Feb. 6, 1973 SHUJI OHTA 3,715,014

INDUSTRIAL TRUCK

Filed March 16, 1971

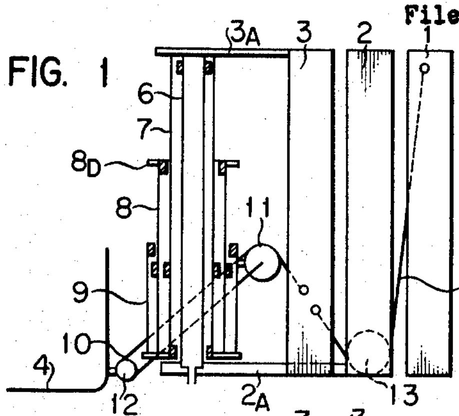

FIG. 1

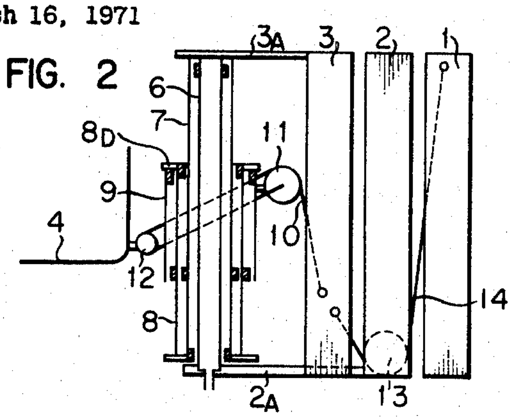

FIG. 2

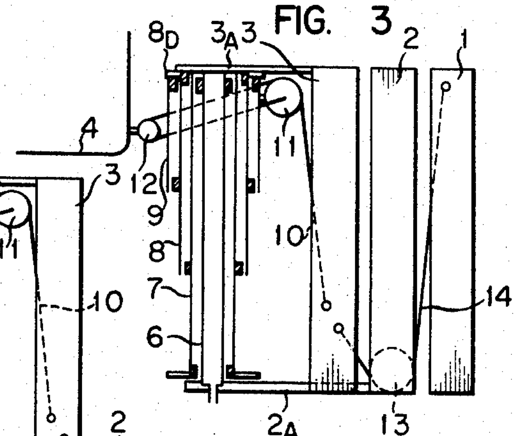

FIG. 3

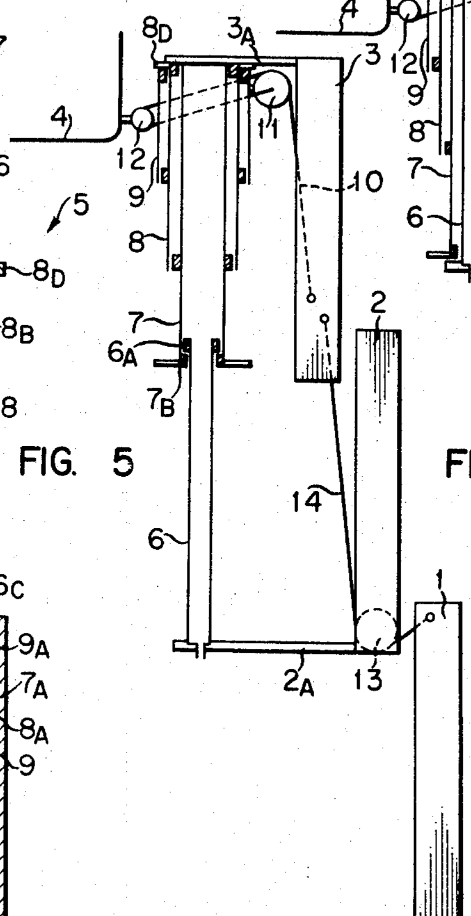

FIG. 4

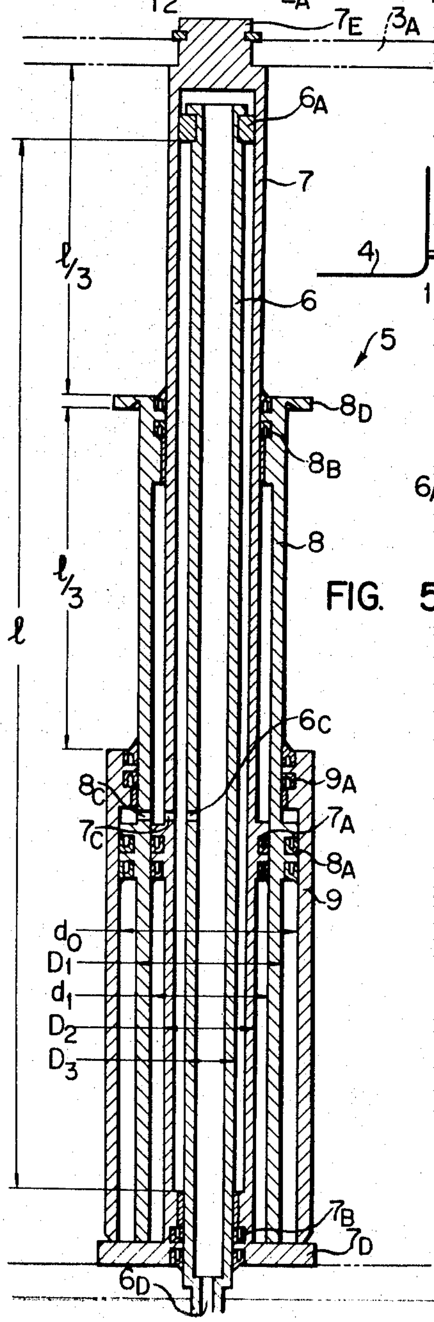

FIG. 5

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1

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INDUSTRIAL TRUCK

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Int. Cl. B66b *9/20*
U.S. Cl. 187—9 1 Claim

ABSTRACT OF THE DISCLOSURE

An industrial truck of the type of so-called full free triple stage uprights or masts, comprising an outer mast, an intermediate mast vertically movable relative to said outer mast, an inner mast vertically movable relative to said intermediate mast, a load carriage vertically movable relative to said inner mast, a second ram connected with said inner mast, an inner cylinder concentrically arranged within said second ram, a first ram engaging concentrically with the outer side of said second ram, an outer cylinder concentrically engaging with the outer side of said first ram, chain wheels rotatably supported by said outer cylinder, and intermediate mast and said load carriage respectively, a chain of which one end and other end being mounted on said outer mast and said inner mast respectively and guided by said chain wheel at said intermediate mast, and a chain connected at one end with said outer cylinder and at the other end with said inner mast after passing over said chain wheels at said load carriage and at said outer cylinder.

This invention relates to an industrial truck or fork lift, particularly provided with so-called full free triple stage uprights or masts. With respect to a fork lift with triple stage uprights, usually there is an intermediate upright adapted for telescopic vertical movement relative to an outer upright which is rigidly mounted to the truck frame, and the inner upright adapted for telescopic movement relative to said intermediate upright, said inner upright being lifted by means of an oil cylinder. A chain wheel mounted on the upper part of said oil cylinder is lifted thereby and the lift bracket and the fork guided by the inner upright are also lifted by means of the oil cylinder. However, in such fork lifts the piston rod of the oil cylinder and the upper part of the inner upright are rigidly mounted, so that the inner upright is lifted according to the lift of the fork and the total height of the lift truck is increased. This makes it difficult for use in a place with a low overhead ceiling, such as in a cargo boat. To solve the above mentioned problem, heretofore a fork lift with so-called full free triple stage uprights has been employed. The characteristic feature of such fork lift resides in that the inner upright is elevated after the load carriage is lifted to the top of the inner uprights, so that the above mentioned disadvantage may be removed. The most superior type of such kind of fork lift is mentioned in the specification of U.S. Pat. No. 3,252,545. In such fork lift, the oil cylinder proper as a whole is adapted for vertical movement relative to each upright, so that it is necessary to provide a latch device for connecting the upper end of the oil cylinder with the upper end of the inner upright when the inner upright is elevated in order to allow the downward movement of the inner upright according to the total weight of the inner upright, the oil cylinder, the lift bracket, the fork and the load. Assuming that there is not provided such latch device, and that the frictional resistance between the inner upright and the

2

intermediate upright exceeds the weight of the inner upright, the latter will not be moved downwardly, but will be in an unstable condition supported solely by frictional resistance. Afterward, if the frictional resistance is decreased due to vibration of the carriage, the inner upright will be suddenly dropped due to its weight, so that it impinges the upper end of the oil cylinder which is in the dropped position. Such sudden dropping of the oil cylinder and succeeding shock of the upper end of the oil cylinder will be very noisy, annoying the operator. On the other hand, the provision of the latch device is not only expensive, but also results in a complex structure of the fork lift. Furthermore, accidental failure of the operation of the latch is unavoidable. Therefore, it would of course be most desirable to have a fork lift not provided such a latch device.

The principal object of the present invention is to provide an industrial truck with full free triple stage uprights, in which the operator's front field of vision is wider.

Another object of the present invention is to provide a new industrial truck or fork lift with so-called full free triple stage uprights which is adapted for smooth operation without providing any latch device. A still further object of the present invention is to provide an industrial truck of full free triple stage uprights of simple construction where the upper and lower ends of the oil cylinder may be rigidly mounted on the mast.

The present invention will be described with reference to the accompanying drawings, wherein:

FIGS. 1 to 4 show side views of the masts or uprights of the industrial truck according to one embodiment of the present invention; FIG. 1 showing an oil cylinder for lifting the fork in its retracted position; FIG. 2 showing said oil cylinder in its first elongated position; FIG. 3 showing said oil cylinder in its second elongated position; and FIG. 4 showing said oil cylinder in its third elongated position. FIG. 5 shows one embodiment of said triple stage liftable oil cylinder.

Referring to the drawings, the reference numeral **1** designates an outer upright or mast mounted to the truck frame (not shown), and **2** designates an intermediate upright or mast vertically movable relative to said outer mast **1**. **3** designates an inner upright or mast vertically movable up and down relative to said intermediate mast **2**. **4** designates a lift bracket vertically movable relative to said inner upright **3**. In said triple stage uprights, the lift bracket **4**, the inner mast **3** and the intermediate mast **2** are adapted to be vertically movable by means of the oil cylinder **5**, the chains **10**, **14** and the chain wheels **11**, **12** and **13**.

The chain wheel **13** is rotatably mounted adjacent the lower end of the intermediate mast **2**, and both ends thereof are adapted for guiding the chain **14**, of which both ends are rigidly mounted to the outer mast **1** and the inner mast **3**. The oil cylinder **5** consists of the outer cylinder **9**, the first ram **8**, the second ram **7** and the inner cylinder **6**, which are concentrically arranged. The lower end of the inner cylinder **6** is connected with the lower end of the intermediate mast **2** by means of the lower connector **2A**, and the chain wheel **11** is rotatably mounted to the upper end of the outer cylinder **9**. One end of the chain **10** is connected with the mid point of the chain wheeel **11** or with the outer cylinder **9** and the other end extends down around a chain wheel **12** rotatably mounted on the lift bracket **4** and then over the chain wheel **11** mounted to the inner mast **3**.

Now, with reference to FIG. 5, further detail of the oil cylinder will be described. At the mid portion of the first ram **8**, seal member **8A** sliding along the inner surface of the outer cylinder **9** is provided. A seal member

9A is mounted to the upper end of the outer cylinder **9**, which seal member **9A** is adapted together with said seal member **8A** for sealing the space between the outer cylinder **9** and the first ram **8**. Similarly, at a point slightly lower than the mid point of the second ram **7**, there is provided a seal member **7A** sliding along the inner surface of the first ram **8**. Said seal member **7A**, together with the seal member **8B** mounted on the upper end of the first ram **8** are adapted for sealing the space between the first ram **8** and the second ram **7**. Furthermore, at the upper end of the inner cylinder **6** there is provided a sliding member **6A** sliding along the inner surface of the second ram **7**, and by means of sealing member **7B** mounted at the lower end portion of the second ram **7**, thereby sealing the space between the second ram **7** and the inner cylinder **6**. For supplying pressure oil for the outer cylinder, the first ram and the second ram, and the inner cylinder are provided with oil ducts **8C**, **7C** and **6C** respectively. In the drawing, d_0, D_1, d_1, D_2, D_3 show the inner diameter of the outer cylinder **9**, the outer diameter of the first ram **8**, and the inner diameter of the latter, the outer diameter of the second ram **7** and the outer diameter of the inner cylinder **6**, respectively.

In the condition when the lift bracket and the fork **4** are in the lowermost position as shown in FIG. 1, when oil under pressure is supplied through the lowermost part **6D** of the inner cylinder **6**, the outer cylinder is lifted a distance $l/3$) relative to the intermediate mast **2**. Then, the upper end of the outer cylinder will engage with the upper part of the first ram **8** as shown in FIG. 2, while the chain wheel **11** will also be lifted a distance $l/3$. Assuming that one end of the chain **10** is not connected to the inner mast **3** at this time, but that it is connected to the chain wheel **11**, the chain wheels **11** and **12** would be connected through the chain **10** so that the lift bracket and the fork **4** will also be lifted a distance $l/3$. Since one end of the chain **10** is attached to the inner mast **3** as the chain wheel is lifted a distance of $l/3$ the chain **10** will be pulled for the length of $l/3$. As as result the chain wheel **12** will further be lifted an additional $l/6$. Consequently, the lift bracket and the fork **4** will be lifted $l/3+l/6=l/2$.

In the state shown in FIG. 2, if pressure oil is further supplied, the upper end of the outer cylinder **9** will push up the upper flange **8D** of the first ram **8**, and upon being lifted a further distance $l/3$ will engage with the upper connector **3A** of the inner mast **3** as shown in FIG. 3. During said movement, the lift bracket and the fork **4** will further be lifted a distance $l/2$ according to the principle discussed above. Furthermore, the first ram **8** will be forced downwardly by its weight M, and the oil pressure of cross sectional area$=\pi/4\times(d_0{}^2-D_1{}^2$ and forced upwardly by the oil pressure of cross sectional area $=\pi/4\times(d_1{}^2-D_2{}^2$. Therefore, if the oil cylinder is designed $(d_0{}^2-D_1{}^2)\geqq(d_1{}^2-D_2{}^2)$ is fulfilled, the first ram **8** will not be lifted before the outer cylinder **9** is lifted.

If the pressure oil is further supplied in the state shown in FIG. 3, the upper end of the outer cylinder **9** will lift the upper connecting element **3A** of the inner mast **3** through the upper flange **8D** of the first ram **8**. In addition the second ram **7** and the inner mast **3** will also be lifted, so the the inner cylinder **6** and the intermediate mast **2** for the stroke l through the sliding member **6A** of the inner cylinder **6** will abut against the seal member **7B** reaching to the state shown in FIG. 4. During such operation, the inner mast **3** and the outer cylinder **9** will be lifted together, so that there will not be any relative movement between the inner mast **3** and the chain wheel **11**, between which both ends of the chain **10** are mounted. Consequently, the chain wheel **12**, the lift bracket and the fork **4** will also be lifted similarly to the outer cylinder **9**, the first ram **8**, the second ram **7**, the inner mast **3**, being lifted for the length of l relative to the inner cylinder and the intermediate mast **2**. Further, as a result of the lifting of the inner mast **3** for length of l relative to the intermediate mast **2**, the chain **14** of which one end is mounted to the inner mast **3** will also be pulled for the length of l. As as result, the outer mast **1** of which other end is mounted to the intermediate mast **2** will be pulled downwardly for length of l. But, since the outer mast **1** is mounted on the truck frame (not shown), the intermediate mast **2**, the inner mast **3**, the lift bracket, the fork **4** and the oil cylinder **5** as a whole will be lifted for length l. Consequently the lift bracket and the fork **4** will be lifted for length of l relative to the inner cylinder **6** and the intermediate mast **2**. Further, the intermediate mast **2** will be lifted for length l relative to the outer mast **1**, so that during the period of changing from the state of FIG. 3 to the state of FIG. 4, the lift bracket and the fork **4** will be lifted for the length of $2l$ in total. Further, if the total lift $l/2+l/2=l$ between FIG. 1 and FIG. 3 is added thereto, it results in that the lift bracket and the fork **4** are lifted for the length of $3l$ during movement effected between FIG. 1 and FIG. 4.

