United States Patent [19]

Kelley, Jr.

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[45] **Oct. 30, 1973**

[54] **LIFT TRUCK MAST**

[75] Inventor: **Wilfred H. Kelley, Jr.,** Maple Plain, Minn.

[73] Assignee: **White Farm Equipment Co.,** Hopkins, Minn.

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[21] Appl. No.: **55,064**

[52] **U.S. Cl.** **187/9,** 187/95, 214/671, 308/6

[51] **Int. Cl.** **B66b 9/20**

[58] **Field of Search** 187/9

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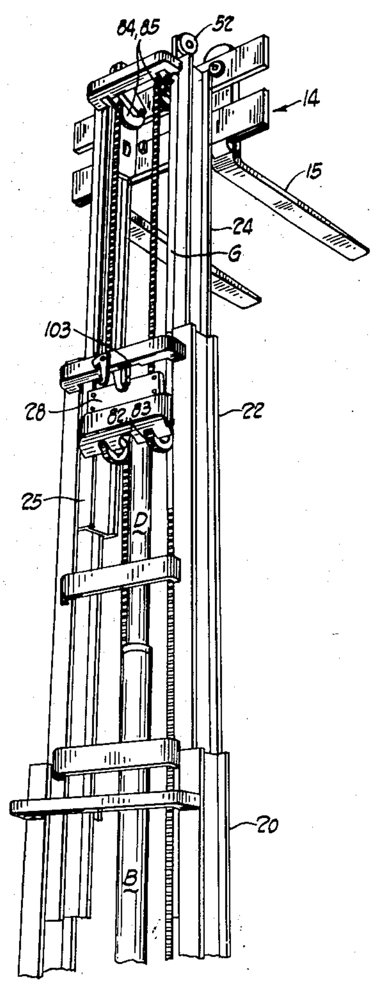
Primary Examiner—Evon C. Blunk
Assistant Examiner—H. S. Lane
Attorney—Watts, Hoffmann, Fisher & Heinke

[57] **ABSTRACT**

A lift truck mast having extensible uprights received one within the other. Each upright includes a pair of rail members each of which has a web and flanges such that the members are I-shaped in cross section. The rail members are nested together with the web portion and end flanges of the inner overlapping the web portions and end flanges to the outer. The web portions of one rail member carry rollers which ride on the rear end flanges of the adjacent nested rail member. Each web portion, when viewed in cross section, provides a straight section of uniform thickness and a tapered portion gradually increasing in thickness toward the rear end flange. The rollers are spaced from, but mounted parallel to, the straight web portions so as to rotatably engage the rear end flanges and tangentially contact the tapered web portion. Forward mast bending loads are taken radially by the rollers and side thrust loads parallel to their axes of rotation for improved anti-friction properties and longer wear.

10 Claims, 19 Drawing Figures



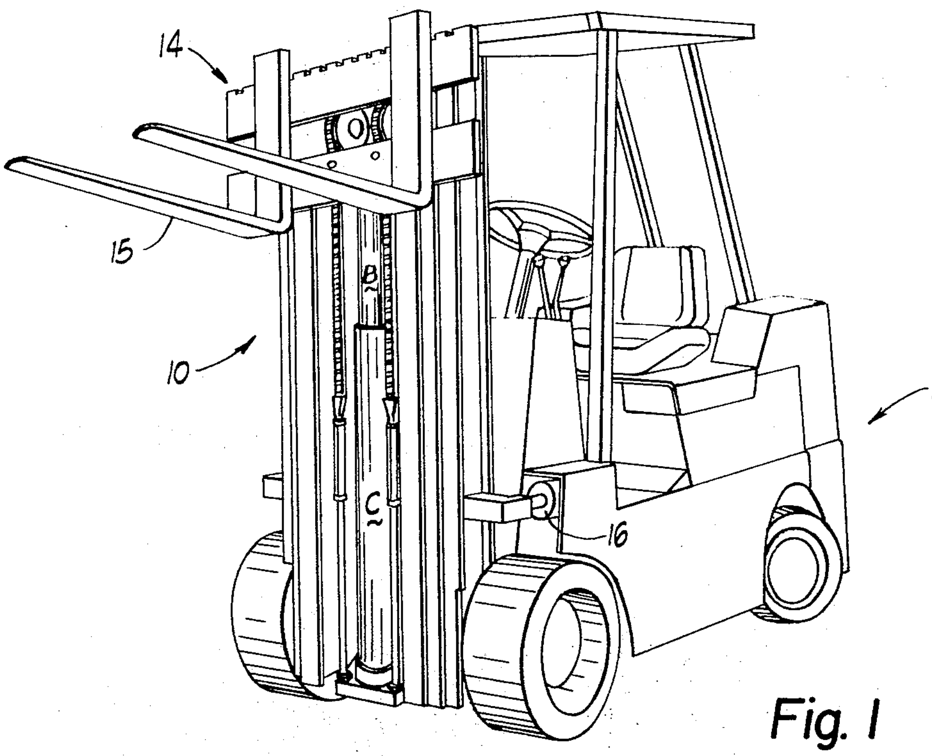


Fig. 1

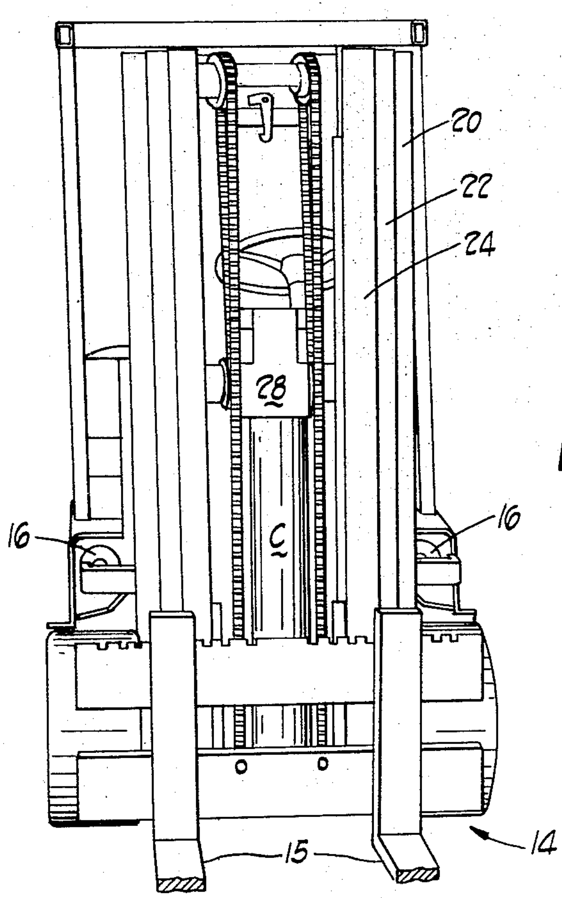
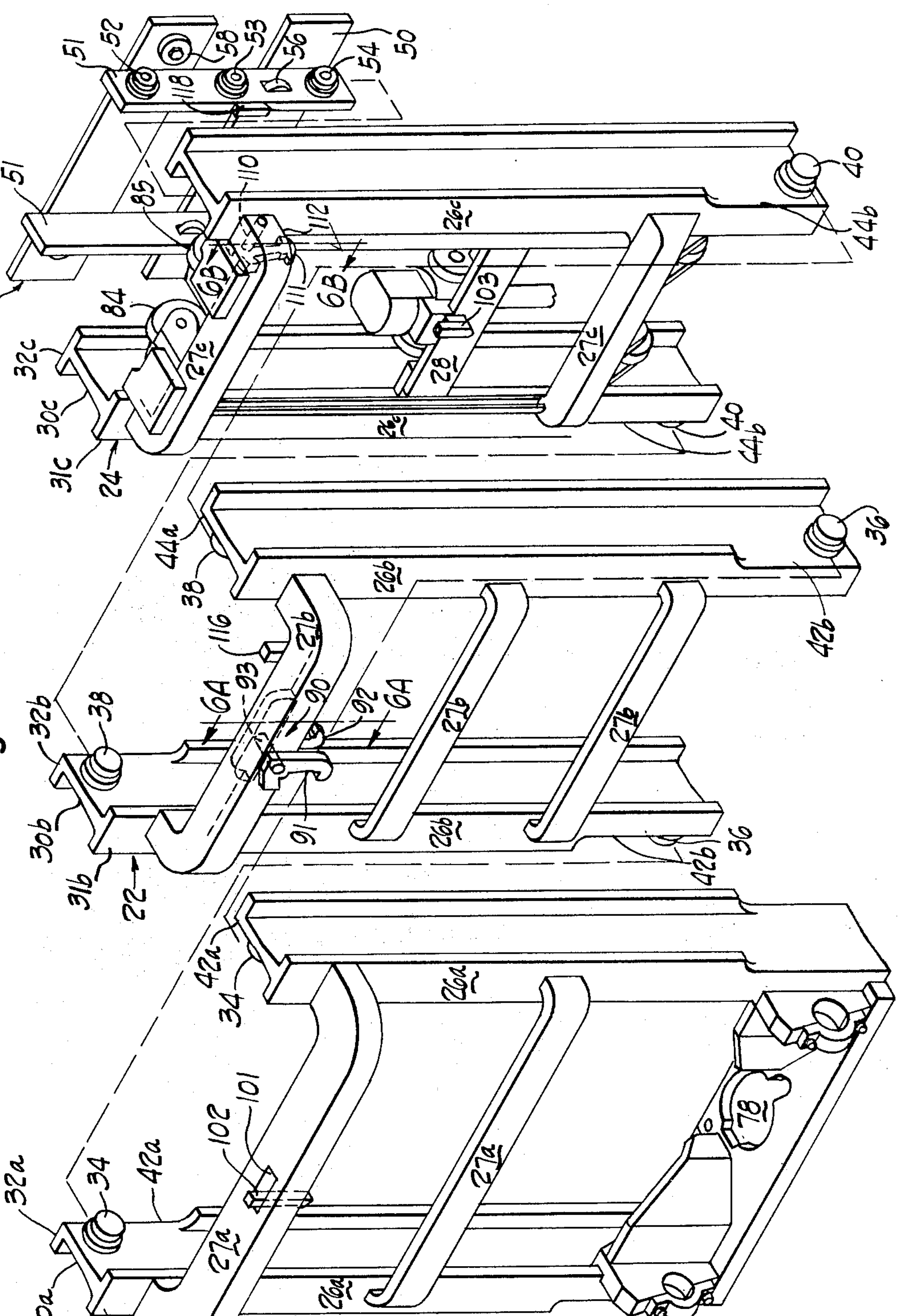


