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3,077,951

LIFT TRUCK MAST OPERATION SEQUENCE MECHANISM

Filed Sept. 22, 1958

2 Sheets-Sheet 1

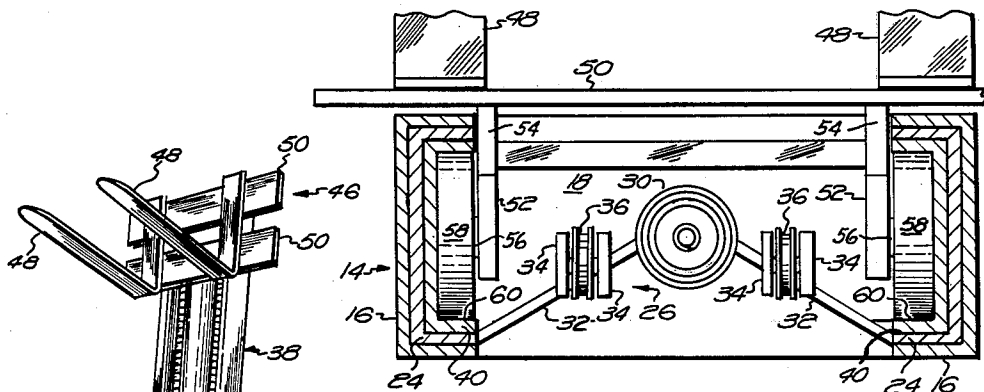


FIG. 5

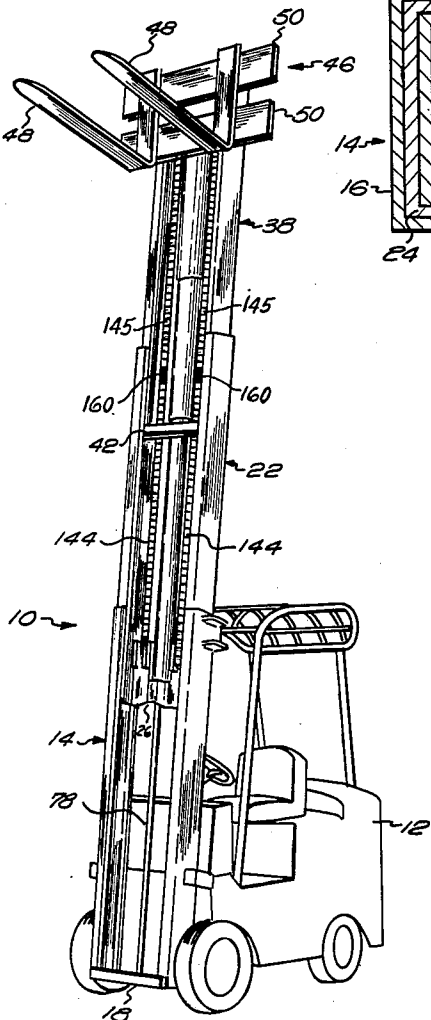


FIG. 1

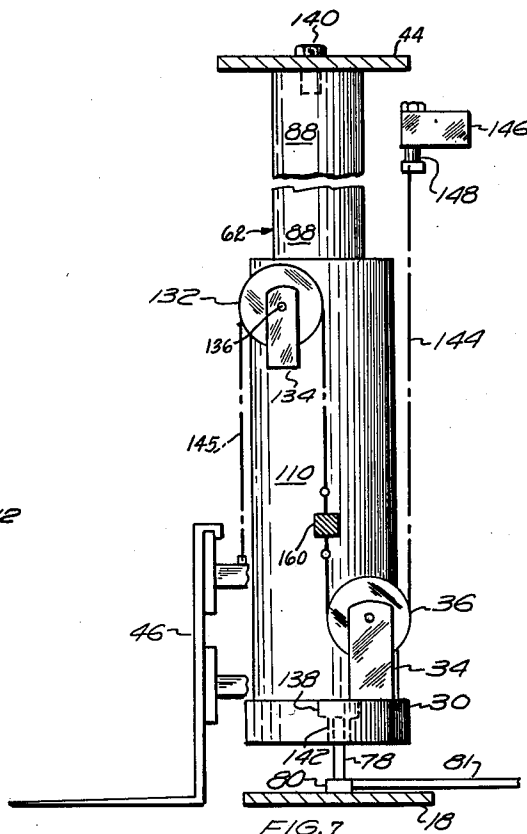


FIG. 7

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2 Sheets-Sheet 2

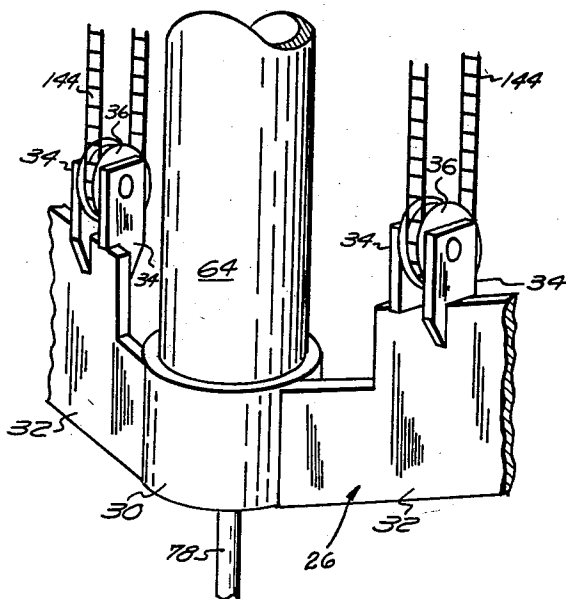


FIG. 6

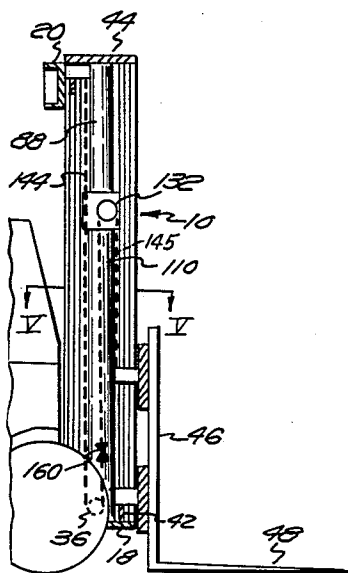