Assuming that the oil pressure during the period of transportion of state shown in FIG. 2 to FIG. 3 is represented by p the following force is acted upon the second ram **7**. Upward force$=\pi/4\times D_3{}^2\times p+$tension of the chain **10**. Donward force$=\pi/4\times(d_1{}^2-D_2{}^2)\times p+$weight of the inner mast **3**+tension of the chain **14**. Assuming that total weight of the fork **4** and the load on the fork is L, the tension of the chain **10**$=L/2$. The tension of the chain **14**$=L+$weight of the inner mast **3**+weight of the intermediate mast **2**.

Accordingly,

Downward force—upward force$=\pi/4\times(d_1{}^2-D_2{}^2)\times p$ +weight of the inner mast **3**+weight of the intermediate mast **2**$-\pi/4\times D_3{}^2\times p-L/2=\pi/4\times p(d_1{}^2-D_2{}^2-D_3{}^2)+L/2+$weight of the inner mast **3**×2+weight of the intermediate mast **2**.

Now, with respect to the chain wheel, upward oil pressure

$$\frac{\pi}{4}p(d_2{}^1-D_2{}^2)$$

and downward tension

$$3\times\frac{L}{2}$$

are balanced. Consequently, it will result in the following equation: vis

$$\frac{L}{2}=\frac{\pi}{12}p(d_1{}^2-D_2{}^2)$$

Applying this formula,

Downward force—upward force$=\frac{\pi}{12}\times p(4d_1{}^2-4D_2{}^2-3D_3{}^2)+$weight of the inner mast **3**×2+weight of the intermediate mast **2**.

Therefore, by designing in satisfying the condition of $(d_1{}^2-D_2{}^2)\geqq\frac{3}{4}D_3{}^2$, for the second ram **7** of the inner mast **3** the downward force will always act so that the second ram **7** will not be lifted before lifting of the outer cylinder **9** or the first ram **8**. In the above calculation, weight of the first ram **8**, the second ram **7** and the outer cylinder **9** have been simplified or omitted.

At the time of downward movement from the state shown in FIG. 4 to the state shown in FIG. 3, the friction between each mast will tend to prevent the downward movement of the inner mast **3** and the intermediate mast **2**. However, to the inner mast **3** said downward force will act, while to the intermediate mast **2** the load **L** on the fork, the weight of the inner mast **3**+the weight of the intermediate mast **2** will be applied as the downward force. Consequently, both the inner mast **3** and the intermediate mast **2** will be smoothly dropped.

According to the present invention, as mentioned, the upper end of the oil cylinder **6** is rigidly mounted on the upper end of the inner mast **3**, while its lower end is rigidly mounted to the lower end of the intermediate mast **2**. It is thus designed employing no latch device, so that it is not only safe in operation, but also is inexpensive to manufacture.

Furthermore, according to the present invention, at the time of running the lift truck with the fork slightly lifted, the height of the outer cylinder **9**, the chain wheel **11** and the chain **10** will be lower (half or less) than the front field of view of the operator.

What I claim is:

1. In an industrial lift truck having multistage uprights or masts, the improvement comprising an outer mast; an intermediate mast vertically movable relative to said outer mast; an inner mast vertically movable relative to said outer and intermediate masts; a load carriage carried by said inner mast and vertically movable relative thereto; a second ram connected to the upper end of said inner mast; an inner cylinder concentrically arranged within said second ram and connected with the lower end of said intermediate mast, said second ram and said inner cylinder having substantially the same length as said inner mast; a first ram concentrically arranged about the outer side of said second ram; an outer cylinder concentrically arranged about the outer side of said first ram, said first ram having a length substantially equal to two-thirds the length of said inner mast and said outer cylinder having a length substantially equal to one-third the length of said inner mast; first, second and third chain wheels rotatably supported by said intermediate mast, said outer cylinder and said load carriage, respectively; a first chain having one end thereof connected to said outer mast, said first chain passing around said first chain wheel and having its other end connected to said inner mast; and a second chain connected at one end to said outer cylinder, said second chain extending around said third chain wheel and over said second chain wheel, and having its other end connected to said inner mast.

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U.S. Cl. X.R.

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