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(54) Aerial lift vehicle

(57) An aerial lift vehicle is formed by a travelling body; a derrickably attached boom 30; a derricking cylinder for raising and lowering the boom 30; an arm 40, which is vertically swivel ably attached to the distal end of the boom 30; an arm swivelling cylinder, which swivels the arm 40 in the vertical direction relative to the boom 30; a platform 50, which is vertically swivel ably attached to the distal end of the arm 40; a platform swivelling cylinder, which swivels the platform 50 in the vertical direction relative to the arm 40; and levelling control means for carrying out control for maintaining the platform 50 in a horizontal state by preferentially actuating one of the arm swivelling cylinder and the platform swivelling cylinder over the other one of the arm swivelling cylinder and the platform swivelling cylinder in accordance with a derricking operation of the boom 30.

FIG.5A

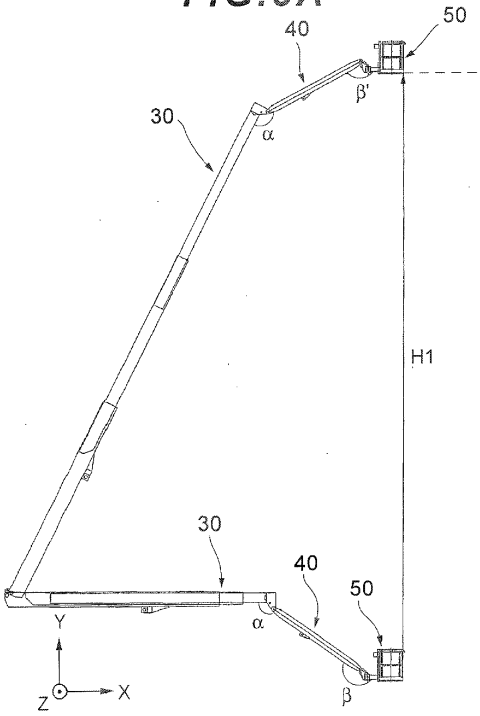
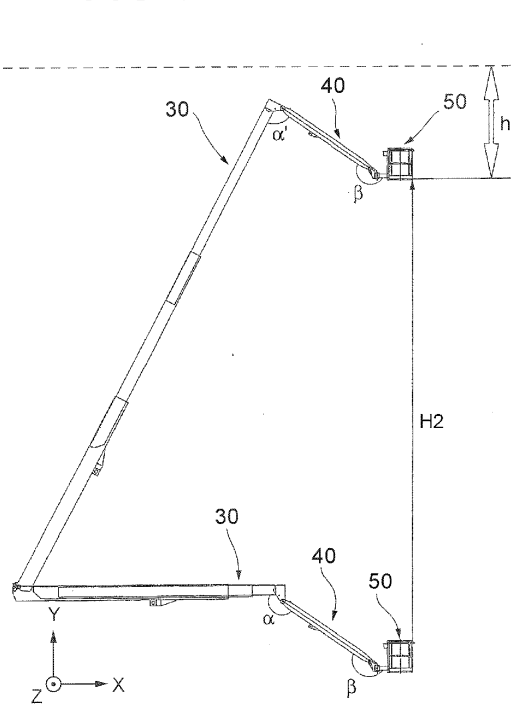


FIG.5B



EP 2 404 862 A1

Description

[0001] This invention claims the benefit of Japanese Patent Application No. 2010-153077 which is hereby incorporated by reference.

[0002] The present invention relates to an aerial lift vehicle having a derrickable boom, an arm, which is vertically swivably disposed at the distal end of the boom, a platform, which is attached at the distal end of the arm, and a levelling apparatus for stabilizing the attitude of the platform.

[0003] As one example of the above-mentioned aerial lift vehicle, there is an aerial lift vehicle, which comprises a boom, which is disposed on top of a mobile chassis so as to be able to move upwardly and downwardly, to extend and contract, and to rotate, an arm disposed at the distal end of this boom so as to be able to swivel up and down, and a platform, which is at the distal end of the arm and is boarded by a worker, and which is configured such that the worker riding in the platform performs work by moving the platform to a desired aerial lift location, and this lift vehicle, for example, is used in power-supply work and construction work. A levelling apparatus, which maintains the floor of the platform horizontal at all times regardless of the derricking angle of the boom, is disposed in an aerial lift vehicle like this so that the platform in which the worker is riding does not tilt in accordance with the raising and lowering of the boom.

[0004] For example, a closed-loop hydraulic-type levelling apparatus like this is configured such that a levelling cylinder, which causes the platform to swivel up and down, extends and contracts in accordance with the extension and contraction of a derricking cylinder, which raises and lowers the boom, thereby maintaining the floor of the platform horizontal at all times despite the derricking angle of the boom. Furthermore, besides this type levelling apparatus, a levelling apparatus, which detects the elevation angle of the arm and maintains the platform in a horizontal attitude at all times despite the swiveling of the arm by extending and contracting the levelling cylinder in accordance with this angle of elevation is also well known, as is disclosed in Patent Document 1.

[0005] However, there is also an aerial lift vehicle, which comprises horizontal actuation operating means and vertical actuation operating means, which are operated to move the platform in either the horizontal direction or the vertical direction, and a horizontal/vertical actuation control apparatus, which carries out control (hereinafter, called HV control) for moving the platform in the horizontal direction and the vertical direction by controlling the boom derricking and telescoping actuation in accordance with the operation of the above-mentioned operating means. In an aerial lift vehicle that is capable of this HV control, conventionally, the swivel angle of the arm relative to the boom has been kept constant, the platform has been moved in accordance with boom derricking and telescoping alone, and levelling of the platform has been carried out using this levelling cylinder to swivel the platform up and down relative to the arm. However, in recent years, an aerial lift vehicle, which performs platform levelling by swiveling the arm relative to the boom in accordance with boom derricking and maintaining the elevation angle of the arm constant regardless of the boom derricking angle, has also become known, as is disclosed in Patent Document 2. This type of aerial lift vehicle is advantageous in that it makes it possible to ensure an even wider work range when moving the platform in the horizontal direction because the elevation angle of the arm is constant at all times even in a case where the platform has been moved in the horizontal direction in accordance with boom derricking.

Patent Document 1: Japanese Laid-Open Patent Publication No. 2001-220098 (A)
Patent Document 2: Japanese Laid-Open Patent Publication No. 2001-206694 (A)

[0006] As described above, there are two systems for platform levelling, i.e., a system, which performs platform levelling by keeping the elevation angle of the arm constant despite the derricking angle of the boom, and a system, which performs platform levelling by using a levelling cylinder to keep the swivel angle of the arm constant relative to the boom and move the platform up and down relative to the arm. With respect to these two systems, the problem is that when horizontal/vertical control is carried out by keeping the arm elevation angle constant as in the former, a wider work range can be ensured under horizontal control, but the height is lower under vertical control, and when horizontal/vertical control is carried out by keeping the swivel angle of the arm constant relative to the boom as in the latter, it is possible to go higher under vertical control, but the work range becomes narrower under horizontal control.

[0007] To solve for the above-mentioned problem, it was necessary to allow both the arm elevation angle and the arm swivel angle relative to the boom to fluctuate in order to broaden the work range under horizontal control and increase the height under vertical control, raising the problem of increasing the load on the control apparatus. Furthermore, in a conventional levelling apparatus like the closed-loop hydraulic system described above, the problem is that configuration-wise only one of the two systems described above can be used, making it impossible to take advantage of the above-described merits of the two systems.

[0008] With the foregoing problem in mind, an object of the present invention is to provide an aerial lift vehicle, which makes it possible to expand the range of movement of the platform in the horizontal direction and the vertical directions and to enhance the workability of the worker without increasing the load on the control apparatus.

[0009] An aerial lift vehicle related to the present invention has: a mobile chassis (for example, the travelling body 10 in the embodiment); a boom, which is derrickably

attached to the chassis; a boom derricking cylinder (for example, the derricking cylinder 22 in the embodiment), which raises and lowers the boom relative to the chassis; an arm, which is vertically swivably attached at the distal end of the boom; an arm swivel cylinder, which swivels the arm in the vertical direction relative to the boom; a platform, which is vertically swivably attached to the distal end of the arm; a platform swivel cylinder, which swivels the platform in the vertical direction relative to the arm; and levelling control means (for example, the controller 80 in the embodiment), which carries out control for maintaining the platform in a horizontal state by preferentially actuating one of the arm swivel cylinder and the platform swivel cylinder over the other one of the arm swivel cylinder and the platform swivel cylinder in accordance to a boom derricking operation.

[0010] It is also preferable that the aerial lift vehicle related to the present invention comprise selection operating means (for example, the levelling selector switch 94 in the embodiment), operated to select either the arm swivelling cylinder or the platform swivelling cylinder to be preferentially actuated. Furthermore, the boom is telescopically attached to the chassis, and the aerial lift vehicle further has a boom telescoping cylinder (for example, the telescoping cylinder 23 in the embodiment), which extends and contracts the boom; horizontal actuation operating means (for example the boom operating lever 91 in the embodiment), operated to move the platform in the horizontal direction; vertical actuation operating means (for example the boom operating lever 91 in the embodiment), which is operated to move the platform in the vertical direction; and horizontal/vertical actuation control means (for example, the controller 80 in the embodiment), which, when either horizontal actuation operating means or vertical actuation operating means is operated, carries out control to move the platform in either the horizontal direction or the vertical direction by actuating the boom derricking cylinder and the boom telescoping cylinder in accordance with the operation of either the operated horizontal actuation operating means or vertical actuation operating means, and levelling control means may be configured so as to carry out control for selecting either the arm swivel cylinder or the platform swivel cylinder for preferential actuation to maintain the platform in the horizontal state by preferentially actuating the selected cylinder for each direction in which the platform moves in accordance with horizontal/vertical actuation control means.

[0011] Then, it is preferable that the aerial lift vehicle related to the present invention has selection setting means (for example, the XYZ control selector switch 95 in the embodiment) for setting beforehand which one of the arm swivel cylinder and platform swivel cylinder levelling control means selects for each direction in which the platform moves. Also, levelling control means may carry out control so as to maintain the platform in the horizontal state by selecting the arm swivel cylinder and preferentially actuating the arm swivel cylinder vice the platform swivel cylinder when horizontal actuation operating means is operated, and may carry out control so as to maintain the platform in the horizontal state by selecting the platform swivel cylinder and preferentially actuating the platform swivel cylinder vice the arm swivel cylinder when vertical actuation operating means is operated.

[0012] In the above-described aerial lift vehicle related to the present invention, in accordance with levelling control means preferentially actuating either one of the arm swivel cylinder or the platform swivel cylinder vice the other in accordance with boom derricking operations, it is possible to switch between a system, which performs platform levelling by preferentially actuating the arm swivel cylinder and keeping the arm elevation angle constant regardless of the book derricking angle, and a system, which performs platform levelling by preferentially actuating the platform swivel cylinder and keeping the swivel angle of the arm constant relative to the boom. In accordance with this, since the preferentially actuated cylinder is determined in accordance with platform levelling control, it is possible to switch between the above-described two levelling systems without increasing the load on the control apparatus.

[0013] Also, in a case where the aerial lift vehicle related to the present invention comprises selection operating means, it becomes possible to allow the worker to carry out the levelling system switching operation, thereby enabling the switching of the levelling system to be done in accordance with the worker's preference, and, for example, in a case where a novice carries out an operation, switching to the levelling system, which preferentially actuates the arm swivel cylinder and keeps the arm elevation angle constant, makes it possible for the novice to more easily recognize the swivel trajectory of the platform relative to the arm.

[0014] Then, in a case where platform HV control is carried out by horizontal/vertical actuation control means, it becomes possible to either expand or reduce the work range for each direction in which the platform moves in accordance with levelling control means selecting the implementation of platform levelling control by selecting to preferentially actuate either the arm swivel cylinder or the platform swivel cylinder for each direction in which the platform moves. In accordance with the aerial lift vehicle related to the present invention comprising selection setting means, it becomes possible to switch the levelling system for each directions in which the above-mentioned platform moves. Furthermore, in accordance with carrying out levelling by preferentially actuating the arm swivel cylinder when the platform is moved in the horizontal direction, the work range of the platform in the horizontal direction can be expanded due to the arm elevation angle becoming constant. Then, in accordance with carrying out levelling by preferentially actuating the platform swivel cylinder when the platform is moved in the vertical direction, the work range of the platform in the vertical direction can be expanded due to

the swivel angle of the arm relative to the boom becoming constant.

[0015] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

[0016] The present invention will become more fully understood from the detailed description given herein below and the accompanying drawings which are given by way of illustration only and thus are not limitative of the present invention.

FIG. 1 is a side view of an aerial lift vehicle related to the present invention.

FIG. 2 is an enlarged side view showing the boom tip, the arm, and the platform of the above-mentioned aerial lift vehicle.

FIG. 3 is block diagram showing the levelling control in the above-mentioned aerial lift vehicle.

FIG. 4 is side view showing the operation of the arm and the platform in the above-mentioned serial lift vehicle when swivelling the arm relative to the boom.

FIGS. 5A and 5B are diagrams showing the vertical movement control of the platform in the above-mentioned aerial lift vehicle; FIG. 5A is a diagram showing the vertical movement control in a boom/arm linked levelling mode, and FIG. 5B is a diagram showing the vertical movement control in a boom/arm independent levelling mode.

FIGS. 6A and 6B are diagrams showing the horizontal movement control of the platform in the above-mentioned aerial lift vehicle; FIG. 6A is a diagram showing the horizontal movement control in a boom/arm independent levelling mode, and FIG. 6B is a diagram showing the horizontal movement control in a boom/arm linked levelling mode.

[0017] The preferred embodiment of the present invention will be explained below by referring to the drawings. First of all, the overall configuration of an aerial lift vehicle 1 related to the present invention will be explained while referring to the side view of FIG. 1. The aerial lift vehicle 1 comprises a truck-type travelling body 10, which has tired wheels 11, and is capable of being driven from an operator's cab 12; a rotary pedestal 20 disposed on top of the travelling body 10; a vertically swivably attached telescoping boom (below simply be referred to as the boom) 30, the base end of which is pivotally connected to a foot pin 21 of the rotary pedestal 20; and an extensible arm (below simply referred to as the arm) 40, which is attached to the distal end of this boom 30 and is able to swivel up and down relative to the boom 30; and a platform 50, which is attached at the distal end of this arm 40.

[0018] Outriggers 13, which support the travelling body 10 in a stable state while work is in progress, are disposed at respective locations at the front, back, left and right of the travelling body 10, and when carrying out aerial lifting, the outrigger 13 is configured so as to jut downward, and lift up and support the travelling body 10. The rotary pedestal 20 is configured on top of the travelling body 10 to enable rotation in accordance with a rotation motor (not shown in the drawing). Furthermore, a derricking cylinder 22 is disposed between the rotary pedestal 20 and the boom 30, and the boom 30 becomes derrickable relative to the rotary pedestal 20 in accordance with the extension and contraction of this derricking cylinder 22. The boom 30 comprises a base end boom 30a, an intermediate boom 30b and an distal end boom 30c in a nested configuration, and is configured to enable extension and contraction in accordance with the actuation of a telescoping cylinder 23 disposed inside the boom 30.

[0019] The arm 40, as shown in FIG. 2, comprises a boom head 41, which is pivotally connected to the distal end of the boom 30, a head bracket 42, which supports the platform 50, and an arm member 43, one end of which is pivotally connected to the boom head 41 to enable up-down swivelling, and the other end of which is pivotally connected to the head bracket 42 to enable up-down swivelling. A hydraulically driven arm swivelling cylinder 44 is disposed between the distal end boom 30c and the arm member 43, and the extension and contraction of the arm swivelling cylinder 44 makes it possible to swivel the arm 40 in the up-down direction relative to the boom 30.

[0020] Also, one end of a first link plate 45 is pivotally connected to the head bracket 42 to enable up-down swivelling, and one end of a second link plate 46 is pivotally connected to the arm member 43 to enable up-down swivelling. The other end of the first link plate 45 and the other end of the second link plate 46 are pivotally connected to enable relative swivelling, and a hydraulically driven platform swivelling cylinder 47 is disposed between the arm member 43 and the pivotal connection point on the above-mentioned other ends of the first and second link plates 45, 46. The extension and contraction of this platform swivelling cylinder 47 makes it possible to swivel the platform 50 in the up-down direction relative to the arm 40 and maintain the platform 50 in a horizontal state at all times.

[0021] An arm swivelling cylinder control valve 48 and a platform swivelling cylinder control valve 49 in the above-described arm swivelling cylinder 44 and platform swivelling cylinder 47, respectively, are connected via a hydraulic loop (not shown in the drawing) (refer to FIG. 3). Furthermore, the arm swivelling cylinder control valve 48 and the platform swivelling cylinder control valve 49 are connected to a controller 80, which will be described further below, via a signal wire (not shown in the drawing), and are actuated on the basis of a signal from the controller 80 to extend and contract the arm swivelling cyl-

inder 44 and the platform swivelling cylinder 47 (a detailed description will be given below).

[0022] A vertical post 60 is attached to the head bracket 42, one end of the platform swivelling cylinder 47 is pivotally connected to the head bracket 42 such that the actuation of the platform swivelling cylinder 47 maintains the vertical post 60 in a vertical state at all times, the platform 50 is supported so as to be able to rotate around the axis of this vertical post 60, and is able to rotate horizontally around the axis of the vertical post 60 in accordance with the actuation of a yawing motor 61 disposed in the vertical post 60. Furthermore, the platform 50 can be boarded by a worker, and the worker can operate an operating apparatus 90, which will be described further below, to raise and lower, extend and contract, and rotate the boom 30, and swivel the arm 40, and, in addition, to move the platform 50 horizontally and vertically to a desired location using an HV mode, which will be described further below.

[0023] Furthermore, an arm swivel angle detection apparatus 71 is disposed between the boom head 41 and the arm member 43, and a platform swivel angle detection apparatus 72 is disposed between the head bracket 42 and the arm member 43, respectively. The arm swivel angle detection apparatus 71 detects the swivel angle of the arm 40 relative to the boom 30 (hereinafter, will be referred to as the arm swivel angle a), the platform swivel angle detection apparatus 72 detects the swivel angle of the platform 50 relative to the arm 40 (hereinafter, will be referred to as the platform swivel angle β), and the detected arm swivel angle α and platform swivel angle β are outputted to the controller 80. A boom derricking angle detection apparatus 73 for detecting the derricking angle of the boom 30 relative to the rotary pedestal 20 is disposed in the boom 30, and a platform elevation angle detection apparatus 74 for detecting the elevation angle of the platform 50 is disposed in the platform 50, respectively, and the boom derricking angle and the platform elevation angle are also outputted to the controller 80.

[0024] In the aerial lift vehicle 1 configured as described hereinabove, the operating apparatus 90 is disposed on the arm 40 side of the platform 50 (refer to FIG. 2). The operating apparatus 90, as shown in FIG. 3, comprises a boom operating lever 91, an arm operating lever 92, a mode selection switch 93, and a levelling selector switch 94. The boom operating lever 91 comprises a grip (not shown in the drawing) on the top end thereof, can be tilted around a centre position in any of the directions forward, backward, right, and left, and, in addition, the grip can be twisted clockwise and counter-clockwise. The arm operating lever 92, for example, can be a joystick, and can be tilted forward and backward.

[0025] A toggle switch, which can be positioned either forwards or backwards, can be used as the mode selection switch 93, and positioning the mode selection switch 93 in the forward location makes it possible to select a normal mode, and positioning this switch 93 in the backward location makes it possible to select the HV mode (the horizontal/ vertical movement mode). As used here, the normal mode makes it possible to separately carry out the raising and lowering, extending and contracting, and rotating of the boom 30 in accordance with tilting and twisting the boom operating lever 91, and the HV mode makes it possible to move the platform 50 in the horizontal direction by tilting the boom operating lever 91, and, in addition, makes it possible to move the platform 50 in the vertical direction by twisting the boom operating lever 91 (a detailed explanation will be given below).

[0026] Furthermore, tilting the boom operating lever 91 and the arm operating lever 92 respectively output a boom operating signal and an arm operating signal, and twisting the boom operating lever 91 outputs a rotation signal, and these signals are inputted to the controller 80. When the arm operating lever 92 is tilted forward and backward, the controller 80 receives the arm operating signal, and the controller 80 outputs signals to the arm swivelling cylinder control valve 48 and the platform swivelling cylinder control valve 49 at this time to extend or contract the arm swivelling cylinder 44 and the platform swivelling cylinder 47. Then, the arm swivelling cylinder 44 is extended or contracted in response to the above-mentioned tilting operation, and the arm 40 is swung relative to the boom 30, and at the same time, the platform swivelling cylinder 47 is extended or contracted so as to maintain the floor of the platform 50 in the horizontal state despite the swivelling of the arm 40. Therefore, as shown in FIG. 4, for example, when the swivel angle of the arm 40 relative to the boom 30 increases by γ, the platform swivel angle β of the platform 50 relative to the arm 40 decreases by γ and the horizontal state of the platform 50 is maintained.

[0027] Furthermore, a yaw operating lever (not shown in the drawing), which is configured the same as the arm operating lever 92, is disposed in the operating apparatus 90 to enable tilting in the left-right directions, and tilting the yaw operating lever to the left causes the yawing motor 61 to rotate in the forward direction, enabling the clockwise yawing of the platform 50, and tilting the yaw operating lever to the right causes the yawing motor 61 to rotate in the reverse direction, enabling the counter-clockwise yawing of the platform 50.

[0028] When switched to either the normal mode or the HV mode, the mode selection switch 93 outputs a signal corresponding to the switch-selected mode, and this signal is also inputted to the controller 80. In a case where the normal mode has been selected in accordance with the mode selection switch 93 and the boom operating lever 91 is tilted in the front-back direction at this time, the controller 80 outputs a signal for extending or contracting the derricking cylinder 22 to a derricking cylinder control valve (not shown in the drawing), causing the derricking cylinder 22 to extend or contract and the boom 30 to raise or lower in accordance with the above-mentioned front-back direction tilting operation. When the boom operating lever 91 is tilted in the left-right direction,

the controller 80 outputs a signal for extending or contracting the telescoping cylinder 23 to a telescoping cylinder control valve (not shown in the drawing), causing the telescoping cylinder 23 to extend or contract and the boom 30 to extend or contract in accordance with the above-mentioned left-right direction tilting operation. Also, when the grip of the boom operating lever 91 is twisted either clockwise or counter-clockwise, the controller 80 outputs a signal for driving a rotation motor (not shown in the drawing) to a rotation motor control valve (not shown in the drawing), driving the rotation motor in accordance with the above-mentioned clockwise or counter-clockwise twisting operation and causing the rotary pedestal 20 to rotate.

[0029] Alternatively, in a case where the HV mode has been selected in accordance with the mode selection switch 93, the boom operating lever 91 can only be tilted to the front, back, right and left, and the grip can only be twisted either clockwise or counter-clockwise. Then, the platform 50 can be moved in the vertical direction by tilting the boom operating lever 91 in the front-back direction, the platform 50 can be moved in the horizontal direction, and, in addition, in the front-back direction of the travelling body 10 by tilting the boom operating lever 91 in the right-left direction, and the platform 50 can be moved in the horizontal direction, and, in addition, in the right-left direction of the travelling body 10 by twisting the grip of the boom operating lever 91 either clockwise or counter-clockwise. In this way, the platform 50 can be moved in six directions in the HV mode, i.e., up, down, right, left, front and back. Furthermore, as shown in FIG. 1, the horizontal direction parallel to the longitudinal axis of the travelling body 10 will be explained as the X direction (the left direction in FIG. 1), the vertical direction will be explained as the Y direction (the upward direction in FIG. 1), and the horizontal direction orthogonal to the longitudinal axis of the travelling body 10 will be explained as the Z direction (the depth direction in FIG. 1). However, the X direction, the Y direction, and the Z direction are defined strictly for convenience of explanation.

[0030] In the HV mode, tilting the boom operating lever 91 in the left-right direction outputs an X operation signal, twisting the grip of the boom operating lever 91 either clockwise or counter-clockwise outputs a Z operation signal, and tilting the boom operating lever 91 in the front-back direction outputs a Y operation signal. The respective outputted operation signals are all inputted to the controller 80. Upon receiving the above-mentioned X operation signal, Y operation signal, or Z operation signal, the controller 80 computes the rotation amount of the rotary pedestal 20, the derricking amount and telescoping amount of the boom 30, and the yawing amount of the platform 50 based on the relevant operating signal. Then, the controller 80 outputs drive signals to the respective control valves (not shown in the drawing), which control the operation of a rotary motor of the rotary pedestal 20, the derricking cylinder 22 and telescoping cylinder 23 of the boom 30 and the yawing motor 61, and controls the rotation of the rotary pedestal 20, the derricking and telescoping of the boom 30, and the yawing of the platform 50. In so doing, the boom 30 can be raised/lowered and extended/contracted, and the platform 50 can be moved in either the X direction or the Y direction by tilting the boom operating lever 91 in either the left-right or front-back directions in the HV mode, and the rotary pedestal 20 can be rotated, the boom 30 can be extended/ contracted, and the yawing of the platform 50 can be performed to move the platform 50 in the Z direction by twisting the grip of the boom operating lever 91 either clockwise or counter-clockwise in the HV mode.

[0031] The aerial lift vehicle 1 configured as described hereinabove comprises two types of levelling modes for using two cylinders, i.e., the arm swivelling cylinder 44 and the platform swivelling cylinder 47 described above, to carry out levelling control for maintaining the platform 50 in the horizontal state regardless of the derricking status of the boom 30, and for preferentially actuating either one of these two cylinders. Specifically, it is possible to switch between a boom/arm linked levelling mode, which, as shown in FIG. 5A, for example, keeps the arm swivel angle α constant and fluctuates the platform swivel angle β by preferentially actuating the platform swivelling cylinder 47, and a boom/arm independent levelling mode, which, as shown in FIG. 5B, for example, keeps the platform swivel angle β constant and fluctuates the arm swivel angle α by preferentially actuating the arm swivelling cylinder 44. Two examples will be given below in explaining the method for switching these levelling modes.

[0032] Practical example 1 is a case in which the above-described levelling modes are switched manually in a state in which the mode selection switch 93 has been switched to the normal mode. In practical example 1, the boom/arm linked levelling mode and the boom/arm independent levelling mode are switched manually using the levelling selector switch 94 shown in FIG. 3. Also, a display lamp (not shown in the drawing) is disposed in the vicinity of the levelling selector switch 94, and in accordance with this display lamp, it is clear which of the boom/arm linked levelling mode and the boom/arm independent levelling mode has been selected. Furthermore, for example, a toggle switch that is able to be positioned either forwards or backwards the same as the mode selection switch 93 can be used as the levelling selector switch 94. The relationship between the levelling mode selection status according to the levelling selector switch 94 and the operation of the boom operating lever 91 and the arm operating lever 92, as well as the actuation will be explained below.

[0033] First of all, when the boom operating lever 91 is tilted in the front-back direction in the normal mode, the controller 80 extends and contracts the derricking cylinder 22 to raise and lower the boom 30, but in a case where the selection status of the levelling selector switch 94 is checked and the boom/arm linked levelling mode is selected at this time, the platform 50 is made to swivel relative to the arm 40 in accordance with the raising and

lowering of the boom 30, that is, the levelling of the platform 50 is carried out by preferentially actuating the platform swivelling cylinder 47. In this case, the arm swivel angle α is constant despite the raising and lowering of the boom 30. Alternatively, in a case where the boom/arm independent levelling mode is selected using the levelling selector switch 94, the arm 40 is made to swivel relative to the boom 30 in accordance with the raising and lowering of the boom 30, that is, the levelling of the platform 50 is carried out by preferentially actuating the arm swivelling cylinder 44. In this case, the platform swivel angle α is constant despite the raising and lowering of the boom 30. Furthermore, in the normal mode, since tilting the boom operating lever 91 in the left-right direction or performing a twisting operation only results in either the telescoping or the rotating of the boom 30 and the elevation angle of the platform 50 is not changed, levelling control in accordance with the operation of the arm swivelling cylinder 44 or the platform swivelling cylinder 47 is not performed.

[0034] Furthermore, when the arm operating level 92 is tilted in the front-back direction in the normal mode, the controller 80 extends and contracts the arm swivelling cylinder 44 to swivel the arm 40 relative to the boom 30, but the levelling of the platform 50 is carried out by actuating the platform swivelling cylinder 47 regardless of the selection status of the levelling selector switch 94 at this time, and causing the platform 50 to swivel relative to the arm 40 in accordance with the swivelling of the arm 40 relative to the boom 30 (for example, refer to FIG. 4). Then, even in a case where the boom operating lever 91 and the arm operating lever 92 are simultaneously tilted in the front-back direction in the normal mode, the controller 80 carries out platform 50 levelling by actuating the platform swivelling cylinder 47 regardless of the selection status of the levelling selector switch 94, and causing the platform 50 to swivel relative to the arm 40 in accordance with the raising and lowering of the boom 30 and the swivelling of the arm 40.

[0035] In practical example 1 hereinabove, the levelling selector switch 94 can be used to manually switch between the boom/arm linked levelling mode and the boom/arm independent levelling mode, and the levelling modes can be properly used in accordance with the nature of the aerial lifting, conditions at the worksite, or the preference of the worker, thereby achieving the effect of improving workability. Furthermore, since the worker is able to switch the levelling mode, in the case of a novice worker, for example, the worker can select the boom/arm independent levelling mode to keep the platform swivel angle β constant and to keep the elevation angle of the arm 40 constant regardless of the derricking status of the boom 30, thereby making it easier for the worker to anticipate the movement of the platform 50 relative to the arm 40 and enabling workability to be improved.

[0036] Furthermore, in practical example 1, in a case accompanied by a tilting operation of the arm operating lever 92, the arm swivelling cylinder 44 is actuated and the arm 40 is made to swivel relative to the boom 30 regardless of the levelling mode selection status, and levelling of the platform 50 is always performed by actuating the platform swivelling cylinder 47, thereby making it possible to maintain the orientation of the platform 50 in the horizontal state and to ensure the safety of the worker even when swivelling the arm 40. Furthermore, the manual switching system of practical example 1 can even be applied to an aerial lift vehicle, which does not have a mode selection switch 93 that enables switching to the HV mode, and which comprises only boom operating means for raising and lowering the boom 30 and arm operating means for swivelling the arm 40 relative to the boom 30.

[0037] Practical example 2 is a case in which the above-mentioned levelling modes are switched automatically in a state in which the mode selection switch 93 has been switched to the HV mode. First of all, in a case in which the boom operating lever 91 is tilted in the front-back direction in the HV mode to move the platform 50 in the Y direction (the vertical direction) as shown in FIG. 5, the controller 80 automatically switches to the boom/arm linked levelling mode. Specifically, when the boom operating lever 91 is tilted to the front or back, a Y operation signal is outputted to the controller 80 as was described hereinabove, and the controller 80, upon being inputted with the Y operation signal, raises or lowers and extends or contracts the boom 30 to move the platform 50 in the Y direction, and preferentially actuates the platform swivelling cylinder 47 vice the arm swivelling cylinder 44 and swivels the platform 50 relative to the arm 40 to keep the swivel angle of the arm 40 constant relative to the boom 30. Therefore, in this case, the platform tilt angle β changes from β to β', which is smaller than β, but the arm swivel angle α remains constant in accordance with the movement of the platform 50 in the Y direction as shown in FIG. 5A.

[0038] Alternatively, in a case where the boom/arm independent levelling mode is set when the boom operating lever 91 is tilted in the front-back direction to move the platform 50 in the Y direction as described above, the levelling of the platform 50 is performed by keeping the platform swivel angle β constant and changing the swivel angle of the arm 40 relative to the boom 30 from α to α', which is smaller than α, in accordance with moving the platform 50 in the Y direction as shown in FIG. 5B.

[0039] As described hereinabove, in the boom/arm linked levelling mode (FIG. 5A), the platform 50 is at a location in the Y direction that is higher by h than in the boom/arm independent levelling mode (FIG. 5B) even when the derricking amounts and the telescoping amounts of the booms 30 are the same, and in a case where it is supposed that the work range in the Y direction of the boom/arm independent levelling mode is H2, the work range of H1 achieved in the boom/arm linked levelling mode is higher by h than the H2. In accordance with this, a broader work range can be achieved by switching to the boom/arm linked levelling mode in a case

where the boom operating lever 91 is tilted in the front-back direction in the HV mode to move the platform 50 in the Y direction.

[0040] Furthermore, as shown in FIG. 6, in a case where either the boom operating lever 91 is tilted in the left-right direction or the grip is twisted in the HV mode to move the platform 50 in either the X direction or the Z direction (a horizontal direction), the controller 80 automatically switches to the boom/arm independent levelling mode. Specifically, when either the boom operating lever 91 is tilted to the left or right or the grip is twisted in the HV mode, either an X or a Z operation signal is outputted to the controller 80, and the controller 80, upon being inputted with an X operation signal, raises or lowers and extends or contracts the boom 30 to move the platform 50 in the X direction and preferentially actuates the arm swivelling cylinder 44 vice the platform swiveling cylinder 47. In addition, the controller 80, upon being inputted with a Z operation signal, rotates the rotary pedestal 20, raises or lowers and extends or contracts the boom 30, and yaws the platform 50, and also preferentially actuates the arm swivelling cylinder 44 vice the platform swivelling cylinder 47 in this case as well. That is, the controller 80, when inputted with either an X or a Z operation signal, preferentially actuates the arm swivelling cylinder 44, and as shown in FIG. 6A, controls the levelling of the platform 50 in accordance with moving the platform 50 in either the X or Z direction, for example, by changing the arm tilt angle from α to α', which is larger than α, to keep the platform swivel angle β constant.

[0041] Alternatively, in a case where the boom/arm linked levelling mode is set when either the boom operating lever 91 is tilted in the left-right direction or the grip is twisted to move the platform 50 in either the X or the Z direction as described above, as shown in FIG. 6B, the arm swivel angle α is kept constant and the platform swivel angle β is changed in accordance with moving the platform 50 in either the X or the Z direction. The levelling of the platform 50 is performed in the boom/arm linked levelling mode here by keeping the arm swivel angle α constant, and changing the tilt angle of the platform 50 relative to the arm 40 from β to β', which is larger than β.

[0042] As described hereinabove, in the boom/arm independent levelling mode (FIG. 6A), the platform 50 is at a location in either the X or Z direction that is longer by w than in the boom/arm linked levelling mode (FIG. 6B) even when the derricking amounts and the telescoping amounts of the booms 30 are the same, and in a case where it is supposed that the work range in either the X or Z direction of the boom/arm linked levelling mode is W2, the work range of W1 achieved in the boom/arm independent levelling mode is longer by w than the W2. In accordance with this, a broader work range can be achieved by switching to the boom/arm independent levelling mode in a case where either the boom operating lever 91 is tilted in the left-right direction or the grip is twisted in the HV mode to move the platform 50 in either the X or Z direction.

[0043] In practical example 2 above, the configuration is such that switching between the boom/arm linked levelling mode, which preferentially actuates the platform swivelling cylinder 47 to keep the arm swivel angle α constant and cause the platform swivel angle β to fluctuate, and the boom/arm independent levelling mode, which preferentially actuates the arm swivelling cylinder 44 to keep the platform swivel angle β constant and cause the arm swivel angle α to fluctuate, is automatically carried out for each direction of movement of the platform 50, that is, for the X direction, the Y direction, and the Z direction. Therefore, a broader work range can be ensured with respect to the movement of the platform 50 in the horizontal direction and the vertical direction than with a conventional aerial lift vehicle having platform 50 HV control capabilities.

[0044] Furthermore, the configuration may also be such that in switching between the boom/arm linked levelling mode and the boom/arm independent levelling mode in practical example 2, for example, an XYZ control selector switch 95 (refer to FIG. 3) is provided to enable switching between the boom/arm linked levelling mode and the boom/arm independent levelling mode in each of the X direction, the Y direction, and the Z direction. In accordance with this, for example, in a case where it is desirable to narrow the work range, the controller 80 can respectively switch to the boom/arm linked levelling mode for the X direction or the Z direction (refer to FIG. 6B), and to the boom/arm independent levelling mode for the Y direction (refer to FIG. 5B).

[0045] In the aerial lifting vehicle of the embodiment described hereinabove, since it is possible to switch between the boom/arm linked levelling mode and the boom/arm independent levelling mode manually in practical example 1 and automatically in practical example 2, and to decide which of the arm swivelling cylinder 44 or the platform swivelling cylinder 47 is to be preferentially actuated, the work range of the platform 50 can be expanded and reduced without increasing the load on the controller 80. For example, since the platform swivel angle β can be kept constant in a case where the platform swivel angle β is set to an approximate right angle and the boom/arm independent levelling mode is used, so-called tuck work, in which the platform 50 is moved height wise in a work area that is narrow in the horizontal direction, can be carried out efficiently.

[0046] The embodiment of the aerial lift vehicle related to the present invention has been explained hereinabove, but the scope of the present invention is not limited to the embodiment described above. For example, in the above-described embodiment, an example in which mode selecting means (a mode selection switch 93) and levelling switching means (a levelling selector switch 94) are toggle switches was explained, but another configuration may be used as long as a switching operation is possible. Also, an example in which a boom operating lever 91 is used as input means for carrying out inputting for moving the platform 50 in the X direction, the Y direc-

tion, and the Z direction when the HV mode is selected was explained, but the horizontal and vertical movements of the platform 50 may be controlled using another operating lever, such as the arm operating lever 92, and HV control operating levers, such as an X direction operating lever, a Y direction operating lever, and a Z direction operating lever may be provided separately. In addition, operating means does not necessarily have to be an operating lever, and another configuration, for example, a switch or the like may also be used.

[0047] Furthermore, in the above-described embodiment, an example in which a controller 80, which is control means, simultaneously carries out control of the derricking and telescoping of the boom 30 for moving the platform 50, and the actuation control of the arm swivelling cylinder 44 and the platform swivelling cylinder 47 for levelling the platform 50 was explained, but the configuration may be such that platform movement control means and levelling control means are provided separately, with platform movement control means carrying out control for moving the platform 50 and levelling control means carrying out control for levelling the platform 50.

[0048] Furthermore, in the aerial lift vehicle in the above-described embodiment, an example in which the boom 30 is configured by nesting a base end boom 30a, an intermediate boom 30b, and a distal end boom 30c, and the arm 40 comprises an arm head 41, a head bracket 42, an arm member 43, a first link plate 45 and a second link plate 46 was explained, but the configurations of the boom 30 and the arm 40 are not limited to the above descriptions. Furthermore, in the above description, an example in which control valves (an arm swivelling cylinder control valve 48 and a platform swivelling cylinder control valve 49) are respectively provided for the arm swivelling cylinder 44, which swivels the arm 40 relative to the boom 30, and for the platform swivelling cylinder 47, which swivels the platform 50 relative to the arm 40, was explained, but the present invention is not limited to this configuration, and, for example, the arm swivelling cylinder 44 and the platform swivelling cylinder 47 may both share a single control valve.

[0049] In addition, in the above-described embodiment, a tired wheel-type aerial lift vehicle, the travelling body 10 of which comprises tired wheels 11, was explained, but the travelling body need not be a tired wheel-type vehicle, and, for example, the present invention can also be applied to a vehicle that travels using a crawler apparatus, or a vehicle, which comprises wheels for travelling on a track and which travels on the track.

[0050] The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. An aerial lift vehicle, comprising:

a mobile chassis;
a boom, which is derrickably attached to the chassis;
a boom derricking cylinder, adapted to raise and lower the boom relative to the chassis;
an arm, which is vertically swivably attached to the distal end of the boom;
an arm swivelling cylinder, which is adapted to swivel the arm in the vertical direction relative to the boom;
a platform, which is vertically swivably attached to the distal end of the arm;
a platform swivelling cylinder, which is adapted to swivel the platform in the vertical direction relative to the arm; and
levelling control means for carrying out control for maintaining the platform in a horizontal state by preferentially actuating one of the arm swivelling cylinder and the platform swivelling cylinder over the other one of the arm swivelling cylinder and the platform swivelling cylinder in accordance with the derricking operation of the boom.

2. The aerial lift vehicle according to claim 1, comprising selection operating means adapted to select either the arm swivelling cylinder or the platform swivelling cylinder to be preferentially actuated.

3. The aerial lift vehicle according to claim 1, **characterized in that**
the boom is telescopically attached to the chassis,
the aerial lift vehicle further comprises:

a boom telescoping cylinder adapted to extend and to contract the boom;
horizontal actuation operating means, adapted for moving the platform in the horizontal direction;
vertical actuation operating means, adapted for moving the platform in the vertical direction; and
horizontal/vertical actuation control means, when the horizontal actuation operating means or the vertical actuation operating means is operated, adapted to move the platform in either the horizontal direction or the vertical direction by actuating the boom derricking cylinder and the boom telescoping cylinder in accordance with the operation of either the operated horizontal actuation operating means or vertical actuation operating means,
the aerial lift vehicle being further **characterized in that** the levelling control means are adapted to control the maintenance of the platform in the

horizontal state by selecting the arm swivelling cylinder or the platform swivelling cylinder to be preferentially actuated, and then preferentially actuating the selected cylinder for each direction in which the platform is moved by the horizontal/vertical actuation control means.

4. The aerial lift vehicle according to claim 3, comprising selection setting means for setting beforehand which to select between the arm swivelling cylinder and the platform swivelling cylinder by the levelling control means for each direction in which the platform is to be moved.

5. The aerial lift vehicle according to claim 3, **characterized in that** the levelling control means are adapted to control the maintenance of the platform in the horizontal state, when the horizontal actuation operating means is operated, by selecting the arm swivelling cylinder and preferentially actuating the arm swivelling cylinder over the platform swivelling cylinder, and
to control the maintenance of the platform in the horizontal state, when the vertical actuation operating means is operated, by selecting the platform swivelling cylinder and preferentially actuating the platform swivelling cylinder over the arm swivelling cylinder.

FIG.1

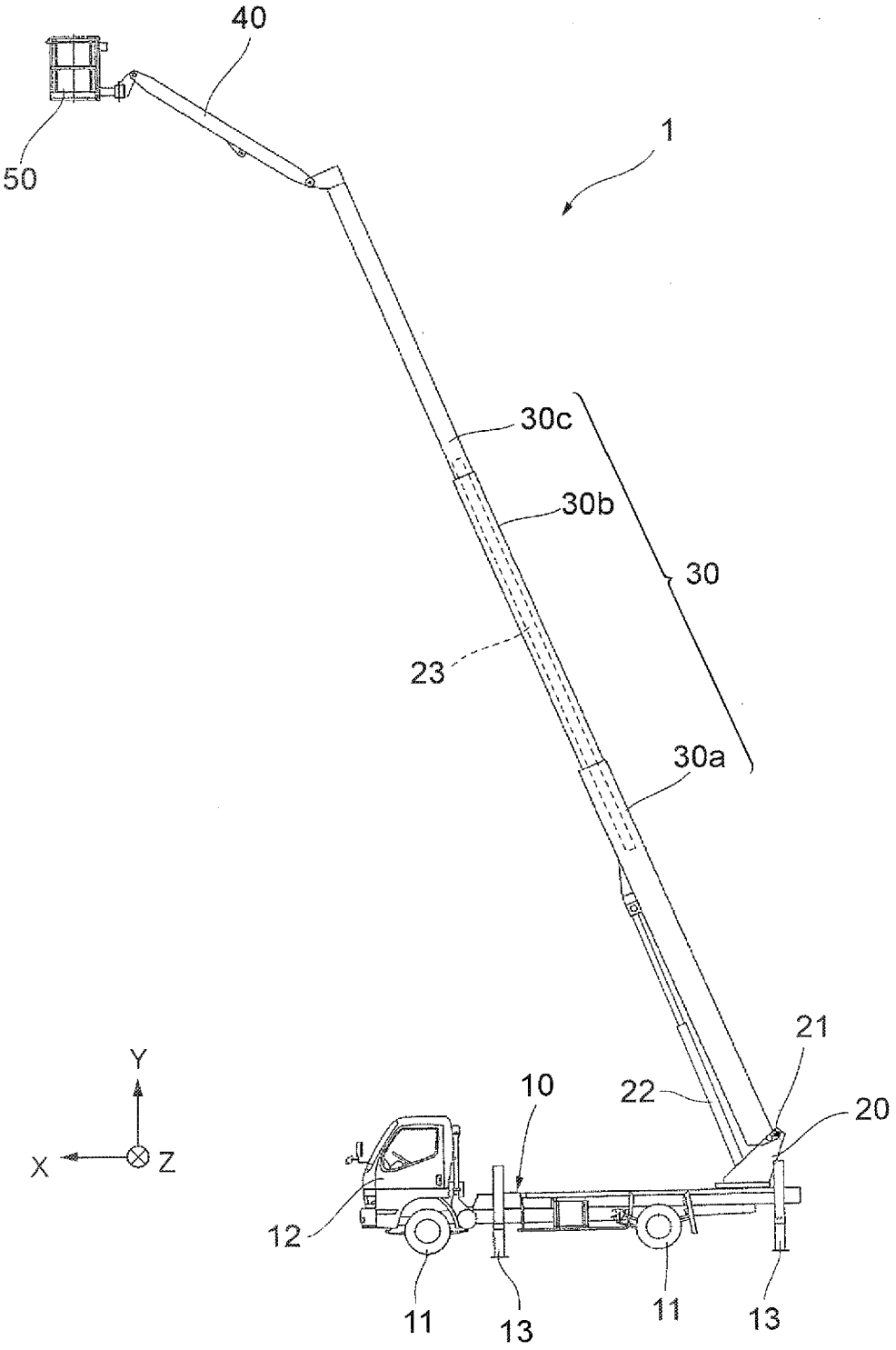


FIG. 2

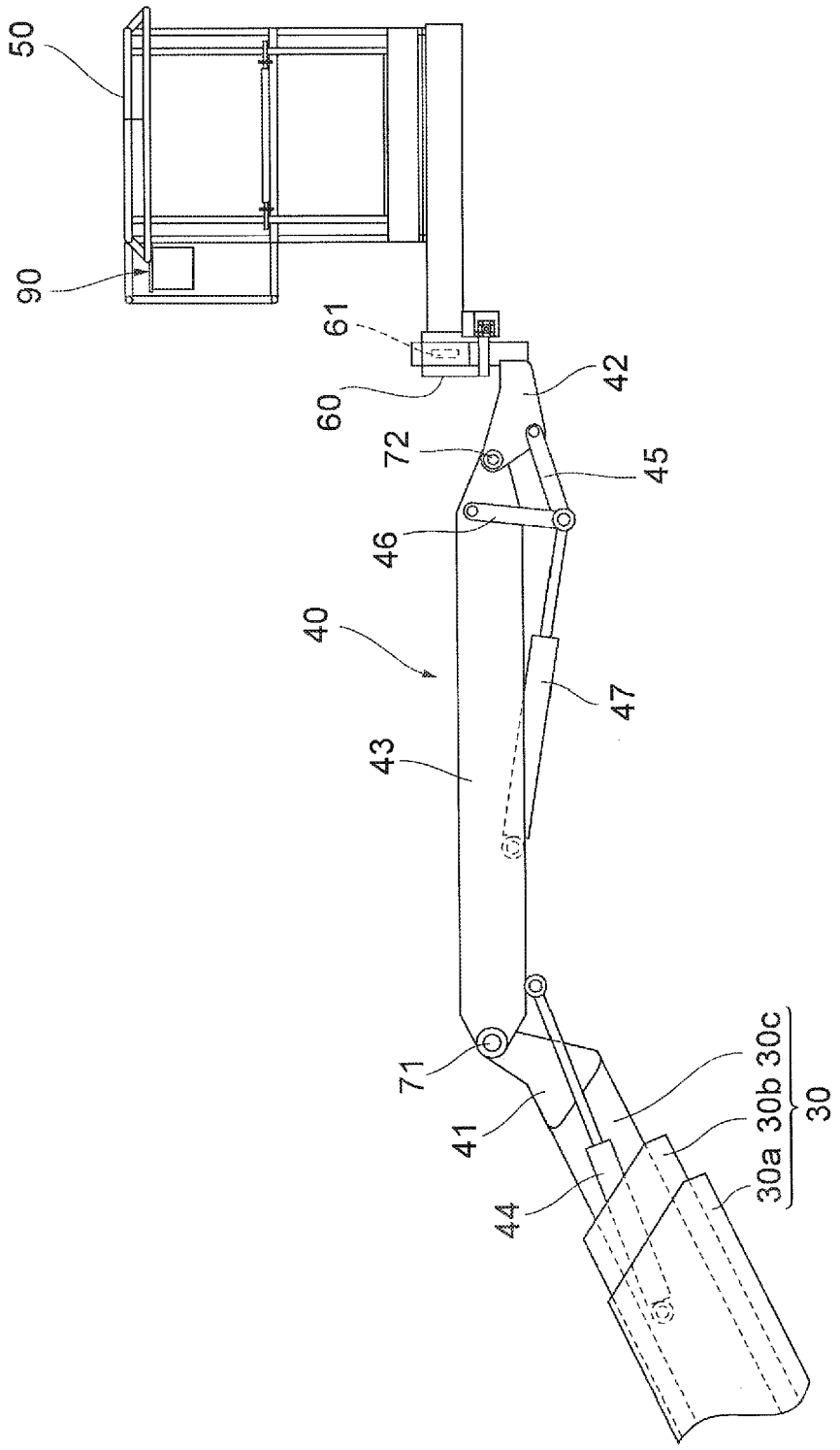


FIG.3

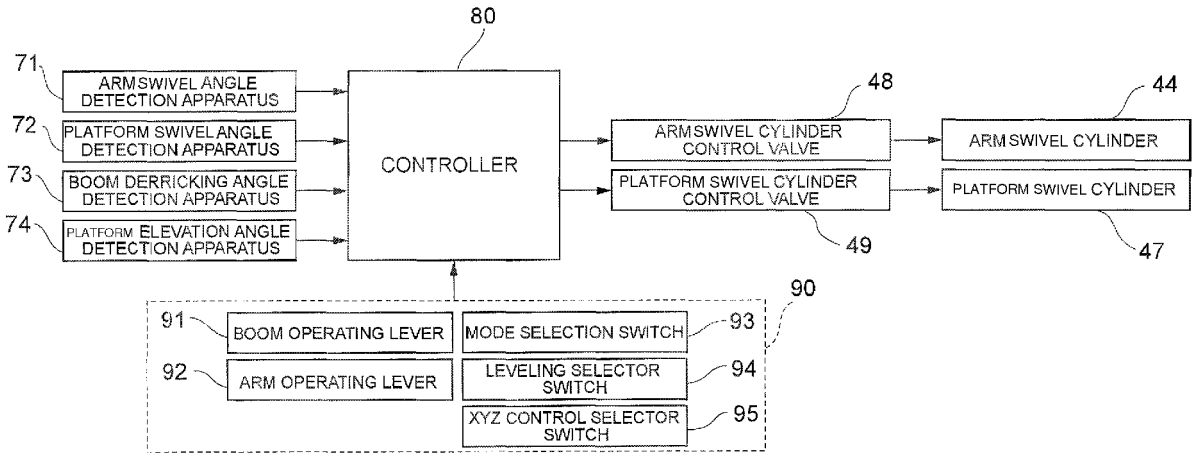

80
71
ARM SWIVEL ANGLE DETECTION APPARATUS
72
PLATFORM SWIVEL ANGLE DETECTION APPARATUS
73
BOOM DERRICKING ANGLE DETECTION APPARATUS
74
PLATFORM ELEVATION ANGLE DETECTION APPARATUS
CONTROLLER
48
ARM SWIVEL CYLINDER CONTROL VALVE
PLATFORM SWIVEL CYLINDER CONTROL VALVE
49
44
ARM SWIVEL CYLINDER
PLATFORM SWIVEL CYLINDER
47
90
91
BOOM OPERATING LEVER
92
ARM OPERATING LEVER
MODE SELECTION SWITCH
93
LEVELING SELECTOR SWITCH
94
XYZ CONTROL SELECTOR SWITCH
95

FIG.4

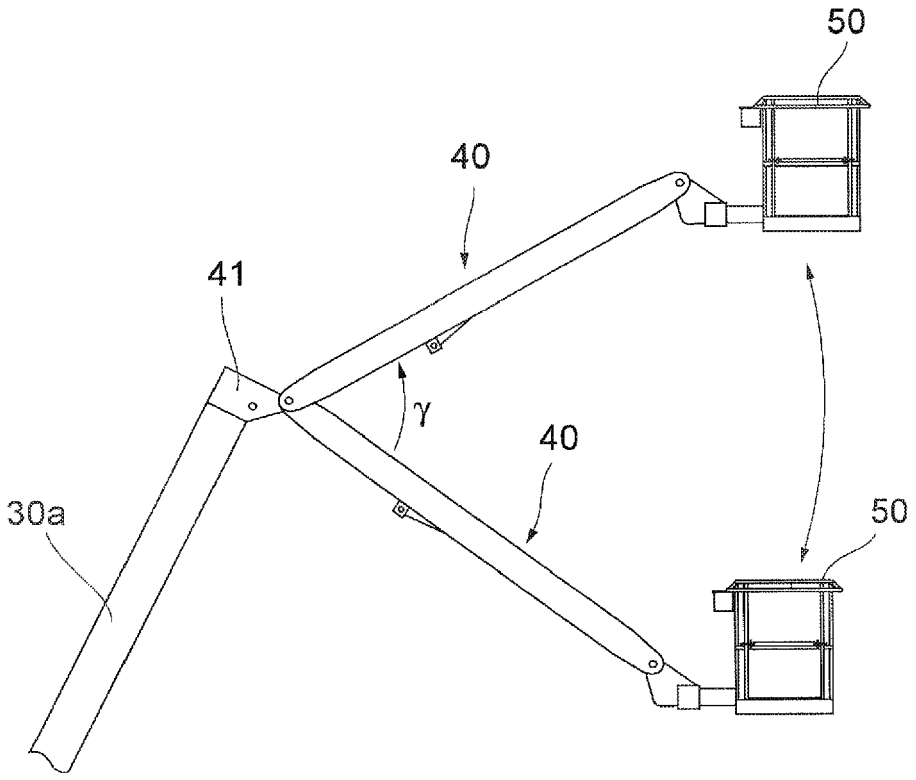


FIG.5B

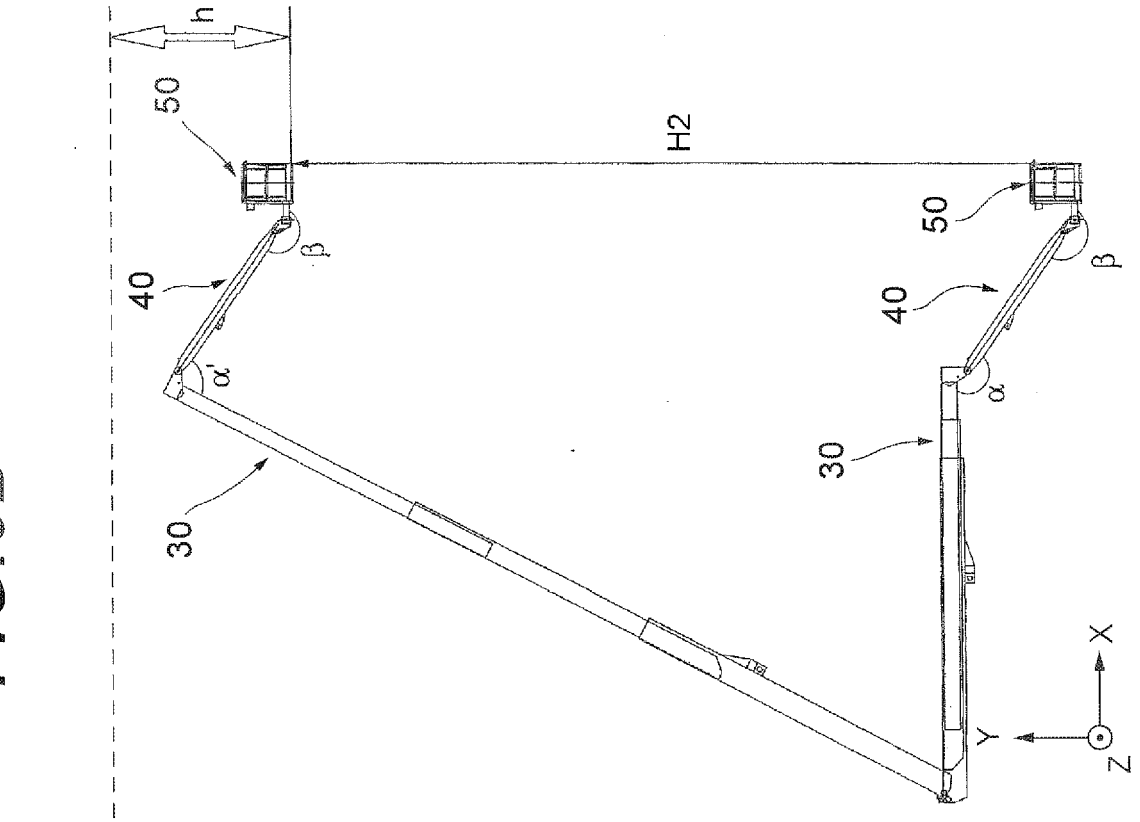
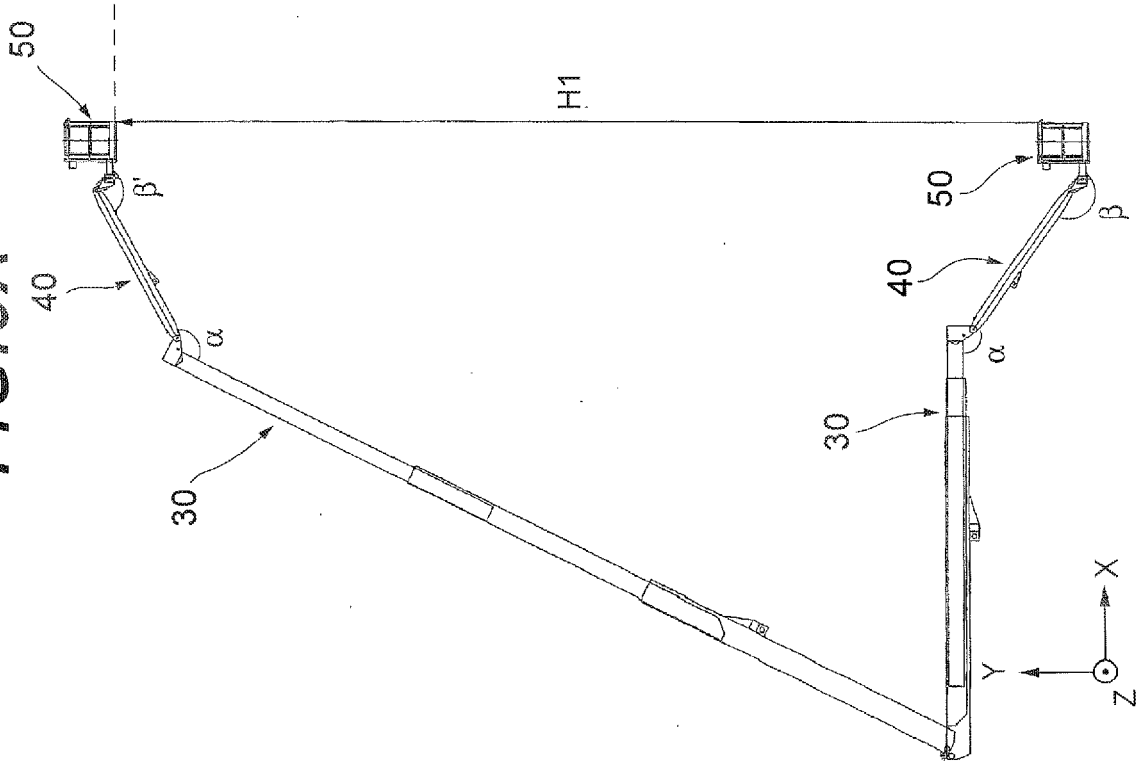


FIG.5A



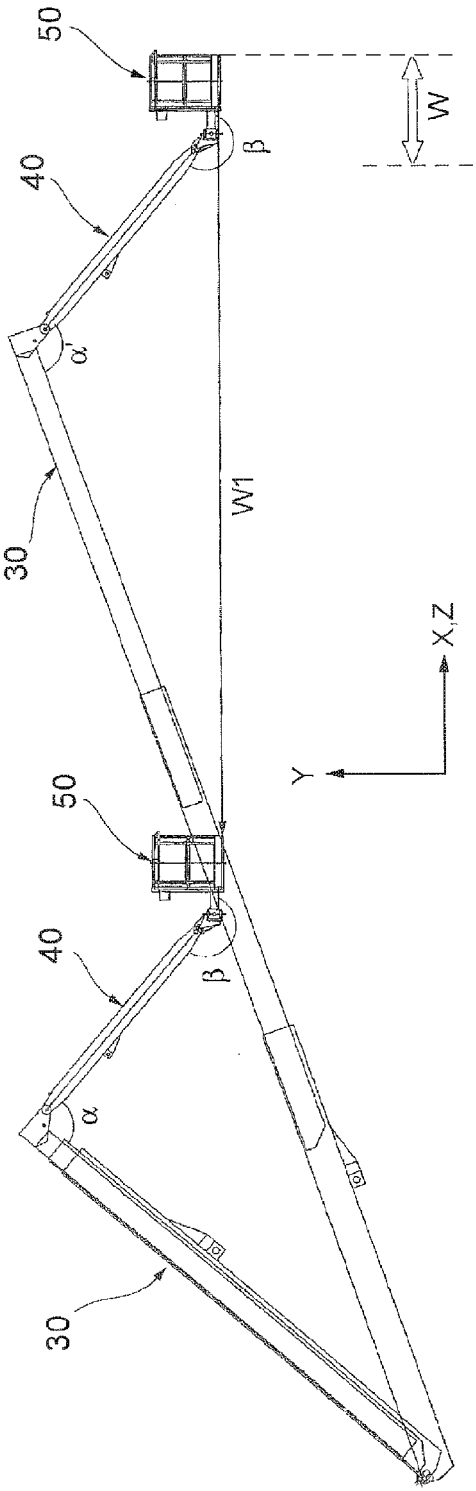


FIG. 6A

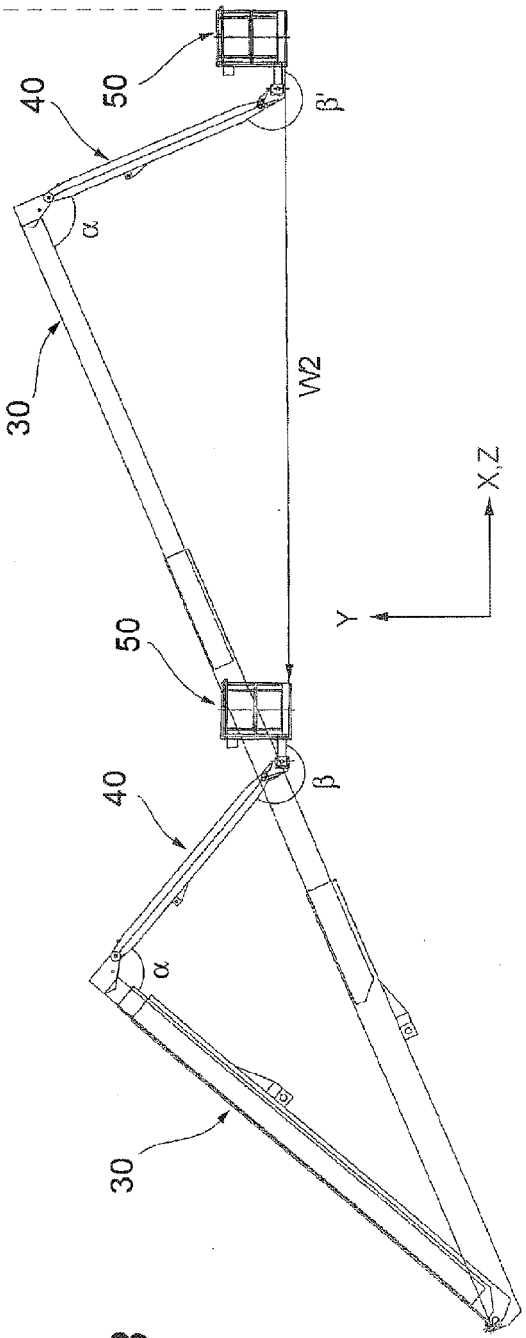


FIG. 6B

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EUROPEAN SEARCH REPORT

Application Number
EP 11 17 1955

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X	EP 0 596 498 A1 (MERLO IND METALMECC [IT]) 11 May 1994 (1994-05-11) * column 2 - column 5; figure 1 *	1	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27 September 2011	Rupcic, Zoran

CATEGORY OF CITED DOCUMENTS

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D : document cited in the application
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1

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 17 1955

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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