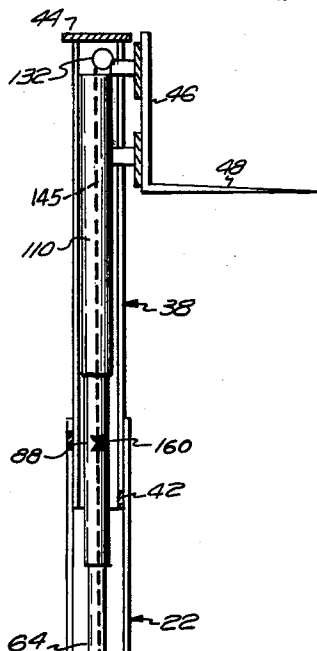


FIG. 2

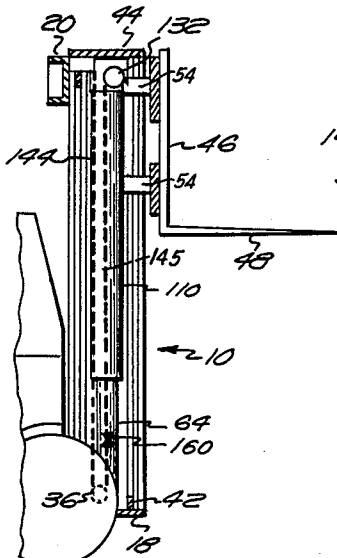


FIG. 3

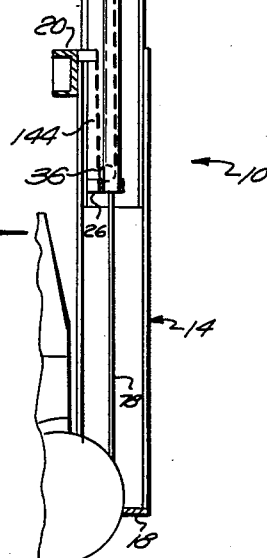


FIG. 4

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LIFT TRUCK MAST OPERATION SEQUENCE MECHANISM

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The invention relates to industrial lift trucks and particularly pertains to hydraulically operated mast and cylinder structure.

