in the lifting operation. Piston 28 is caused by the hydraulic system to descend in pull cylinder 24, with the pulley 36 and chain connection 38 moving downwardly. All of the other pulleys remain fixed throughout this initial movement. As a result, the fork 14 will be raised through its full free lift to the position B shown in FIG. 5. It might be mentioned that during this full free lift of fork 14 the inner mast 20 is latched against upward movement by latching means 54 shown in FIGS. 11, 13 and 14, which will be explained in detail hereinafter.

Upon arrival of the fork 14 at position B with respect to the inner mast, as shown in FIG. 5, a sequence valve 56 (see FIGS. 10, 11 and 18) is automatically opened, permitting the hydraulic fluid to start to flow into push cylinder 30. This starts the ram plunger 32 moving upwardly, which brings about the situation shown in FIGS. 6 and 7. When the fork 14 has reached position B of FIG. 5, the latch 54 (see FIG. 13) holding the inner mast 20 to the ram plunger 32 is released so that inner mast 20 is now free to move upwardly under the influence of upward movement of ram plunger 32. This upward movement is brought about as follows: Pulley 36 on piston 28 has reached a fixed down position where it is maintained by the continuance of fluid pressure in the pull cylinder 24. Pull cylinders 22 and 24 are pivotally anchored to the bottom plate 17 of the main mast 16. The chain end at the lug 52 has reached the limit of upward travel with respect to inner mast 20 through engagement of the fork structure 62 with the cross plate 66 of the inner mast 20. That is to say, both ends of the chain 40 are now fixed with respect to the main and inner masts at 38 and 52. Therefore, upward movement of pulley 44 affixed to ram plunger 32 causes an upward force to be applied on pulley 46 which in turn, of necessity, lifts inner mast 20. Inner mast 20 is slidable with respect to intermediate mast 18 and intermediate mast 18 is slidable with respect to the fixed mast 16.

Upward movement of intermediate mast 18 is accomplished in the following manner: A cable 68 is secured to inner mast 20 at point 70. This cable 68 extends down and around a pulley 72 mounted at the lower end of intermediate mast 18. The other end of cable 68 is secured to the fixed mast 16 at 74. It is thought apparent from an inspection of FIGS. 5 and 6 that when the inner mast 20 is moved upwardly by the upward movement of ram plunger 32, cable 68 will pull upwardly on pulley 72 to lift intermediate mast 18 at a rate just half that of inner mast 20. This arrangement has the desirable effect of always placing the intermediate mast 18 in a position where it provides as much support to the fixed mast as it does to the inner mast. That is to say, the overlap of the intermediate mast with the fixed and inner masts is always the same but, of course, the amount of the overlap decreases as the inner mast moves higher. However, the extent of the overlap is always sufficient to support the loads that will be present.

In FIG. 7, the inner mast 20 has reached its maximum up position by virtue of the full upward movement of ram plunger 32 which has carried the pulley 44 to its upper limit. Likewise, the intermediate mast 18 has been carried by cable 68 to a maximum up position where it is supporting the inner mast at its uper end and is supported by the fixed mast at its lower end.

Cable 68 has been the means used to cause intermediate mast 18 to rise proportionately with the rise of inner mast 20. Similar means is provided for insuring that intermediate mast 18 will descend in a corresponding proportional manner as inner mast 20 descends. A second cable 76 has one end fastened at 78 to the inner mast. This cable then passes up and around pulley 80 mounted on the upper end of the intermediate mast, with the cable then traveling downwardly to be secured at 82 at the bottom of the fixed mast. Thus as inner mast 20 moves downwardly as permitted by descent of the ram plunger 32, the cable 76, pulling downwardly on pulley 80, compels descent of the intermediate mast 18 with respect to the fixed mast 16. The descent, of course, is limited by cable 68, which acts in opposition. In summary then, cable 68 acts during the rise of inner mast 20 to lift intermediate mast 18 and cable 76 acts during the descent of inner mast 20 to compel corresponding descent of intermediate mast 18. When the inner and intermediate masts have telescoped downwardly to return to the position of FIG. 5, the fork 14 will be at position B. Its weight then is sufficient to lift pull cylinder pistons 26 and 28 from their downward position to their up position as in FIGS. 4, 10 and 11, at which point fork 14 will have dropped to its lowermost position A.