Fig. 1A

INVENTOR.
WILFRED H. KELLEY JR

BY Watts, Hoffmann, Fisher & Heinke
ATTORNEYS

Fig. 2



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WILFRED H. KELLEY JR

BY Watts, Hoffmann,
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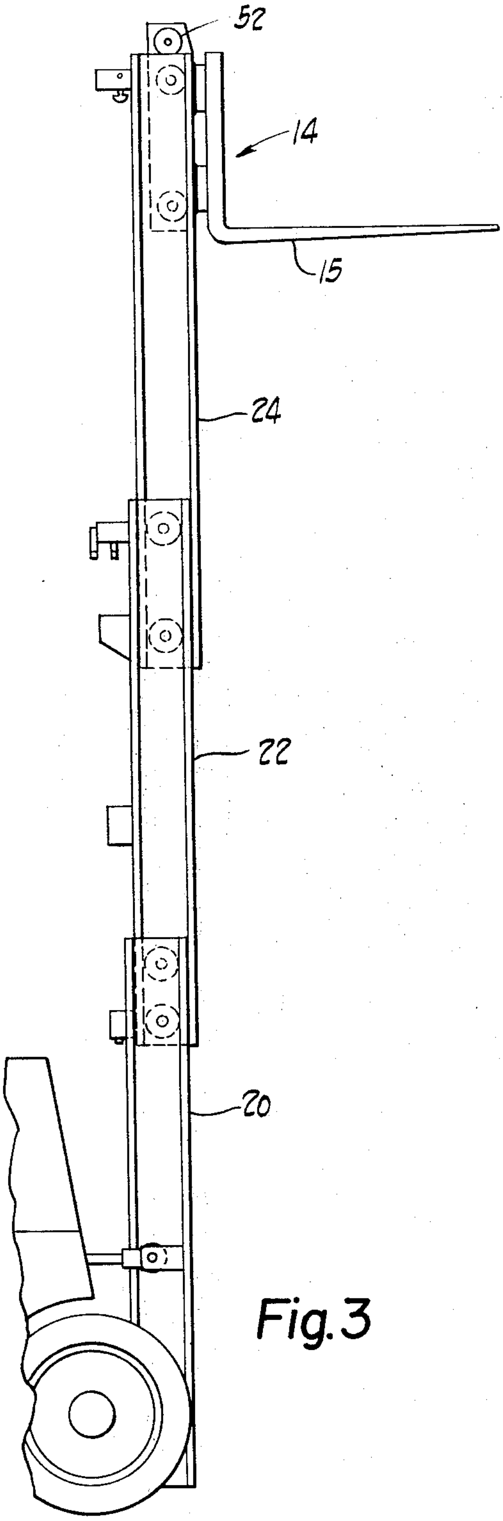

