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(54) Industrial truck comprising an extendable mast

(57) An industrial truck (1) comprising:
 an extendable mast (8) comprising at least a lower and
 an upper mast segment (20, 22); a load carriage (9) that
 is movable arranged in said upper mast segment (21); a
 first and a second main hydraulic cylinder (40, 41) ar-

anged to extend said mast (8); a third hydraulic cylinder
 (46) arranged to raise and lower said load carriage (9)
 along said upper mast segment (22) wherein said first
 and second main hydraulic cylinders (40, 41), in an ex-
 tended position, are lockable against movement in ver-
 tical direction.

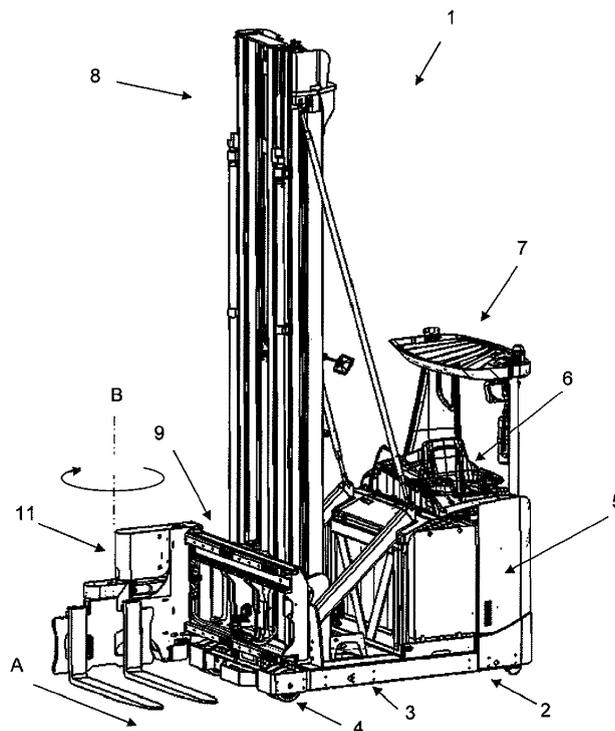


Figure 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to an industrial truck according to the preamble of claim 1.

BACKGROUND ART

[0002] Industrial trucks of known type may be provided with an extendable mast that comprises several mast segments. A load carriage is guided in one of the mast segments and a pair of hydraulic cylinders is provided for moving the load carriage and extending the mast. In operation the hydraulic cylinders first raises the load carriage to the top of the un-extended mast, i.e. the free-lift and thereafter is the mast extended to the desired height by lifting the mast segments, i.e. the main-lift.

[0003] In recent development of this truck type one hydraulic cylinder has been provided for actuating the load carriage and two other hydraulic cylinders have been provided for actuating the mast segments. An advantage with this construction is that the movement of the load carriage and extension of the mast is performed simultaneously and independent from each other. Thereby can a smooth transition between the free-lift and the main-lift be achieved.

[0004] A problem related to the aforementioned truck types is that the uprights of the mast may bend or deflect when a load transported by the truck is unevenly distributed on the uprights of the mast. This problem may occur in truck types where the forks can be moved in horizontal direction along the load carriage, so called "side shift" of the forks or in "narrow aisle" trucks where the forks can swing to a position orthogonal to the direction of the truck and then be moved along the load carriage to place or retract a load from a shelf. The uneven load distribution may also result from the fact that the load itself is unbalanced, i.e. one side of the load is heavier than the other side. A further problem with this truck type is that the line of sight between driver and a load on a shelf may be obstructed by mast components when the mast is extended.

[0005] In warehouse operation, trucks with side shift capability must be positioned at a distance from the shelves in the warehouse since the bent mast otherwise risk hitting the shelves. This reduces the storage capacity in the warehouse since the shelves in the warehouse must be placed at distance from each other that is greater than optimal.

[0006] Attempts have been made to reduce bending and deflection of the mast uprights. For example does EP1528035 describe a narrow aisle truck of the first mentioned truck type, i.e. that has one pair of hydraulic cylinders that are arranged to both move the load carriage and to raise the segments of the mast. The hydraulic system of EP1528035 is designed so that the hydraulic pressure can be varied independently in the two cylinders

in order to counteract a deflection in one of the mast uprights. This hydraulic system is quite complex and comprises several parts, such as flow dividers, motors and different types of sensors, which are necessary for detecting and counteracting a deflection of a mast upright. A similar solution is known through US2007/0089934A.

[0007] Another solution for reducing deflection of the mast includes the arrangement of mechanical locking means between the mast segments as shown in US4155428. It is also known to stabilize the mast with tilting cylinders that are arranged between the chassis of the truck and the mast as described in WO8202188A1 or GB998314A1. However, all these solutions are expensive and involve several additional parts and manufacturing steps.

[0008] Thus, it is an object of the present invention to provide a simple and inexpensive industrial truck in which bending and deflection of the mast uprights is reduced and which provides good visibility for the driver through the mast. In particular, the truck is a narrow aisle truck in which the driver operates the truck from a driver's compartment that is located on the truck frame.

SUMMARY OF THE INVENTION

[0009] According to the invention, this object is achieved by an industrial truck comprising: an extendable mast comprising at least a lower and an upper mast segment; a load carriage that is movable arranged in said upper mast segment; a first and a second main hydraulic cylinder arranged to extend said mast and a third hydraulic cylinder that is arranged to raise and lower said load carriage, characterized in that said first and second main hydraulic cylinders, in an extended position, are lockable against movement in vertical direction.

[0010] By "lockable" is meant that the pistons of the hydraulic cylinders, in extended position, can be prevented from movement. Thus, the pistons can neither be retracted into the hydraulic cylinders nor be extended further.

[0011] When the first and second main hydraulic cylinders are locked in an extended position they form two stable pillars that support the mast. Therefore, when a load is moved to one side of the mast, for example when the load is to be placed on a storage shelf, the force from the load is principally taken by the locked hydraulic cylinder on that side. This considerably reduces the moment that is transferred to the uprights and the cross bars of the mast. The deflection, which mostly occurs in the uprights and the cross bars of the mast, is thereby minimized. In a truck comprising three mast segments, a FEM-analysis has shown that the deflection is reduced by 30-35% in the middle segment of the mast, if the hydraulic cylinders of the mast are locked during transverse movement of the load on the forks. For the whole mast the deflection is reduced by up to 30%.

[0012] An advantage with the provision of the lockable

hydraulic cylinders is that the number and the size of cross bars as well as the size of the cross bars and the overall dimensions of the mast can be reduced. This reduces cost, weight and increases visibility for the driver. In the truck type according to the invention, i.e. a narrow aisle truck in which the driver operates the truck from a driver's compartment on the frame of the truck, the driver therefore has good visibility through the extended mast segments. This permits the driver to easily determine the position of forks, shelves and pallets from his position in the driver's compartment near the floor. Lifting or lowering of loads can therefore be performed safe and easily even at the top shelves in narrow storages. Thus, the driver does not need to move his head in order have a good overview around the truck. This provides an ergonomic advantage.

[0013] Preferably, the industrial truck comprises a hydraulic system that is arranged such that, when said main hydraulic cylinders are in a predetermined extended position, flow of hydraulic fluid between said main hydraulic cylinders is prevented.

[0014] Preferably, the hydraulic system is arranged such that said third hydraulic cylinder can be operated independent from said first and second main hydraulic cylinder.

[0015] According to one embodiment, the hydraulic system is arranged such that the flow of hydraulic fluid is controlled separately for each first and second main hydraulic cylinder.

[0016] According to an alternative, the hydraulic system comprises a first and second valve, having a open position and a closed position, that are arranged to control the flow of hydraulic fluid to and from the first main hydraulic cylinder and third and fourth valve, having a open position and closed position, that are arranged to control the flow of hydraulic fluid from the second main hydraulic cylinder.

[0017] According to one alternative, the hydraulic system comprises a first and a second directional valve and a first and a second non-return valve for controlling the flow of fluid to the first and second main hydraulic cylinder and a third and a fourth directional valve for controlling the flow of hydraulic fluid from said first and second main hydraulic cylinders.

[0018] According to a second embodiment the hydraulic system comprises a first directional valve, that is arranged to control the flow of hydraulic fluid to the first and second main hydraulic cylinders and a second directional valve, that is arranged to control the flow of hydraulic fluid from the first and second main hydraulic cylinders, wherein the hydraulic system is arranged such that flow of hydraulic fluid between said first and second main hydraulic cylinder is prevented by non-return valves.

[0019] Preferably, a first non-return valve is arranged between the first directional valve and the first main hydraulic cylinder for preventing fluid from flowing in a direction from the first main hydraulic cylinder towards the main second hydraulic cylinder and a second non-return

valve is arranged between the first directional valve and the second main hydraulic cylinder for preventing fluid from flowing in a direction from the second main hydraulic cylinder towards the first main hydraulic cylinder.

5 **[0020]** Preferably, a third non-return valve is arranged between the second directional valve and the first main hydraulic cylinder for preventing fluid from flowing in a direction from the second main hydraulic cylinder towards the first main hydraulic cylinder and a fourth non-return valve is arranged between the second directional valve and the second main hydraulic cylinder for preventing fluid from flowing in a direction from the first main hydraulic cylinder towards the second main hydraulic cylinder.

10 **[0021]** At least a further mast segment may be arranged between said upper and lower mast segments.

15 **[0022]** Preferably, the industrial truck is a narrow aisle truck comprising load engaging means that are movable along the load carriage, transverse to the mast.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

25 Figure 1 shows a perspective view of an industrial truck according to the invention.

Figure 2 shows a detailed view of the extendable mast of the industrial truck according to figure 1 in retracted position.

30 Figure 3 shows a detailed view of the extendable mast of the industrial truck according to figure 1 extended position.

35 Figure 4 shows a scheme over a hydraulic system of a first preferred embodiment of the inventive industrial truck.

40 Figure 5 shows a scheme over a hydraulic system of a second preferred embodiment of the inventive industrial truck.

45 Figures 6a - 6d shows schematically the moments in the mast/mast cylinder during a lifting cycle of the inventive industrial truck.

50 Figure 7 is a detailed view of a directional valve that is used in the first and second preferred embodiments of the inventive truck.

DETAILED DESCRIPTION

[0024] Figure 1 shows schematically an industrial truck 1 according to the invention. The industrial truck is typically known as narrow aisle truck or swing reach truck.

[0025] The industrial truck 1 comprises a frame 2 which in its forward portion extends into two forward support

legs 3 carrying support wheels 4. In figure 1 is only one of the support legs and the support wheels shown. The frame 2 supports a housing 5 in which an electrical drive motor for propelling a drive wheel and a hydraulic system for providing power to movable parts on the truck is accommodated (these parts are not shown in figure 1). The housing 5 further accommodates a driver's compartment 6, comprising a seat and controls for driving the truck and actuating parts on the truck. A roof 7 is arranged over the driver's compartment. The truck further comprises an extendable lifting mast 8. In the truck shown in figure 1, the mast 8 is firmly fixed to the frame 2 of the truck. Thus, the driver's compartment 6 and one segment of the extendable mast 8 are fixed on the frame 2 of the truck.

[0026] Alternatively, in a so called reach truck, the mast 8 may be supported on a carriage which is journalled in the support legs so that the mast can be moved horizontally forward and backwards on the support legs.

[0027] The lifting mast 8 further comprises a load carriage 9 that is movable arranged in one segment of the extendable lifting mast 8, i.e. journalled with bearings. The load carriage 9 is thus movable along the mast segment. Different load engaging means 10 may be attached to the load carriage. In the truck shown in figure 1, a so called "narrow aisle truck", the load carriage 9 comprises a turret head unit 11 that is arranged such that the forks can be moved along the load carriage 9 as indicated by arrow A, i.e. in a direction transverse to the mast uprights of the truck. The turret head unit 11 is further arranged such that the forks to be rotated around the vertical axis as indicated by arrow B. The turret head unit 11 is actuated by a hydraulic arrangement, not shown in figure 1. Instead of a turret head unit, the truck could comprise a so called "shuttle fork unit" which moves the forks back and forth in a direction orthogonal to the uprights of the mast, i.e. in direction A in figure 1.

[0028] Figure 2 and 3 shows detailed views of the extendable mast in retracted and extended positions. As most clearly is visualized in figure 3, the extendable mast 8 comprises three mast segments 20, 21, 22. Each mast segment comprises two vertical uprights of e.g. I-beam shape. The uprights of each segment are connected by cross bars. Thus, the lower (first) mast segment 20 comprises uprights 23, 24 that are connected by cross bar 25. The second (middle) mast segment 21 comprises uprights 26, 27 that are connected by cross bar 28. The third (upper) segment 22 comprises uprights 29, 30 that are connected by cross bar 31. The load carriage 9 is journalled in the uprights of the uppermost, thus the third mast segment 22, so that the load carriage can be raised and lowered along this mast segment. The first mast segment 20 is fixed to the truck as previously described. The second mast segment 21 is journalled, e.g. by bearings, in the first mast segment 20 so that the second mast segment 21 can slide in the first segment 20. The third mast segment 22 is journalled and slidable in the second mast segment 21. The mast 8 can thereby be extended in a telescopic manner. Although the mast 8 described

in this embodiment comprises three mast segments it is obvious that the mast also could consist of two mast segments or comprise more than three segments.

[0029] Figure 2 and 3 further show the hydraulic lifting cylinders of the industrial truck. Two main lifting hydraulic cylinders 40, 41, see figure 3, are arranged to raise and lower the extendable mast. These two hydraulic cylinders, that in know manner comprises a piston 42, 44 that is slidably arranged in a cylinder, 43, 45 are each supported on an upright of the first mast segment 20, for example supported on shelves that are attached to the uprights of the mast. The main hydraulic cylinders 40, 41 may also be supported on the frame 2 or on the support legs 3 of the truck, next to each of the uprights of the first mast segment. The piston 42, 44 of each hydraulic cylinder is attached to the second mast segment 21 i.e. the middle mast segment. A chain and pulley arrangement (not shown in figure 3) is arranged in known manner to lift the third mast segment 22 when the second mast segment 21 is lifted by the hydraulic pistons 42, 44. The chain and pulley arrangement comprises one or several chains that are attached to the bottom of the third mast segment 22. The chains are wound around a pulley that is attached to the top of the second mast segment 21 and are further attached to the first mast segment 20. For the case that the mast only comprises two segments, the cylinders directly lifts the upper segment.

[0030] A third hydraulic cylinder 46, known as free-lift hydraulic cylinder, is arranged to raise and lower the load carriage 9 on the third mast segment 22. The third hydraulic cylinder 46 comprises a piston 47 that is slidably arranged in a cylinder 48. The third hydraulic cylinder 48 is supported on the center of a lower crossbar 31 on the third mast segment. The piston 47 of the third hydraulic cylinder is attached to the load carriage 9. Thereby, when the third hydraulic cylinder is operated the load carriage 9 is raised or lowered along the upper mast segment.

[0031] The main hydraulic cylinders 40, 41 and the third hydraulic cylinder 46 are connected to a hydraulic system that is located in the truck housing and therefore not visible.

[0032] Figure 4 shows a scheme over a hydraulic system 100 of a first preferred embodiment of the inventive industrial truck.

[0033] The hydraulic system 100 comprises first and a second main hydraulic cylinders 40, 41 and a third hydraulic cylinder 46 i.e. the free-lift hydraulic cylinder. The system 100 further comprises a pump 101 for supplying hydraulic fluid to the hydraulic cylinders 40, 41 and 46. The pump 101 is connected to an electrical motor 102 and to a tank 103 for hydraulic fluid.

[0034] The flow of hydraulic fluid to and from the third hydraulic cylinder 46, the first main hydraulic cylinder 40 and the second main hydraulic cylinder 41 is for each cylinder 40, 41, 46 controlled by two separate directional valves. The directional valves have two positions, see figure 7 which schematically shows a directional valve. In a first position, indicated by an arrow in figure 7, hy-

draulic fluid flows freely through the valve in direction of the arrow. In the second position, indicated by a circle and an angle, hydraulic fluid can only flow through the valve in the direction of the circle, i.e. in the direction opposite to the arrow of the first position. The use of two separate directional valves for each lifting cylinder provides for a very precise control of the movement of the three lifting cylinders.

[0035] The hydraulic system 100 comprises a first directional valve 104 that is arranged to control the flow of hydraulic fluid to the third, free-lift, cylinder 46. Directional valve 104 is arranged such that when the valve is in the first position hydraulic fluid flows from the pump 101 via duct D2 through the valve 104 and via duct D3 to the third cylinder 46 which then is raised. When the valve 104 is in the second position fluid only can pass through valve 104 in a direction from the third cylinder towards the tank 103. A first non-return valve 107 is arranged in duct D2 between the pump 101 and the first directional valve 104. The non-return valve 107 effectively blocks fluid flow in a direction from the valve towards the tank and forms a tight seal which prevent hydraulic fluid from escaping from the valve when a load is lifted by hydraulic cylinder 46.

[0036] A second directional valve 110, of the same type as valve 104, is arranged to control the flow of hydraulic fluid from the third hydraulic cylinder 46 back to the tank 103 when cylinder 46 is lowered. A second non-return valve 113 is arranged after the second directional valve 110 in the flow direction towards the tank. The second non-return valve 113 prevents the flow of hydraulic fluid coming from the pump or other parts of the hydraulic system to reach valve 110.

[0037] A third directional valve 105, of the same type as valve 104, is arranged to control the flow of hydraulic fluid from the pump to the first main hydraulic cylinder 40. Valve 105 is arranged such that when the valve is in the first position, fluid can flow from the pump 101, via duct D6 and D7 through valve 105 and via duct D8 to hydraulic cylinder 40.

[0038] A third non-return valve 108 is arranged in duct D7 between the pump and the directional valve 105. The non-return valve effectively blocks fluid flow in a direction from the valve 105 towards the tank 103.

[0039] A fourth directional valve 106, of the same type as valve 104, is arranged to control the flow of hydraulic fluid from the pump to the second main hydraulic cylinder 41. Valve 106 is arranged such that when the valve is in the first position, fluid can pass from the pump 101, via ducts D6, D9, D10 and D7 through valve 106 and via duct D11 to hydraulic cylinder 41.

[0040] A fourth non-return valve 109 is arranged in duct D10 between the pump and the directional valve 106. The non-return valve effectively blocks fluid flow in a direction from the valve 106 towards the tank.

[0041] A fifth directional valve 111 is arranged to control the flow of hydraulic fluid from the hydraulic cylinder 40, via duct D8 through valve 111 and via ducts D5 and

D1 back to the tank 103. A fifth non-return valve 114 is arranged in duct D5 between the pump and valve 111 to prevent hydraulic fluid from the pump or other parts if the hydraulic system to reach valve 111. A sixth directional valve 112 is arranged to control the flow of hydraulic fluid from the hydraulic cylinder 41, via duct D11 through valve 112 and via ducts D12, D9, D6 back to the tank 103. A sixth non-return valve 115 is arranged in duct D12 between the pump and valve 112 to prevent hydraulic fluid coming from the pump or other parts if the hydraulic system to reach valve 112.

[0042] The hydraulic system 100 further comprises a security valve 116, typically a relief valve, which opens at a predetermined pressure, which typically is the maximum pressure of the hydraulic system, to lead fluid from the system via duct D13 to the tank 103.

[0043] Each of the directional valves 104, 105, 106, 110, 111, 112 are connected, i.e. electrically wired to the control system of the truck so that opening and closing of the valves can be executed in accordance with a selected program such as a selected lifting or lowering cycle. The opening and closing of the valves 104, 105, 106 and valves 110, 111, 112 can also be performed manually by the driver of the truck.

[0044] According to the invention, when the mast has been extended to a selected height the mast hydraulic cylinders 40 and 41 are locked against further movement. This is achieved in that the directional valves 105, 106 are moved to the second position in which flow of hydraulic fluid through the valves is restricted to the direction from the hydraulic cylinders towards the tank.

[0045] As described above, non-return valves 108 and 109 are arranged in the ducts D7 and D10 and effectively block flow from the directional valves 105 and 106 in a direction from the hydraulic cylinder. The arrangement of non-return valves in this manner between the valves 105 and 106 and the tank provides for a very tight and leak proof seal so that no fluid can escape through the valves 105 and 106 when a load is put on the hydraulic cylinders. Flow of fluid in the other direction through the valves 105 and 106, for example due to actuation of the third hydraulic cylinder is effectively blocked when valves 105 and 106 are in the second position, as shown in figure 4. Directional valves 111 and 112 are also in the second position, in which fluid flow cannot pass through the valves in a direction from the hydraulic cylinders 40 and 41.

[0046] When the directional valves 105, 106, 111 and 112 are in the above described position, no hydraulic fluid can flow to or from the hydraulic cylinders 40, 41. Nor can hydraulic fluid flow between the hydraulic cylinders 40 and hydraulic cylinder 41. The hydraulic cylinders 40, 41 are therefore locked against movement in vertical direction and form two stable pillars that reinforce the mast. Since the third lift cylinder 46 is controlled by the separate two valves 104, 110 this cylinder can be raised or lowered independent from the main hydraulic cylinders 40 and 41.

[0047] Figure 5 shows a scheme over a hydraulic system 200 of a second embodiment of the inventive industrial truck.

[0048] The hydraulic system 200 comprises first and a second main hydraulic cylinder 40, 41 and third hydraulic cylinder 46, i.e. the free-lift hydraulic cylinder. The system 200 further comprises a pump 101 for supplying hydraulic fluid to the hydraulic cylinders 40, 41 and 46. The pump 101 is connected to an electrical motor 102 and to a tank 103 for hydraulic fluid.

[0049] The flow of hydraulic fluid to and from the third cylinder 46 is controlled in the same manner as in the first hydraulic system 100, i.e. with first and second directional valves 104, 110 and first and second non-return valves 107, 113, and will therefore not be discussed further. Components of hydraulic system 200 that are similar or identical to components in the first hydraulic system 100 have been given the same reference numbers.

[0050] In the hydraulic system 200 are only two directional valves necessary for controlling the flow of hydraulic fluid to and from the first and the second main lift cylinder 40, 41. Flow of hydraulic fluid between the main cylinders is prevented by non-return valves which only permits flow in one direction. This provides for a robust and inexpensive hydraulic system since it comprises few components.

[0051] The hydraulic system 200 comprises a third directional valve 121 which is arranged such that when the valve is in the first position the hydraulic fluid flows from the pump 101, via duct D7 through valve 121 and via ducts D8, D9, D10, D11 and 12 to the first and second main hydraulic cylinders 40, 41 which then are raised.

[0052] A third non-return valve 119 is arranged in duct D9 between the directional valve 121 and the first cylinder 40, non-return valve 119 prevents flow in a direction from hydraulic cylinder 40 towards directional valve 121 or towards hydraulic cylinder 41. A fourth non-return valve 120 is arranged in duct D10 between the valve 121 and the second cylinder 41, non-return valve 120 prevents flow from hydraulic cylinder 41 towards directional valve 121 or hydraulic cylinder 40. Thus non-return valves 119, 120 prevent flow of hydraulic fluid between hydraulic cylinders 40 and 41.

[0053] A fourth directional valve 122, is arranged to control the flow of hydraulic fluid from the first and second main hydraulic cylinders 40, 41 via ducts D12, D11 and D13 through valve 122 and via duct D1 to the tank 103 when cylinders 40, 41 are lowered. A fifth non-return valve 117 is arranged in duct D12 between directional valve 122 and hydraulic cylinder 40. Non-return valve 117 prevents flow from hydraulic cylinder 41 in a direction towards the hydraulic cylinder 40. A sixth non-return valve 118 is arranged in duct D11 between valve 122 and hydraulic cylinder 41. Non-return valve 120 prevents flow from hydraulic cylinder 41 in a direction towards the hydraulic cylinder 41. Thus non-return valves 117, 118 prevent flow of hydraulic fluid between hydraulic cylinders 40 and 41.

[0054] When valve 121 is moved to the first position and valve 122 is in the second position, fluid flows through valve 121 into duct D8 and further through ducts D9 and D12 into hydraulic cylinder 40 as well as through ducts D10 and D11 into cylinder 41. Cylinders 40 and 41 are thereby raised. When the hydraulic cylinders 40 and 41 have been raised a predetermined distance, valve 121 is moved to the second position. Valve 122 remains in the second position during this procedure. When the valves 122, 121 are in the second position the hydraulic cylinders are locked against further movement in vertical direction. No hydraulic fluid can flow to or from the hydraulic cylinder 40, 41 since this is prevented by directional valves 121, 122 and non-return valves 119, 120. Nor can hydraulic fluid flow between the first and second hydraulic cylinder 40, 41, since this is prevented by the non-return valves 117, 118 and also by non-return valves 119 and 120. Therefore, if the force from a load is shifted towards one of the hydraulic cylinders this cylinder remains immovable and forms a stable pillar that supports the load.

[0055] To lower the cylinders valve 122 is opened, fluid can then flow from hydraulic cylinders 40, 41 through the non-return valves 117, 118 through valve 122 to the tank 103 via the pump 101.

[0056] As described under hydraulic system 100, the third hydraulic cylinder 46 can be raised or lowered independent of the mast lift cylinders 40 and 41.

[0057] In the following will the operation of the inventive industrial truck be described with reference to figures 6a - 6d. The force that is exerted from a load on forks and the corresponding counteracting force in the mast segments is illustrated by arrows. The length of the arrow corresponds to the magnitude of the force. In figures 6a - 6b is a mast comprising two mast segments shown in which the upper mast is directly lifted by the main cylinders. However the mast could comprise further mast segments, e.g. three as described previously.

[0058] Figure 6a, shows schematically the extendable mast 8 of an industrial truck according to invention in a position in which the forks is in a position slightly above the floor. The mast comprises a lower segment 20 and an upper segment 22. The mast is in a retracted position and the forks 10 are positioned on the center of the load carriage 9. The force from the load on the forks is therefore equally divided on the two uprights of the mast. therefore is no moment present in the mast.

[0059] First, see figure 6b, the load carriage 9 is raised a predetermined distance on the upper mast segment 22 by operation of the third hydraulic cylinder 46 and is then stopped. Thus, a free-lift is performed. The predetermined distance is selected such that some space is left to the maximum height that the load carriage can be raised to on the mast segment. For example, the load carriage may be raised to a position of approximately 100-150 mm from the maximum height that the load carriage can be raised to on the mast segment. This allows for maneuvering of the load carriage when the mast is

extended and locked in a subsequent step.

[0060] Second, see figure 6c, the mast 8 is extended by actuation of the two main hydraulic cylinders 40, 41, i.e. the main-lift is performed. In this step the load carriage 9 is raised together with the upper mast segment 22 to a position slightly above the height of shelf where the load shall be placed, e.g. 50 -100 mm above the shelf. When the load carriage has reached this height, the main hydraulic cylinders are locked. This may be achieved as described under the hydraulic systems 100 and 200.

[0061] Third, see figure 6d, the forks, carrying the load, are moved along the load carriage 9, transverse to the mast uprights, towards shelf where the load is to be placed. The movement is continued until the load is located above the shelf. During this movement the force from the load is shifted towards the left side of the mast. However, since the main hydraulic cylinders 40, 41 are locked, the uprights of the left side of the mast (i.e. where the load is) are reinforced by the extended main hydraulic cylinder 41. The left main hydraulic cylinder 41 therefore absorbs the force from the load which so that substantially no deflection of the mast occurs.

[0062] Fourth, not shown in the figures, the third hydraulic cylinder is actuated until the pallet is lowered to the shelf. Thereafter are the forks moved backwards towards the centre of the load carriage. When the forks have reached the predetermined central position on the load carriage the force is equal on both of the mast uprights and the risk for deflection does no longer exist. In this position the main hydraulic cylinders are unlocked as described under the hydraulic systems 100 and 200 and the mast is lowered.

[0063] Although particular embodiments have been disclosed in detail this has been done for purpose of illustration only, and is not intended to be limiting. In particular it is contemplated that various substitutions, alterations and modifications may be made within the scope of the appended claims. It is for instance possible to use on/off valves instead of directional valves. By on/off valves is intended a valve that has an open position in which fluid can flow through the valve and a closed position in which no fluid can pass through the valve. The use of on/off valve makes it possible to omit some of the non-return valves in the hydraulic systems 100 and 200 which reduces manufacturing costs for the hydraulic system. For higher accuracy the directional valves could be proportional valves.

Claims

1. An industrial truck (1) comprising:

an extendable mast (8) comprising at least a lower and an upper mast segment (20, 22); a load carriage (9) that is movable arranged in said upper mast segment (21); a first and a second main hydraulic cylinder (40, 41) arranged to ex-

tend said mast (8); a third hydraulic cylinder (46) arranged to raise and lower said load carriage (9) along said upper mast segment (22) **characterized in that** said first and second main hydraulic cylinders (40, 41), in an extended position, are lockable against movement in vertical direction.

2. The industrial truck according to claim 1 further comprising a hydraulic system (100, 200) that is arranged such that, when said main hydraulic cylinders (40, 41) are in a predetermined extended position, flow of hydraulic fluid between said main hydraulic cylinders (40, 41) is prevented.
3. The industrial truck according to claim 1 - 2, wherein said hydraulic system (100, 200) is arranged such that said third hydraulic cylinder (46) can be operated independent from said first and second main hydraulic cylinder (40, 41).
4. The industrial truck according to claims 1 - 3, wherein said hydraulic system (100) is arranged such that the flow of hydraulic fluid is controlled separately for each first and second main hydraulic cylinder (40, 41).
5. The industrial truck according to claims 2—4 wherein said hydraulic system comprises a first and second valve (105, 111), having an open position and a closed position, that are arranged to control the flow of hydraulic fluid to and from the first main hydraulic cylinder (40) and third and fourth valve (105, 111), having an open position and closed position, that are arranged to control the flow of hydraulic fluid from the second main hydraulic cylinder (41).
6. The industrial truck according to claims 2 — 4, wherein said hydraulic system (100) comprises a first and a second directional valve (105, 106) and a first and a second non-return valve (108, 109) for controlling the flow of fluid to the first and second main hydraulic cylinder (40, 41) and a third and a fourth directional valve (111, 112) for controlling the flow of hydraulic fluid from said first and second main hydraulic cylinders.
7. The industrial truck according to claim 2 - 4, wherein the hydraulic system (200) comprises a first directional valve (121), that is arranged to control the flow of hydraulic fluid to the first and second main hydraulic cylinders (40, 41) and a second directional valve (122), that is arranged to control the flow of hydraulic fluid from the first and second main hydraulic cylinders (40, 41), wherein the hydraulic system (200) is arranged such that flow of hydraulic fluid between said first and second main hydraulic cylinder (40, 41) is prevented by non-return valves (117, 118, 119,

120).

- 8. The industrial truck according to claim 7 wherein a first non-return valve (119) arranged between the first directional valve (121) and the first main hydraulic cylinder (40) for preventing fluid from flowing in a direction from the first hydraulic cylinder (40) towards the second hydraulic cylinder (41) and a second non-return valve (120) is arranged between the first directional valve (121) and the second main hydraulic cylinder (41) for preventing fluid from flowing in a direction from the second hydraulic cylinder (41) towards the first hydraulic cylinder (40). 5
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- 9. The industrial truck according to 7 or 8 wherein a third non-return valve (117) is arranged between the second directional valve (122) and the first main hydraulic cylinder (40) for preventing fluid from flowing in a direction from the second main hydraulic cylinder (41) towards the first main hydraulic cylinder (40) and a fourth non-return valve (118) is arranged between the second directional valve (122) and the second main hydraulic cylinders (41) for preventing fluid from flowing in a direction from the first main hydraulic cylinder (41) towards the second main hydraulic cylinder (40). 15
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- 10. The industrial truck according to claims 1 - 9, comprising at least a further mast segment (21) arranged between said upper and lower mast segments (21, 22). 30

- 11. The industrial truck according to any of claims 1 — 10, wherein the industrial truck is a narrow aisle truck comprising load engaging means (10) that are movable along the load carriage (9), transverse to the mast (8). 35

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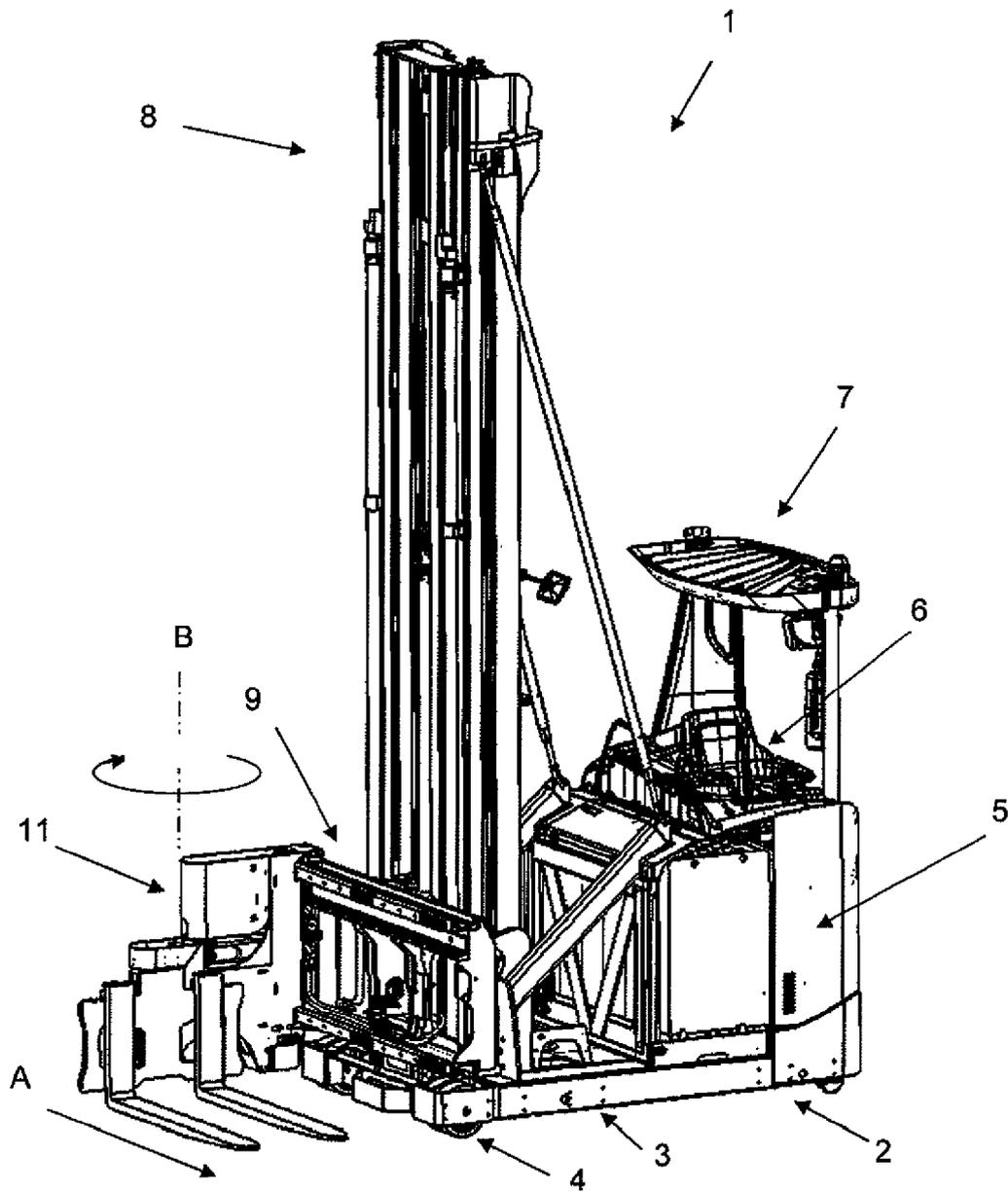


Figure 1

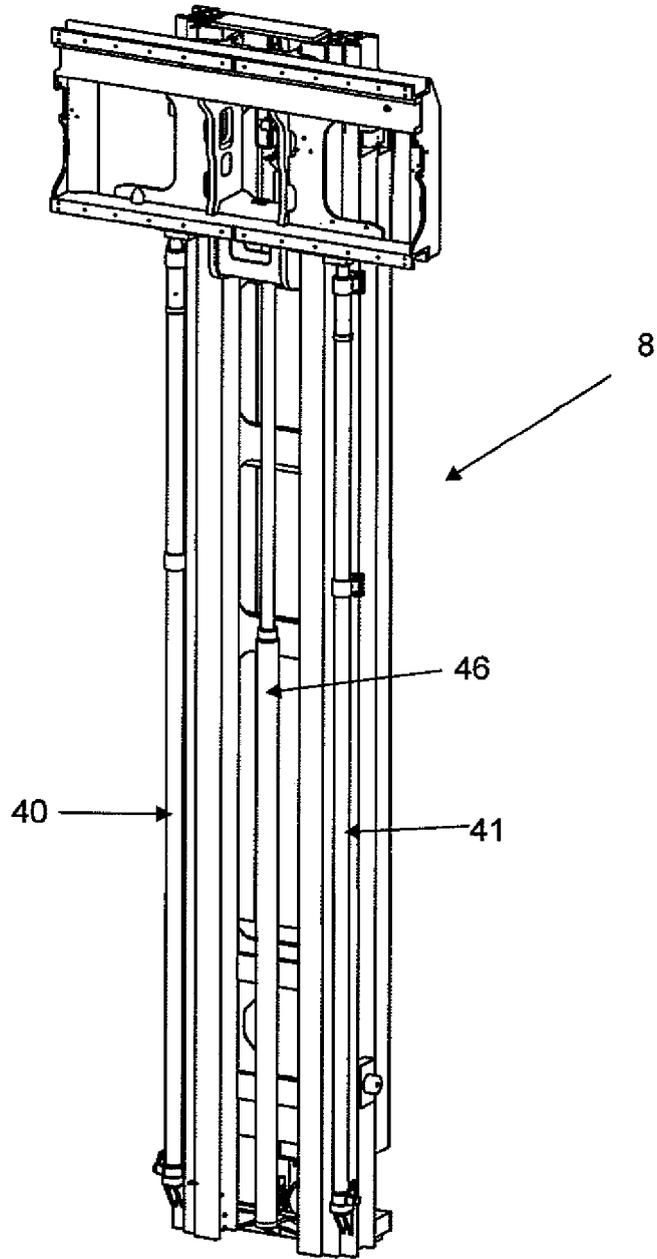


Figure 2

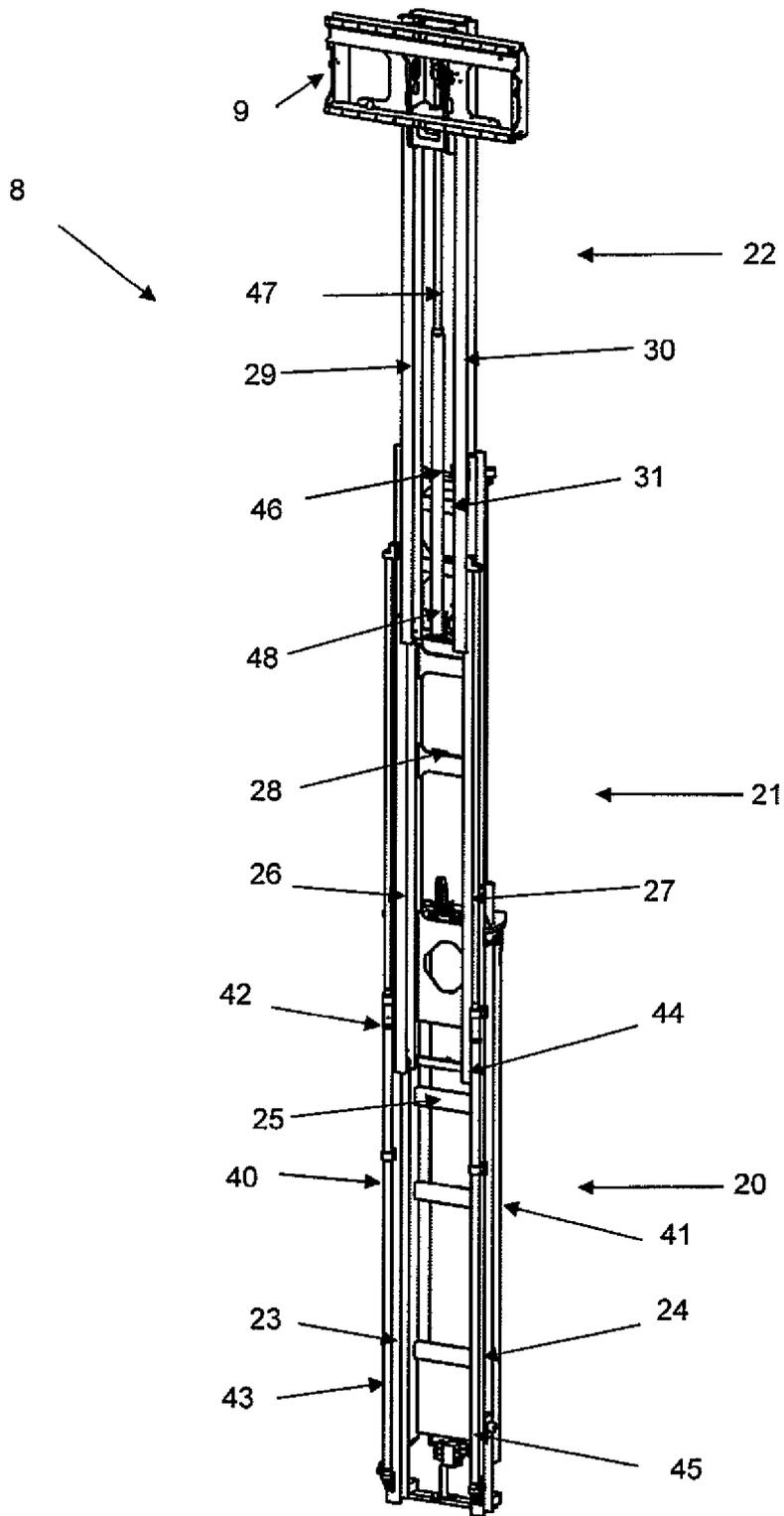


Figure 3

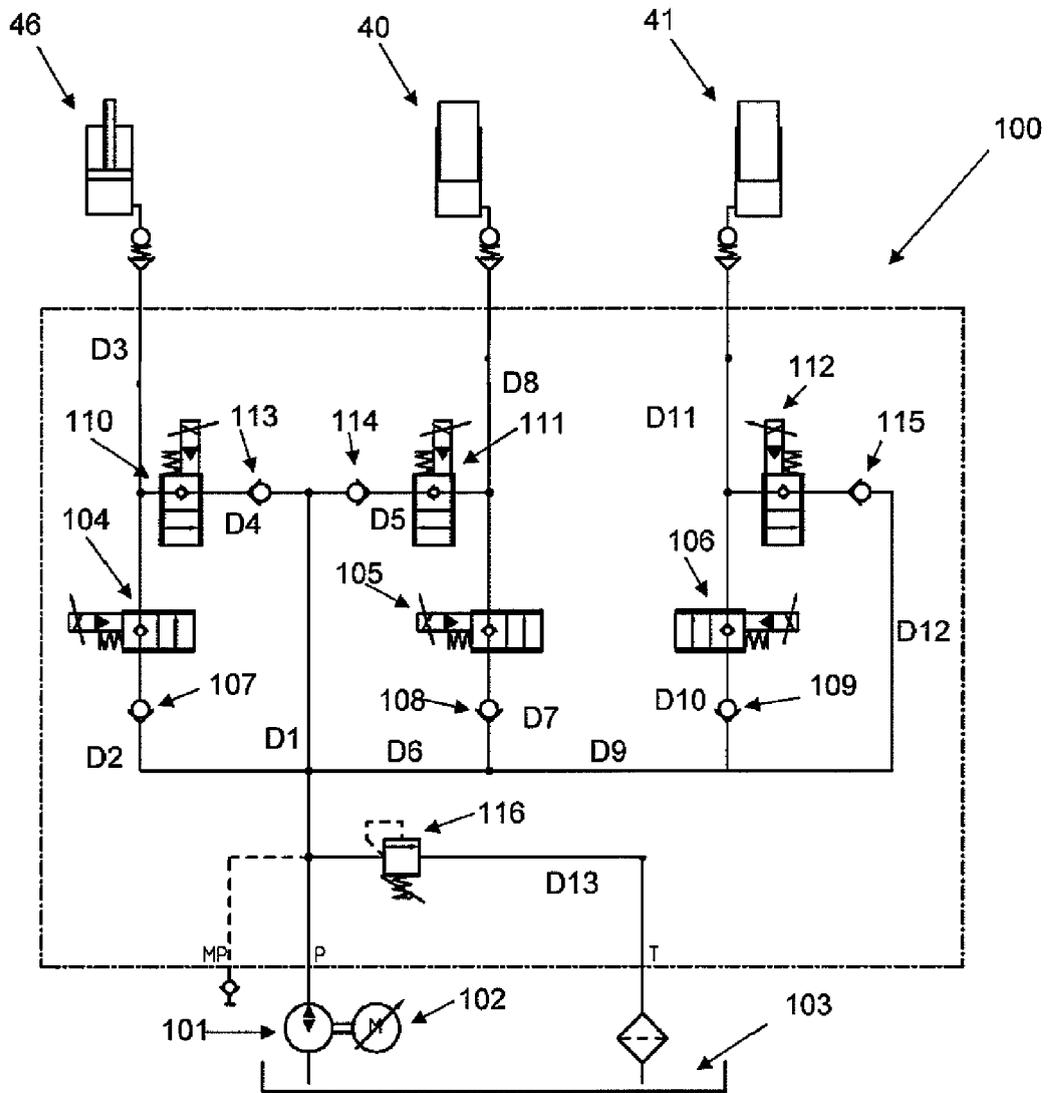


Figure 4

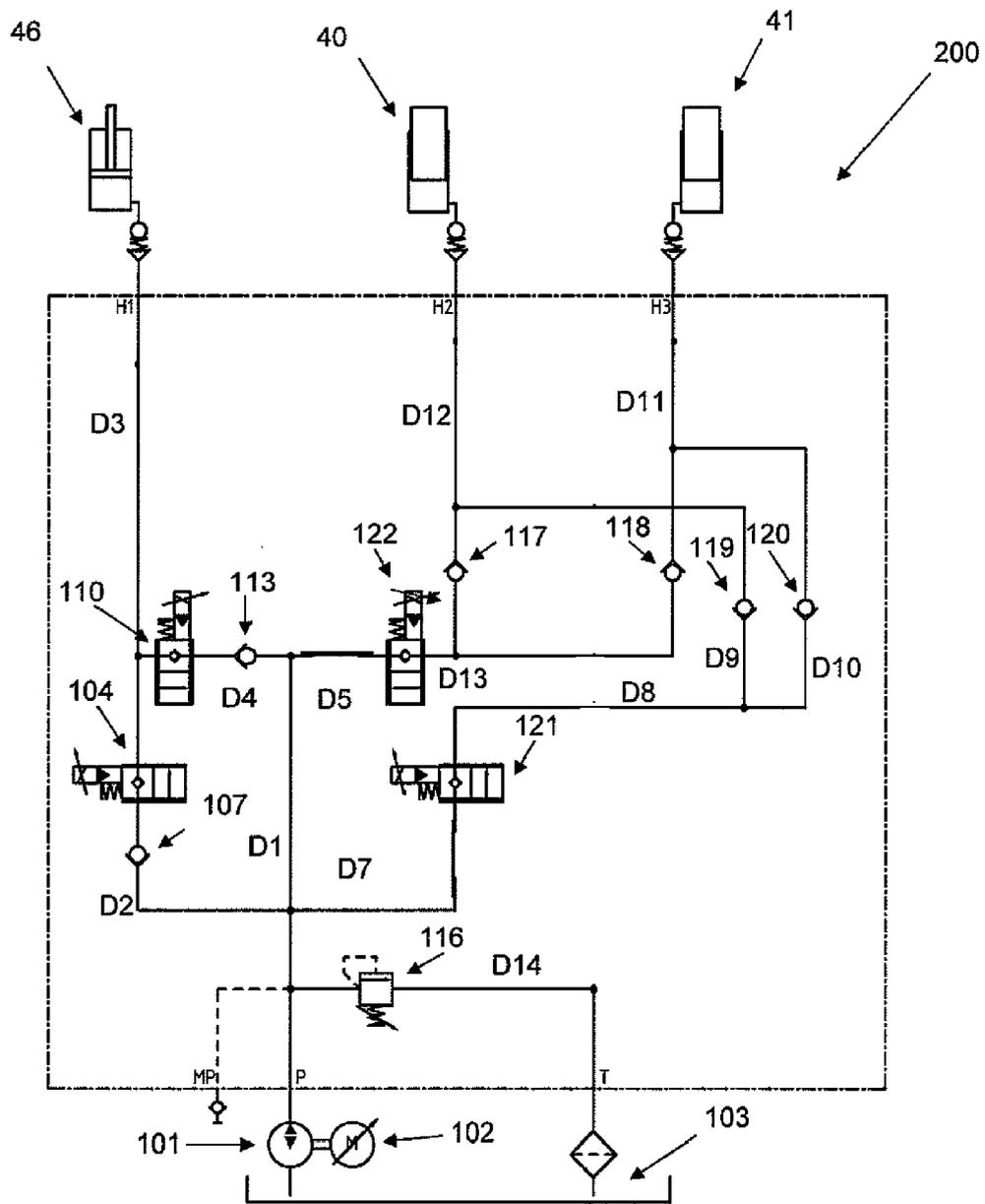


Figure 5

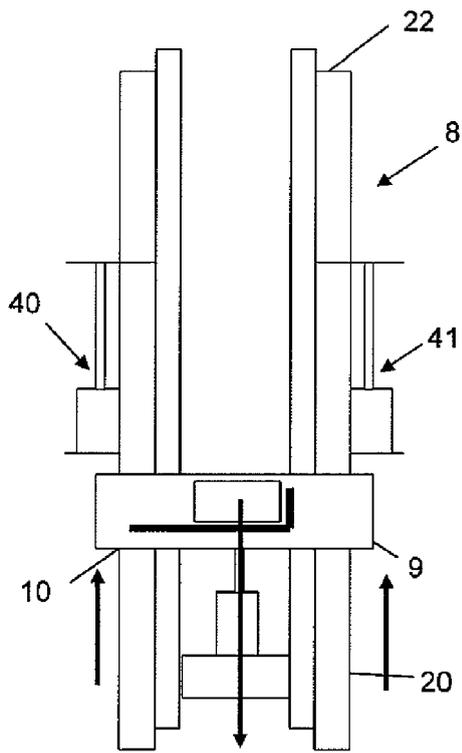


Figure 6a

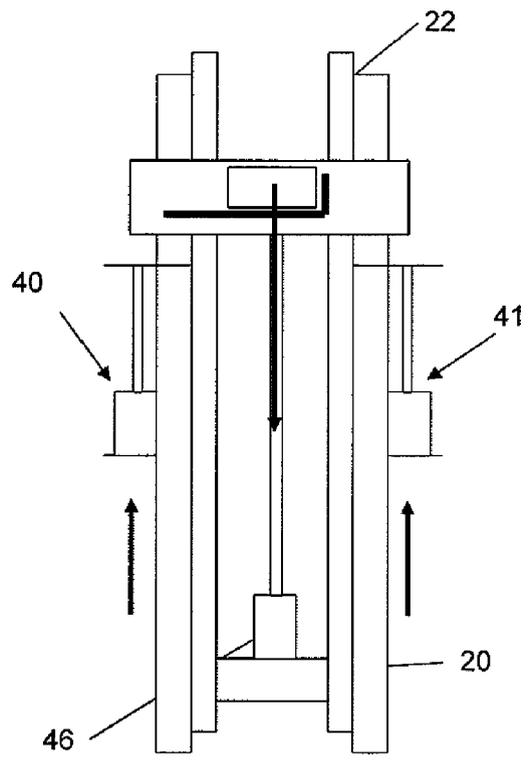


Figure 6b

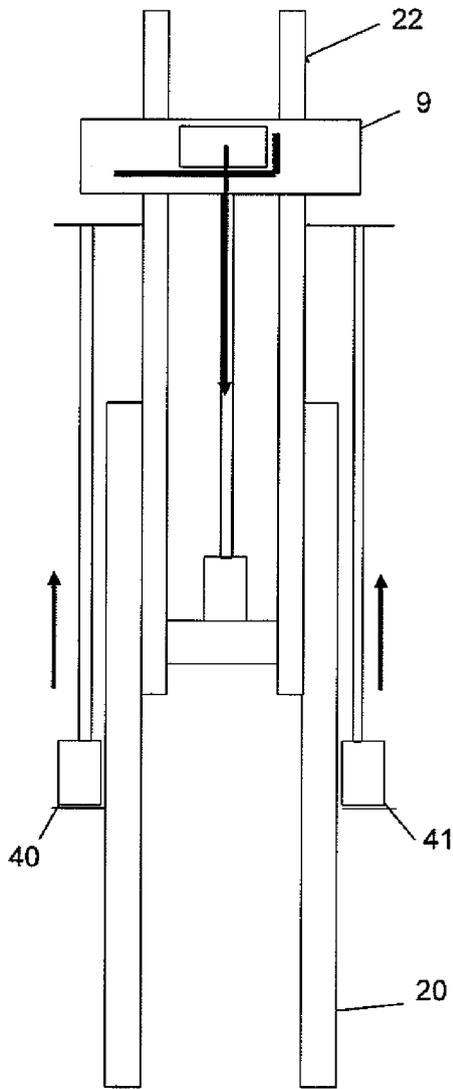


Figure 6c

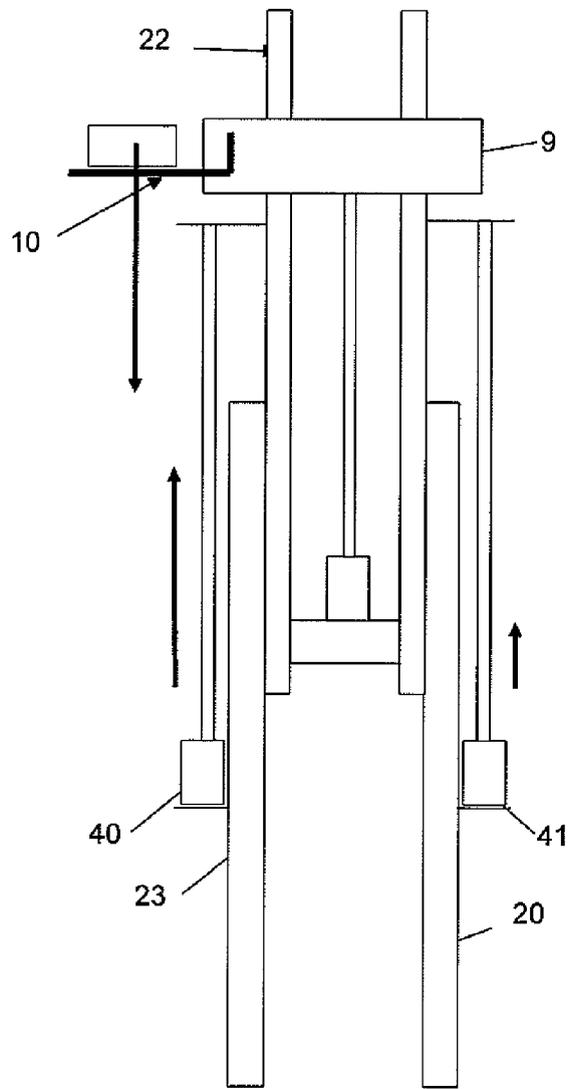


Figure 6d

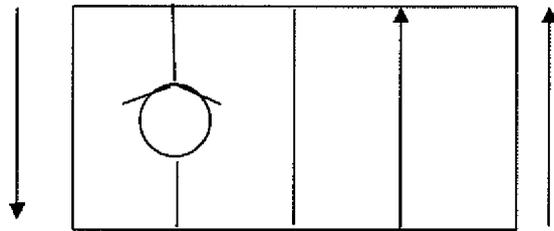


Figure 7



EUROPEAN SEARCH REPORT

 Application Number
 EP 10 19 5454

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 02/06679 A2 (RAYMOND COMPANY [US]) 24 January 2002 (2002-01-24) * the whole document * -----	1-4,10, 11	INV. B66F9/22
X	US 4 593 791 A (MATTHEWS DEAN A [US]) 10 June 1986 (1986-06-10) * column 2 - column 4; figure 2 * -----	1,3	
X	EP 1 635 072 A1 (HAWE HYDRAULIK GMBH & CO KG [DE]) 15 March 2006 (2006-03-15) * column 5 - column 9; figures 3,4 * -----	1,3	
X	US 2002/174766 A1 (NORTON KENNETH E [US] ET AL) 28 November 2002 (2002-11-28) * page 1 - page 2; figures 1,2 * -----	1,10,11	
A	EP 1 780 171 A2 (JUNGHEINRICH AG [DE]) 2 May 2007 (2007-05-02) * abstract; figures 4-6 * -----	2,4	
A	DE 10 2009 011865 A1 (JUNGHEINRICH AG [DE]) 16 September 2010 (2010-09-16) * abstract; figures 1-3 * -----	1	TECHNICAL FIELDS SEARCHED (IPC) B66F F15B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 13 May 2011	Examiner Rupcic, Zoran
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 10 19 5454

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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13-05-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0206679 A2	24-01-2002	AU 7028101 A	30-01-2002
		AU 2001270281 A8	03-01-2008
		CA 2383669 A1	24-01-2002

US 4593791 A	10-06-1986	NONE	

EP 1635072 A1	15-03-2006	DE 202004014030 U1	12-01-2006

US 2002174766 A1	28-11-2002	CA 2387281 A1	24-11-2002
		DE 60214076 T2	04-01-2007
		EP 1260479 A2	27-11-2002

EP 1780171 A2	02-05-2007	CN 1994855 A	11-07-2007
		DE 102005050733 A1	26-04-2007
		US 2007089934 A1	26-04-2007

DE 102009011865 A1	16-09-2010	NONE	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1528035 A [0006]
- US 20070089934 A [0006]
- US 4155428 A [0007]
- WO 8202188 A1 [0007]
- GB 998314 A1 [0007]