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(54) Industrial lift truck with speed control

(57) The present invention relates to industrial lift truck (1), comprising: a lifting frame having a vertically movable load lifting device (9), a hydraulic cylinder assembly (11) for driving the load lifting device (9), a variable hydraulic pump (17) for supplying hydraulic fluid to the hydraulic cylinder assembly (11), a variable hydraulic valve assembly (19a-b) arranged for controlling the hydraulic fluid supplied to/drained from the hydraulic cylinder assembly (11), a position measuring assembly (25a-b) for measuring vertical positions of the load lifting device (9) with respect to the lifting frame, an operator input device (31) for choosing an operation mode of the load lifting device (9), a controller (33) comprising: means for calculating the actual speed of the load lifting device (9) based on the vertical position measurements, means for generating a set point speed of the load lifting device (9) based on the chosen operation mode, and means (37) for comparing the calculated actual speed with the set point speed, The controller (33) is **characterised in that** it comprises means for determining any differences between the calculated actual speed and the set point speed, and means (39) for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly (19a-b) to change its valve opening degree, if a difference exist between the calculated actual speed and the set point speed of the load lifting device (9), so as to compensate for the difference.

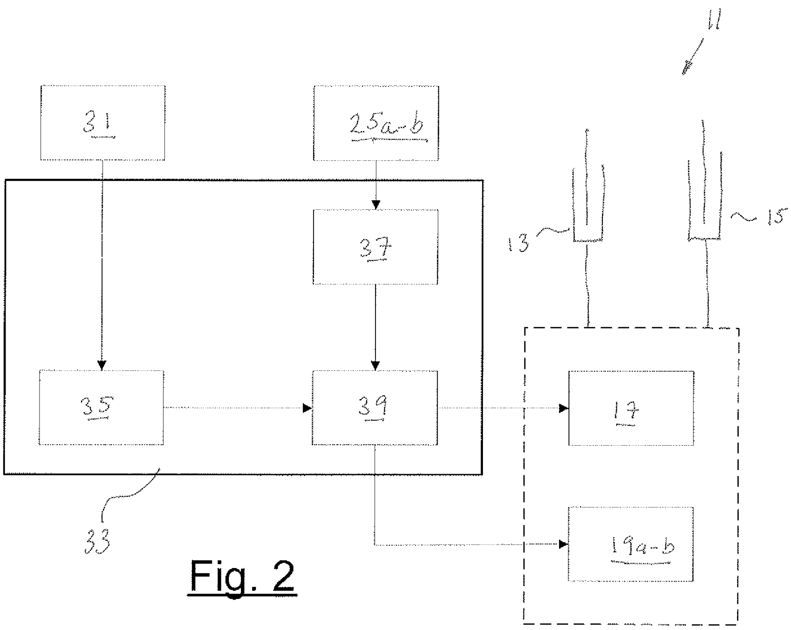

Fig. 2

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Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] Load lifting devices of industrial lift trucks are often driven by means of hydraulic cylinders supplied by hydraulic pumps. The operator can choose between different operation modes of the load lifting device, in dependence of the actual material handling situation, which correspond to different set point speeds of the load lifting device. The maximum lifting and lowering speeds of the load lifting device are restrained due to safety regulations so as to avoid accidents, e.g. due to unexpected load movements during lifting/lowering of the load lifting device. Accordingly, the maximum speeds allowed must fall within stipulated speed ranges.

[0003] However, the actual lifting and lowering speeds of the load lifting device are affected by e.g. the weight of the load, component wear and variations in hydraulic fluid temperature. Accordingly, the actual speed value of the load lifting device will deviate from the set point speed value. These deviations are difficult to predict so the load lifting devices and associated equipment are calibrated to fall well within the stipulated speed ranges. Thus, the potentially allowed maximum speeds are not fully utilized.

[0004] One way to avoid load movements during lifting/lowering is to avoid speed variations and to keep the load lifting device at a constant speed. However, industrial lift trucks of today often comprise two or more lifting stages, each stage being driven by a separate hydraulic cylinder. Thus, during transition from one stage to another, e.g. when a free lift cylinder approaches its end stroke and the main lift cylinder starting its stroke, such constant speed control may be difficult to accomplish.

[0005] One way of solving the problem of constant speed control is disclosed in US 2005/0263354 A1. The transition between stages is accomplished by decelerating the initial stage at a rate which equals the acceleration rate of the next stage to maintain the load lifting device at a constant vertical speed. The fact that speed variations may occur, e.g. due to variations of the weight of the load, component wear and variations in hydraulic fluid temperature, as described above, is however not taken into consideration, since the hydraulic fluid flow is only redirected from one hydraulic cylinder to another. Accordingly, a constant speed during the transition stage can not be guaranteed.

SUMMARY OF THE INVENTION

[0006] An object of the present invention is thus to provide an industrial lift truck having a load lifting device which vertical speed can be maintained at desired set point speeds, e.g. constant, even though the weight of the load, component wear and the hydraulic fluid temperature is varying.

[0007] Yet an object of the present invention is to maintain a constant speed of the load lifting device during a transition stage, when the lifting/lowering operation shifts from a first hydraulic cylinder to a second hydraulic cylinder.

[0008] Another object of the present invention is to increase the maximum speeds allowed for the load lifting device, still falling within stipulated speed ranges.

[0009] These objects are accomplished by means of an industrial truck having the features of the characterising portion of claim 1.

[0010] According to claim 1, the controller comprises means for determining any differences between the calculated actual speed and the set point speed, and means for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly to change its valve opening degree, if a difference exist between the calculated actual speed and the set point speed of the load lifting device, so as to compensate for the difference. Hereby, the desired speed of the load lifting device will always be maintained. Thus, during the transition period between the free lift stage and the main lift stage, the load lifting device can be maintained at a constant speed, so that load movements can be avoided. Moreover, it also becomes possible to adapt set point speeds which are closer to stipulated maximum speeds of the load lifting device, since the uncertainty due to load weights, variations in hydraulic fluid temperatures and component wear automatically is compensated for.

[0011] Suitably, the vertical lifting frame comprises a stationary lifting frame section and at least one telescopic lifting frame section, wherein the load lifting device is movably arranged with respect to the telescopic lifting frame section, and the telescopic lifting frame section is movably arranged with respect to the stationary lifting frame section, and wherein the hydraulic cylinder assembly comprises a first hydraulic cylinder for driving the load lifting device with respect to the telescopic lifting frame section, and a second hydraulic cylinder for driving the telescopic lifting frame section with respect to the stationary lifting frame section. Hereby, a suitable way of handling the load and of driving the load lifting device is achieved.

[0012] Advantageously, the position measuring assembly comprises at least a first position measuring device for measuring the vertical position of the load lifting device with respect to the telescopic lifting frame section, and at least a second position measuring device for measuring the vertical position of the telescopic lifting frame section with respect to the stationary lifting frame section. Hereby, a suitable way of measuring the height of the load lifting device is achieved.

[0013] Preferably, said means for calculating the actual speed of the load lifting device is adapted to calculate a relative speed of the load lifting device with respect to the telescopic lifting frame section based on vertical position measurements of the first position measuring device, and to calculate a relative speed of the telescopic lifting frame section with respect to the stationary lifting frame section based on vertical position measurements of the second position measuring device, wherein the actual speed of the load lifting device is the sum of the relative speeds. Hereby, the control of the speed of the load lifting device can be divided into sub controls of the relative speed of the load lifting device with respect to the telescopic lifting frame section, and the relative speed of the telescopic lifting frame section with respect to the stationary lifting frame section.

[0014] Suitably, said means for generating a set point speed of the load lifting device based on the chosen operation mode is adapted to generate a relative set point speed of the load lifting device with respect to the telescopic lifting frame section, and to generate a relative set point speed of the telescopic lifting frame section with respect to the stationary lifting frame section, wherein the set point speed of the load lifting device is the sum of the relative set point speeds. Hereby, the set point speed of the load lifting device can be dived into a sub set point speed of the load lifting device with respect to the telescopic lifting frame section, and to a sub set point speed of the telescopic lifting frame section with respect to the stationary lifting frame section.

[0015] Advantageously, said means for comparing the calculated actual speed with the set point speed is adapted to compare the relative speed with the relative set point speed of the lifting device with respect to the telescopic lifting frame section, and to compare the relative speed with the relative set point speed of the telescopic lifting frame section with respect to the stationary lifting frame section. Hereby, separate comparison steps are performed which makes the speed control more accurate.

[0016] Preferably, the variable hydraulic valve assembly comprises at least one variable supply valve and at least one variable drainage valve.

[0017] Suitably, said means for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly to change its valve opening degree is adapted to send signals to the hydraulic pump and/or the at least one supply valve only during lifting motions of the load lifting device. Hereby, an effective way of compensating for the difference between the actual speeds and the set point speeds is achieved.

[0018] Advantageously, said means for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly to change its valve opening degree is adapted to send signals to the at least one drainage valve only during lowering motions of the load lifting device. Hereby, an effective way of lowering the load lifting device is achieved.

[0019] Preferably, said means for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly to change its valve opening degree is adapted to send signals to the hydraulic pump and/or the at least one supply valve, or to the at least one drainage valve, so as to maintain the load lifting device at a constant speed when both the load lifting device and the telescopic lifting frame section are in motion. Hereby, an effective way of maintaining the load lifting device at a constant speed during the transition stage between the free lift stage and the main lift stage is achieved.

[0020] Suitably, said means for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly to change its valve opening degree is adapted to send signals to the hydraulic pump to increase its speed, and/or signals to the at least one supply valve to increase its valve opening degree, if the relative speed is lower than the relative set point speed of the lifting device with respect to the telescopic lifting frame section, or if the relative speed is lower than the relative set point speed of the telescopic lifting frame section with respect to the stationary lifting frame section. Hereby, an effective way of compensating for the difference between the actual speed and the set point speed, when the actual speed is lower than the set point speed, is achieved.

[0021] Advantageously, said means for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly to change its valve opening degree is adapted to send signals to the hydraulic pump to decrease its speed, and/or signals to the at least one supply valve to decrease its valve opening degree, if the relative speed is higher than the relative set point speed of the lifting device with respect to the telescopic lifting frame section, or if the relative speed is higher than the relative set point speed of the telescopic lifting frame section with respect to the stationary lifting frame section. Hereby, an effective way of compensating for the difference between the actual speed and the set point speed, when the actual speed is higher than the set point speed, is achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The present invention will now be described with reference to accompanying drawings, on which:

Fig. 1 shows a perspective view of an industrial truck according to the present invention,
Fig. 2 shows a schematic diagram of a controller for the industrial truck,
Fig. 3 shows a speed-position diagram for the free lift cylinder and the main lift cylinder, i.e. a speed-position diagram for the load lifting device.

DETAILED DESCRIPTION

[0023] Reference is first made to fig. 1 which shows a perspective view of an industrial lift truck 1 according to the present invention, and to fig. 2 which schematically shows a controller as well as components of the hydraulic system and the position measurement system of the industrial lift truck. The industrial lift truck 1 comprises a vertical lifting frame 3 having a stationary lifting frame section 5 and at least one telescopic lifting frame section 7. The telescopic lifting frame section 7 is vertically movable within the stationary lifting frame section 5 between a retracted and an extended position. A load lifting device 9 in the form of a fork is vertically movable within the telescopic lifting frame section 7 between a retracted and an extended position. This will be more fully described below.

[0024] The load lifting device 9 is driven by a hydraulic cylinder assembly 11 which comprises a first hydraulic cylinder 13 (henceforth referred to as free lift cylinder 13) and a second hydraulic cylinder 15 (henceforth referred to as main lift cylinder 15). The free lift cylinder 13 connects the telescopic lifting frame section 7 with the load lifting device 9, while the main lift cylinder 15 connects the stationary lifting frame section 5 with the telescopic lifting frame section 7. Thus, the load lifting device 9 will be movable with respect to the telescopic lifting frame section 7, while the telescopic lifting frame section 7 will be movable with respect to the stationary lifting frame section 5 during operation of the free lift cylinder and the main lift cylinder.

[0025] The hydraulic cylinder assembly 11, i.e. the free lift cylinder 13 and the main lift cylinder 15 are supplied with hydraulic fluid from a variable hydraulic pump 17, i.e. having a variable speed. A variable hydraulic valve assembly 19 in the form of one or more variable hydraulic valves (one or more supply valves 19a for the lifting operation and one or more discharge valves 19b for the lowering operation) is arranged in the hydraulic system. The one or more variable hydraulic valves 19a for the supply of hydraulic fluid to the hydraulic cylinder assembly 11 are arranged between the variable hydraulic pump 17 and the hydraulic cylinder assembly 11, while the one or more discharge valves 19b for the lowering operation are arranged between the hydraulic pump 17 and a not shown hydraulic fluid tank. The term "variable" means that the variable hydraulic valves 19 have a variable valve opening degree, so that the amount of hydraulic fluid that passes through the valves can be controlled.

[0026] The industrial lift truck 1 is provided with a position measuring assembly 25a-b in the form of height sensors for measuring the vertical position of the load lifting device 9. The position measuring assembly 25a-b comprises at least a first position measuring device 25a for measuring the vertical position of the load lifting device 9 with respect to the telescopic lifting frame section 7, but also at least a second position measuring device 25b for measuring the vertical position of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5. The first and second position measuring devices 25a-b may be composed of sensor bearings or any other sensors/detectors, such as laser sensors, ultrasound sensors, which are suitable to detect the position of the load lifting device 9 with respect to a fixed point on the telescopic lifting frame section 7, as well as the position of the telescopic lifting frame section 7 with respect to a fixed point on the stationary lifting frame section 5.

[0027] Moreover, the industrial lift truck 1 comprises an operator interface 31 in the form of an operator input device 31 for inputting an operation mode of the load lifting device 9. The operation mode could e.g. be a preselected height setting or a setting for manually control the load lifting device 9 upwards or downwards.

[0028] The industrial lift truck 1 comprises a controller 33 for controlling the speed of the load lifting device 9 during the lifting/lowering operations of the load lifting device 9.

[0029] The controller 33 comprises a set point generator 35 for generating set point speeds and set point heights values in dependence on the operation mode chosen by the operator and with which the lifting/lowering motion has to comply with, e.g. a maximum speed for the load lifting device 9 or remaining distance to complete stroke of free lift cylinder 13. In this respect, the set point speed of the load lifting device 9 generated by the set point generator 35 can be divided into a relative set point speed of the load lifting device 9 with respect to the telescopic lifting frame section 7 and into a relative set point speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5. The sum of the relative set point speeds corresponds to the set point speed of the load lifting device 9.

[0030] The controller 33 also comprises means 37 for calculation of the actual position/height and the actual speed of the load lifting device 9 based on measurements made by the first and second position measuring devices 25a-b. The height of the load lifting device 9 will correspond to the sum of the height of the load lifting device 9 with respect to a fixed point on the telescopic lifting frame section 7 and the height of the telescopic lifting frame section 7 with respect to a fixed point on the stationary lifting frame section 5. In a corresponding way, the actual speed of the load lifting device 9 will correspond to the sum of a relative speed of the load lifting device 9 with respect to the telescopic lifting frame section 7 and a relative speed of the telescopic lifting frame section 7 with respect of the stationary lifting frame section 5. The relative speed of the load lifting device 9 with respect to the telescopic lifting frame section 7 is based on the vertical position measurements of the first position measuring device 25a, while the relative speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5 is based on the vertical position measurements of the second position measuring device 25b. The actual speed of the load lifting device 9 can also be defined as the sum of the stroke rates of the free lift cylinder 13 and the main lift cylinder 15.

[0031] The controller 33 further comprises means 39 for comparing the calculated actual position and speed values with the set point values generated by the set point generator 35, so as to determine any differences between them. Accordingly, it is adapted to compare the relative actual speed with the relative set point speed of the lifting device with respect to the telescopic lifting frame section 7, and to compare the relative actual speed with the relative set point speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5.

[0032] Finally, the controller 33 comprises means 39 for sending compensation signals to the variable hydraulic pump 17 to change its speed, and/or signals to the hydraulic valve assembly 19 to change its valve opening degree in dependence of the difference between the actual speed and the set point speed of the load lifting device 9 so as to compensate for the difference. During a lifting motion, the compensation signals are only sent to the variable hydraulic pump 17 to change its speed and/or to the one or more supply valves 19a to change its valve opening degree, while during a lowering motion of the load lifting device 9 the compensation signals are only sent to the one or more discharge valves 19b to change its valve opening degree.

OPERATION

[0033] The operation of the load lifting device 9 will now be described with reference to fig. 2-3. As described above the set point speeds of the load lifting device 9 depends on the operation mode of the load lifting device 9 chosen by the operator of the industrial lift truck 1. The operation modes correspond to speed values which secure a safe and effective material handling, and which have been calibrated and programmed beforehand. The invention serves to compensate for any deviations from these set point speed values which can occur during various material handling situations, and which will be exemplified below.

[0034] With reference to fig. 3 the operation of the load lifting device 9 will now be described. The operation begins with the operator inputting an operation mode to be performed, in this case a manual lifting mode. Starting with the load lifting device 9 being positioned at its lowermost position carrying a pallet or any other suitable load, a lifting operation can commence. To lift to the uppermost position, i.e. the position where the telescopic lifting frame section 7 is fully extended and the load lifting device 9 is at the uppermost position relative the telescopic lifting frame section 7, the lifting operation can be divided into three stages: a free lift stage, a transition stage and a main lift stage.

[0035] During the free lift stage only the free lift cylinder 13 operates (the main lift cylinder is in idle mode) and moves the load lifting device 9 with respect to the telescopic lifting frame section 7. Thus, the speed of the load lifting device 9 during this free lift stage equals the stroke rate of the free lift cylinder 13. The speed of the load lifting device 9 starts gently to avoid load movements from zero speed (not shown in the diagram) and reaches a maximum speed, which is to be held constant during the remaining part of the free lift stage. At a predetermined height of the load lifting device 9 with respect to a fixed point on the telescopic lifting frame section 7, but before the free lift cylinder 13 has reached its full stroke, the free lift stage ends and the transition lift stage begins. During this transition lift stage, the main lift cylinder 15 begins its stroke with a linearly increasing stroke rate. Meanwhile, the free lift cylinder 13 linearly decreases its stroke rate in a corresponding way. Thus, the speed of the load lifting device 9 equals the sum of the stroke rates of the free lift cylinder 13 and the main lift cylinder 15, which thus is maintained at a constant speed level due to the balancing behaviour of the stroke rates of the free lift cylinder 13 and the main lift cylinder 15. When the free lift cylinder 13 reaches its full stroke, the transition lift stage ends, and the main lift stage begins. The stroke rate of the main lift cylinder 15 has now reached its maximum, while the stroke rate of the free lift cylinder 13 has become zero. The speed of the load lifting device 9 now solely corresponds to the stroke rate of the main lift cylinder 15. The shift from the free lift stage to the main lift stage is thus performed so that the load lifting device 9 is held at a constant level, whereby the risk of load movements is minimized.

[0036] During the free lift stage, the means for calculating the actual speed of load lifting device 9 receives vertical position signals from the first position measuring device 25a, e.g. every 20 ms. These signals are processed so that the actual speed values can be calculated for the free lift cylinder 13, i.e. the load lifting device 9 with respect to the telescopic lifting frame section 7. Since the main lift cylinder 15 is in idle mode, the actual speed of the load lifting device 9 corresponds solely to the relative speed of the load lifting device 9 with respect to the telescopic lifting frame section 7, i.e. the stroke rate of the free lift cylinder 13. If the actual speed value, at a given point of time during the free lift stage deviates from the set point speed, which set point speed has been established by the set point generator 35 in dependence of the operation mode chosen by the operator, a compensation signal is sent either to the variable hydraulic pump 17 and/or to the variable hydraulic valve assembly 19. If for instance the actual speed of the load lifting device 9 is higher than the set point speed, a compensation signal is sent to the variable hydraulic pump 17 to decrease its speed. However, instead of sending a compensation signal to the hydraulic pump to increase its speed, a compensation signal could alternatively or as a complement be sent to the associated supply valve 19a to increase its valve opening degree. On the other hand, if the actual speed is lower than the set point speed, a compensation signal is sent to the variable hydraulic pump 17 to increase its speed. However, instead of sending a compensation signal to the hydraulic pump to decrease its speed, a compensation signal could alternatively or as a complement be sent to the associated supply valve 19a to decrease its valve opening degree.

[0037] During the transition stage, if the actual speed of the load lifting device 9, i.e. the sum of the relative speed of the load lifting device 9 with respect to the telescopic lifting frame section 7 and the relative speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5, i.e. the sum of the stroke rates of the free lift cylinder 13 and the main lift cylinder 15, is higher than the set point speed several options exist: a compensation signal could be sent to the variable supply valve 19a associated with the free lift cylinder 13 to decrease its valve opening degree, if only the relative speed of the load lifting device 9 with respect to the telescopic lifting frame section 7, i.e. the stroke rate of the free lift cylinder 13 is deviating from the relative set point speed, while the relative speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5, i.e. the actual stroke rate of the main lift cylinder 15 equals the relative set point speed, i.e. the set point stroke rate.

[0038] The opposite applies if the actual speed of the load lifting device 9, i.e. the sum of the relative speed of the load lifting device 9 with respect to the telescopic lifting frame section 7 and the relative speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5, i.e. the sum of the stroke rates of the free lift cylinder 13 and the main lift cylinder 15, is lower than the set point speed. That means that a compensation signal could be sent to the variable supply valve 19a associated with the free lift cylinder 13 to increase its valve opening degree, if only the relative speed of the load lifting device 9 with respect to the telescopic lifting frame section 7, i.e. the stroke rate of the free lift cylinder 13 is deviating from the set point speed of the load lifting device 9 with respect to the telescopic lifting frame section 7, while the relative speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5, i.e. the stroke rate of the main lift cylinder 15 equals the relative set point speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5. An analogous approach applies to the main lift cylinder 15 if its actual stroke rate deviates from the set point stroke rate, while the stroke rate of the free lift cylinder 13 equals the set point stroke rate.

[0039] On the other hand, if the actual speed of the load lifting device 9 is higher than the set point speed and this is because both the relative speed of the load lifting device 9 with respect to the telescopic lifting frame section 7 and the relative speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5 are higher than corresponding relative set point speeds, the speed of the variable hydraulic pump 17 should be decreased, instead of decreasing the valve opening degree for both the variable supply valves 19a associated with the free lift cylinder 13 and the main lift cylinder 15. The opposite applies if the actual speed of the load lifting device 9 is lower than the set point speed and this is because both the relative speed of the load lifting device 9 with respect to the telescopic lifting frame section 7 and the relative speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5 are lower than corresponding set point speeds. That is, the speed of the variable hydraulic pump 17 should be increased, instead of increasing the valve opening degree for both the variable supply valves 19a corresponding to the free lift cylinder 13 and the main lift cylinder 15.

[0040] Concerning the main lift stage, the same rules apply as for the free lift stage. That is, if the actual speed value at a given point of time deviates from the set point speed established by the set point generator 35, i.e. the relative actual speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5, a compensation signal is sent either to the variable hydraulic pump 17 and/or to the one or more supply valves 19a of the variable hydraulic valve assembly 19. If for instance the actual speed of the load lifting device 9, i.e. the actual speed of the telescopic lifting frame section 7 with respect to the stationary lifting frame section 5 (since the free lift cylinder 13 is in idle mode) is higher than the set point speed, a compensation signal is sent to the variable hydraulic pump 17 to decrease its speed. On the other hand, if the actual speed, i.e. the stroke rate of the main lift cylinder 15, is lower than the set point speed, a compensation signal is sent to the variable hydraulic pump 17 to increase its speed.

[0041] Concerning lowering of the load lifting device 9, the variable hydraulic pump 17 is not controlled at all so as to compensate for any speed deviations. Instead the variable discharge valves 19b of the variable hydraulic valve assembly 19 are employed. These discharge valves 19b are controlled in an analogous manner as for the supply valves 19a of the variable hydraulic valve assembly 19 during the lifting operation, and reference is therefore made to these passages.

[0042] It is of course conceivable that the stroke rates of the free lift cylinder and the main lift cylinder during the transition stage of the lifting and lowering operation of the load lifting device adopts a speed changing behaviour other than linear as depicted in fig. 3., the speed changing behaviour could e.g. be S-shaped when plotted in the fig. 2 diagram.

[0043] The invention has been described with reference to an industrial lift truck having a lifting frame with a free lift stage and a main lift stage. It is conceivable that the industrial lift truck has a lifting frame with only a main lift stage, i.e. a transition between different stages will not occur.

Claims

1. An industrial lift truck (1), comprising:

   - a lifting frame having a vertically movable load lifting device (9),
   - a hydraulic cylinder assembly (11) for driving the load lifting device (9),

- a variable hydraulic pump (17) for supplying hydraulic fluid to the hydraulic cylinder assembly (11),
- a variable hydraulic assembly (19a-b) arranged for controlling the hydraulic fluid supplied to/drained from the hydraulic cylinder assembly (11),
- a position measuring assembly (25a-b) for measuring vertical positions of the load lifting device (9) with respect to the lifting frame,
- an operator input device (31) for choosing an operation mode of the load lifting device (9),
- a controller (33) comprising: means (37) for calculating the actual speed of the load lifting device (9) based on the vertical position measurements, means (35) for generating a set point speed of the load lifting device (9) based on the chosen operation mode, and means (39) for comparing the calculated actual speed with the set point speed,

characterised in that the controller (33) comprises:

means (39) for determining any differences between the calculated actual speed and the set point speed, and means (39) for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly (19a-b) to change its valve opening degree, if a difference exist between the calculated actual speed and the set point speed of the load lifting device (9), so as to compensate for the difference.

2. Industrial lift truck (1) according to claim 1, wherein the vertical lifting frame (3) comprises a stationary lifting frame section (5) and at least one telescopic lifting frame section (7), wherein the load lifting device (9) is movably arranged with respect to the telescopic lifting frame section (7), and the telescopic lifting frame section (7) is movably arranged with respect to the stationary lifting frame section (5), and wherein the hydraulic cylinder assembly (11) comprises a first hydraulic cylinder (13) for driving the load lifting device (9) with respect to the telescopic lifting frame section (7), and a second hydraulic cylinder (15) for driving the telescopic lifting frame section (7) with respect to the stationary lifting frame section (5).

3. Industrial lift truck (1) according to claim 2, wherein the position measuring assembly (25a-b) comprises at least a first position measuring device (25a) for measuring the vertical position of the load lifting device (9) with respect to the telescopic lifting frame section (7), and at least a second position measuring device (25b) for measuring the vertical position of the telescopic lifting frame section (7) with respect to the stationary lifting frame section (5).

4. Industrial lift truck (1) according to claim 3, wherein said means for calculating the actual speed of the load lifting device (9) is adapted to calculate a relative speed of the load lifting device (9) with respect to the telescopic lifting frame section (7) based on vertical position measurements of the first position measuring device (25a), and to calculate a relative speed of the telescopic lifting frame section (7) with respect to the stationary lifting frame section (5) based on vertical position measurements of the second position measuring device (25b), wherein the actual speed of the load lifting device (9) is the sum of the relative speeds.

5. Industrial lift truck (1) according to any of claims 2-4, wherein said means (33) for generating a set point speed of the load lifting device (9) based on the chosen operation mode is adapted to generate a relative set point speed of the load lifting device (9) with respect to the telescopic lifting frame section (7), and to generate a relative set point speed of the telescopic lifting frame section (7) with respect to the stationary lifting frame section (5), wherein the set point speed of the load lifting device (9) is the sum of the relative set point speeds.

6. Industrial lift truck (1) according to any of claims 2-5, wherein said means (37) for comparing the calculated actual speed with the set point speed is adapted to compare the relative speed with the relative set point speed of the lifting device with respect to the telescopic lifting frame section (7), and to compare the relative speed with the relative set point speed of the telescopic lifting frame section (7) with respect to the stationary lifting frame section (5).

7. Industrial lift truck (1) according to any of claims 2-6, wherein the variable hydraulic valve assembly (19a-b) comprises at least one variable supply valve (19a) and at least one variable drainage valve (19b).

8. Industrial lift truck (1) according to claim 7, wherein said means (39) for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly (19a-b) to change its valve opening degree is adapted to send signals to the hydraulic pump and/or the at least one supply valve (19a) only during lifting motions of the load lifting device (9).

9. Industrial lift truck (1) according to claim 7, wherein said means (39) for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly (19a-b) to change its valve opening degree is adapted to send signals to the at least one drainage valve (19b) only during lowering motions of the load lifting device (9).

10. Industrial lift truck (1) according to any of claims 7-9, wherein said means (39) for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly (19a-b) to change its valve opening degree is adapted to send signals to the hydraulic pump and/or the at least one supply valve (19a), or to the at least one drainage valve (19b), so as to maintain the load lifting device (9) at a constant speed when both the load lifting device (9) and the telescopic lifting frame section (7) is in motion.

11. Industrial lift truck (1) according to any of claims 7-8, wherein said means (39) for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly (19a-b) to change its valve opening degree is adapted to send signals to the hydraulic pump to increase its speed, and/or signals to the at least one supply valve (19a) to increase its valve opening degree, if the relative speed is lower than the relative set point speed of the lifting device with respect to the telescopic lifting frame section (7), or if the relative speed is lower than the relative set point speed of the telescopic lifting frame section (7) with respect to the stationary lifting frame section (5).

12. Industrial lift truck (1) according to any of claims 7-8, wherein said means (39) for sending signals to the hydraulic pump to change its speed, and/or signals to the hydraulic valve assembly (19a-b) to change its valve opening degree is adapted to send signals to the hydraulic pump to decrease its speed, and/or signals to the at least one supply valve (19a) to decrease its valve opening degree, if the relative speed is higher than the relative set point speed of the lifting device with respect to the telescopic lifting frame section (7), or if the relative speed is higher than the relative set point speed of the telescopic lifting frame section (7) with respect to the stationary lifting frame section (5).

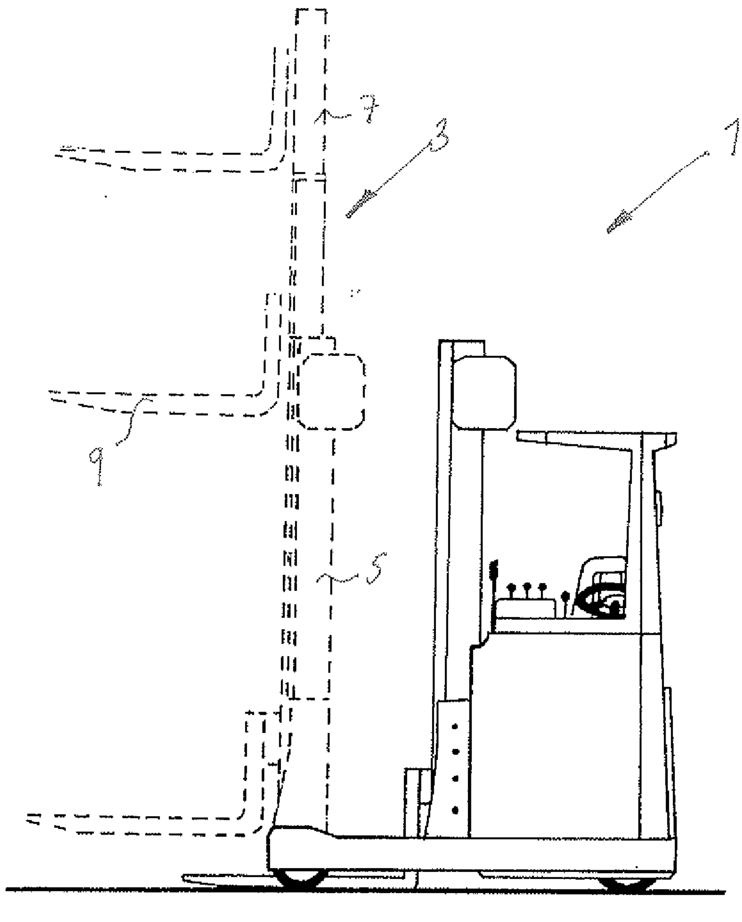

Fig. 1

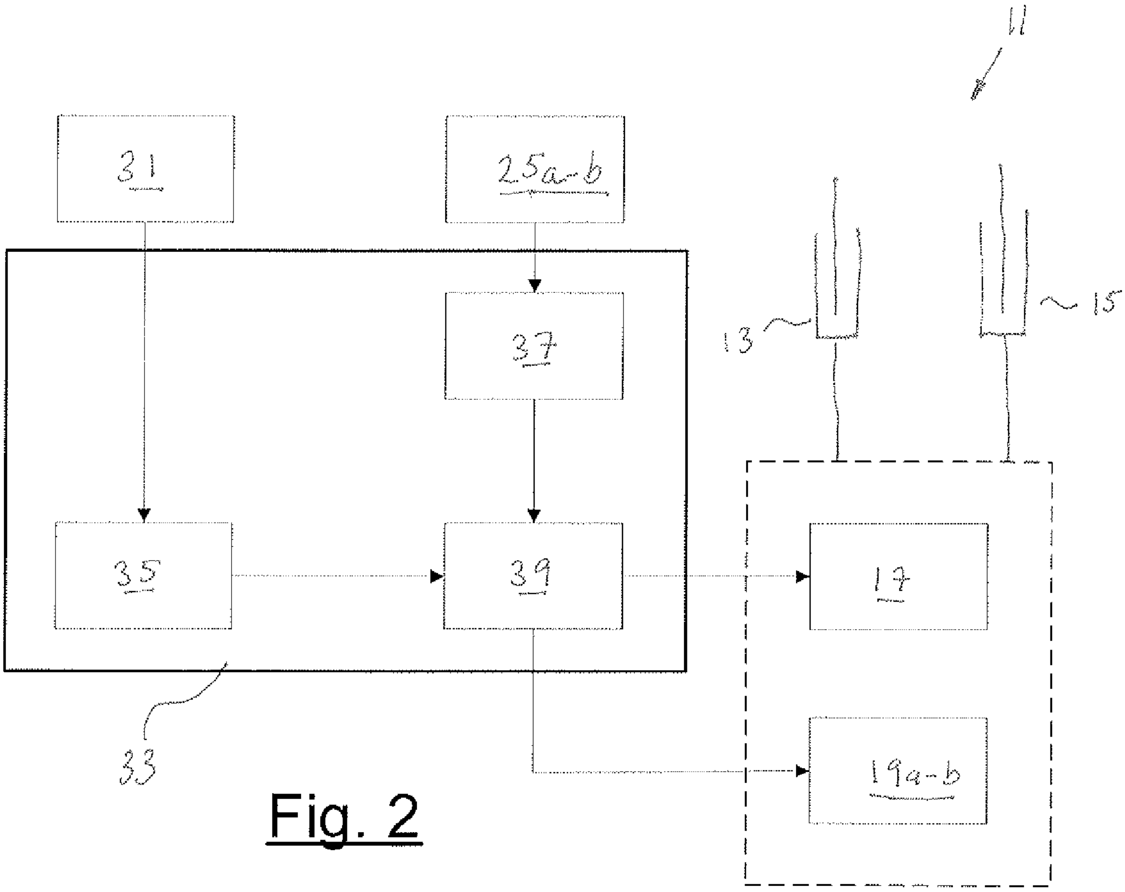
11
31
25a-b
37
13
15
35
39
17
19a-b
33

Fig. 2

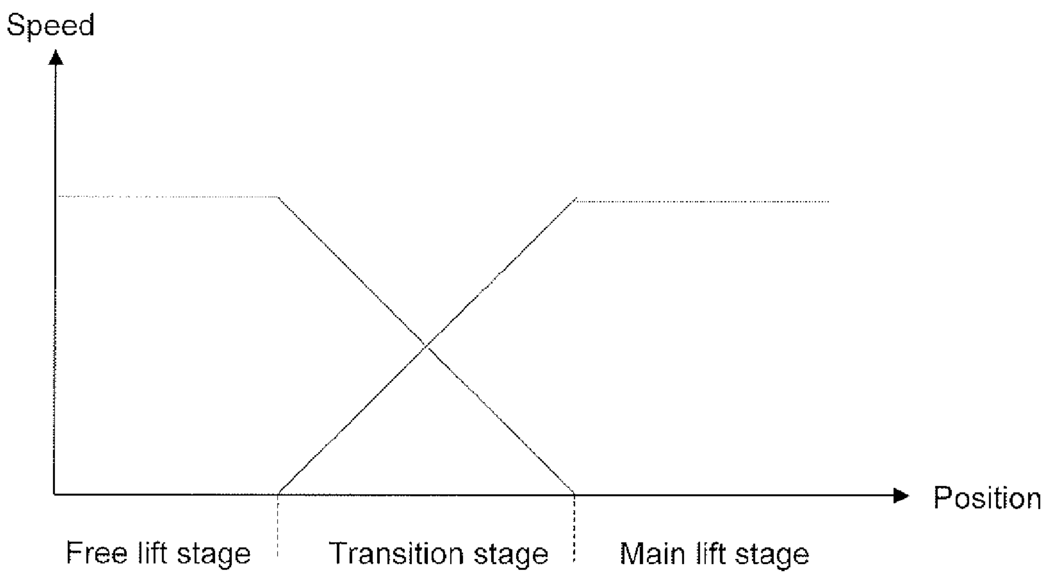
Speed
Position
Free lift stage
Transition stage
Main lift stage

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
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