Fig.3

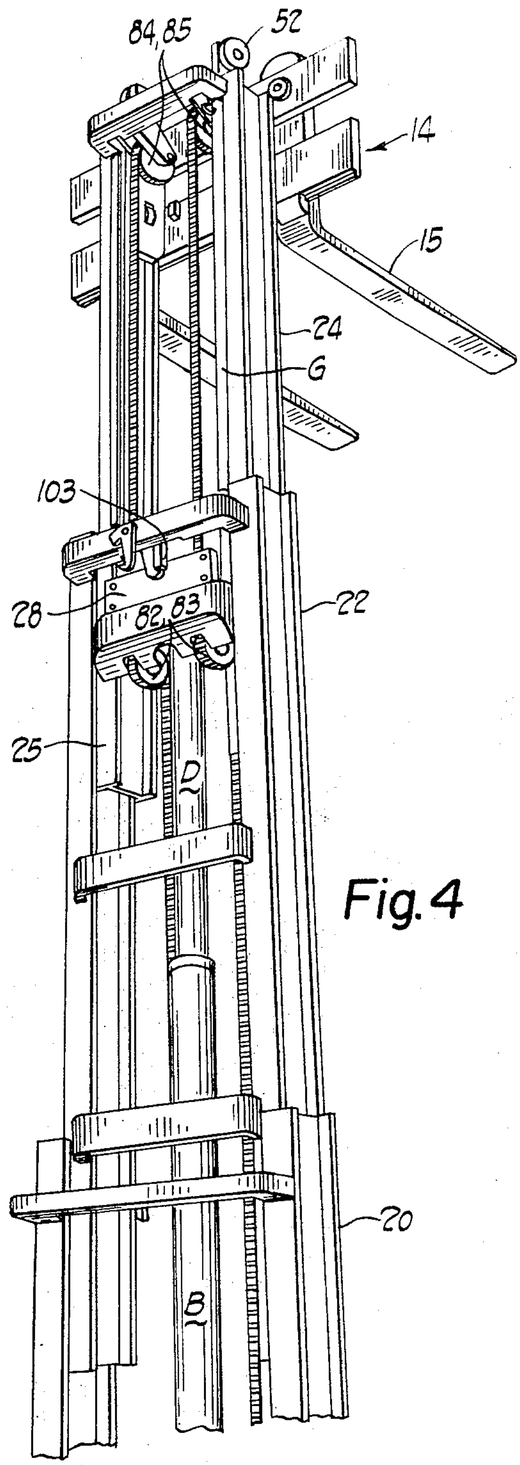

Fig.4

INVENTOR.
WILFRED H. KELLEY JR

BY Watts, Hoffmann, Fisher & Heinke
ATTORNEYS

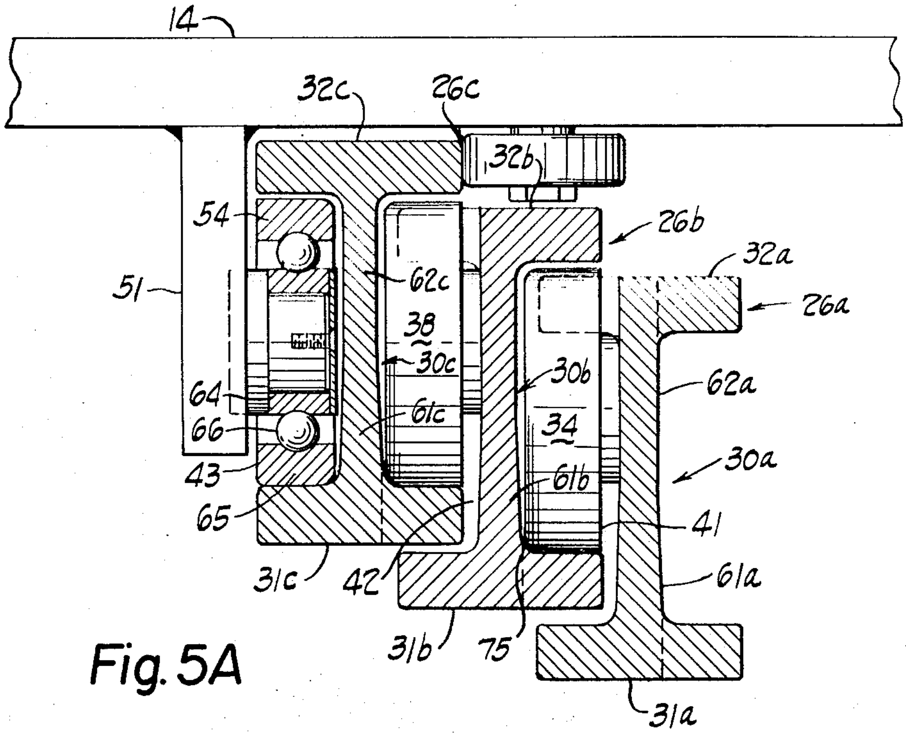

Fig. 5A

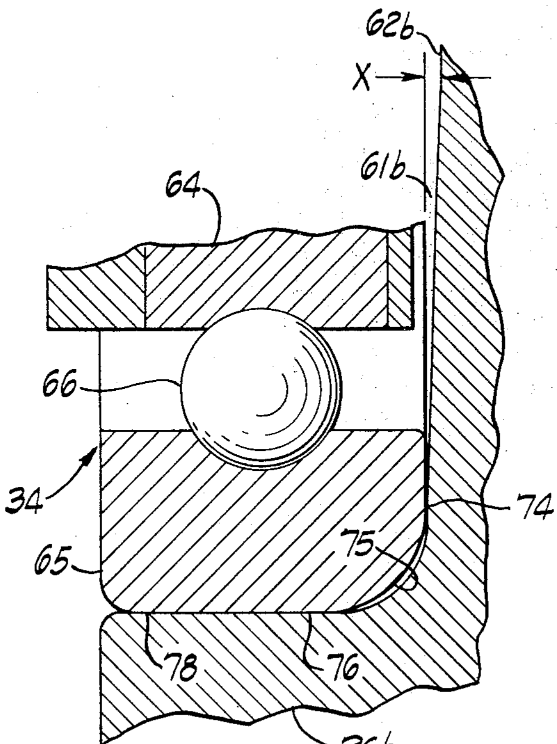

Fig. 5B

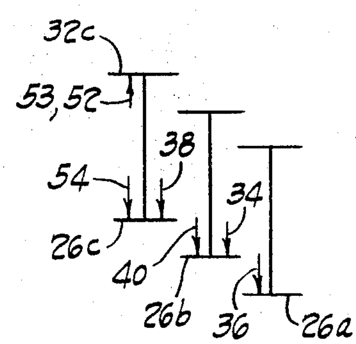

Fig. 5C

INVENTOR.
WILFRED H. KELLEY JR.
BY Watts, Hoffmann,
Fisher & Heinke
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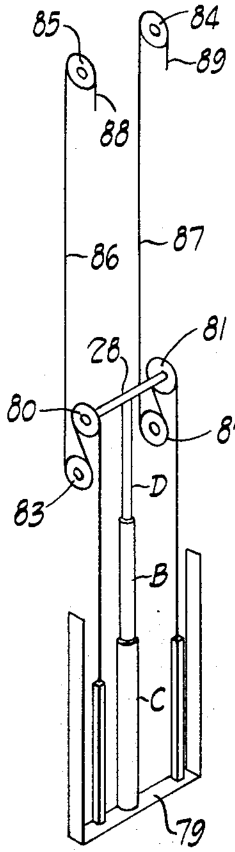


Fig. 6

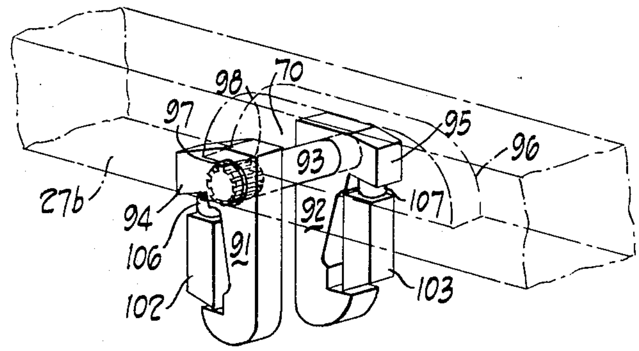


Fig. 6A

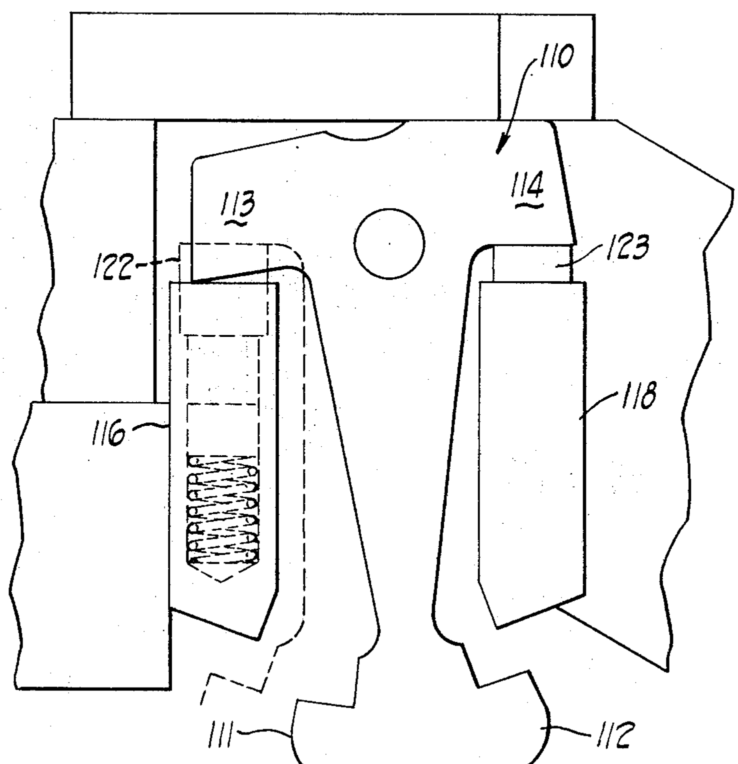


Fig. 6B

INVENTOR.
WILFRED H. KELLEY JR
BY Watts, Hoffmann,
Fisher & Heinke
ATTORNEYS

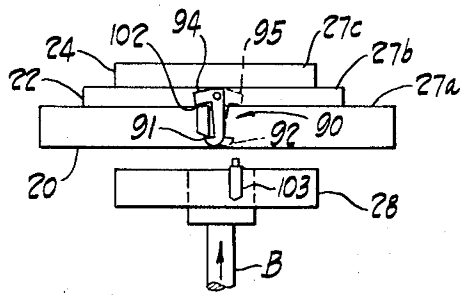


Fig. 7A

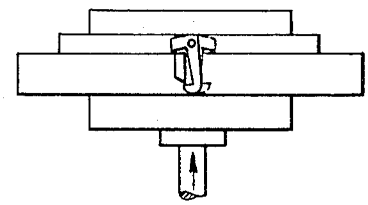


Fig. 7B

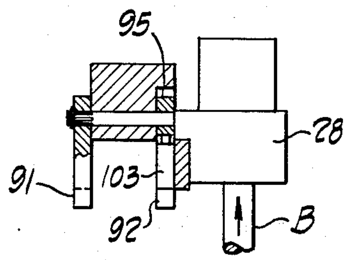
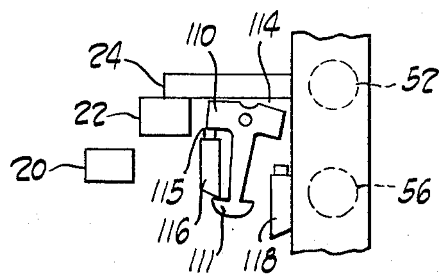


Fig. 7C



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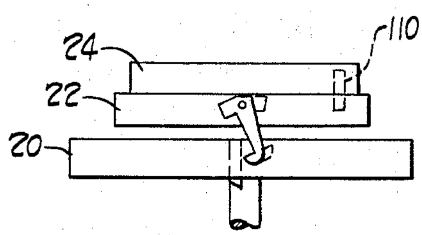

Fig. 7E

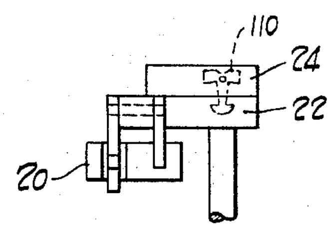

Fig. 7F

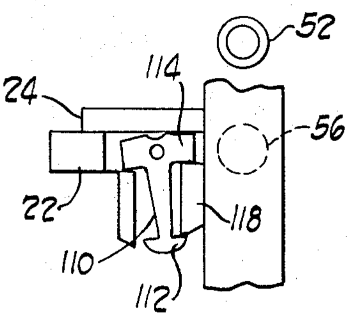

Fig. 7G

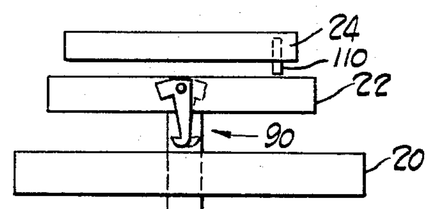

Fig. 7H

INVENTOR.
WILFRED H. KELLEY JR.
BY Watts, Hoffmann,
Fisher & Heinke
ATTORNEYS

LIFT TRUCK MAST

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention pertains generally to the art of elevator mechanisms. More specifically, the invention relates to a sectional lift truck mast of the type having nested uprights. Certain aspects of the invention are directed to a so-called "triplex" mast having three sections. One section is stationary, a second is extensible from the first, and a third from the second so that the mast can reach a greatly-extended height as compared to its collapsed height.