The Hydraulic System

In FIG. 10 is shown the hydraulic system. An oil reservoir 34 is connected with the fluid pump 8 by pipe 84

from which leads pipe 86 to the two-way control valve 10 of known construction and actuated by control handle 12.

When handle 12 is moved to the right, upward movement of the fork is initiated. When the handle 12 is moved to the left, the movement of the fork will be downward. Pipe 86 has a branch 88 leading to an overload relief valve 90 leading back to the reservoir which functions to prevent the development of excessive pressure in the system. Pipe 86, after leaving valve 10, continues on at 92 to feed into the upper end of pull cylinder 24 as at 94. Included in the pipe 92 is a flow control valve 96 which functions to limit the lowering speed of all of the pistons by controlling the rate at which fluid may return through pipe 92 to the reservoir 34.

Another pipe 98, which may be considered a continuation of pipe 92, extends to the upper end of pull cylinder 22 where it enters at 100.

Connected to outlet 102 from the top of pull cylinder 22 is the mechanical sequence valve 56. This valve, the details of which are shown in FIG. 18, comprises a ball 104 which is normally closed in its position against valve seat 106, being held there under the influence of spring 108. The valve can be opened by depressing the valve rod 110. This occurs automatically at the end of the descent of piston 26 by virtue of engagement of the laterally extending finger 112 with the button 114 on the upper end of valve rod 110. The location of finger 112 is such that valve 104 is opened just as piston 26 reaches the bottom of its stroke.

A pipe 116 leads from the sequence valve 56 to the bottom of the push cylinder 30, entering the cylinder at 118. A drain pipe 120 leading back to the reservoir 34 is connected with the upper ends of pull cylinders 22 and 24 by pipes 122 and 124 and to the upper end of push cylinder 30 by pipe 126.

The operation of the hydraulic system is as follows: With pump 8 in operation, handle 12 is moved by the operator to the right. This causes fluid under pressure to flow simultaneously into the upper ends of pull cylinders 22 and 24, simultaneously driving pistons 26 and 28 downwardly. Since the areas of the two pistons are equal, they will descend at the same rate. Just as pistons 26 and 28 together reach the bottom of their strokes, finger 112 opens valve 56 so that fluid then immediately commences to flow through pipe 116 to enter the bottom of push cylinder 30. This causes the ram plunger 32 to start its upward movement, which continues until it reaches the upper end of its stroke or until valve 10 is closed. With valve 10 closed, the fluid under pressure in the pull and push cylinders is locked therein so that the fork is maintained at any desired level. When the fork is to be lowered, the control handle 12 is moved to the left to lower position which reverses the position of the ports in valve 10 permitting the liquid to flow back to the reservoir through pipe 128. The liquid first flows through pipe 116 from the push cylinder as the ram plunger descends under the weight of the fork and the inner and intermediate masts, through sequence valve 56, across the upper end of pull cylinder 22, through pipe 98, control valve 96 and pipe 92, and finally through pipe 128 into the reservoir 34.

When ram plunger 32 has reached the bottom of its stroke with the fork 14 in position B of FIG. 5, both pistons 26 and 28 will be at the bottom of their strokes. Thereafter the weight of fork 14 causes pistons 26 and 28 to rise simultaneously, forcing the liquid above the piston heads back through pipes 98 and 92, valve 10 and pipe 128 into the reservoir.

A drain pipe 130 connected at the bottoms of pull cylinders 22 and 24 permits discharge of air and/or accumulated oil in the bottoms of the pull cylinders back to reservoir 34 as the pistons 26 and 28 complete their downward strokes.

Details of the cross-section of piston 26 are shown in FIG. 18, but since this structure is in general known in the art and does not constitute the invention it is thought no detailed description need be supplied except to point out that there is adequate packing 132 to prevent leakage along piston 26 and the drain pipe 122 is connected with the circumferential groove 134 to drain off any oil that may get by the sealing ring 136. The construction of cylinder 24 and piston 28 is the same as that of cylinder 22 and piston 26.

The details of the construction of push cylinder 30 and ram plunger 32 are shown in FIG. 19. Oil entering through port 118 is effective against the under side of the piston head 138. Oil may also pass upwardly through the cylindrical passage 140 to fill the cylindrical space 142. As ram plunger 32 moves upwardly, the oil in space 142 flows downwardly through space 140 without resistance to the piston head as the forces on sleeve 144 are balanced. Upward movement of the ram plunger is limited by engagement of sleeve 144 with the circumferential stop 146. Any leakage of oil past the packing 148 will drain off through drain 126.

The Chain Hoist and Pulley System

As best seen in FIG. 19, the push cylinder 30 is positioned within a cylindrical tube 150 which carries on opposite sides of its upper end the fixed pulleys 42 and 42'. It will be understood that, whereas a single chain 40 and a single set of related pulleys was shown in FIGS. 4, 5, 6 and 7, there are in fact two chains and two sets of pulleys which are actuated by the pull pistons and the ram plunger. These pulleys and the related second chain will be designated by the same numbers found in FIGS. 4 to 7 plus the addition of the prime.

In FIG. 10, the pulleys 36 and 36' are carried by a pair of forks 152 and 152' on the upper ends of pistons 28 and 26 respectively. The pulleys 42 and 42' are mounted on opposite sides of the upper end of tube 150 as heretofore explained. The object of providing the extra tube or support cylinder 150 is to free the push cylinder 30 from distorting forces applied through pulleys 42 and 42' while at the same time providing a construction which will maintain these pulleys in a fixed relation to the push cylinder. Furthermore, it will be noticed in FIG. 19 that the lower end of push cylinder 30 is mounted in a shallow cupped surface 154 which permits the push cylinder 30 to be self-aligning as the ram plunger 32 is extended.

The pulleys 46 and 46' are secured to a cross brace 194 of inner frame 20 by means of fork-shaped brackets 158 and 158' best seen in FIGS. 16, 20 and 23. The pulleys 48, 48', 50 and 50' are attached by suitable brackets 160 and 160' depending from the under side of cross plate 66 that connects the upper ends of the parallel I-beams 20' and 20'' that constitute the inner mast 20.

The pulleys 44 and 44' are carried by brackets 162 and 162' on the ends of a transversely extending plate 164 on the upper end of ram plunger 32.

The Mast Construction

Referring to FIGS. 1 and 20, the fixed mast 16 is pivoted to the truck at 166. A short distance above this, mast 16 is connected to 168 and 170 with a pair of hydraulic cylinders, one of which is shown in FIG. 1 at 172. The pistons, when actuated by the truck operator, enable the mast 16 to be tilted within limits forward and backward from the vertical. It is tilted forward when the fork 14 at bottom position A is to be inserted below an article to be lifted. After the merchandise has been picked up, the mast 16 is tilted backward so that the goods will be better balanced with respect to the truck as the load is raised. This construction is in common use in trucks of this type and does not constitute any part of the present invention.

Referring to FIG. 20, which is a section taken on the line 20—20 of FIG. 11, it can be seen that the fixed mast 16 comprises a pair of spaced channels 16' and 16'' connected by crosswise extending braces 174, 176 and 178

(see FIGS. 20 and 21). The lower ends of channels 16' and 16'' rest on and are connected by a bottom plate 17. The intermediate mast 18 comprises a pair of spaced I-beams 18' and 18'', the outer flanges of which fit within the confines of the channels 16' and 16''. The connecting braces for intermediate mast 18 are numbered 180, 182 and 184 (see FIGS. 20 and 22). Two rollers 186 and 186' mounted near the upper ends of channels 16' and 16'' and another pair of rollers 188 and 188' mounted on the lower ends of I-beams 18' and 18'' guide the intermediate mast 18 with respect to the fixed mast 16 as the former moves up and down with respect to the latter. As can be seen in FIGS. 20 and 23, the inner mast I-beams 20' and 20'' are connected by braces 190, 192 and 194.

The inner I-beams 20' and 20'' are guided with respect to the intermediate mast I-beams by two pairs of rollers 196 and 196' and 198 and 198', the first pair being secured to the upper ends of members 18' and 18'' and the second pair being secured to the lower ends of I-beams 20' and 20''. Thus as members 18 and 20 are extended upwardly with respect to fixed mast 16 they will be maintained in aligned condition and move easily by virtue of the included rollers.

As can be seen in FIGS. 15 and 20, the fork 14 comprises a vertical plate 200 from which extend rearwardly a pair of parallel vertical plates 202 and 202' each carrying on its outer face a pair of vertically spaced rollers 204 and 206 on plate 202 and 204' and 206' on plate 202'. These rollers fit within the confines of the inner flanges of I-beams 20' and 20''. As can be seen in FIG. 20, the chains 40 and 40' are connected to the plate 200 at 52 and 52'. Thus as the fork 14 is initially raised, it is guided in a vertical direction by the I-beams of inner mast 20.

Upward movement of fork 14 with respect to inner mast 20 is limited by the engagement of the upper edges of plates 202 and 202' with the under side of cross plate 66 that connects the upper ends of I-beams 20' and 20'' of the inner mast.

The Latching Mechanism

Referring to FIGS. 11, 12, 13 and 14, there is shown a latching mechanism 54 which holds the inner mast 20 latched to the upper end of ram plunger 32. The object of this construction is to prevent any upward movement of the inner mast until the fork 14 has reached the upper limit of its full free lift. The construction of the latch and the means by which it is unlatched at the appropriate time will now be described.

Depending from cross plate 66 that connects the upper ends of the I-beams of the inner mast is a bracket 208 and an inner depending plate 210 between which extends a shaft 212 having pivoted thereon a hook 214. As viewed in FIGS. 11 and 13, the hook is urged counterclockwise by a spring 216 shown in FIG. 14. A short lever arm 218 extends laterally from the body of the hook adjacent shaft 212. This arm has associated therewith an adjustment screw 220 making it possible to adjust the instant of release of the hook from a detent 222 which is an integral part of the plate 164 on the upper end of ram plunger 32. Since ram plunger 32 cannot move upwardly until hydraulic fluid is forced into the lower end of push cylinder 30, it follows that so long as hook 214 is in engagement with detent 222 the inner mast cannot move upwardly during the initial upward movement of fork 14 caused by the downward movement of the pull cylinder pistons 26 and 28.

The vertical face plate 200 of fork 14, as can be seen in FIG. 14, has a short rearwardly extending finger 224 which is so located as to engage the adjustment screw 220 on arm 218 just prior to the engagement of vertical plates 202 and 202' with the under side of cross plate 66. In other words, just as the fork reaches the upper limit of its travel with respect to the full free lift aspect of its movement, the inner mast 20 will be released from the ram plunger 32. The unlatching occurs substantially coincidentally with the opening of mechanical sequence valve 56 which occurs as the pull cylinder pistons 26 and 28 complete their downward movement which brings the fork to position B where its full free lift is completed. The sequence valve 56 can be adjusted to open ahead of the completion of the upward movement of the fork 14, in which case the inner mast 20 and ram plunger 32 will start moving upwardly together since the hook 214 has not as yet been released from detent 222 by the completion of the upward movement of fork 14. However, the upward movement of fork 14 is completed within a matter of a few inches of movement of ram plunger 32, whereupon hook 214 is released and upward movement of inner mast 20 then proceeds at a ratio of two-to-one with respect to the movement of ram plunger 32.

When the masts have been lowered and re-telescoped, automatic engagement of hook 214 with detent 222 occurs so that the parts are conditioned for the next lifting operation.

