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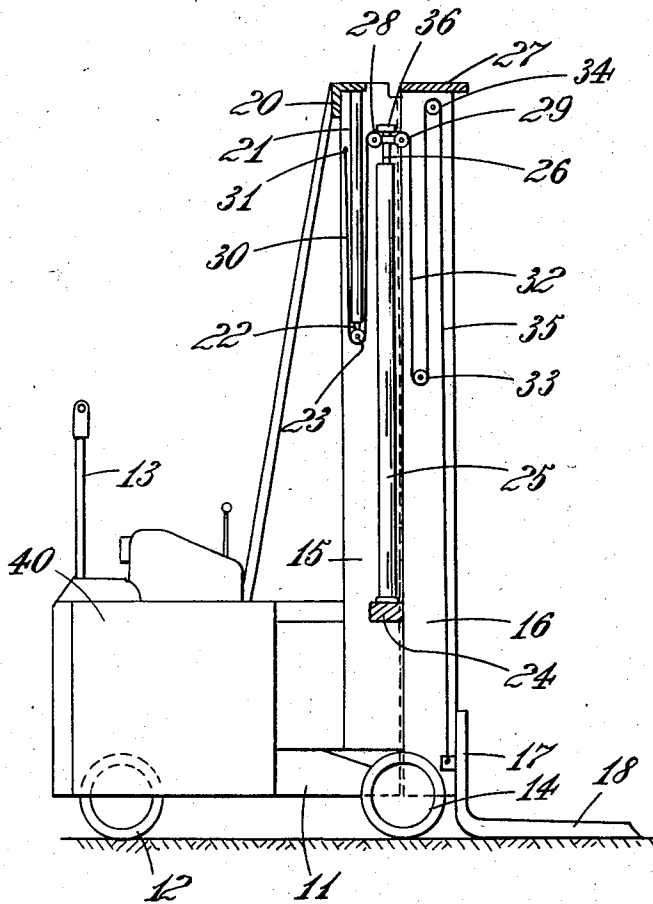
A. E. R. ARNOT  
MAST LIFT TRUCKS

2,883,003

Filed May 12, 1955

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*Fig. 1.*



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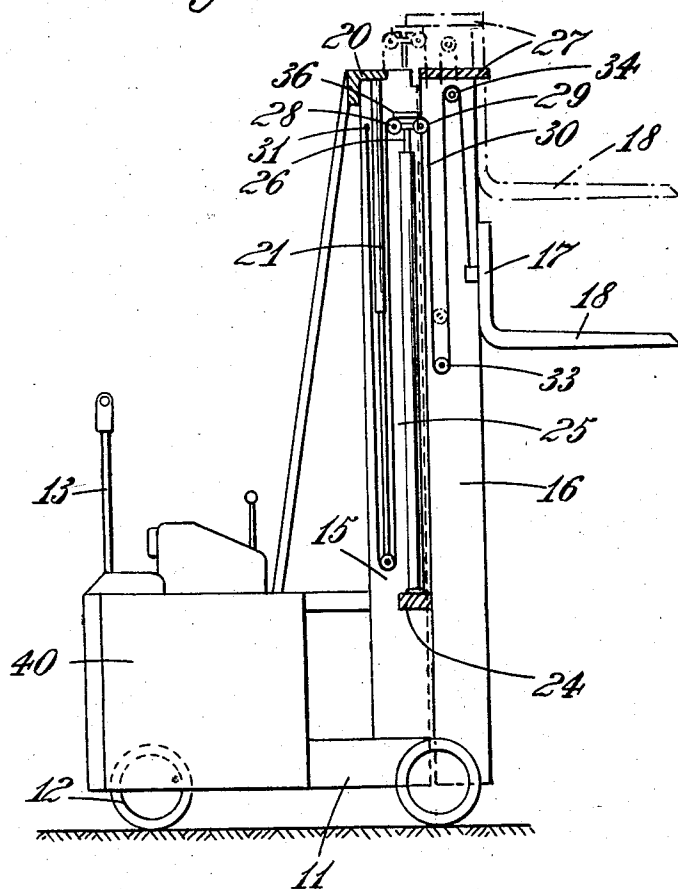
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*Fig. 2.*