2. Description of the Prior Art

Industrial fork lift trucks normally have a vertically extensible cargo mast mounted on the forward end of the truck. It is generally desirable that the collapsed height of the mast be fairly low to ensure vertical clearance through passageways and access into boxcars or the like. But on the other hand, the maximum fork height should be as great as possible to permit stacking cargo to a considerable height such as in an open yard or warehouse. Thus, the triple sectional or triplex mast is often desirable since it has great height, fully extended, yet a low profile in the collapsed position.

The mast will have a load carriage for lifting the cargo. The load carriage reciprocates on the inner extensible mast section. The distance the load carriage can be raised from its fully lowered position without any extension of the mast occurring, the so-called free lift height, is another important consideration. This allows a cargo to be lifted to the uppermost position consistent with overhead clearance without extending the mast itself, for example, inside of a boxcar where elevation of the mast to increase the cargo height would be prohibited.

The typical mast has a power cylinder which cooperates with a chain lift arrangement for raising the load carriage and sequentially extending the mast sections. One type of commercially available cylinder which can be used with a triplex mast has vertically extensible cylinder rods selectively movable in opposite directions out of the cylinder. In the collapsed position of the mast and the fully lowered position of the load carriage, the cylinder rods are withdrawn and the cylinder is lowered. In raising the load carriage to its free lift height, a first cylinder rod strokes out to the extent permitted by the clearance between the top of cylinder and the mast. Successively the other cylinder rods are extended in raising the mast. In the process the cylinder is elevated. When the last cylinder rod has been fully extended, the mast reaches its maximum overall height and the cylinder has been elevated several feet, tending to obstruct the operator's vision through the mast.

Aside from creating an obstruction, another disadvantage is that the cylinder is not solidly supported on the mast frame. With the mast in a collapsed position, the lower cylinder rod projects out slightly preventing the cylinder from resting solidly on the mast frame. When the mast is elevated, the cylinder rod extends out raising the cylinder as well as the entire load of the mast. Obviously there is a degree of instability in supporting the mast on a small extended cylinder rod to say nothing of supporting a load of several thousand pounds in an elevated position.

In masts where the power cylinder remains fixed and does not elevate, usually a cylinder is required which is larger than the described elevating type. Since this large cylinder is mounted directly in front of the operator, his view to the front tends to be obstructed by it and other structure such as the hydraulic lines and the load chains. Thus, whether the power cylinder is fixed or movable vertically as with prior art constructions, operators have, at times, been forced to lean out of the side of the truck to see around an obstructing cylinder.

Many mast sections have used generally C-shaped channels for carrying and for engaging rollers. Forward bending loads of the mast are taken by the rollers traveling on the end flange portions of the channels and other rollers, to absorb side thrust loads, are provided. These thrust loads can be considerable when an unbalanced load is on the fork of the load carriage.

The space consumed by most prior thrust arrangements has limited the extent to which mast sections can be nested and, therefore, further contributed to the problems of limited visibility. An arrangement has been proposed to reduce cost and provide nesting through the use of I-beams and cocked forward load absorbing rollers. That is, the axes of the rollers are inclined at a slight non-perpendicular angle with respect to a path of mast section elevational travel. The upper roller is cocked in one direction and lower roller in the opposite direction. Since the rollers are cocked, portions of the forward bending loads are applied to the forward load absorbing rollers at all times as axial rather than radial loads. In addition, the rollers are required to take axial loads resulting from imbalanced side thrust loads. Roller bearings which are designed to withstand axial loads as well as radial loads are more expensive and have shorter lives than those which have only radial loads applied.

Moreover, in the described prior mast arrangement, the axial loading component from the forward bending loads is applied in one direction while the axial component resulting from thrust loads is taken in the opposite direction. Thus there are axial loadings in both directions where cocked rollers are used.

Normally, a system of latches is employed to control the relative movement of mast sections when the mast is extended or collapsed. For example, at some point during the elevation of the load carriage, one latch is tripped to release the first extensible mast section from the outer or stationary section. The extensible section in turn carries a latch which releases the inner section, the latter continuing to elevate until it reaches its full extension.

A variety of latching mechanisms have been proposed in the prior art, but for one reason or another none has been entirely satisfactory. Some have sacrificed free lift height. Others have employed complex latching systems which, aside from the cost, require an inordinate amount of adjustment and maintenance.

Most prior latching devices have contributed to poor bearing conditions for in a typical prior triplex mast, the inner mast section will be fully extended before the latches release the intermediate mast section permitting it to extend. Thus, the inner mast section is fully extended upwardly before the intermediate section is released to commence its upward travel. This means that the bearings between the inner mast section and the intermediate mast section are overworked much of the time since many lifts do not require extension of the intermediate section. In addition these bearings are under their worst loading conditions when the inner section is extended before the intermediate section commences to move. This is because the bearings are moved closer together which is the worst loading condition. The bearing loads are in the best condition with the bearings spaced widely apart. In other words, the loading conditions are a function of the amount of vertical overlap between mast sections. As a result, the bearings interposed between the inner and the intermediate mast sections are excessively loaded and experience excessive wear since there is relatively little vertical overlap in many of the frequently encountered lift heights reached by the extended position of the inner section alone.

SUMMARY OF THE INVENTION

The mast of this invention has a plurality of sections or uprights nested one within the other and extensible relative to each other. Each upright includes a pair of rails which, with the rails of the nested adjacent upright, define parallel, longitudinally extending trackways. Rollers mounted on each rail of at least one upright are adapted to roll in the trackways during raising and lowering of the mast. Each rail is formed, in part, by a transverse portion on which the rollers ride. A second portion extends from the transverse portion at an angle diverging from the rollers. The rollers are in line engagement with the transverse portions and are spaced from the second portion but for small tangential contact such that any side thrust loads are accepted essentially parallel to the roller axes and forward bending loads are taken only radially. As a consequence, axial loads are applied to the rollers in one direction only and normally only under imbalanced load conditions. Accordingly, wear and friction are minimized on both the rails and rollers.

In the preferred form of triplex mast, the rails have a generally I-shaped cross section with a central web section and spaced end flanges. The web section and end flanges of one rail overlap, in a fore and aft direction, the web section and end flanges of the other. The rear half of the web section of each rail is tapered forwardly toward the load at an angle of between 2° and 6° and preferably about 3 ½°, but may range to a maximum of between 1° and 20°. The front half of the web section, forwardly of the tapered portion, is of constant thickness providing a straight surface parallel to the longitudinal axis of the lift truck.

Rollers at one end of one upright run longitudinally on the rear end flanges of the rails of the nested upright. Each roller is laterally spaced from the opposite straight web portion and has a peripherally curved outer edge which tangentially contacts the tapered web portion at one point near to the rearward end flange.

A power cylinder rests on a bed plate of the outer upright and is stationary except for slight pivotal movement permitted to accommodate any possible misalignment. The cylinder has vertically extensible cylinder components which, in cooperation with a chain wrap, successively raise a load carriage and thereafter concurrently extend the intermediate and inner uprights. The sequence is provided for by a series of latches which ensure that there is maximum overlap between mast sections during extension and retraction of the mast.

A first latch is pivotally mounted on the intermediate upright on a fore and aft extending axis. In the mast collapsed position, the first latch locks the intermediate upright to the outer. The first latch is unlocked by the extensible cylinder component after it has stroked out to an intermediate raised position corresponding to the position of load carriage at the free lift height. The intermediate upright, and thus the inner which remains locked to it by means of a second latch, can now be raised by the cylinder component.

A second latch is pivotally mounted on a transversely extending axis on the inner upright and locks it to the intermediate until the cylinder component reaches a position corresponding to the highest point of travel of the load carriage in the inner upright. The second latch is then actuated unlocking the inner upright. The latter now becomes attached to the load carriage and strats moving out of the intermediate.

Each latch has dual, oppositely movable elements which simultaneously unlock one part and lock it to another while either raising or lowering the mast. Specifically, each latch comprises a pair of hook elements pivoted on a common shaft and facing in opposite directions. When either latch is pivoted in one direction in raising the mast, one hook element causes the opposite hook element to unlock and the other to lock and vice versa when collapsing the mast.

The chain wrap is such that the load carriage travels at twice the rate of extension of the cylinder components. The arrangement of the latches provides that the inner upright remains locked and travels with the intermediate upright for only a short distance. Thereafter it is unlocked from the intermediate and locked to the load carriage. The intermediate and inner uprights now commence to move relative to each other, the inner rising out of the intermediate at twice the rate of extension of the intermediate since it is locked to the load carriage. The uprights extend simultaneously maintaining a maximum overlapped relationship, inner-to-intermediate-to-outer, which progressively decreases as the mast extends to its full height. Thus loads are distributed on the rollers at near optimum conditions for all mast positions.

Another of the advantages of this invention is to provide an extensible lift truck mast in which the spacing of parts, both in the collapsed and fully raised positions, is such as to provide a maximum viewing area through the mast by the operator eliminating blind spots in the critical areas. This is accomplished, in part, owing to the closer nesting of the rails providing a wider open area of visibility through the mast. But more importantly, the top of the cylinder remains below the line of sight of the operator eliminating the cylinder blind spot problem of some prior art masts.