Means for Obtaining Uniform Rate of Travel

As has already been explained, the fork 14 is initially raised by the two pull cylinders at a distance ratio of three-to-one. That is to say, one foot of travel of the pistons in the pull cylinders raises the fork three feet. When the full free lift has been completed by the movement of the pull cylinder pistons, the subsequent upward movement of the fork and inner and intermediate masts is caused by the operation of the single centrally located push cylinder 30. The ratio of upward movement of the fork to the upward movement of the ram plunger 32 of the push cylinder 30 is two-to-one. Since the pumping rate and pressure of the hydraulic pump 8 is constant, it is necessary to properly relate the cylinder diameters if a constant upward speed is to be maintained as the shift is made from a three-to-one to two-to-one ratio. This is accomplished by having the effective area of the central push cylinder equal to two-thirds of the combined annular areas of the two pull cylinders. By so doing, uniform hydraulic pressure and displacement throughout the entire carriage travel will achieve the uniform speed conditions required. For example, if the effective cross-sectional area of the piston in the push cylinder was four square inches, then the effective cross-sectional area of the pistons in the two pull cylinders should be three square inches each. The volume of fluid to be pumped into the pull cylinders for one foot movement of the pistons would be 3×12 plus 3×12 equals 36 plus 36 equals 72 cubic inches of hydraulic fluid. This would result in a three-foot movement of the fork in a unit of time. When the push cylinder takes over, the movement of the ram plunger to produce a three-foot movement of the fork would be one and one-half feet or eighteen inches. Thus with an effective piston area of four square inches the volume of fluid to be pumped to move the ram plunger eighteen inches would be 4×18 or 72 cubic inches, the same volume that had been pumped in the same unit of time into the pull cylinders. In other words then, it can be seen that the fork, regardless of the load thereon, can be raised at a constant speed throughout its entire range of travel by a pump supplying a constant volume at a constant pressure in a fixed unit of time, even though the piston to travel ratio shifts from three-to-one to two-to-one.

Summary of Operation

With the mast collapsed and the fork in lowermost position, the operator will maneuver the truck to place the fork under the load to be lifted. By manipulation of valve handle 12, the fork may then be raised to lift the load from the floor. With the fork any place between lowermost position A and position B, which is the upper limit of the full free lift, there will be no extension of the masts so the truck while in this condition is free to proceed

while still in its minimum height condition. Thus it may pass readily under low doorways and the like. At the discharge position, the load will be raised to the required height which may be any height up to position D illustrated in FIGS. 3 and 7.

As soon as the fork **14** moves above position B, the proportionate extension of the inner and intermediate masts will occur, with the intermediate mast movement being caused by the cooperation of cables **68** and **76** with the pulleys **72** and **80**.

When the valve handle **12** is moved in the opposite direction so that the hydraulic fluid may flow back to the oil reservoir, descent of the extended masts is initiated, but the fork **14** will remain at the top of the inner mast until the inner and intermediate masts are fully collapsed to the position illustrated in FIG. 5. At this point, the descent of the fork **14** from position B commences and will continue until the lowermost position A is reached. Gravitational forces alone cause the descent of the masts and fork.

It is our intention to cover all changes and modifications of the examples of the invention herein chosen for purposes of the disclosure which do not constitute departures from the spirit and scope of the invention.

We claim:

1. A tri-lift fork truck comprising a fixed mast, an intermediate mast and an inner mast, a fork mounted on and movable vertically with respect to the inner mast, a pair of pull cylinders having their lower ends fixed with respect to said fixed mast, cooperating pistons in said pull cylinders and chain and pulley means actuated by said pistons for raising said fork at a three-to-one ratio through its full free lift with respect to said inner mast while the inner mast is held in fixed relation to said fixed mast, a push cylinder and ram plunger therein operable only upon completion of the movement of the pistons in said pull cylinders, means comprising the same chain and pulleys acting in cooperation with the upward movement of said ram plunger for raising said inner mast and fork with respect to said fixed mast at a two-to-one ratio, and other means independent of said chain and pulleys for causing said intermediate mast to move up and down along with said inner mast at a rate equal to one-half that of the inner mast.

2. A tri-lift fork truck comprising a fixed mast, an intermediate mast movable vertically with respect to said fixed mast, and an inner mast movable vertically with respect to said intermediate mast, a fork mounted for vertical movement with respect to said inner mast, a push cylinder centrally located with respect to said masts, a pair of pull cylinders and pistons therein fixed with respect to said fixed mast and located on either side of said push cylinder, a pair of chains secured to said fork, said chains extending from said fork upwardly and rearwardly over top rollers secured to the top of said inner mast, said chains extending downwardly from said inner mast top rollers and passing over lower rollers affixed to the lower end of said inner mast, said chains extending upwardly and passing over ram plunger rollers affixed to opposite sides of the upper end of the ram plunger of said push cylinder, said chains extending downwardly and passing around pull cylinder rollers secured to the upper ends of the pistons of said pull cylinders, said chains extending upwardly and passing around push cylinder rollers fixed with respect to the upper end of said push cylinder, said chains extending downwardly and terminating at and affixed to the upper ends of the pistons of said pull cylinders, whereby when said pistons of said pull cylinders are moved downwardly said fork will move upwardly with respect to said inner mast at a three-to-one ratio and whereby when said fork has reached the upper limit of its travel with respect to said inner mast and the said ram plunger of said push cylinder is moved upwardly said fork and inner mast will move upwardly with respect to said ram plunger at a two-to-one ratio, the movement of the pistons in said pull cylinders and the ram plunger in said push cylinder being caused by a hydraulic pump system supplying fluid under constant pressure and at a constant volume per unit of time, the effective area of the said pistons and ram plunger being such that the rate of upward movement of said fork will be constant whether it is moved by said pull cylinders or said push cylinder.

3. In a fork truck of the type described, a tri-lift mast comprising a fixed mast, an intermediate mast and an inner mast, a fork movable with respect to said inner mast, means for moving said fork from the bottom of said inner mast to the top of said inner mast, other means for moving said inner mast upwardly while said fork is at the top thereof with respect to said intermediate mast and said fixed mast, and independent means for causing said intermediate mast to move upwardly with said inner mast at the ratio of one-to-two, said independent means comprising a cable secured close to the tops of said fixed mast and said inner mast and passing over a pulley fixed near the bottom of said intermediate mast.

4. In a fork truck of the type described, a fixed mast, an intermediate mast and an inner mast, a fork movable with respect to said inner mast, a hydraulically operated system for causing lifting of said fork from the bottom to the top of said inner mast and for then causing the lifting of said inner mast and intermediate mast, said hydraulic system comprising a pair of pull cylinders and pistons and a single push cylinder and ram plunger located between said pull cylinders, said cylinders being secured against longitudinal movement with respect to said fixed mast, chains and pulleys associated with said inner mast, said fork, said push cylinder and said pull cylinders whereby downward movement of the pistons of said pull cylinders will raise said fork to the top of said inner mast at a three-to-one ratio, and whereby upward movement of said ram plunger will cause upward movement of said inner mast at a two-to-one ratio, said pull cylinders having a combined effective piston area which is three-halves the effective piston area of said push cylinder, said chain and pulley means arranged to produce, under conditions of constant hydraulic volume and pressure, constant speed upward movement of said fork with respect to said inner mast and said inner mast with respect to said fixed mast, and means for preventing upward movement of said ram plunger until said pistons have substantially completed their downward movement.

5. In a tri-lift fork truck which includes a fixed mast, an intermediate mast and an inner mast and a fork movable vertically with respect to said inner mast, a hydraulic system comprising a pair of pull cylinders having their closed ends fixed adjacent the bottom of said fixed mast, pistons in said pull cylinders, means actuated by downward movement of said pistons of said pull cylinders for raising said fork through its full free lift from the bottom to the top of said inner mast, a push cylinder intermediate said pull cylinders, said push cylinder having a ram plunger movable upwardly to move said inner mast upwardly with respect to said fixed and intermediate masts, a hydraulic pump and piping including a control valve leading to said pull cylinders whereby upon opening of said control valve the pistons of said pull cylinders will be moved downwardly by the hydraulic fluid, a pipe leading from said pull cylinders to said push cylinder, a sequence valve normally closed in said last mentioned pipe, and means controlled by one of said pull cylinder pistons for causing said sequence valve to open at or about the time the pistons in said pull cylinders have reached the end of their downward travel, whereby the ram plunger of said push cylinder will commence upward movement as soon as the downward movement of the pistons of said pull cylinders has stopped, chain and pulley means connecting said pistons of said pull cylinders to said fork whereby downward movement of said pull cylinder pistons will cause upward movement of

said fork at a one-to-three ratio, means for supplying constant hydraulic pressure first to said pull cylinders and thereafter, upon opening of said sequence valve, to said push cylinder, the effective piston areas of said pull cylinders totaling three-halves of said push cylinder, whereby upward movement of said fork through its full free lift will be at the same rate as the subsequent upward movement of the said inner mast.

6. In a fork truck of the type described, a fixed mast, an intermediate mast and an inner mast arranged in telescoped condition, each of said masts comprised of a pair of vertically extending spaced members connected by crosswise braces, a fork mounted for vertical movement on the members of said inner mast, two pull cylinders with pistons mounted between the members of said inner mast and in fixed relation to said fixed mast, a push cylinder with a ram plunger, two sets of vertically aligned pulleys, each set located as follows: a pulley at the top of said inner mast, a pulley at the bottom of said inner mast, a pulley on said ram plunger, a pulley on said piston below said ram plunger pulley, a pulley fixed with respect to said push cylinder and disposed vertically between said ram plunger and piston pulleys, two chains each extending from said fork and passing successively over one set of said pulleys and terminating at the upper end of said piston, means for forcing hydraulic fluid first into said pull cylinders to move the pistons downward to draw said chain over said pulleys and thereby to move said fork to the top of said telescoped masts at a three to one ratio and thereafter to force said fluid into said push cylinder to move said ram plunger upward to draw said chains solely over said ram plunger pulleys and thereby to move said inner mast upwardly at a two to one ratio.

7. In a fork truck of the type described, a fixed mast comprising spaced vertical members, an intermediate mast comprising spaced vertical members located between the fixed mast members and vertically movable relative thereto, an inner mast comprising spaced vertical members between the intermediate mast members and vertically movable relative thereto, a fork mounted on said inner mast and movable vertically relative thereto, first hydraulic means for moving said fork for its full free lift relative to said inner mast at a three to one ratio and second hydraulic means for thereafter moving said inner mast relative to said fixed mast at a two to one ratio, and other means for simultaneously moving said intermediate mast with and in the direction of movement of said inner mast at a rate which will maintain equal mast overlaps.

8. In a fork truck of the type described and comprising first, second and third telescoped masts and a fork mounted on and vertically movable on said third mast, a hydraulic fluid actuated system for moving said fork with respect to said third mast and for sequentially moving said second and third masts with respect to said first mast, said system comprising a fluid pump, a pair of pull cylinders with the pistons thereof extended when said masts are in telescoped position, a push cylinder with its ram plunger in contracted position when said masts are in telescoped position, a manually actuated control valve, piping extending from said pump to said valve and thence to said pull cylinders, piping leading from the pressure side of one of said pull cylinders to said push cylinder, a sequence valve in said last named piping which is normally closed when said masts are telescoped, and means actuated by the downward movement of the piston of one of said pull cylinders to open said sequence valve to cause sequential operation of the ram plunger of said push cylinder, means moved by said pull cylinders for solely moving said fork with respect to said third mast, and other means moved by said push cylinder for solely moving said third mast with respect to said first mast, and means actuated by said third mast for moving said second mast in the direction of movement of said third mast at a rate which will maintain equal mast overlaps.

9. In a fork truck of the type described, three telescoped and extendable masts comprising a fixed mast, an intermediate mast and an inner mast, an hydraulic circuit including therein a pair of fixed pull cylinders and pistons therein and a fixed push cylinder with a ram therein, means in said circuit for causing sequential operation of said pistons and ram, a fork movably mounted on said inner mast, means actuated by said pull cylinders for moving said fork to the top of said inner mast, stop means for limiting the upward movement of said fork with respect to said inner mast, the ram of said fixed push cylinder being in contracted position when said masts are telescoped, a latch holding said inner mast to said ram plunger during operation of said pull cylinders, means on said fork for releasing said latch shortly before said fork has engaged said stop means, means operable by said ram plunger after release of said latch for moving said inner mast and elevated fork upwardly with respect to said fixed mast, and means for simultaneously moving said intermediate mast upwardly as said inner mast moves upwardly.

10. In a fork truck of the type described and comprising a plurality of telescoped and extendable masts one of which is fixed against vertical movement, a fork vertically movable on one of said movable masts, two hydraulically operated pistons of identical stroke and a single piston of longer stroke, means for causing actuation of said two pistons and single piston in sequence only, means actuated by said two pistons for moving said fork with respect to a movable mast at a ratio of one to three, and other means actuated by said single piston only after completion of the travel of said fork with respect to said movable mast for moving said movable mast at a ratio of one to two, the rate of travel of said fork with respect to said movable mast being the same as the rate of travel of said movable mast with respect to said fixed mast whereby said fork during its entire upward movement will travel at a constant rate with respect to said fixed mast.

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