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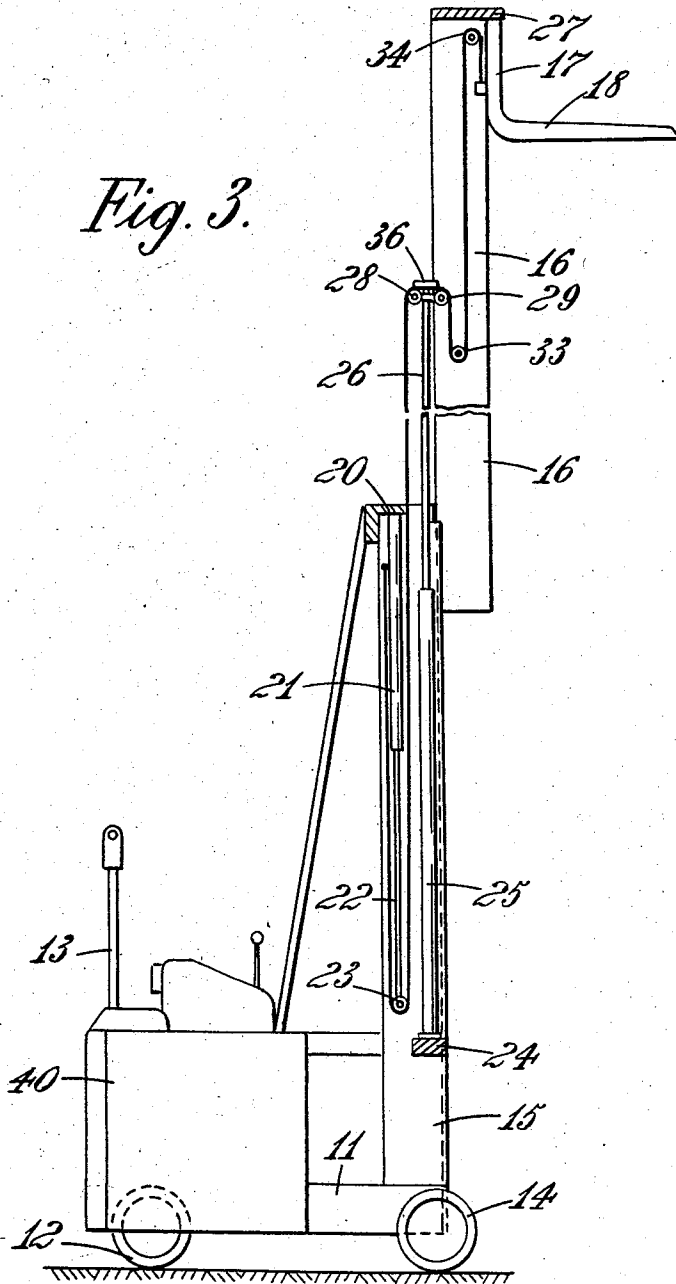
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*Fig. 3.*



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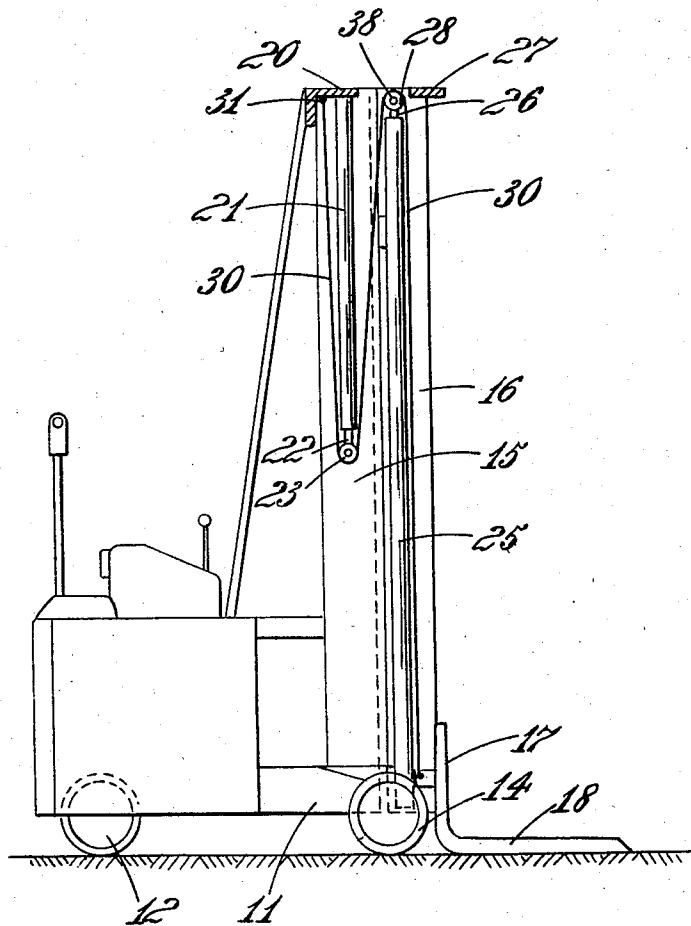
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*Fig. 4.*



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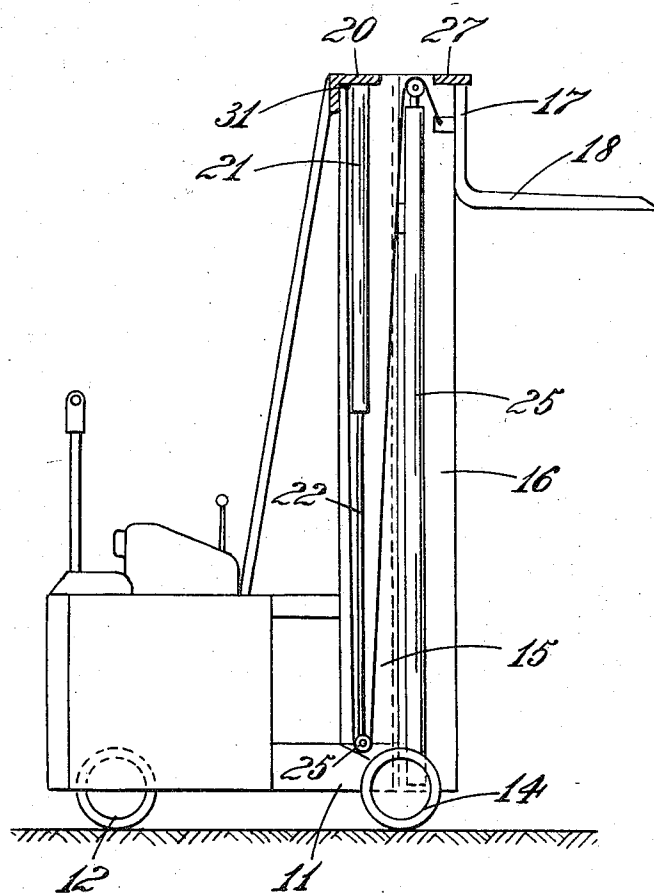
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Filed May 12, 1955

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*Fig. 5.*



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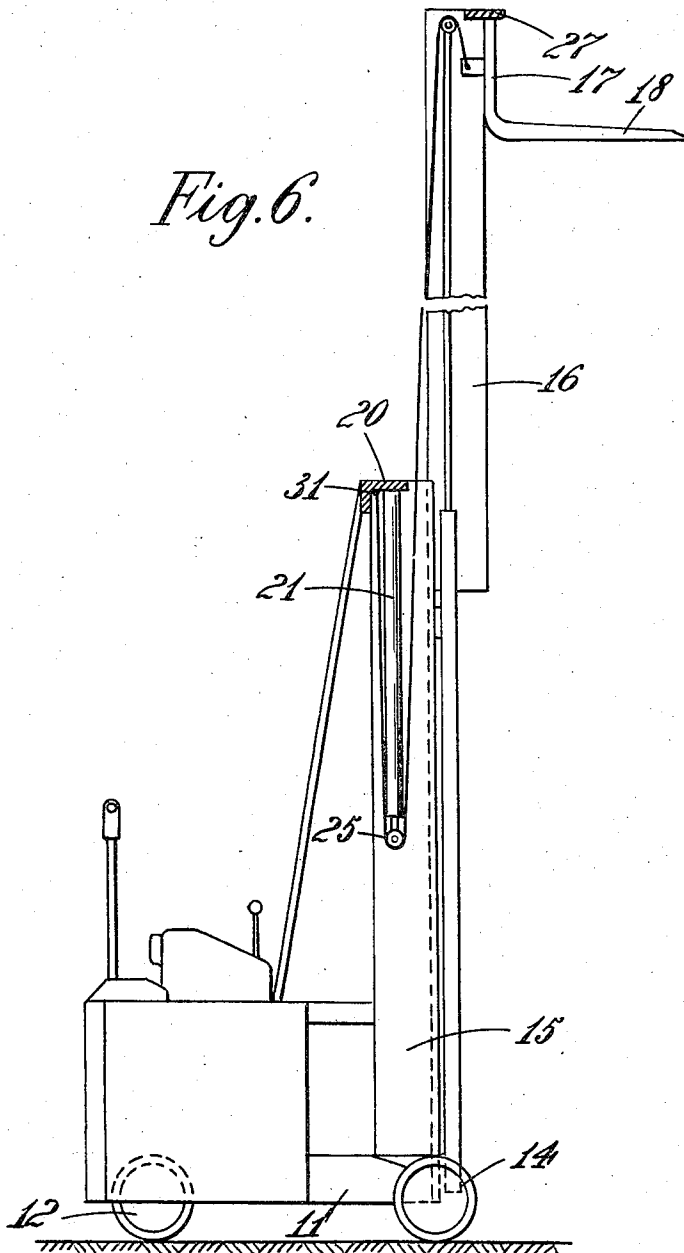
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Filed May 12, 1955

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*Fig. 6.*



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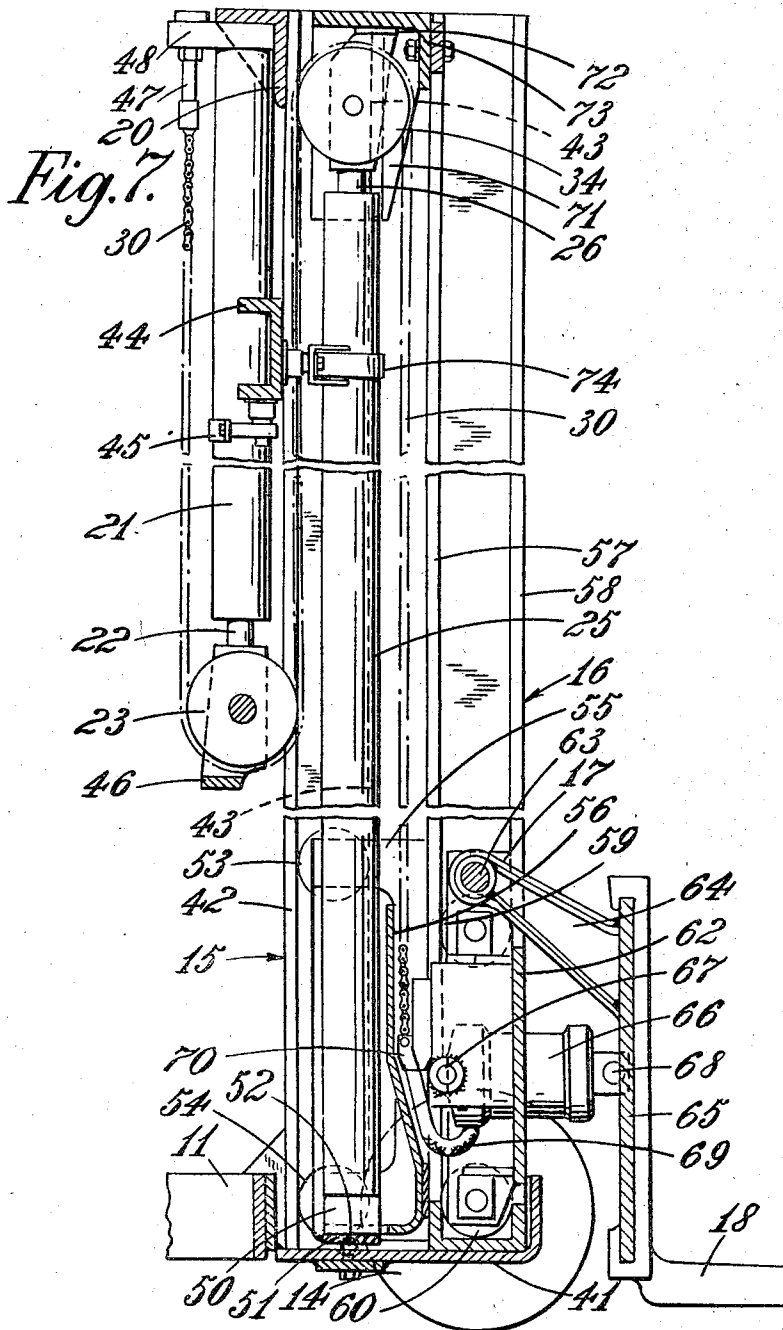
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Filed May 12, 1955

7 Sheets-Sheet 7



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2,883,003

## MAST LIFT TRUCKS

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Application May 12, 1955, Serial No. 507,964

Claims priority, application Great Britain  
December 24, 1954

7 Claims. (Cl. 187—9)

This invention comprises improvements in or relating to mast lift trucks.

The invention particularly relates to mast lift trucks of the type which comprise a mast, a rising section on the mast and a lifting carriage on the rising section. Various arrangements have hitherto been adopted for applying hydraulic power to extend the mast and lift the carriage. Such arrangements usually involve a certain complication in the construction and some of them involve the use of a plurality of lifting chains and flexible hydraulic connections to jacks which are mounted on the rising section of the mast. Space is usually cramped on masted trucks and it is an object of the present invention to provide a construction which occupies a minimum of vertical space in the mast and so allows more room for other items of equipment; further objects of the invention are to provide a construction in which the use of flexible high-pressure tubing is obviated and in which "free lift" is obtained. This means that the lift of the lifting carriage for part or all of its movement on the rising section can be obtained without requiring the rising section of the mast to be lifted, the rising section of the mast being subsequently elevated.

According to the present invention, in a truck of the type described, two lifting jacks are provided both fixed in relation to the mast structure and working in opposite directions, each jack operating movable pulley guides for chain or cable which is led from a fixed anchoring point to and fro around first one of said movable guides and then the other, and thence to the rising mast and lifting carriage, to lift it. The use of an inverted jack permits the use of a simple pulley system giving free lift.

In one construction according to the present invention the two jacks are separately controlled and the controls are such that pressure is admitted first to the inverted jack, which on extension lifts the carriage on the rising section of the mast, while extension of the mast occurs when the upright jack is operated.

In a second construction, in a truck of the type described the means for effecting lift of the carriage and of the rising section of the mast comprises a lifting jack or jacks for the rising section, a chain or equivalent for the carriage running over a pulley on the rising section and thence to a fixed anchoring point, via a pulley on a second jack or jacks engaging a bight in the chain between the pulley and anchoring point, together with a common pressure supply for extending the two jacks. If the jacks are so relatively proportioned that the jack for lifting the rising section of the mast cannot extend against the weight of the rising section, plus the carriage load plus the pull of the chain, until the second jack has taken up the free lift, this construction will operate with a single control on the common supply to the two jacks and as neither jack needs to be mounted on the rising section of the mast, all flexible trailing pipes are avoided.

The following is a description by way of example of

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two constructions in accordance with the invention, reference being made to the accompanying drawings, in which:

Figure 1 is a diagrammatic side elevation of one construction with the parts in their lowest position;

Figure 2 is a similar view with only the fork carriage lifted;

Figure 3 shows the mast fully extended and the carriage thereon fully lifted;

Figures 4, 5 and 6 are views corresponding respectively to Figures 1, 2 and 3, but of a second construction; and

Figure 7 shows the mechanism of the second construction in more detail.

Referring to Figures 1 to 3, these show a construction to truck comprising a chassis 11 which has a driving and steering wheel 12 at the back capable of being steered by a tiller handle 13. At the front are two side wheels 14 mounted on fixed stub axles and between the side wheels 14 there is mounted on the chassis 11 a fixed mast 15. In front of the fixed mast 15 is an extending, that is to say rising mast 16 which slides upon it. It will be understood that the drawings are diagrammatic and that any desired or usual parts so far described may be adopted. The rising mast section 16 carries a movable fork-carriage 17 provided with fork arms 18, which fork-carriage is capable of running up and down the mast 16. In order to operate the fork-carriage and the extending mast there is provided the hydraulic cylinder and chain mechanism now to be described.

From the underside of a cross-member 20 at the top of the mast 15 there extends downwardly an inverted hydraulic cylinder 21 (it will be understood that in the drawing the masts 15, 16 are treated as being shown in vertical section so that the cylinders appear in full). At the lower end of the cylinder 21 there extends downwardly a ram 22 which at the bottom carries a pair of pulleys 23. Also between the two sides of the mast 15 and at a much lower level is a second cross-member 24 on which is secured a second hydraulic cylinder 25 which extends upwardly parallel to and close in front of the cylinder 21 above referred to. The cylinder 25 is longer than the cylinder 21 and its ram 26 when contracted into the cylinder extends nearly to the upper cross-member 27 of the mast 16. The head of the ram 26 carries two pairs of pulleys 28, 29 which are spaced apart from one another sufficiently to allow double chains 30, which extend from an anchoring point 31 near the top of the mast 15 and downward under the pulleys 23, to pass upward and over the two pairs of pulleys 28, 29 without fouling the cylinder 25. The portions of the chains 30 which pass downwardly as shown at 32 from the pulleys 29, pass under pulleys 33, the spindle of which is secured to the extending section 16 of the mast and thence upwardly over pulleys 34, the spindle of which is secured again to the mast 16 and thence downwardly as shown at 35 to the carriage 17.

In the operation of this apparatus, if the downwardly depending jack 21 is first extended, as shown in Figure 2, it will begin by lifting the fork-carriage 17, all the intermediate pulleys 28, 29, 33 and 34 remaining at rest. It will be observed that as the said chains pass first downwardly under the pulleys 33 and thence upwardly over the pulleys 34, the net force on the rising section 16 of the mast is zero. The amount of the lift so imparted is equal to twice the stroke of the jack 21, as can be seen from Figure 2. During this operation the chains run freely round the pulleys 28, 29, 33, and 34. The lift shown in Figure 2 is sufficient for many purposes without using the second jack 25. If a greater lift is required the second jack is brought into use.

It will be seen that the pulleys 28, 29 are mounted on

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a cross-head 36 on the top of the ram 26 and the cross-head 36 in the position of the parts shown in full lines in Figure 2 is a little below the cross-member 27 of the mast 16. The first effect of extending the second jack 25 is therefore to lift the fork-carriage 17 further on the mast 16 until the cross-head 36 engages beneath the cross-member 27. The cross-head 36 thereafter commences to lift the movable mast 16 directly. This operation is shown in chain lines in Figure 2 after it has taken place for a little distance. In lifting the mast 16 the cross-head 36 also lengthens the path for the chains 30 and causes the fork-carriage 17 to move up rather faster than the mast so that in a short distance the top of the fork-carriage engages the underside of the cross-member 27 on the mast 16. This is the end of the travel of the fork-carriage on the mast 16. Thereafter further extension of the jack 25 continues to lift the fork-carriage at twice the speed of the extension of the jack and the fork-carriage carries the mast 16 upwardly with it as far as the parts will go, the position ultimately reached being shown in Figure 3 where the jack 25 is fully extended.

It will be noted that all the jack mechanism is located above the lower cross-member 24 and that if desired there is space beneath this cross-member for other parts on the truck, such as a storage battery. An electric motor operated by a storage battery or a petrol motor for driving the wheel 12 may be located within a casing 40 on the chassis 11.

Referring now to Figures 4-6, this shows another truck also comprising a chassis 11, driving and steering wheel 12 and side wheels 14 at the front. Similarly there is a fixed mast 15 at the upper end of which is a cross-member 20 from which depends a jack 21. On the mast 15 is a rising section 16 which is similar to the mast 15 but so connected to the section 15 that it is guided thereby for raising and lowering. On the rising section 16 are guides for a carriage 17 which can run up and down therein and which carries forwardly projecting fork-arms 18 for pallets or other loads as already described in connection with Figures 1-3.

As before, the depending jack-cylinder 21 has a ram 22 which carries a chain pulley or pulleys 23. The jack 21 is given a stroke equal to half the lifting travel of the fork-carriage 17 on the rising section 16 of the mast. In addition there is a second jack 25 located with its cylinder pointing upwards and having a ram 26 which carries a pulley 28 on a spindle 38. In this construction of truck, however, the chain 30 extends from an anchoring point 31 downward under the pulley 23, upward and over the pulley 28 and thence downward to the carriage 17. The spindle 38 runs in bearings carried by the top of the rising section 16 of the mast so that the jack 25 if extended raises the section 16 directly. For this purpose it is given a stroke equal to the lifting stroke of the mast 16. The diameter of the jack 25 is made the same as that of the jack 21, but by reason of its direct connection to the mast 16 it has approximately twice the stroke of the jack 21. The pressure ends of the jacks 21, 25 are connected together and to the controls of a hydraulic supply system.

In operation, if a load is placed on the fork-arms 18 and pressure is applied to the jacks, the first effect is to cause the inverted jack 21 to extend and thereby to lift the carriage 17 with the fork-arms 18 and the load thereon, which it can do to the whole extent of the available lifting movement of the carriage 17 on the rising section 16 of the mast. During this operation the long jack 25 cannot extend although it is subjected to the same pressure as the other jack because it has to work against the downward pull of the chain 30 passing over the pulley 28 in addition to working against the weight of the rising section 16 of the mast and of the carriage and load thereon and the total of these forces is greater than that which the inverted jack 21 must exert merely to lift the carriage and load. Therefore the carriage 17 can be con-

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trolled to any height within the height of the rising section 16 of the mast without lifting the latter. In other words the lift is "free," which means that it is free of causing overhead obstruction by lifting the rising section 16 of the mast.

When the jack 21 has reached the limit of its extension the parts have reached the position shown in Figure 5 of the drawing where the carriage 17 abuts against the underside of the cross-member 27 at the head of the rising section of the mast. If the supply of hydraulic fluid to the jacks 21, 25 is still continued, the jack 25 will now begin to extend.

It may at first sight seem odd that it was unable to extend against the push of the inverted jack 21 as long as the carriage 17 was free on the rising section of the mast, yet is able to do so afterwards, but the reason for this is that once the travel of the carriage 17 on the rising section of the mast has been completed, the long jack only has to operate against the weight of the rising section of the mast and the load, plus the pull of one side of the chain 30 where it passes over the pulley 28, whereas the inverted jack 21 has to operate against the pull of two stretches of chain, one on either side of it which are doubled around the underside of pulley 23. The effect is that the mast section 16 now rises and the inverted jack 21 is compelled to contract while the long jack 25 expands. As the long jack has twice the stroke of the other, the volume of hydraulic fluid in the system as a whole continues to increase. This movement continues until the rising section of the mast has reached the upper limit of its travel as shown in Figure 6.

It will also be understood that additional chain multiplication can be introduced on the jacks and that the jacks can be inverted or placed crosswise by the introduction of appropriate idler pulleys.

The principle of operation has been described with reference to Figures 4-6. Figure 7 shows in more detail the actual construction of the mast portion of a truck. Figure 7 is a longitudinal vertical section through the mast and it will be seen that at the front of the chassis 11 the sides of the chassis are connected together by a channel-shaped cross-member 41 from which there extends upwardly a fixed section 15 of the mast which consists of two channel-shaped members secured at their lower ends to the cross-member 41 and set with their flanges facing towards one another. One of the flanges 42 can be seen in full lines in Figure 7 and the other appears in dotted lines at 43. The two sides of the mast are united by an angle member 20 at the top and to the underside of the angle member the inverted jack 21 is secured. The jack 21 is also held by being clipped to a channel-shaped cross-member 44 by a clip 45. The ram 22 of the jack 21 carries a head 46 in which the pulley 23 runs. The chain 30 is anchored at 47 to a foot 48 which forms the base of the cylinder 21 and is bolted to the underside of the angle member 20. It will be understood that there may be either one or two pulleys 23 side by side on the same axis and that there will be a corresponding number of chains 30. The jack 25 has a foot 50 which is secured on a cross-plate 51 just above the channel-shaped member 41. The cross-plate 51 has a conical seat which corresponds with a similar conical seat in the channel member 41 and locates a large steel ball 52 which sustains the downward force of the jack. The cross-plate 51 is retained in position by means of bolts, flexibly securing it to the channel member 41. The rising section 16 of the mast is supported on a carriage 55 provided with rollers 53, 54 which run between the flanges 42, 43 and the carriage 55 is stiffened by a cross plate 56.