Another important advantage of the invention is that the uprights are mounted on anti-friction rollers which, owing to the design of the rails, take any side thrust loads parallel to their rotational axes and forward bending loads are taken only radially thereby minimizing wear on the roller assemblies and rails.

A further advantage is the combination of latch mechanisms which allows the maximum free lift height to be obtained before any extension of the mast occurs.

It is also a feature of the invention that the load carriage which travels in the inner upright be mounted on a plurality of sets of rollers in an arrangement that allows the carriage to be supported with the bearings in the best loading condition while it is traveling but yet permits the carriage to be elevated to a maximum extended height. This is accomplished by extending the load carriage above the inner upright thereby gaining added height while statically supporting the carriage on at least two sets of rollers which remain in the rail trackways.

Another feature of importance is the arrangement of latching mechanisms where the extensible uprights are simultaneously extended even for lifts that do not require the fully raised height of the mast thereby distributing the load on the rollers to minimize friction and wear.

A still further advantage is realized in the design of the I-shaped rails which affords maximum strength to weight ratio at lower tooling costs.

These and other advantages will become apparent by referring to the following description and drawings wherein:

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a lift truck and mast of the type incorporating the features of the invention where the mast is in a collapsed position and the load carriage is raised to the free lift height;

FIG. **1A** is a front elevational view of the truck and mast of FIG. **1** showing the load carriage in the lowered position;

FIG. **2** is a schematic view showing the mast uprights disassembled;

FIG. **3** is a side elevational view and FIG. **4** a rear perspective view of the mast shown in its fully-raised or extended position;

FIG. **5A** is a cross sectional view showing the nested relationship of the rails and rollers;

FIG. **5B** is a broken out enlarged sectional view showing the roller-to-rail engagement;

FIG. **5C** is a schematic diagram showing the balanced distribution of forward bending loads on the rollers;

FIG. **6** is a schematic perspective view showing the chain wrap arrangement with the power cylinder fully extended;

FIG. **6A** is a fragmentary perspective view showing the latch mechanism employed between the outer upright and cylinder sheave block for controlling the intermediate upright;

FIG. **6B** is a fragmentary view showing the latch mechanism employed between the intermediate upright and load carriage for controlling the inner upright; and

FIGS. **7A–7H** are schematic views depicting the sequence of latch operation and mast extension.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in the drawings, the present invention will be described in connection with a triple sectional mast assembly **10** for an industrial lift truck **12**. The invention contemplates, however, improvements in mast elevator assemblies generally and should not be interpreted as being limited to the description herein, reference being had instead to the appended claims for a comprehension of the scope of the invention.

In FIG. **1**, the mast **10** is shown in its collapsed position and the load carriage **14** fully raised to its free lift height, i.e., the maximum elevation achieved by the carriage before any extension of the mast **10** occurs. A fork **15** extends forwardly from the carriage **14** for carrying loads. With the load carriage **14** fully lowered (FIG. **1A**) the fork **15** is slightly off the ground. The mast is pivotally mounted at its lower end to the truck frame and by means of a pair of hydraulic cylinders **16** operated from the truck, may be tilted a limited extent in a fore and aft direction.

The mast **10** comprises three nested uprights **20, 22, 24**. The outer upright **20** is stationary. The intermediate and inner uprights **22, 24** are vertically extensible to a maximum height as depicted in FIGS. **3** and **4**. The mast is raised and lowered by means of a chain wrap arrangement, generally indicated at **25** in FIG. **4** and depicted schematically in FIG. **6**, which is driven by a hydraulic power cylinder C controlled from the truck. The power cylinder C is permitted limited pivotal movement to accommodate any vertical misalignment and rests on a bed plate at the bottom of the outer upright **20**. The cylinder includes a first extensible section B within which telescopes a second extensible section D carrying at the top a sheave block **28** which is guided on the sides in parallel, longitudinally extending guideways G (FIG. **4**) secured on the rear of the inner upright **24**.

As will be described more in detail hereinafter, a latching mechanism (FIG. **6A**) is actuated as the cylinder strokes out and the load carriage is raised to its free lift height (FIG. **1**). The latch unlocks the intermediate from the outer upright. The intermediate upright now becomes attached to the sheave block **28** and commences to rise out of the outer upright. Almost simultaneously, a second latching mechanism (FIG. **6B**) is actuated as the load carriage reaches its full height in the inner upright **24**. At this point the inner upright **24** becomes attached to the load carriage and commences to rise out of the intermediate upright **22**. Both the intermediate and inner uprights continue to move relative to the outer upright until the full extension of the mast is reached as shown in FIGS. **3–4**.

MAST CONSTRUCTION

Referring to FIG. **2**, the outer, intermediate and inner uprights **20, 22, 24** and the load carriage **14** are shown in a diagrammatic disassembled fashion. As described hereinafter, like parts of different sub-assemblies will be identified with the same numerals with a letter character added to identify a separate sub-assembly.

The uprights **20, 22, 24** each comprise a pair of parallel rails **26*a*, 26*b*, 26*c***. The rails are joined at the rear by a plurality of cross beams **27*a*, 27*b*, 27*c***. Viewed in cross section, each rail is generally I-shaped. There is a central web section **30*a*, 30*b*, 30*c*** and spaced end flanges **31*a*, 31*b*, 31*c*** and **32*a*, 32*b*, 32*c***. The rails **26*a*** of outer upright **20** are spaced wider apart than the rails **26*b*** of the intermediate upright **22** which in turn are laterally spaced wider than the rails **26*a*** of the inner upright **24**. When assembled the uprights roll end-for-end within each other as denoted by the dotted assembly lines in FIG. **2**. The web sections **30*a*, 30*b*, 30*c*** overlap in a fore and aft direction, outer to intermediate and intermediate to inner as shown in the partial cross sectional view in FIG. **5A**. The rear end flanges **31*a*, 31*b*, 31*c*** likewise overlap laterally as do the front end flanges **32*a*, 32*b*, 32*c***.

A pair of rollers **34** face inwardly adjacent the upper end of the outer upright **20**. The intermediate upright **22** carries two sets of opposed rollers **36, 38**, one set **36** facing outwardly at the lower end and the other set **38** facing inwardly at the upper end. The inner upright **24** carries one set of opposed rollers **40** adjacent the lower end facing outwardly.

The forward end flanges **32***a* of each rail **26***a* and the rear end flanges **31***b* of each rail **26***b* have longitudinal cut-outs **42***a*, **42***b*. The cut-outs **42***a* face inwardly on the upper end of the outer upright **20** and the cut-outs **42***b* face outwardly on the lower end of the intermediate upright **22.** Likewise, the forward end flange **32***b* of each rail of the intermediate upright and the rear end flange **31***c* of each rail of the inner upright **24** are cut out respectively at **44***a*, **44***b*. The cut-outs **44***a* face inwardly at the upper end of the intermediate upright **22** and the cut-outs **44***b* face outwardly at the lower end of the inner upright **24.**

The sets of rollers **34, 36, 38, 40** on each upright are mounted on stub shafts adjacent the upper and lower ends of the uprights leaving a clearance in the cut-outs **42***a*, **42***b*, **44***a*, **44***b* sufficient to receive the rollers of the nested upright. The cut-outs **42***a* of the outer upright **20** receives the rollers **36** at the lower end of the intermediate upright **22** as indicated by the dotted assembly lines in FIG. **2.** Likewise, the cut-outs **44***a* at the upper end of the intermediate upright **22** receive the rollers **40** at the lower end of the inner upright.

When nested together, as shown in FIG. 5A, the inner rails **26***c* roll inside the intermediate rails **26***b* and the intermediate rails in turn roll inside the outer rails **26***a* which are stationary. The rear end flanges **31***c* overlap and lie inside of the rear end flanges **31***b* which in turn overlap and lie inside of the rear end flanges **31***a*. The front end flanges **32***c* overlap and lie outside the front end flanges **32***b* which in turn overlap and lie outside the front end flanges **32***a*. Each rail when nested with the companion rail forms parallel longitudinally extending trackways **41, 42** in which the roller pairs **34, 36, 38, 40** ride in raising and lowering the mast as will be described in more detail hereinafter.

The load carriage **14** has upper and lower apron members **50** (FIG. **2**) held by vertically parallel members **51.** The members **51** carry three opposed sets of rollers **52, 53, 54.** The members **51** are laterally spaced to cause the rollers to track within rails **26***c* of the inner upright **24.** A pair of lower side thrust rollers **56** mounted in the vertical members **51** roll against the inside surfaces of web sections **30***c* and take any side thrusts resulting from imbalanced loads in cooperation with an upper pair of side thrust rollers **58** mounted on the upper apron **50** and which track along the outer edges of the front end flanges **32***c* of the inner upright **24.** It will be apparent that when assembled the carriage **14** reciprocates in the inner upright **24.** During travel of the carriage, forward bending loads on the fork **15** are taken by the upper set of rollers **52** riding against the front end flanges **32***c* of the rails **26***c* and by the lower set of rollers **54** rolling on the rear end flanges **31***c*. It will be noted that the bearing loading is advantageously distributed between the most widely spaced pairs of rollers **52, 54.** Where the carriage is fully raised (FIGS. **3,** 4), the upper rollers **52** project above the top of rails **26***c*. Static loads are now taken by the roller pairs **53, 54** which remain in the rails **26***c*. This arrangement allows for a greater overall fork height than would be otherwise possible as well as providing for longer bearing life through better load distribution during carriage travel.