It is customary in the lift truck art to employ hydraulic cylinders as the motive force of the lifting mechanism due to the large forces producible within concise space requirements, flexibility of control, smooth operation and other well known advantageous characteristics of hydraulic fluid systems. Such use of cylinders is satisfactory in cases where the maximum height of the fork lift is ten feet or under, however, in order to fully utilize warehouse storage capacities it is desirable to be able to lift loads higher than ten feet and at heights above this distance problems are presented due to limitations of conventional hydraulic cylinder and mast construction. In the usual mast construction the cylinder is placed intermediate the uprights of the track carrier and is affixed at the bottom to the main track guide, which is in a substantially vertical fixed position, and the piston affixed to an inner mast which is vertically movable, and chains or cables are often used to raise the lift fork or carriage. Thus the height of the lowered mast and consequently minimum height of the truck will be largely determined by the length of the cylinder in the unextended position and to obtain stacking heights above ten feet a cylinder of considerable length must be used, even when utilizing telescoping piston construction, making the lowered height of the mast too great to pass through conventional freight car and loading dock doors. Increased heights have been obtained in the art by the use of a series or plurality of cylinders, however, such arrangements are heavy and costly to produce and maintain. Another disadvantage of prior high multi mast systems lies in the heretofore inability to maintain a constant load raising speed throughout each sequence of operation thus producing dangerous vibrations during the lifting operation which may dislodge a portion of the load or cause the load to shift.

It is thus an object of the invention to provide a lift for a lift truck which is capable of safely raising loads well over ten feet and utilizing a single, concise cylinder arrangement throughout the entire range of the lift.

Another object of the invention is to provide a lift for an industrial lift truck capable of raising a load to greater than average heights yet incorporates a free lift into the load elevating sequence capable of raising the entire height of the unextended mast and a two chain arrangement is employed to insure the proper sequence of mast operation during lowering. "Free lift" pertains to the raising of the fork or load carrying bracket without simultaneous movement of the mast thereby permitting loads to be raised from the floor and transported through low clearance freight car door and the like.

Another object of the invention is to produce a lift mast structure composed of three nesting masts operated by a single hydraulic cylinder such that the first lifting sequence consists of raising the load carriage without movement of the masts and the second sequence involving a simultaneous raising of the inner and intermediate masts, whereby complete elevation or retraction of both masts is simultaneously achieved producing a smooth and steady raising and lowering motion.

A further object of the invention is to provide a lift

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mast arrangement incorporating three telescoping masts with a single hydraulic cylinder and connecting chain structure whereby the multiple chain arrangement provides the proper sequence of mast operation and produces a safety factor.

Yet another object of the invention is to provide a lift mast utilizing free lift and extended mast sequences wherein the load lifting and lowering velocity is constant throughout the entire load movement.

These and other objects of the invention will become apparent when viewed with regard to the accompanying description and drawings wherein:

FIG. 1 is a perspective view of a lift truck employing the mast of the invention in fully extended position,

FIGS. 2, 3 and 4 are sectional elevational views of the mast of the invention in lowered position, top of free lift position and fully extended position, respectively,

FIG. 5 is a cross sectional plan view of the mast taken along line V—V of FIG. 2,

FIG. 6 is a perspective view of the lower cross member of the intermediate mast, and

FIG. 7 is a semi schematic view of the cylinder, mast and chain arrangement.

As illustrated in FIG. 1 the mast assembly 10 is mounted on the front end of a conventional lift truck generally indicated at 12. Mast assembly 10 is supported upon the truck in the normal manner whereby the assembly may be tilted forward or backward to facilitate fork movements as desired.

The primary element of the mast assembly is the outer mast 14 which is the member attached to the truck mountings. Mast 14 consists of a pair of channel members 16 held in spaced parallel relation by a bottom plate 18 and an upper cross member 20. Plate 18 and member 20 are welded to the channel members 16 insuring proper spacing throughout the height of the outer mast and the channels are arranged so as to be in opposed relation, opening toward each other, see FIG. 5.

The intermediate mast 22 is of somewhat similar construction also consisting of a pair of channel members 24 interconnected at the bottom by the bracket 26 and at the upper regions by the cross member 28. Channel members 24 also are in opposed parallel relation opening toward each other, the dimensions being such to provide a close, sliding, telescoping fit within the channels 16 of the outer mast 14. The bracket 26 performs an important function as the lower support of the hydraulic expansion unit and is best illustrated in FIGS. 5 and 6 wherein it will be observed that bracket 26 is offset whereby the enlarged portion 30 is located at the center of the rectangle defined by a cross section of the outer mast 14, FIG. 5. In the arms 32 which support portion 30 are located sheave or pulley bearing support members 34 between which the pulley or sheaves 36 are rotatably journaled. It will be noted that sheaves 36 are provided with a flat peripheral groove to receive a chain, the function of which will be later apparent.

An inner mast 38 is located in supported, guided, telescoping relation to intermediate mast 22 and consists of the channel members 40 interconnected at the bottom by cross member 42 and at the top by an upper plate 44 which is welded across the top of inner mast 38. The plate 44 is of sufficient width and length to act as a cover or protective cap for the complete mast assembly when in the retracted position. Plate 44 is of high strength as considerable forces are imposed thereon as will be later apparent. It will therefore be understood that the mast assembly 10 consists of the outer, vertically fixed mast 14 which telescopically supports intermediate mast 22 and the telescoping inner mast 38. The cross members and interconnecting plates of the masts are positioned so as not to interfere with extension and retraction of the as-

sembly and the clearances and tolerances between the masts are such to permit easy sliding when greased but are close enough to prevent relative rocking or swaying of the masts when fully extended.

The load is carried upon the load supporting carriage 46 which may consist of the conventional forks 48 and back transverse brackets 50. The brackets 50 are mounted to the roller plates 52 by braces members 54, FIG. 5. A pair of roller plates 52 are employed with the disclosed mast assembly, each being located adjacent the inner side of the channel members 40 of the inner mast 38. Each roller plate 52 supports a pair vertically disposed shafts 56 on which guide rollers 58 are rotatably journaled. As will be noted from FIG. 5 the rollers 58 roll within and are guided by the track 60 formed by the channel members 40 in the inner mast and are of slightly smaller diameter than the inner width of track. Thus the carriage 46 is vertically movable the height of inner mast 38 when the mast assembly is in the retracted position as in FIG. 2.

The means for raising and lowering the mast assembly consists of an expansion member, preferably of the hydraulic type. Such hydraulic means may be provided with pressurized fluid from a pump and reservoir supported and powered by the truck 12. Such components are conventional and need not be shown or explained in detail.

The preferred hydraulic expansion member is shown in FIGS. 4 and 7 and consists basically of four tubular members in concentric sliding relation whereby a two stage movement and expansion is produced having smooth and efficient sequential operation. The expansion member, generally indicated at 62, includes an inner cylinder 64 of a length a little less than the height of the mast assembly 10 when in retracted position. A feed tube 78 slidingly projects into the interior of cylinder 64 through appropriate sealing means and provides the expansion member with pressurized fluid through a supply conduit 81 affixed to fitting 80 at the outer end of tube 78, FIG. 7.

An intermediate cylinder 88 encompasses the inner cylinder 64 and is adapted to reciprocate axially thereto and is in sealing connection therewith. Cylinder 88 is enclosed at the upper end, and is formed with a threaded hole which permits the intermediate cylinder to be affixed to the plate 44 by means of a bolt or threaded stud 140.

The outer cylinder 110 is tubular and slideably mounted on cylinder 88, and defines an annular chamber with cylinder 88 having communication with the interior of cylinder 64, and is externally provided with a pair of pulleys or sheaves 132 which are rotatably journaled on bearing brackets 134 and shafts 136 on opposite sides of the cylinder 110 over which a chain passes in the assembled mast assembly. The shafts 136 are located slightly ahead of the axis of the expansion member 62 to provide chain clearance as will be later apparent.

The expansion member 62 is located between the channel members of the mast assembly having a projection on cylinder 64 which is received within a complementary recess 138, in portion 30 of bracket 26, thus affixing cylinder 64 to the intermediate mast 22. The upper end of the expansion member is affixed to plate 44 by means of a bolt 140 as described above. Thus the intermediate cylinder 88 is attached to the inner mast 38. The feed tube 78 extends downward through a hole 142 in portion 30 within the recess 138 and the fitting 80 is affixed to plate 18 of the outer mast and connected to the fluid supply line 81.

Chains are used to drivingly connect the masts and load carriage to provide the proper sequence of operation and raising of the masts. It will be understood that a cable or other flexible tension force transmitting means may be used in place of chains, however, a link chain is preferably employed. One end of a chain 144 is indirectly fastened to a bracket 146 welded to the cross member 20 of the outer mast 14 by means of bolt 148 which

permits adjustment of the chain tension. The chain is then threaded under the pulley 36 and affixed to a lower eye bolt attached to bracket 160 which is mounted on the inner mast 38. Another chain 145 is attached to the upper eye bolt of bracket 160 and is passed over pulley 132 on outer cylinder 110 and back down to the load supporting carriage 46 to which the other end of chain 145 is secured. If desired chain tensioning means may also be provided at the load carriage to achieve adjustment of the chain length 145. Thus, the chain 144 is attached to a fixed point, bracket 146 and the intermediate mast 22 through pulleys 36 and the inner mast 38. The chain 145 is attached to the mast 38, the outer cylinder 110 through pulleys 132; and the load supporting carriage 46. As will be observed, a pair of sets of chains 144 and 145 and pulleys are used in the mast assembly. Each set being located on opposite sides of the expansion member 62 thereby equalizing the forces on the masts preventing bending or other deflections of the mast which would interfere with telescoping of the channel members.

The operation of the mast assembly is as follows:

Initially the masts and carriage 46 will be in the position shown in FIG. 2. The carriage 46 is in the lowermost position and forks 48 may be inserted under a load. The component cylinders of expansion member 62 will be in the position shown in FIG. 7 as no fluid pressure is being supplied to the fitting 80 and the weight of the masts and carriage 46 will draw the member 62 to the retracted position.

When it is desired to lift the load, fluid pressure is introduced into the inner cylinder 64 via conduit 81 and feed tube 78. Thus, all of the fluid within member 62 will be under the same pressure. As the pressure is increased the weight due to the load will be overcome and the outer cylinder 110 will begin to rise in relation to the intermediate cylinder 88. As cylinder 110 rises, the pulleys 132 also rise causing the portion of chain 145 between pulley 132 and carriage 46 to be drawn over pulley 132 thereby lifting carriage 46 and the load thereon.

This initial lifting sequence constitutes the "free lift" of the mast, e.g. the load is lifted the height of the retracted masts without extension of the masts. During the "free lift" operation the masts will not rise as inner cylinder 64 is affixed to intermediate mast 22 thereby requiring a force necessary to lift the load plus the weight of the masts to initiate movement of the masts, therefore the first sequence of lifting will always be the carriage 46 which will be guided in its ascent by rollers 58 within track 60. As pulley 132 is being translated vertically, as well as rotating, the vertical velocity of the carriage will be twice that of the cylinder 110 thus cylinder 110 may be dimensioned so as to rise only half the distance that carriage 46 travels.

The "free lift" sequence terminates upon the cylinder 110 abutting the underside of plate 44 of the inner mast 38. Thereafter the expansion of member 62 takes place between inner cylinder 64 and intermediate cylinder 88 due to fluid pressure within these cylinders.

When cylinder 110 contacts plate 44 the load supporting carriage is in the position shown in FIG. 3 and relative movement of carriage 46 to the inner mast 38 and track 60 ceases. At this point the intermediate cylinder 88 begins to rise, thereby elevating plate 44 and the inner mast 38 connected thereto. During relative expansion of the cylinders 64 and 88 the outer cylinder 110 is maintained in engagement with plate 44 during extension of the inner mast 38 and as mast 38 rises the pulleys 132 will likewise be elevated at the same rate.

As inner mast 38 begins to rise the resulting tension within chain 144 between pulley 36 and bracket 148 will also tend to lift pulley 36 and consequently the intermediate mast 22 due to the end of the chain being stationarily affixed to the outer mast 14 at a point vertically above pulley 36. Thus, as cylinders 64 and 88 axially expand, both the intermediate mast 22 and the inner

mast 38 will rise due to the interconnection of the masts by chain 144 and the fact that the reaction of expansion member 62 and support thereof is directly imposed upon the movable masts 22 and 38. Thus continued relative movement of cylinders 64 and 88 will lift both mast 22 and 38 plus the load supporting carriage 46 and at the same time raise the expansion member 62.

During this lifting stage, the intermediate mast 22 is rising at a relative velocity to outer mast 14 equal to the relative sliding velocity between inner mast 38 and intermediate mast 22, thus in reference to a fixed stationary point such as outer mast 14 the inner mast 38 and load carriage 46 will raise twice the distance as intermediate mast 22 in a given length of time, thereby producing equal telescoping support between each of the adjacent masts at any point during extension of the mast assembly. To insure a smooth, vibration free ascent of the load from "pick up" to maximum lift the effective fluid reaction area within the fluid chamber defined by cylinders 88 and 110 is the same as the fluid reaction area between inner cylinder 64 and intermediate cylinder 88 thereby equalizing the rate of expansion of the cylinders 64 and 88 and the speed of cylinder 110 during "free lift" and providing a constant velocity of rise or fall of the load, at a given fluid pump output, throughout the "free lift" and mast extension stages of load elevation or descent. Thus the velocity of the load movement is the same during the "free lift" stage and the mast extension stage thereby producing a minimum of vibrations and stresses on the mast assembly.