The rising section 16 of the mast also consists of channel-members with inwardly directed flanges 57, 58 and between the flanges there run rollers 59, 60 on the carriage 17. The carriage 17 consists of vertical plates which carry the rollers 59, 60 and which are united by a cross-

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plate 62 and a pivot pin 63. The pivot pin 63 spans the side-plates of the carriage near their top end above the upper rollers 59 and it carries pivoted bracket arms 64 on which is mounted a tilting plate 65 which carries the fork-arms 18. The tilting plate is operated by a tilting jack 66 which is pivoted at 67 to the carriage 17 and at 68 to the back of the plate 65. The tilting jack is supplied with hydraulic fluid under pressure through a pipe 69 and the chain 30 is anchored to the carriage 17 at 70. The pipe 69 passes upwardly parallel to and preferably between the two parts of the chain 30. It is made flexible and passes with the chain over the pulley 34 at the top of the rising section of the mast under the pulley 23 at the bottom of the jack 21 and thence upwardly to a fixed point of supply. The pipe 69 only has to supply the small capacity jack 66. This is the only flexible supply pipe required by the mechanism as the foot 50 of the jack 25 and the foot 48 of the jack 21 are secured to fixed portions of the mast.

It is to be noted that the pulley 34 is secured in a sheave 71 which is secured at 72 to an angle-plate 73 forming a cross-member at the head of the rising section 16 of the mast and the sheave is secured also to the ram 26 of the jack 25. The jack 25 is held from lateral movements by a clip 74 which secures it to the cross-member 44.

I claim:

1. A goods handling truck comprising in combination a fixed mast, a rising mast running on the fixed mast and having guide means adjacent the upper end thereof, a lifting carriage running on the rising mast, fluid pressure means for said lifting carriage including jack means having one element mounted in fixed position on the upper portion of said fixed mast and having its other element movable downwardly, a guide portion on said element for raising said lifting carriage, fluid pressure means for said rising mast including jack means mounted in fixed position relative to said fixed mast and having a portion movable upwardly for raising said rising mast, flexible means connected at one end to said carriage and at its other end connected in fixed position on said mast above said lifting carriage jack means guide portion and running upwardly from said carriage over said guide means and downwardly around said lifting carriage jack means guide portion.

2. A goods handling truck as claimed in claim 1, wherein said rising mast has a second guide means below its first guide means adjacent the upper end thereof and wherein said jack means for said rising mast includes a guide portion movable upwardly relatively to said rising

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mast, said flexible means running upwardly over said first guide means, downwardly around said second guide means, and upwardly around said rising mast jack means guide portion.

3. A truck as claimed in claim 1, wherein the jacks are so relatively proportioned that the jack for lifting the rising section of the mast cannot extend against the weight of the rising section, plus the carriage load plus the pull of the chain, until the second jack has taken up the free lift.

4. A truck as claimed in claim 1, wherein the lifting jack for the rising section of the mast is made long enough to effect the whole lift of the rising section directly, and the movable element of the jack is directly connected to said mast.

5. A truck as claimed in claim 4, wherein the lifting jack for the rising section of the mast is located between the sides of the fixed section of the mast and connected directly to the rising section by a bracket on the head of the jack which is secured to the back of the rising section of the mast.

6. A truck as claimed in claim 5, wherein the first jack rests on a ball seating at the bottom of the fixed mast.

7. A goods handling truck comprising in combination a fixed mast, a rising mast running on the fixed mast and having first guide means adjacent the upper end thereof and second guide means below said first guide means, a lifting carriage running on the rising mast, fluid pressure means for said lifting carriage including jack means mounted on the upper portion of said fixed mast and having a guide portion movable downwardly relatively thereto for raising said lifting carriage, fluid pressure means for said rising mast including jack means mounted in fixed position relative to said fixed mast and having a guide portion for moving said rising mast which guide portion is movable upwardly relatively to said fixed mast and to said rising mast for a stroke equal to one-half stroke of said rising mast, flexible means connected at one end to said carriage and at its other end connected in fixed position relative to said mast and running upwardly from said carriage over said first guide means, downwardly around said second guide means, upwardly around said rising mast jack means guide portion, and around said lifting carriage jack means guide portion.

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