The forward bending loads thus transmitted to the inner upright **24** tend to force the rails **26***c* forwardly at the top and rearwardly at the bottom such that the uuper rollers **38** on the intermediate upright **22** and the lower rollers **40** on the inner upright **24** are respectively forced into rolling engagement with the rear end flanges **31***c*, **31***b* of the nested rails **26***b*, **26***c*. Likewise, the forward bending loads transmitted to the intermediate upright **22** force the rear end flanges **31***b* of the intermediate rails forwardly against the opposed rollers **34** of the outer upright and the lower rollers **36** of the intermediate rails ride against the rear end flanges **31***a* of the outer rails. This interaction of forces between the rails and rollers is depicted in FIG. 5C and is a factor in the design which greatly minimizes friction and wear on the rails and rollers as will be more fully explained.

Referring to FIG. 5A, which is a partial cross sectional view of the nested uprights, each rail web section **30***a*, **30***b*, **30***c* will be seen to have a tapered portion **61***a*, **61***b*, **61***c* and a straight portion **62***a*, **62***b*, **62***c*. The stub shafts which carry the rollers **34, 38** project laterally from the straight portions **62***a*, **62***b* on perpendicular axes. The lower rollers **36, 40** project in the opposite direction from the tapered portions **61***b*, **61***c* (FIG. **2**) on axes perpendicular to the central plane of the web sections. While only the one carriage roller **54** is shown in cross section, each roller on both the carriage and uprights includes an inner race **64** mounted on the stub shaft and an outer race **65** rotatably carried by the inner race **64** on balls **66.** The upper and lower rail rollers **34, 36,** riding in the outer longitudinally extending trackways **41** lie in a common plane parallel to the plane of upper and lower rollers **38** and **40** in the intermediate trackways **42.** The same applies to the load carriage rollers **52, 56, 54** rolling in the inner rails **26***c*. Each of the respective roller planes is parallel to the longitudinal center plane of the lift truck.

Unlike some prior art arrangements where the rollers are cocked so as to run more or less in the corners of the rails requiring them at all times to take axial loadings in one direction thereby increasing the friction and wear, the present invention contemplates a completely different solution to the problem of friction and wear which has plagued such mast structures heretofore. Referring to FIG. 5B, an enlarged broken out view of the roller **34** and rail **26***b* is shown, but each roller **36, 38, 40** will be similarly in rolling engagement with its respective rail. The load carriage rollers **52, 53, 54** are spaced from the web sections of rails **26***c* by the thrust rollers **56, 58.** Each roller **34, 36, 38, 40** is spaced from the opposite rail straight portion **62***a*, **62***b*, **62***c* owing to the fact that the tapered web portion **61***a*, **61***b*, **61***c* has a critical angle diverging from the roller. The rollers **34, 36, 38, 40** tangentially contact the tapered web portions at only a single point **74** on the roller edge **75** (FIG. 5B). It has been found that the angle of contact X should be from about 2° to 6° and preferably 3 ½°, but may range for a maximum of from 1° to 20°. For example, if the angle X gets much beyond 20°, then the nested width of the rails is inordinately increased. This also creates the condition where the application of axial loads becomes appreciably a factor. On the other hand, if the angle X is diminished much below 1°, the possibility of contact by the roller faces on the straight web portions **62***a*, **62***b*, **62***c* increases. Rubbing contact should be reduced to the smallest possible area to minimize wear on the rails and rollers. Ideally, the inclination of the tapered portions **61***a*, **61***b*, **61***c* should be such as to produce a diverging angle X preferably of in the range indicated, 2° to 6° and most satisfactory about 3 ½°. In this way, any axial thrust loads, if not entirely eliminated, are at least minimized when the rollers are traveling up and down the rails with a balanced loading on the fork.

If an imbalanced load is lifted, only thrust in one direction is taken, not in both directions as with prior art cocked rollers, and this thrust condition is only temporary since any such loads are due to abnormal loading conditions on the fork which disappear when the load is spotted. The radius of edge **75** of the roller will inscribe an arc tangential with the web tapered portion **61***a*, **61***b*, **61***c* and rail end flange **31***a*, **31***b*, **31***c* at **74**, **75** providing clearance in the corner. The rollers have line engagement with the rear end flanges **31***a*, **31***b*, **31***c* from the point of tangency **76** to the inner edge **78** of the roller. This means that forward bending loads are taken radially and uniformly along a line extending between **76** and **78** greatly increasing roller life and providing for smoother mast operation.

FIG. **5C** depicts the interaction of the rollers and rails as described earlier. The forward bending loads are depicted in FIG. **5C** as vectors acting on the rails as indicated by the directional arrows. The upper carriage rollers **52** act forwardly against front flange **32***c* of the inner upright **26***c*. However, all of the other roller pairs i.e., the lower carriage rollers **54** and each of the rail rollers **34, 36, 38, 40** act rearwardly against the rear end flanges **31***a*, **31***b*, **31***c* of the rails **26***a*, **26***b*, **26***c*. The result is a balance of forces on the mast which has the effect of providing smooth, stick-free operation while raising and lowering the mast.

POWER CYLINDER AND CHAIN LIFT ARRANGEMENT

Referring to FIG. **6**, the hydraulic power cylinder C which is of conventional design, has a cylinder outer housing which is solidly but pivotally mounted on a bed plate **79** which has a recess R (FIG. **2**) adapted to receive the base of the cylinder outer housing. The cylinder has a first extensible cylinder component B in which telescopes a second cylinder component D. The components B and D may be successively extended by the operator. The sheave block **28** at the upper end of the cylinder component D carries at the opposite ends thereof sheaves **80, 81.** The inner upright **24** also carries adjacent its lower end a sheave block in which are rotatably mounted sheaves **82, 83.** Guideways G (FIG. **4**) on the rear end flanges of the upright **24** guide the cylinder-driven sheave block **28.** Also mounted on the inner upright adjacent the upper end are a pair of sheaves **84, 85** (FIG. **4**) in parallel alignment with the sheaves **80, 81, 82 83.** A pair of chains **86, 87** are each anchored at the lower end to the bed plate **79** and extend upwardly over the sheaves **80, 81** thence down and around the sheaves **82, 83** and again upwardly over the sheaves **84, 85** being anchored at the opposite end to the load carriage **14** at **88, 89.** It will be appreciated that in FIG. **6**, as well as in FIGS. **3** and **4**, the cylinder and chain wrap are as they would be with the mast fully extended. That is to say, with the mast fully extended, the cylinder components B, D have each stroked out to the maximum extent and the sheaves **80, 81, 82, 83** are at the closest point of travel to each other and the load carriage **41** is at its uppermost position in the inner upright **24.** The mechanical movement of the chain wrap is such that the rate of travel of the load carriage is twice the rate of extension of cylinder components B, D. This allows a shorter cylinder to be used so that the sheave block **28** occupies a position below the line of vision of the operator in the lowered position (FIG. 1A).

LATCH MECHANISM

The invention provides that the extensible mast uprights are locked and unlocked in a novel sequence utilizing to the maximum extent possible, the 2-to-1 ratio of the chain wrap to provide better load distribution. The latching sequence is such as to ensure that there is always sufficient overlap of the intermediate with the outer upright and inner with the intermediate upright. This also gives maximum strength and rigidity to the mast throughout the upward movement. The present invention provides a novel latch arrangement achieving all of these advantages without sacrificing a high mast strength to weight ratio.

1. First Latch Mechanism

Referring again to FIG. **2**, it will be ssen that the intermediate upright **22** has mounted in the upper cross beam **27***b* a latch **90.** The latch **90** comprises a pair of oppositely-facing hook elements **91, 92** pivotally mounted on a common fore and aft extending shaft **93** in the longitudinal center plane of the lift truck. As best shown in FIG. **6A**, an arm **94** on the hook element **91** projects laterally from the shaft **93** and an arm **95** on the hook element **92** projects laterally in the opposite direction. The hook elements **91, 92** have identical profiles. The hook element **91** pivots on the rear side of the cross beam **27***b* while the hook element **92** pivots on the front side within a cut-out **96.** The hook element **91** is preferably splined onto shaft **93** and held in place by a pair of lock rings **97, 98.** Hook element **92** is welded on the shaft at the opposite end The splined mounting means of securing the hook element **91** has been found to produce a stronger assembly able to better withstand the forces acting on the latch.