Elevation or extension of the masts 22 and 38 continues until an abutment on cylinder 88, not shown, engages an abutment on cylinder 64, at which point maximum extension and load height is obtained and the mast assembly will appear as in FIGS. 1 and 4. In this position it will be observed that the bracket 26 of the intermediate mast 22 is disposed near the top of outer mast 14 and the expansion member 62 is located almost entirely above outer mast 14. It will be understood that during the extension of the masts the inner cylinder 64 will be rising relative to the fixed feed tube 78 and that the tube 78 is of sufficient length to always maintain fluid communication with the interior of cylinder 64 thereby providing communication with the fluid pump during all positions of the expansion member 62.

Once the load is at the desired height the truck operator will maintain the fluid pressure within member 62, move the truck forward, lower the load slightly to stacking relation and back the truck to clear forks 48. Upon operation of the hydraulic control valves to direct the fluid within expansion member 62 to the reservoir the cylinders 64 and 88 will telescope together and masts 22 and 38 will descend. Upon complete retraction of the masts the carriage 46 and cylinder 110 will lower from the position of FIG. 3 to that of FIG. 2 to complete the lowering operation.

Lowering of the inner mast 38 and carriage 46 simultaneously is assured by attaching chains 144 and 145 to the inner mast structure at a point intermediate the sheaves 36 and 132 when the masts and carriage are fully retracted as in FIG. 2. Thus, by attaching the chains 144 and 145 to the inner mast 38 at bracket 160, any relative movement between the carriage 46 and inner mast is prevented while the cylinder 110 abuts the underside of plate 44. As plate 44 is always engaged by the cylinder 110 except when all the masts are fully retracted the desired relationship may be maintained.

It will thus be understood that the invention provides a lift mast assembly which is capable of a very high lift utilizing a single cylinder. The "free lift" stage permits the carriage to be raised the full height of the retracted mast assembly providing clearance through freight car doors and the like, yet producing sufficient vertical load carriage movement to lift loads of unusual configuration free of the floor. The expansion member construction

provides a smooth constant speed load movement through all stages of the carriage ascent or descent and the use of three concentric cylinders permits extensive expansion from a relatively concise cylinder arrangement. By interconnecting the masts with the chains as shown and mounting the expansion member on the movable masts the degree of expansion necessary to provide a given lift is reduced from that expansion necessary where one of the expansion elements is attached to a vertically fixed mast member as in conventional lift mast structure and proper mast operation sequence is assured. By combining these features in a single mast assembly a mast of moderate cost may be produced which is capable of performance only found in expensive, bulky lift masts of conventional construction.

Various modifications to the disclosed embodiment may be apparent to those skilled in the art without departing from the spirit and scope of the invention and it is intended the invention be defined only by the following claims.

I claim:

1. In a lift mast structure comprising in combination, outer, intermediate and inner masts in telescoping relation, a guide formed on said inner mast, a load carrying member movably supported within said guide, an expansion unit having first and second relatively expansible elements, said first element being affixed to said intermediate mast and inner mast abutment means engaging said second element for transferring movement of said second element to said inner mast to lift said inner mast, a first sheave rotatably supported on said intermediate mast, a second sheave rotatably supported on said second element, a first chain portion affixed at one end to said outer mast, passing under said first sheave and affixed at the other end to said inner mast, and a second chain portion affixed at one end to said inner mast and passing over said second sheave and affixed at the other end to said load carrying member.

2. A lift mast assembly comprising in combination an outer upright mast having vertical guides, an intermediate upright mast having vertical guides slidably supported within the guides of said outer mast, an inner upright mast defining a vertical track slidably supported within the guides of said intermediate mast, a load supporting carriage slidably guided within said track, an inner cylinder supported on said intermediate mast, an intermediate cylinder affixed to said inner mast in concentric expansible relation to said inner cylinder, an outer cylinder concentrically supported on said intermediate cylinder in axially movable relation thereto, a first chain portion anchored at one end to an upper portion of said outer mast passing under a sheave mounted at the lower portion of said intermediate mast and anchored at the other end to said inner mast, a second chain portion affixed at one end to said inner mast and passing over a sheave mounted on said outer cylinder and affixed at the other end to said load carriage, and means providing fluid pressure to said cylinders whereby said outer cylinder will rise on said intermediate cylinder lifting said carriage and lift said inner mast upon engagement with said inner mast whereupon said inner and intermediate cylinders relatively expand causing said inner and intermediate masts to rise thereby additionally lifting said carriage.

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