As seen in FIG. **2**, the cross beam **27***a* of the outer upright **20** has a vertically extending slot **101.** Within the slot **101** and projecting below the cross beam **27***a* is a first dog **102.** A second dog **103** is mounted on the rear side of the sheave block **28** which is shown schematically in FIG. **2** traveling within the inner upright **24.**

As shown in FIG. **6A**, the first and second dogs **102, 103** are laterally offset so as to be in vertical alignment with the arms **94, 95** Each dog **102, 103** receives a coil spring which yieldably supports a button **106, 107** engageable with the detent **94, 95.** Each dog is beveled on the lower end so as to make engagement with the hook element **91, 92.** It will be noted that clockwise rotation of the latch **90** simultaneously locks hook element **91** and unlocks hook element **92** and vice versa. The button **106** extends against the arm **94** to yieldably hold the hook element **91** extending through the slot **101** in locked engagement with the beveled end of the dog **102.** Similarly, the button **107** yieldably holds the hook element **92** engaged with the dog **103** when the latch is rotated to the counterclockwise position. When dog **103** moves upwardly with the sheave block **28** it engages detent **95** rotating the latch **90**, unlocking hook element **91** from dog **102** and locking hook element **92** to dog **103.** This will be discussed later in the description of the operation of the mast as a whole.

2. Second Latch Mechanism

Referring again to FIG. 2, a second latch mechanism **110** is pivotally mounted on a transversely extending axis adjacent the upper cross beam **27**c of the inner upright **24.** Latch **110** pivots in a fore and aft direction in a plane laterally offset from the centerline of the mast. As best shown in FIG. **6**B, oppositely facing hook elements **111, 112** are integral with oppositely facing arms **113, 114.** The hook element **111** and arm **113** project rearwardly in alignment with a third dog **116** mounted on the upper cross beam **27**b of the intermediate upright **22.** The hook element and arm **112, 114** project forwardly in alignment with a fourth dog **118** carried on back edge of the right vertical member **51** of the load carriage **14.**

Referring to FIG. **6**B, it will be seen that the hook element **111** cooperates with the third dog **116** upon rearward movement. The hook element **112** and arm **114** cooperate with the fourth dog **118** upon forward pivotal movement. As with the other dogs, the dogs **116, 118** each receive coil springs which yieldably support buttons **122, 123.** The buttons **122, 123** are engageable with the arms **113, 114** respectively and cooperatively pivot the hook elements **111, 112** alternately into locked or unlocked engagement with the dogs **116, 118.** The operation is similar to that of latch **90** in that oppositely facing hook elements simultaneously unlock one part of the mast while locking it to another part.

MAST OPERATION

FIGS. 7A–7H are diagrammatic sequence views showing the mast operation. Referring to FIG. 7A, assume that the mast is in the collapsed position with the upper cross beams **27**a, **27**b, **27** c shown nested, one above the other as they would appear if viewing FIG. **1**A from the rear and representing here the uprights **20, 22, 24.** The fork **15** is fully lowered. The operator now causes the first cylinder component B to be extended. As it strokes out, the sheave block **28** advances the dog **103** toward the latch **90.** The latch **90** at this moment is rotated to the locked position with hook element **91** and arm **94** in locking engagement with the dog **102** such that the intermediate upright is locked to the outer. Also at this moment the second latch **110** is in the position shown in FIG. 7D. That is, the hook element **111** and detent **113** are in locking engagement with the dog **116.** Thus the inner upright is locked to the intermediate and the intermediate to the outer.

As the cylinder strokes out only the load carriage is free to move. As the sheave block **28** moves vertically to a position corresponding to the free lift height of the load carriage (FIG. **1**) it advances the dog **103** into engagement with the arm **95** pivoting the hook element **92** into locking engagement with the dog **103.** Hook element simultaneously simultaneously disengages from dog **102.** This is the condition depicted in FIGS. 7B, 7C. At this point, any further upward movement of the sheave block **28** commences to elevate the extensible uprights **22, 24.** It is important to note that at the position shown in FIGS. 7B, 7C, the load carriage **14** is already at its free lift height, i.e., the maximum height of the fork without any extension of the mast occurring. It may continue to move upwardly in the inner upright **24** only a few more inches as depicted in FIG. 7D before the latch **110** is tripped releasing the inner from the intermediate upright.

At the position of the uprights shown in FIGS. 7E and 7F, the load carriage **14** will have reached its highest point of travel in the inner upright and any further elevation of the fork **15** comes about as a result of the simultaneous extension of the intermediate and inner uprights rather than movement of the load carriage. As will be seen in FIGS. 7E, 7F the intermediate and inner uprights are no longer locked to the outer upright **20** by the latch **90.** Instead, they are locked onto the sheave block **28** and have elevated slightly above the outer upright **20.** The load carriage has now reached the point in the inner upright **24** where the dog **118** will trip the latch **110** as shown in FIG. 7G. The dog **118** on the carriage engages the arm **114** pivoting the latch **110** forwardly (counterclockwise as viewed in FIG. 7G). This disengages the inner from the intermediate upright and engages the hook element **112** with the dog **118** locking the inner upright onto the carriage. The inner upright being now locked to the carriage commences to be pulled upwardly out of the intermediate upright by the carriage. As will be seen in FIG. 7G, the upper set of rollers **52** of the carriage have now extended beyond the top of the rails effectively increasing the lift of the fork.

Further elevation of the sheave block **28** by the cylinder continues to raise the intermediate upright **22** at the rate of travel of the cylinder. Simultaneously the inner upright **24,** which rises out of the intermediate upright as depicted in FIG. 7H at twice the rate of travel of the intermediate upright, will reach its fully extended position (FIGS. **3, 4**) at the same time as does the intermediate.

In lowering the mast the sequence of latching just described will be reversed so that at all times the uprights **20, 22, 24** are positively locked either to the outer upright **20,** the cylinder-driven sheave block **28** or the load carriage **14.**

Various prior art latching arrangements have been employed in a number of combinations. In one arrangement the inner upright is first locked to the stationary cylinder housing to guard against upward movement of the upright with the carriage in the event the latter should stick or bind. Control of the inner upright is then transferred by means of another latch to the carriage which commences to extend the inner upright out of the intermediate. If the mast is to be fully extended, stop blocks on the lower end of the inner upright engage stop block at the upper end of the intermediate which are effective for raising the latter from within the outer upright as the load carriage continues up. The result is that the rollers on the inner upright are over worked since the majority of loads will be spotted at less than full mast height.

With the invention, from the position shown in FIG. 7G, should the mast continue extending until reaching the overall raised height as shown in FIGS. 3 and 4, there will be a uniform decrease in overlap between the uprights. That is, there is alwyas a relatively equal overlap between the inner and intermediate and between the intermediate and outer uprights owing to the chain wrap and latching sequence. The inner upright **24** moves relative to the intermediate **22** which in turn moves relative to the outer upright **20** such that at the initially extended position depicted in FIG. 7H, the extent of overlap is in excess of 90 percent as between the intermediate and outer uprights and in excess of 95 percent, as between the inner and intermediate uprights. Thus throughout the elevation or retraction of the mast the loading on the bearings is maintained in the most favorable conditions owing to the fact that the extensible uprights are simultaneously being elevated rather than one followed by the other. This greatly reduces wear and friction on any given set of rollers since all sets are cooperating when any load is lifted above free lift height.

Still in other prior art latching arrangements a plurality of latch elements are arranged in such fashion as to lock the inner to the intermediate upright but no provision is made to lock the intermediate to the outer. Theoretically the forces applied on opposite sides of the load chains should balance and the load carriage should rise with no tendency to cock or bind in the inner upright. In practice, however, this is not always the case. In masts where reliance is placed on the fact that the weight of the inner upright will prevent the intermediate from moving up prematurely, a considerable weight is required to keep the intermediate upright down. Even so, where extreme side thrust loads occur, it is possible to raise both the inner and intermediate uprights prematurely. This, of course, cannot occur with the present invention since during the free lift period the inner upright is positively locked to the intermediate and the latter in turn is positively locked to the stationary outer upright.

In the present invention the intermediate upright is supported during extension directly by the cylinder which in turn rests on the bed plate of the mast. Thus the intermediate upright always has solid support which increases the mast stability.

To further increase the wear properties of the rails, the surfaces providing rolling engagement for the rollers may be hardened, e.g., by hardening the zone of the rear end flanges **31***a*, **31***b*, **31***c* in rolling contact with rollers **34, 36, 38, 40, 51, 53, 54.** Or these surfaces may be provided with a wear strip of harder material than the rails themselves.

Modifications and changes may be made to the invention as will be apparent to those skilled in the art to which it pertains which modifications and changes are to be regarded as reasonable equivalents thereof and are intended to be covered by the appended claims except insofar as limited by the prior art.

What is claimed is:

1. An extensible mast having collapsed and extended positions, comprising:
- a first upright,
- a second upright slidably received on the first and extensible longitudinally therefrom,
- a load carriage,
- load carriage support means reciprocally supporting the load carriage on the second upright,
- a power lift system operably connected to reciprocate the load carriage and second upright simultaneously at first and second differential rates of travel,
- latch operator means on the load carriage having a raised position corresponding to a raised position of the load carriage, and
- latch means operable for attaching the load carriage support means to the second upright for travel therewith at the first differential rate and actuated by said latch operator means at said raised position to disconnect substantially simultaneously the load carriage support means from the second upright and attach it to the load carriage for travel therewith at the second differential rate, whereby the mast reaches an extended position by employing said simultaneous differential rates of travel.

2. An extensible mast according to claim **1** wherein:
- the oad carriage support means includes a third upright,
- said third upright being slidably received on the second and extensible longitudinally therefrom,
- other latch means operable for attaching the second upright to the first during reciprocation of the load carriage between its lowered and an intermediate raised position, and
- other latch operator means on the lift cylinder having a raised position corresponding to the intermediate raised position of the load carriage operable to disconnect substantially simultaneously the second upright from the first and connect it to the lift cylinder.

3. An extensible mast according to claim **2** wherein said other latch means comprises
- a pair of spaced hook elements facing in opposite directions and pivoted on the second upright on a common fore and aft extending axis,
- first dog means on the first upright engageable with one of the hook elements for preventing extension of the mast,
- second dog means movable with said lift cylinder engageable with said other hook element at said intermediate raised position for attaching the second upright thereto, and
- said first and second dog means cooperating during extension or retraction of the mast to jointly pivot said hook elements, the first hook element pivoted out of engagement with the first dog means and the second into engagement with the second dog means during extension and in the reverse on retraction of the mast.

4. An extensible mast according to claim **3** wherein said latch means comprises
- a pair of spaced hook elements facing in opposite directions pivoted on said third upright on a common transversely extending axis,
- third dog means on the second upright engageable with one of the hook elements for preventing extension of the third upright,
- fourth dog means on the load carriage engageable with the other hook element for attaching the third upright to the load carriage at its highest point of travel in the third upright, and
- said third and fourth dog means cooperating during extension or retraction of the mast to jointly pivot said hook elements, the first hook element pivoted out of engagement with the third dog means and the second into engagement with the fourth dog means during extension and in the reverse upon retraction of the mast.

5. An extensible mast having collapsed and extended positions, comprising:
- a first upright,
- a second upright slidably received in the first and extensible longitudinally therefrom,
- a third upright slidably received in the second and extensible longitudinally therefrom,
- a load carriage,
- means reciprocally supporting the load carriage on one of the uprights, the one upright on the second and the second on the other upright,

a power lift system operably connected to reciprocate the load carriage, and second upright, and the other upright including, extensible lift means, said power lift system being operable to provide a greater rate of travel for said load carriage than the rate of extension of said lift means,

an extensible lift means component having a first intermediate raised position corresponding to a free lift position of the load carriage adjacent the top of the collapsed mast and a second intermediate raised position corresponding to the uppermost position of the load carriage in the one upright,

first latch means mounted on the second upright operable for attaching it to the other upright during reciprocation of the load carriage between its lowered and free lift positions,

second latch means mounted on the one upright operable for attaching it to the second upright during reciprocation of the load carriage between its lowered and uppermost positions,

said first latch means being actuated at the first intermediate position of said lift means component to connect substantially simultaneously the second upright to said lift means component and disconnect it from the other upright during extension of the mast, and

said second latch means being actuated by the load carriage at its uppr most position to connect substantially simultaneously the one upright to the load carriage and disconnect it from the second upright whereby during extension of the mast the second upright and one upright move jointly relative to the other upright between said first and second intermediate positions of said lift means component and thereafter the one upright moves differentially at said greater rate of travel relative to said second upright and the above sequence being reversed in retraction of the mast.

6. An extensible mast having collapsed and extended positions, comprising:

a. a first upright;

b. a second upright slidably received in the first and extensible longitudinally therefrom;

c. a third upright slidably received in the second and extensible loniudinally therefrom;

d. a load carriage

e. means reciprocally supporting load carriage on the third upright, the third on the second and the latter on the first;

f. a power lift system operably connected to reciprocate the load carriage and the second and third uprights including a stationary lift cylinder, said power lift system being operable to provide a greater rate of travel for said load carriage than the rate of extension of said lift cylinder

g. an extensible cylinder component having a first intermediate raised position corresponding to a free lift position of the load carriage adjacent the top of the collapsed mast and a second intermediate raised position corresponding to the uppermost position of the load carriage in said third upright,

h. first, second and third transverse structural members on said first, second and third uprights nested one above the other in the collapsed position of the mast,

i. a first pair of spaced hook elements facing in opposite directions on opposite sides of and pivotally mounted on said second structural member on a common fore and aft extending shaft,

j. each said first hook elements comprising an elongated downwardly extending hook portion and an offset upper detent portion and at least one being splined on the end of the shaft,

k. first dog means mounted on said first structural member and aligned with the detent portion of one of said first hook elements and being engageable therewith to pivot the hook portion thereof into locking engagement with the first dog means between the lowered and free lift positions of the load carriage,

l. second dog means mounted on said cylinder component and aligned with the detent portion on said other first hook element and being engageable therewith to pivot the hook portion thereof out of engagement with said first dog means and substantially simultaneously pivot said other hook portion into locking engagement with said second dog means at the free lift position of the load carriage enabling said second and third uprights to more jointly relative to the first upright,

m. a second pair of hook elements facing in opposite directions pivoted on the third transverse structural member on a common transverse extending axis parallel to said third structural member,

n. each said second hook elements comprising an elongated, downwardly extending hook portion and an upper off-set detent portion,

o. third dog means mounted on said second upright aligned and being engageable with the detent portion of one of said second hook elements to pivot the hook portion thereof into locking engagement with said third dog means between the lowered and uppermost position of the load carriage, and

p. fourth dog means mounted on the load carriage and aligned with the detent portion of said other second hook element and being engageable therewith to pivot the hook portion thereof into locking engagement with the fourth dog means substantially simultaneously disengaging said one hook portion at the uppermost position of the load carriage enabling said second and third uprights to move differentially relative to each other when lowering the mast from the extended to the collapsed position.

7. An extensible lift truck mast having collapsed and extended positions comprising

a first upright,

a second upright slidably received in the first and extensible longitudinally therefrom,

a third upright slidably received in the second and extensible longitudinally therefrom, laterally

a load carriage,

means reciprocally supporting the load carriage on the third upright, the third on the second and the latter on the first,

a power lift system operably connected to reciprocate the load carriage and the second and third uprights including a stationary lift cylinder,

an extensible cylinder component having a first intermediate raised position corresponding to a free lift position of the load carriage adjacent the top of the collapsed mast and a second intermediate raised position corresponding to the uppermost position of the load carriage in the third upright, first latch means mounted on the second upright operable for attaching it to the first upright during reciprocation of the load carriage between its lowered and free lift positions,

second latch means mounted on the third upright operable for attaching it to the second upright during reciprocation of the load carriage between its lowered and uppermost positions,

said first latch means being actuated at the first intermediate position of the cylinder component to simultaneously connect the second upright to the cylinder component and disconnect it from the first upright during extension of the mast,

said second latch means being actuated by the load carriage at its uppermost position to simultaneously connect the third upright to the load carriage and disconnect it from the second upright during extension of the mast and the sequence being reversed when retracting the mast,

each upright comprising parallel, laterally spaced rail members, which when nested with the adjacent rail members of the other upright, overlap outer to intermediate and intermediate to inner to define parallel, longitudinally extending trackways,

each rail member having spaced end flanges separated by a web portion and offset forwardly toward the load carriage such that the end flanges of one laterally overlap with the end flanges of the adjacent rail member and the web portions overlap in a fore and aft direction between the end flanges,

a pair of rollers mounted on the web portions of the outer rail members facing inwardly at the upper end of the first upright,

second and third pairs of rollers mounted on the web portions of the intermediate rail members facing respectively outwardly at one end and inwardly at the opposite end of the second upright, and

a fourth pair of rollers mounted on the web portions of the inner rail members facing outwardly at the lower end of the third upright,

said first and second pairs of rollers situated in common, parallel trackways and said third and fourth pairs of rollers situated in common, parallel trackwasys inwardly of said other trackways, and

the rear end flanges of each rail member providing transversely extending trackway portions engageable with the rollers of the adjacent nested upright and said web portions diverging from the plane of the adjacent roller and tangentially contacting the rollers at the peripheral edge thereof whereby any side thrust loads are taken generally parallel to the axis of the rollers and forward bending loads of the mast are taken radially by the rollers.

8. An extensible lift truck mast according to claim **7** wherein each rail member has a generally I-shaped cross section having spaced end flanges separated by a central web portion,

said web portion including a straight section of uniform thickness extending rearwardly from the forward end flange, said pairs of rollers being mounted on said straight sections and

a tapered section gradually increasing in thickness toward the rear end flange and tangentially contacting the rollers of the nested upright adjacent the peripheral outer circumferential edge at an angle of between 1° and 20°.

9. An extensible lift truck mast according to claim **8** wherein the tangential angle of contact is between 2° and 6°.

10. An extensible lift truck mast according to claim **9** wherein the tangential angle of contact is approximately 3 ½°.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,768,595 Dated October 30, 1973

Inventor(s) WILFRED H. KELLEY, JR.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 9, line 65, delete "41" and substitute - - 14 - - .

Signed and sealed this 4th day of June 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents