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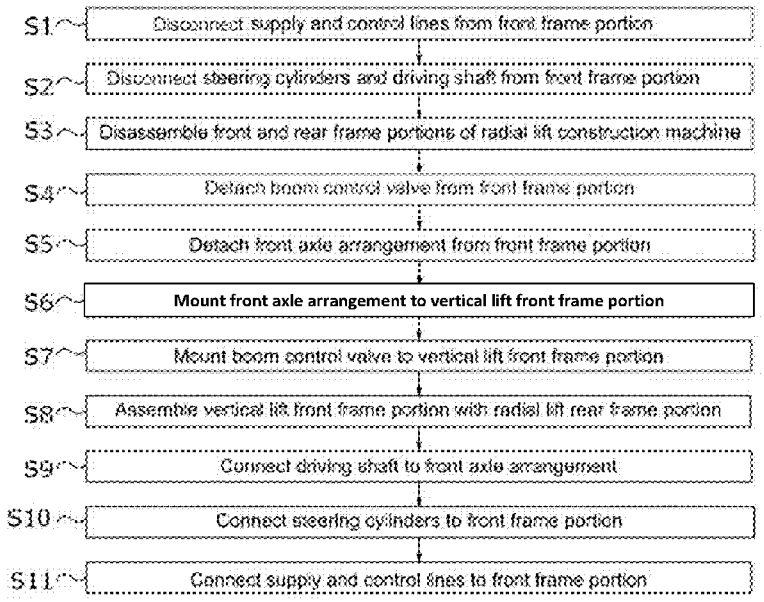
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(54) Title: METHOD OF RETROFITTING CONSTRUCTION MACHINE WITH LIFTING ARRANGEMENT

Fig. 1



(57) Abstract: Provided is a method of retrofitting a construction machine, preferably a loader. The construction machine (1) comprises a frame arrangement (2, 3) and a lifting arrangement (22). The lifting arrangement (22) is mounted to the frame arrangement (2, 3) and includes an equipment connector (222) for mounting an equipment (24). The lifting arrangement (22) is configured to move its equipment connector (222) along a substantially arcuate path between a lowered position and a lifted position. The method comprises the steps of disassembling (S3) the lifting arrangement (22) from the frame arrangement (3), and assembling (S8) a different lifting arrangement (52) to the frame arrangement (3). The different lifting arrangement (52) comprises an equipment connector (522) for mounting an equipment (54). The different lifting arrangement (52) is configured to move its equipment connector (522) along a substantially vertical path between a lowered position and a lifted position.

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METHOD OF RETROFITTING CONSTRUCTION MACHINE WITH LIFTING ARRANGEMENT

Technical Field

The present invention relates to a method of retrofitting a construction machine with a lifting arrangement. The construction machine may be a loader, e.g. a wheel loader. The method comprises a step of disassembling a lifting arrangement from and a step of assembling a different lifting arrangement to the construction machine.

Background of the invention

Construction machines, e.g. wheel loaders, comprise a lifting arrangement for moving an equipment, e.g. a bucket, between a lowered and a lifted position. Said lifting arrangements usually comprises a main arm with a pivot connector at one end for attaching the main arm to a frame arrangement of the construction machine, and an equipment connector at the other end for mounting an equipment thereto. Upon moving the main arm between a lowered and a lifted position, the equipment connector follows a substantially arcuate path, as the main arm is rotated around a point, which is fixed in space relative to the frame arrangement of the construction machine. Such lifting arrangements are known as radial lifting arrangements. The drawback of these conventional lifting arrangements is that due to the movement of the equipment connector along an arcuate path between a lowered and a lifted position, an equipment mounted to the equipment connector exhibits a relatively large maximal distance to a centre of gravity of the construction machine. Therefore, for a given operating weight of the construction machine, the provided lifting capacity may be unsatisfactory.

Summary of the invention

The present invention relates to a method of retrofitting a construction machine with a new lifting arrangement. The construction machine may be a loader, e.g. a wheel loader, or any other type of construction machine comprising a lifting arrangement for lifting an equipment between a lowered and a lifted position. The method includes a step of disassembling a (old) lifting arrangement from a frame arrangement, and a step of attaching a different (new) lifting arrangement to said frame arrangement of the construction machine. The method may further comprise a preparation step of providing the construction machine. In an initial state, before execution of the disassembling step, the construction machine comprises the frame arrangement and the (old) lifting arrangement. The lifting arrangement is mounted to the frame arrangement and includes an equipment connector for mounting an equipment. The (old) lifting arrangement is configured to move said equipment connector along a substantially arcuate path between a lowered position and a lifted position. The equipment may be a bucket, e.g. a wheel loader bucket. The lifting arrangement may be mounted with one or multiple intermediate parts to the frame arrangement. In other words, one or multiple parts may be provided between the lifting arrangement and the frame arrangement. Alternatively, the frame arrangement may be mounted directly, i.e. without any intermediate parts, to the frame arrangement. The lifting arrangement is configured, optionally solely configured, to move the equipment connector along a substantially arcuate path between a lowered and a lifted position. In other words, the lifting arrangement is, optionally only, configured to move the equipment connector along a non-vertical path between a lowered and a lifted position.

The different (new) lifting arrangement comprises an equipment connector for mounting an equipment. The equipment may be the same equipment as the equipment of the old lifting arrangement or a different one. The different lifting arrangement is configured to move the equipment connector along a substantially vertical path between a lowered position and a lifted position. Beside the differences between the lifting arrangements outlined above, the different new lifting arrangement may correspond to the old lifting arrangement.

The lowered position in the context of the present invention is preferably the lowest position of the respective equipment connector in normal operating conditions of the respective lifting arrangement. Further, the lifted position of the equipment connector is preferably the highest position of the respective equipment connector in normal operating conditions of the respective lifting arrangement. A substantially vertical path in the context of the present invention is a path that is of vertical nature having regard to the present context. The path might have slight deviations from a strict vertical path, which do not affect the substantially vertical nature thereof. The substantially vertical path may be a J-shaped path, in which the equipment connector, from the lowered to the lifted position, moves initially upwards and forwards before moving essentially only straight upwards. However, the path may also be a strict vertical path. In other words, a substantially vertical path is not a substantially arcuate path. Besides being configured to move the equipment connector along a substantially vertical path, the different lifting arrangement may also be configured to move the equipment connector along a substantially arcuate path.

With the retrofitting method according to the present invention, existing construction machines with a non-vertical lifting arrangement can be retrofitted with a vertical lifting arrangement. The vertical lifting arrangement reduces the maximal distance of the equipment connector to the construction machine's centre of gravity upon moving an equipment between a lowered and a lifted position. Thus, for a given operating weight of the machine, maximal lifting capacity of said existing machines can be increased by the retrofitting method according to the present invention. At the same time, already existing parts and assemblies of the construction machine may be reused, allowing for a cost-efficient way of providing a vertical lift construction machine with the above-outlined advantages.

The frame arrangement may comprise a front frame portion and a rear frame portion, wherein the lifting arrangement is mounted to the front frame portion. Furthermore, the front frame portion and the rear frame portion may be articulatingly interconnected for providing an articulating steering. The front frame portion may be a part of the machine frame, which supports front wheels and/or tracks. The rear frame portion may be a part of the machine frame, which supports rear wheels and/or tracks. The articulating steering may be provided by an articulating support and one or multiple steering actuators, e.g. hydraulic steering actuators, which may effect a relative displacement of front and rear frame portions with respect to each other.

The disassembling step may comprise disassembling the front frame portion, to which the old lifting arrangement is mounted, from the rear frame portion. The assembling step may further comprise assembling a different front frame portion, to which the different lifting arrangement is mounted, to said rear frame portion. This provides a simple way of attaching the different lifting arrangement to the construction machine. Furthermore, for most construction machines including front and rear frame portions, the engine as well as the core components of the hydraulic system, e.g. the hydraulic pump, are provided in the rear frame portion. Thus, with the retrofitting method of this preferred embodiment, most core components and systems of the machine can remain unchanged.

The method may further comprise a step of disconnecting a supply and/or control line from the front frame portion, and a step of connecting said supply and/or control line to the different front frame portion. The supply line may be provided for supplying a fluid, e.g. oil in case of a hydraulic supply line and/or gas, preferably air, in case of a pneumatic supply line, to front frame portion. The supply line may be provided for supplying fluid to a brake. The control line may be provided for sending control signals to the front frame portion. The control line may be a wire, e.g. a cable. Alternatively, the control line may allow for a mechanical transmission of a control signal and/or a different type of signal transmission to the front frame portion. This embodiment provides the advantage that existing supply and/or control infrastructure may be reused for the different new lifting arrangement and front frame portion, respectively.

The method may further comprise a step of detaching the old front axle arrangement from the old front frame portion, and a step of mounting said old front axle arrangement to the different new front frame portion. Preferably, the existing driving shaft is connected to the front axle arrangement once it has been mounted to said different new front frame portion. The front axle arrangement may comprise front wheels and/or tracks, preferably two front wheels/tracks, wheel hubs for respectively carrying a front wheel/track, wherein the wheel hubs may comprise a planetary gear and/or a brake, a differential, which may be situated in between the wheel hubs, axles for respectively connecting the differential with a wheel hub, and/or a connection device for connecting the front axle arrangement, e.g. the differential, to a driving shaft. The front axle arrangement may be configured such that a torque of the driving shaft connected to the connection device may be transferred via the differential, the axles, and the wheel hubs with the planetary gears to the front wheels/tracks, for example. The front axle arrangement may be provided as a single part, e.g. by being housed in a single housing. With this embodiment, the existing front axle arrangement may be reused for the different new front frame portion. Thus, it is possible to connect the engine and the remaining power train to the front axle arrangement they were designed for, thereby avoiding complex as well as cost intensive constructional changes thereof.

The method may further comprise a step of detaching a boom control valve from the old front frame portion, and a step of mounting said boom control valve to the new different front frame portion. The boom control valve may be configured to control a fluid flow into and/or out of at least one actuating element, e.g. a hydraulic cylinder. The actuating element may be provided for moving at least one element of the lifting arrangement of the construction machine, e.g. for lifting the boom. The opening or closing of the boom control valve may be done electrically via a control line, e.g. one of the control lines described above. The existing boom control valve may thus be reused for the new different lifting arrangement and front frame portion, respectively.

The method may further comprise a step of providing an adapter for at least one of the the assembling step, mounting steps and/or connecting steps. An “adapter” is a means for mechanically and/or electrically connecting at least two devices to each other. More specifically, as described above, a supply and control line, a driving shaft, a steering cylinder, a front axle arrangement and/or a boom control valve may be reused for/in connection with the different front frame portion. However, it is possible that the different front frame portion has different dimensions and/or provides different interfaces than the front frame portion initially mounted to the construction machine. In this case, one or multiple adapters may serve as devices providing the possibility to adapt the respective existing component(s) and/or the respective new component(s) to differences in dimension and/or interface configuration to allow for the envisaged coupling of the respective old and new components, as described above.

The different (new) lifting arrangement may comprise a main arm, which is provided with a pivot connector at a proximate end thereof and an equipment connector at a distal end thereof, and a main arm support means for pivotably supporting said pivot connector of said main, wherein said main arm support means is movable in a direction which includes at least a component in the front-rear direction with respect to said frame arrangement, optionally said front frame portion. The different lifting arrangement may be configured such that the equipment connector, upon pivoting said main arm between a lowered position and a lifted position, follows a substantially vertical path.

The different (new) lifting arrangement according to an embodiment of the invention may further comprise a guiding means engaged to said main arm at a guided portion of said main arm positioned between said pivot connector and said equipment connector, wherein, upon pivoting said main arm between said lowered position and said lifted position, said guiding means guides the main arm such that said equipment connector follows a substantially vertical path. Preferably, the guiding means is connected to the vertical lift front frame portion mentioned above. The guiding means provides a relatively simple mechanical way of realizing the different (new) lifting arrangement with substantially vertical movement path.

The different (new) lifting arrangement according to an embodiment of the invention may further comprise a main arm actuating element engaged to said main arm and an auxiliary actuating element engaged to said main arm support means for moving said equipment connector between said lowered position and said lifted position, a determining means for determining a lifting related quantity reflecting a position of said equipment connector with respect to said frame arrangement, optionally said front frame portion, and a control means for controlling an operation of said main arm actuating element and said auxiliary actuating element based on the determined lifting related quantity, such that a path of said equipment connector upon moving between said lowered and said lifted position follows a substantially vertical path. The main arm actuating element and the auxiliary actuating element, the determining means and the control means for controlling both actuation elements based on the output of the determining means allow for the provision of a vertical lifting path.

Brief description of the drawings

Fig. 1	illustrates a flow chart of a method of retrofitting a construction machine with a lifting arrangement according to an embodiment of the present invention.
Fig. 2	schematically illustrates a side view of a construction machine that is supposed to be retrofitted by the method of Fig. 1
Fig. 3	schematically illustrates a radial lift interface connecting a radial lift rear frame portion to a radial lift front frame portion.
Fig. 4	illustrates top views of an articulating bearing arrangement of the radial lift interface of Fig. 3 of the construction machine of Fig. 2 in different positions.
Fig. 5	schematically illustrates a side view of the construction of Fig. 2 after a third step of the retrofitting method of Fig. 1.
Figs. 6-7	schematically illustrate the construction machine of Fig. 2 before and after an eighth step of the retrofitting method of Fig. 1.
Figs. 8a-8c	schematically illustrate a first configuration of a vertical lifting arrangement, with which the construction machine of Fig. 2 can be retrofitted.
Figs. 9a-9c	schematically illustrate a second configuration of a vertical lifting arrangement, with which the construction machine of Fig. 2 can be retrofitted.
Fig. 10	schematically illustrates a radial-vertical lift interface connecting a radial lift rear frame portion to a vertical lift front frame portion.

Detailed description of embodiments

As illustrated in Fig. 1, the method according an embodiment of the present invention comprises two disconnecting steps S1, S2, a step S3 of disassembling front and rear frame portions, two detaching steps S4, S5, two mounting steps S6, S7, a step S8 of assembling a vertical lift front frame portion with the radial lifting rear frame portion, and three connecting steps S9, S10, S11. The method may further comprise a step of providing a construction machine with a radial lift arrangement attached to a frame arrangement, e.g. a front frame portion, of the construction machine (not shown) and/or a step of providing a vertical lift front frame portion (not shown), e.g. before the first step S1.

More specifically, in the first step S1, supply and control lines, which run from a rear frame portion to a front frame portion of the radial lift construction machine, are disconnected from the radial lift front frame portion. In the second step S2, steering cylinders and a driving shaft of the radial lift construction machine are disconnected from the radial lift front frame portion. In other words, the supply lines, control lines, steering cylinders and the driving shaft remain connected/mounted to the radial lift rear frame portion, while being no longer in connection with the radial lift front frame portion. After the above described steps S1-S2, in step S3, the radial lift front and rear frame portions of the radial lift construction machine are disassembled. In this step S3, the remaining parts

connecting front and rear frame portions of the radial lift construction machine, e.g. bearings coupling front and rear frame portions with each other, are demounted such that two independent physically separated units result.

Afterwards, in the fourth step S4, the boom control valve of the radial lift construction machine is detached from the radial lift front frame portion. In the subsequent fifth step S5, the front axle arrangement of the radial lift construction machine is detached from the radial lift front frame portion. That is, the boom control valve and the front axle arrangement of the radial lift construction machine are demounted/physically separated from the radial lift front frame portion, which has been separated from the radial lift rear frame portion in the previous step S3. Afterwards, in the sixth step S6, the radial lift front axle arrangement, which was detached in step S5 from the radial lift front frame portion, is mounted to a vertical lift front frame portion. In the subsequent seventh step S7, the boom control valve, which was detached in step S4, is mounted to the vertical lift front frame portion. That is, both, the front axle arrangement as well as the boom control valve of the radial lift front frame portion of the radial lift construction machine are reused for the vertical lift front frame portion.

In the eighth step S8, the vertical lift front frame portion equipped with the front axle arrangement and the boom control valve of the radial lift construction machine (refer to steps S6, S7 described above) is mounted/assembled to the radial lift rear frame portion. In the ninth step S9, after mounting the vertical lift front frame portion to the radial lift rear frame portion (refer to step S8 described above), the driving shaft is (re-)connected to the front axle arrangement, said front axle arrangement now being installed in the vertical lift front frame portion (refer to step S6). Therefore, after completion of step S9, it is again possible to transmit torque from an engine housed in an engine compartment of the radial lift rear frame portion to the front axle arrangement, which is now mounted to the vertical lift front frame portion via the driving shaft, which was already present in the radial lift construction machine.

In the following tenth step S10, the radial lift steering cylinders, which have been disconnected from the radial lift front frame portion in step S2, are connected to the vertical lift front frame portion. Therefore, after step S10, it is possible to steer the vertical lift front frame portion by use of the steering cylinders of the radial lift construction machine, said steering cylinders being mounted to the radial lift rear frame portion and the vertical lift front frame portion. Finally, the supply and control lines, which have been disconnected from the radial lift front frame portion in the step S1, are connected to the vertical lift front frame portion in step S11.

In summary, according to the method comprising the above described steps S1-11, the radial lifting arrangement is demounted from the construction machine by detaching the radial lift front frame portion from the radial lift rear frame portion and is replaced by a vertical lifting arrangement by attaching a vertical lift front frame portion to the radial lift rear fame portion. In the following, steps S1-S11 of the method of Fig. 1 are described in detail under reference to the accompanying Figs. 2-7 and 10. Furthermore, configurations of the vertical lifting arrangement, with which the construction machine 1 may be retrofitted in the method of Fig. 1, are described under reference to Figs. 8 and 9.

Fig. 2 schematically shows a radial lift construction machine 1 in a simplified side view. The construction machine 1 comprises a radial lift front frame portion 2 and a radial lift rear frame portion 3, which are articulatingly connected via a radial lift interface 4, the interface 4 being described in the following under reference to Figs. 3 and 4. In the embodiment according to Fig. 2, the radial lift rear frame portion 3 comprises rear wheels 31, an engine compartment 32 and an operator's cab 33. The engine compartment 32 is provided at the rear section of the rear frame portion 3 of the construction machine 1. The engine compartment 32 houses one or multiple power sources for providing power required to operate the construction machine 1. The power sources can include but are not limited to an internal combustion engine, such as a Diesel engine, which can be coupled to further equipment, such as hydraulic pumps, generators and the like. Alternatively or additionally, the power sources can include a battery and an electric engine. The power source is used to provide power for driving wheels, e.g. rear wheels 31 and/or front wheels 211, which will be described in the following, as well as

for providing power for actuators of the radial lift construction machine 1. The actuators may be actuators of a lifting arrangement 22 and/or a steering assembly 43, for example. Furthermore, the radial lift construction machine 1 comprises the operator's cab 33, which is mounted to the rear frame portion 3 in between the engine compartment 32 and the interface 4. Inside the operator's cab 33, space for an operator is provided and required operating and control elements (not illustrated) are accessible by the operator. The operator's cab 33 comprises (not illustrated) windows in order to provide visibility of the surrounding field for the operator.

The front frame portion 2 comprises a front axle arrangement 21, a radial lift arrangement 22, a tilting arrangement 23 and a bucket 24. The front axle arrangement 21 comprises front wheels 211, preferably two front wheels 211, wheel hubs 212 for respectively carrying a front wheel 211, wherein the wheel hubs 212 may comprise a planetary gear and a brake, a differential (not shown) situated in between the wheel hubs 212, axles (not shown) for respectively connecting the differential with a wheel hub 212, and a connection device (not shown) for connecting the front axle arrangement, e.g. the differential, to a driving shaft. The front axle arrangement 21 is configured such that a torque of the driving shaft connected to the connection device may be transferred via the differential, the axles, and the wheel hubs 212 with the planetary gears to the front wheels 211. The front axle arrangement 21 may be provided as a single part, e.g. by being housed in a single housing.

The radial lift arrangement 22 comprises a main arm 221, an equipment connector 222, a pivot connector 223, a carrier element 224 and a lifting actuator 225. The main arm 221 is provided with the pivot connector 223 at a proximate end and the equipment connector 222 at a distal end thereof. The pivot connector 223 is pivotally supported at the radial lift front frame portion 2 via the carrier element 224, which is fixed stationary with respect to the radial lift front frame portion 2. The connection between the pivot connector 223 of the main arm 221 and the carrier element 224 can be provided as a bearing arrangement of a suitable type for providing a pivotability of the main arm 221 with respect to the carrier element 224.

The lifting actuator 225 has a first end, which is pivotably mounted to the carrier element 224, and a second end, which is pivotably mounted to the main arm 221. The lifting actuator 225 is embodied as linear actuator, such as a hydraulic actuator, in the present embodiment but not limited thereto. Upon operation of the lifting actuator 225, the distance between the first end and the second end of the lifting actuator 225 can be changed, e.g. by introducing pressurized fluid into pressure chambers of the radial lifting actuator 225. The configuration of the radial lift arrangement 22 is such that operation of the lifting actuator 225 results in a movement of the equipment connector 222 on a circular path with radius R around the pivot connector 223, as illustrated in Fig. 2. In other words, actuating the lifting actuator 225, results in the main arm 221 to rotate around the pivot connector 223 such that the equipment connector 222 of the main arm 221, to which the bucket 24 can be mounted, is moved on a circular arc with radius R. The lifting arrangement 22 is therefore a radial lift arrangement.

At the equipment connector 222 of the main arm 221, the bucket 24 is provided, which is an example of an equipment which can be mounted to the main arm 221. The bucket 24 comprises a main arm connector 241 for connection to the equipment connector 222 of the main arm 221 and a tilt connector 242 for tiltably operating the bucket 24. The tilt connector 242 may be provided above the main arm connector. The tilt connector 242 of the bucket 24 is connected to the tilting arrangement 23 for tilting the bucket 24. The tilting arrangement 23 comprises a tilt lever 231 and a tilt cylinder 232. The tilt lever 231 is pivotably supported at approximately its centre at the main arm 221. A top end 233 of the tilt lever 231 is connected to the tilt cylinder 232, which is supported at its other end at the main arm 221 in the proximity of the pivot connector 223. A bottom end of the tilt lever 231 is connected via a link, which is not shown, to the tilt connector 242 of the bucket 24. Due to the Z-bar configuration of the tilting arrangement 23, extending the tilt cylinder 232 results in a bucket rollback and vice versa. However, also other configurations of the tilting arrangements are conceivable.

As described above, the front frame portion 2 is mounted to the rear frame portion 3 via the radial lift connection interface 4. The radial lift connection interface 4 is shown in Fig. 3. The connection interface 4 comprises a bearing arrangement 41, a boom control assembly 42, a steering assembly 43 and a driving assembly 44.

The boom control assembly 42 is provided for controlling the radial lifting arrangement 22. More specifically, the boom control assembly 42 comprises a feed line 421, a return line 422, a cable harness 423, a boom control valve 424 and a connector 425. The cable harness 423 comprises a connector cable 4231 and a boom control valve cable 4232. The connector cable 4231 is connected to the connector 425. The connector 425 is a distribution box for distributing at least one of electrical energy and control signals sent from the radial lift rear frame portion 3 to respective portions of the radial lift front frame portion 2. The boom control valve cable 4232, the feed line 421, and the return line 422 are connected to the boom control valve 424. The control valve cable 4232 is provided for sending at least one of electrical energy and control signals from the radial lift rear frame portion 3 to the radial lift front frame portion 2, more specifically to the boom control valve 424. The boom control valve 424 is connected to at least one of the lifting actuator 225 of the radial lifting arrangement 22 and the tilt cylinder 232 of the radial lifting tilting arrangement 23 for controlling them in accordance with operator's control commands. The boom control valve 424 is preferably a directional control valve, which is configured to be opened and closed by control signals sent to the boom control valve 424 via the boom control valve cable 4232. Preferably the boom control valve 424 comprises a spool inside a cylinder, which is electrically controlled. A movement of the spool restricts or permits a flow of a fluid, such as oil in case of a hydraulic actuator connected to the boom control valve 424 or gas (e.g. air) in case of a pneumatic actuator connected to the boom control valve 424. Via the feed line 421, the fluid is supplied from the radial lifting rear frame portion 3 to the boom control valve 424. Via the return line 422, the fluid is returned from the boom control valve 424 to the radial lifting rear frame portion 3. Preferably, the boom control valve 424 comprises two separate valves, wherein one valve is provided for the lifting actuator 225 of the radial lifting arrangement 22 and the other one for the tilt cylinder 232 of the radial lifting tilting arrangement 23. In this case, preferably, the feed line 421, the return line 422, and the boom control valve cable 4232 are provided for each of the valves of the boom control valve 424 separately such that the radial lifting arrangement 22 and the radial lifting tilting arrangement 23 can be controlled separately.

The steering assembly 43 comprises multiple steering cylinders 431, preferably two steering cylinders 431, and multiple cylinder supports 432, in case of two steering cylinders 431, preferably two supports 432 for each one of the steering cylinders 431. The support 432 is fixed/immovably connected to the radial lift front frame portion 2 and rear frame portion 3, respectively. The steering cylinder 431 is connected pivotably to the support 432 of the rear frame portion 3 at one end thereof and at the other end thereof to the support (not shown) of the radial lifting front frame portion 3. Instead of the steering cylinders 431, also other actuating means, such as a lead screw, can be provided. By retracting one of the steering cylinders 431 and extending the other one of the steering cylinders 431, the front frame portion 2 can be rotated relatively to the rear frame portion 2.

The articulating bearing arrangement 41 comprises multiple, optionally two bearings 411, 412, which are situated above each other, for providing an articulating mount between the front frame portion 2 and the rear frame portion 3. A pivoting axis X of the articulating mount, i.e. of the bearing 411, 412, is arranged substantially along the vertical axis of the construction machine 1, i.e. perpendicular with respect to the longitudinal direction of the construction machine 1. Optionally, the individual pivoting axes of the bearing 411, 412 are coaxial with each other. The bearing arrangement 41 can be provided below the operator's cab 33. One of the bearings 411 of the bearing arrangement 41 is preferably, in a direction of the pivoting axis X, provided above and the other bearing 412 below of the boom control assembly 42, the steering assembly 43 and the driving assembly 44.

As illustrated in detail in Fig. 4, the bearing arrangement 41 provides a tilting between the front frame portion 2 and the rear frame portion 3 in order to provide a steering by changing the angle α between the front frame portion 2 and the rear frame portion 3 in a plane parallel to the ground. The bearing arrangement 41 is driven via

the steering assembly 43 by one or multiple actuator(s), such as hydraulic actuators, preferably the two steering cylinders 431 described above. Said two steering cylinders 431 can be driven by a power source of the engine compartment 32. Upon a steering operation, the front frame portion 2 tilts with respect to the rear frame portion 3 and thus the operator's cab 33 and the engine compartment 32, which are provided at the rear frame portion 3.

The bearing arrangement 41 comprises bearings 411, 412, which can respectively comprise complementary arrangements 411a, 411b and 412a, 412b. The complementary arrangements 411a, 411b, 412a and 412b can be brought in articulating engagement, as derivable from Fig. 5, for example. Specifically, the rear frame portion 3 may comprise a first rear frame arrangement 411a for the first bearing 411 and a different second rear frame arrangement 412a for the second bearing 412, which may be provided below the first rear frame arrangement 411a. The front frame portion 2 may comprise a first front frame arrangement 411b for the first bearing 411, which is complementary to the first rear frame arrangement 411a of the rear frame portion 3, and a different second front frame arrangement 412b for the second radial lifting bearing 412, which is complementary to the second rear frame arrangement 412a of the rear frame portion 3. The complementary first 411a, 411b and second arrangements 412a, 412b may be brought in articulating engagement for providing an articulating steering. The first rear frame arrangement 411a and the second rear frame arrangement 412a can be male pieces, e.g. cylindrical pieces, and/or the first front frame arrangement 412a and the second front frame arrangement 412b can be female pieces, e.g. cylindrical holes for engaging with the cylindrical male pieces. A contrary configuration of male and female pieces is also conceivable. Alternatively, the bearing arrangement 41 can comprise only a single bearing or more than two, e.g. three, four, five or more bearings.

The driving assembly 44 is provided for transmitting power from the engine compartment 32 of the rear frame portion 3 to the front wheels 211 of the front frame portion 2. Additionally, the driving assembly 44 is provided for decelerating the construction machine 1. The driving assembly 44 comprises a driving shaft 441, a brake 442 and two brake lines 443, 444. The two brake lines 443, 444 are connected to the brake 442. One of the brake lines 443, 444 is a feed line for supplying a fluid to the break 442 in order to close the brake 442, and the other one of the brake lines 443, 444 is a return line for returning a fluid from the brake 442 in order to open the brake 442. The brake 442 is connected to the front axle arrangement 21 and configured to decelerate the construction machine 1 when being actuated. The driving shaft 441 comprises a rear frame driving shaft 4411 connected via a universal joint 4412 to a front frame driving shaft 4413. The rear frame driving shaft 4411 is situated at the rear frame portion 3 and transmits power, i.e. torque, from the rear frame portion 3 via the universal joint 4412 to the front frame portion 2. The universal joint (Cardan joint) 4412 is a joint or coupling connecting rigid rods, i.e. the rear frame driving shaft 4411 and the front frame driving shaft 4413, whose axes may be inclined with respect to each other, and is provided for transmitting rotary motion.

In the step S3 of the method of retrofitting the radial lifting construction machine with a vertical lifting arrangement, the existing radial lifting arrangement 22 is detached from the machine 1, as shown in Fig. 5. The lifting arrangement is replaced with a vertical lifting arrangement in the step S8, as show in Figs. 6-7. Therefore, the interface 4 connecting the radial lifting rear frame portion 3 and the radial lifting front frame portion 2 has to be disassembled before it is possible to physically separate the rear and front frame portions 2, 3 from each other. Thus, in the first step S1, the supply and control lines are disconnected from the front frame portion 2 of the radial lifting construction machine 1. More specifically, the feed line 421, the return line 422, the cable harness 423 and/or the brake lines 443, 444 are disconnected from the front frame portion 2. However, the supply and control lines remain connected to the rear frame portion 3. Afterward, in the second step S2, the steering cylinders 431 and the driving shaft 441 are disconnected from the front frame portion 2. In other words, the supply lines, control lines, steering cylinders and driving shaft remain connected/mounted to the rear frame portion 3 while being no longer in connection with the front frame portion 2.

Afterwards, in the fourth step S4, the boom control valve 424 is detached from the front frame portion 2 and subsequently, in the fifth step S5, the front axle arrangement 21 is detached from the front frame portion 2. That

is, the boom control valve 424 and the front axle arrangement 21 are demounted/physically separated from the front frame portion 2. In a further step S6, the front axle arrangement 21 is mounted to a vertical lifting front frame portion 5. Afterwards in a seventh step S7, the boom control valve 424, which was detached from the radial lifting front frame portion 2 in step S4, is mounted to the vertical lifting front frame portion 5. Thus, the radial lifting front axle arrangement 21 as well as the radial lifting boom control valve 424 of the radial lifting front frame portion 2 can be reused for the vertical lifting front frame portion 5.

A first configuration of the vertical lifting front frame portion 5 is described under reference to Figs 6-7. The vertical lifting front frame portion 5 comprises the front axle arrangement 21 of the radial lifting front frame portion 2, a vertical lifting arrangement 52, a tilting arrangement 53 and a bucket 54. The front axle arrangement 21 of the radial lifting front frame portion 2 comprises, as described above, the front wheels 211 the front wheels axle 212 and the further above-described components. The vertical lifting arrangement 52 according to a first configuration comprises a main arm 521, an equipment connector 522, a pivot connector 523, a lifting actuator 525, a main arm support means 526 and a guiding means 527. The vertical lifting arrangement 52 is characterized by the fact that it can move the equipment connector 522 and therefore the bucket 54, which is mounted thereto, between a lowered and a lifted position along a substantially vertical path. The substantially vertical path may be a J-shaped path.

The pivot connector 523 is provided at a proximate end and the equipment connector 522 at a distal end of the main arm 521. The pivot connector 523 is pivotally supported at the main arm support means 526, which includes a main arm support link in the present embodiment. The main arm support link 526 has a first end and a second end, the first end being pivotably connected to the pivot connector 523 of the main arm 521 and the second end being pivotably connected to an element of the vertical lifting front frame portion 5. The main arm support link 526 is arranged such that a rotation or pivoting movement of the main arm support link 526 provides a movement of the first end in a direction which at least includes a component in the front-rear direction of the construction machine 1.

The main arm 521 comprises a guided portion 5211, which is shown in Figs. 8a-8c and is provided between the pivot connector 523 and the equipment connector 522. In the present embodiment, the guided portion 5221 is offset by a predetermined amount from a line connecting the pivot connector 523 and the equipment connector 522. As described above, the vertical lifting arrangement 52 according to the first configuration further includes the guiding means 527, which includes a guiding arm having a first end and a second end. The first end is pivotably mounted to an element of the vertical lifting front frame portion 5 and the second end is pivotably mounted to the main arm 521 at the guided portion 5211. A lifting actuator 525 is provided having a first end, which is pivotably mounted to the front frame portion 5, and a second end, which is pivotably mounted to the main arm 521. The lifting actuator 525 is embodied as linear actuator, such as a hydraulic actuator, in the present embodiment but is not limited thereto. Upon operating the lifting actuator 525, the distance between the first end and the second end can be changed, e.g. by introducing pressurized fluid into pressure chambers of the vertical lifting actuator 525.

Furthermore, the vertical lifting front frame portion 5 comprises the tilting arrangement 53. The tilting arrangement 53 comprises a tilt lever 531 as well as a tilt cylinder 532, which may substantially correspond to the ones described in connection with the radial lifting front frame portion 2 of Figs. 2-5. The bucket 54 comprises a main arm connector and a tilt connector. By operating the tilt cylinder 532, the bucket 54, which is mounted to the equipment connector 522 via the main arm connector, may be tilted via the lever 531 and the link (not shown), which is mounted to the lever 531 and the tilt connector of the bucket 54.

In the following, an operation of the first configuration of the vertical lifting arrangement 52 is explained under reference to the illustrations of Figs. 8a-8c. In Fig. 8a, the lifting arrangement 52 is illustrated in the lowered position. In this situation, the main arm 521 is rotated downwards. This is achieved by retracting the main arm

actuator 525, which is provided for operating the main arm 521. The position of the main arm 521 is determined by the linkage between the guiding means 527 and the main arm support means 526. In other words, the position of the pivot connector 523 of the main arm 521 can be changed by changing the rotational position of the main arm support means 526, whereas the guiding means 527 determines, due to its rotational connection between the front frame portion 5 and the guided portion 5211 of the main arm 521, the position of the pivot connector 523 depending on the rotational position of the main arm 521. As such, the vertical lifting arrangement 52 provides a link-based transmission, which uniquely determines the position of the main arm 521.

Upon actuating the lifting actuator 525, the main arm 521 is rotated in the clockwise direction in Fig. 8a to move it to an intermediate position shown in Fig. 8b. With this rotation, the main arm 521 is rotated with respect to the main arm support means 526. At the same time, the guiding means 527 is rotated in the counter clockwise direction. When the guiding means 527 rotates in the counter clockwise direction, the guided portion 5211 of the main arm 521 is forced along a circular path due to the constant distance between the first and second ends of the guiding means 527. As can be seen, the position of the second end of the guiding means 527 has moved with a component of movement in the rearward direction with respect to the construction machine 1. In the same context, the main arm 521 has rotated in the clockwise direction and the equipment connector 522 has lifted by a predetermined amount. Due to the fact that the guided portion 5211 of the main arm 521 is forced in the rearward direction by the predetermined movement path of the second end of the guiding means 527, the main arm support means 526 is rotated in the clockwise direction about its second end, which is mounted to the vertical lifting front frame portion 5. Therefore, the position of the first end of the main arm support means 526 is moved together with the pivot connector 523 of the main arm 521 in the rearward direction with respect to the construction machine 1.

Upon a further operation of the lifting actuator 525, the main arm 521 is further rotated in the clockwise direction and reaches a lifted position shown in Fig. 8c. In this position, the equipment connector 522 of the main arm 521 has reached a position, which is higher than the intermediate position shown in Fig. 8b. Upon further rotating the main arm 521 in the clockwise direction, the guiding means 527 is further rotated in the counterclockwise direction and forces the guided portion 5211 of the main arm 521 further along the circular path. As the second end of the guiding arm 521 has moved forward with respect to the position shown in Fig. 8b, the main arm support means 526 is rotated in the counterclockwise direction from the position shown in Fig. 8b. Therefore, the position of the first end supporting the pivot connector 523 of the main arm 521 is further forward compared to the position thereof shown in Fig. 8b.

Based on the above operation, the bucket 54 can be moved from the lowered position shown in Fig. 8a to the lifted position shown in Fig. 8c through the intermediate position shown in Fig. 8b along a substantially vertical path. In particular, the path deviates from an arcuate or circular path, which is achievable with radial lifting arrangements, in which the pivot connector of the main arm is immovably and stationary with respect to a frame portion of the construction machine 1, as shown in Figs. 2 and 5.

The vertical lifting arrangement attached to the vertical lifting front frame portion 5 of an embodiment of the present invention can also be configured differently. In the following, a second configuration 5' of the vertical lifting arrangement is explained under reference to Figs. 9a-9c. Except for the differences outlined below, the vertical lifting arrangement 5' according to this second configuration is configured as that of the first configuration described above. Alike elements are denoted by the same reference signs.

The second configuration of the vertical lifting arrangement 5' does not comprise a guiding arm 527 but instead an auxiliary actuating element 527' embodied as linear actuator. The auxiliary actuating element 527' has a first end and second end, the first end being pivotably mounted to the main arm support means 526. The second end of the auxiliary actuating element 527' is pivotably mounted to the main arm 521. Accordingly, the auxiliary actuating element 527' operates in order to vary the angle of inclination between the main arm support link 526

and the main arm 521. In other words, by extending the auxiliary actuating element 527', the angle enclosed by the main arm support link 526 and the main arm 521 is increased.

The second configuration of the lifting arrangement further comprises a control system and a determining means determining a lifted related quantity reflecting a position of said equipment connector 522 with respect to the vertical lifting front frame portion 5'. The determining means can include sensors, which provide information on the extension position of the linear actuators used for the main arm actuating element and the auxiliary actuating element. The type of sensors can be selected as needed as long as it is possible to provide information on the relative position of the main arm 521 with respect to the main arm support means 526 as well as the relative position of the main arm support means 526 with respect to the vertical lifting front frame portion 5'. The control system communicates with an output section, which is provided for controlling the actuating system of the lifting arrangement, in particular, the lifting actuator 525 and the auxiliary actuating element 527'. According to the present embodiment, the control system provides a relationship between the movement of the vertical lifting actuator 525 and the movement of the auxiliary actuating element 527'. In other words, a function or pattern included in the control system includes a relationship between the operating position of the vertical lifting actuator 525 and the operating position of the auxiliary actuating element 527'. The relationship can be continuous.

The operation of the control based lifting arrangement is explained in the following. Starting out from the situation in Fig 9a, the operator manipulates a not illustrated operating element in order to initiate a lifting operation for lifting the vertical lifting equipment connector 522 from a lowered position shown in Fig. 9a to a lifted position shown in Fig. 9c through an intermediate position shown in Fig. 9b. With the lifting arrangement shown in Fig. 9a, the lifting actuator 525 is extended in order to rotate the main arm 521 together with the main arm support means 526 in the clockwise direction in the drawing. In the course of the operation of the lifting actuator 525, the auxiliary actuating element 527' is retracted as can be derived from a comparison of Fig. 9a with Fig. 9b. Based on this retraction of the auxiliary actuating element 527', the angle enclosed between the main arm 521 and the main arm support means 526 is decreased and the pivot connector 523 is withdrawn in the rearward direction with respect to the vertical lifting arrangement 5'. Upon further performing the lifting operation from the intermediate position shown in Figure 9b, the lifting actuator 525 is further extended in order to further rotate the main arm 521 in the clockwise direction in the drawing. In the course of the lifting operation between the intermediate position shown in Fig. 9b towards the lifted position shown in Fig. 9c, the auxiliary actuating element 527' is again extended in order to increase the angle enclosed between the main arm 521 and the main arm support means 526. By this, the vertical lifting pivot connector 523 is moved in the forward direction with respect to the vertical lifting arrangement 5'.

Based on the above cooperation of the vertical lifting actuator 525 and the auxiliary actuating element 527' in combination with the construction using the main arm support means 526, a movement pattern of the equipment connector 522 can be provided, which deviates from an arcuate or circular path having a constant radius. Based on the above operation, a bucket can be moved from the lowered position shown in Fig. 9a to the lifted position shown in Fig. 9c through the intermediate position shown in Fig. 9b along a substantially vertical path. A closed loop control utilizing the information received from the determining means can be continuously performed by the control system such that there is always a unique relationship between the extension position of the vertical lifting actuator 525 and the extension position of the auxiliary actuation element 527'. Besides the vertical lifting arrangements 5, 5' described above, in the context of the present invention, also alternative lifting arrangements can be provided.

At a further step S8, as described above, the above described vertical lifting front frame portion 5, 5' is mounted to/assembled with the radial lifting rear frame portion 2. For this purpose, the vertical lifting front frame portion 5, 5' further comprises the first and second arrangement 511b, 512b shown for example in Fig. 6. The first front frame arrangement 511b is complementary to the first rear frame arrangement 411a of the radial lifting rear

frame portion 3. The second front frame arrangement 512b is complementary to the second rear frame arrangement 412a of the radial lifting rear frame portion 3. The first 411a, 511b and second arrangements 412a, 512b of the vertical lifting front frame portion 5 and the radial lifting rear frame portion 3 are brought into engagement for providing an articulating steering. In other words, said arrangements may be pivotably connected. The first and second arrangements 511b, 512b of the vertical lifting front frame portion 5 can be male pieces, e.g. cylindrical pieces, and/or female pieces, e.g. cylindrical holes for engaging with cylindrical male pieces. A contrary configuration of male and female pieces is also conceivable. After mounting the vertical lifting front frame portion 5, 5' to the radial lifting rear frame portion 2 (see step S8 described above), the respective connections, i.e. a radial-vertical connection interface 6, between the vertical lifting front frame portion 5, 5' and the radial lifting rear frame portion 3 is established. The establishing of the radial-vertical lifting connection interface 6 will be described in the following with reference to Fig. 10. The interface 6 shown in Fig. 10 corresponds to the interface 4 of Fig. 3, wherein same components are denoted with same reference signs and only differences between the interfaces 4, 6 will be described in the following.

In the ninth step S9, after mounting the vertical lifting front frame portion 5, 5' to the radial lifting rear frame portion 2 (see step S8 described above), the driving shaft 441 is (re-) connected to the front axle arrangement 21, which has been mounted to the vertical lifting frame portion 5, 5' in step S6. To allow for variations in the alignment and distance between the rear frame driving shaft 4411 and driven components 4412, 4413, the drive shaft may further incorporate an adapter, e.g. an additional universal joint, a jaw coupling, a rag joint, a splined joint and/or prismatic joint (not shown). Thus, it is possible to adapt the existing driving assembly 44 of the radial lifting machine, if necessary, to dimensions of the vertical lifting front frame portion 5, 5'.

In the tenth step S10, the steering cylinders 431, which have been disconnected from the radial lifting front frame portion 2 in the second step S2, are connected to the vertical lift front frame portion 5, 5'. The steering cylinders 431 might be connected to a portion of the vertical lifting front frame portion 5, 5', i.e. to vertical lifting supports 632, with different dimension than the supports 432 of the radial lifting front portion 2. As shown in Fig. 10, an adapter 62 might be provided to adapt the configuration of the steering cylinders 431 to the configuration of the supports 632. Finally, the supply and control lines, which have been disconnected from the radial lifting front frame portion in the step S1, i.e. the feed line 421, the return line 422, the cable harness 423, and the brake lines 443, 444, are connected to the vertical lifting front frame portion 5, 5' in the eleventh step S11. If necessary, respective adapters, e.g. lengthening pieces, can be provide for the respective supply and control lines.

Furthermore, as described above, the radial lifting boom control valve 424, which was detached from the radial lifting front frame portion in the step S4, might be mounted to the vertical lifting front frame portion in the step S7 via an adapter 61. As the boom control valve 424 has to be connected to the lifting actuator 525, the tilt cylinder 532 and/or the auxiliary actuating element 527' of the vertical lifting front frame portion 5, 5', the adapter 61 might be necessary to provide compatibility between ports of the boom control valve 424 of the radial lifting arrangement and the lifting actuator 525, the tilt cylinder 532 and/or the auxiliary actuating element 527' of the vertical lifting arrangement 5, 5'.

Claims

1. A method of retrofitting a construction machine (1), preferably a loader, the construction machine (1) comprising a frame arrangement (2, 3) and a lifting arrangement (22), the lifting arrangement (22) being mounted to the frame arrangement (2, 3) and including an equipment connector (222) for mounting an equipment (24), wherein the lifting arrangement (22) is configured to move its equipment connector (222) along a substantially arcuate path between a lowered position and a lifted position, the method comprising the steps of:

   disassembling (S3) the lifting arrangement (22) from the frame arrangement (3); and

   assembling (S8) a different lifting arrangement (52) to the frame arrangement (3), the different lifting arrangement (52) comprising an equipment connector (522) for mounting an equipment (54), wherein the different lifting arrangement (52) is configured to move its equipment connector (522) along a substantially vertical path between a lowered position and a lifted position.

2. The method according to Claim 1, wherein the frame arrangement comprises a front frame portion (2) and a rear frame portion (3), which are articulatingly interconnected for providing an articulating steering, the lifting arrangement (22) being mounted to the front frame portion (2).

3. The method according to Claim 2, wherein the disassembling step (S3) comprises disassembling the front frame portion (2), to which the lifting arrangement (22) is mounted, from the rear frame portion (3), and wherein the assembling step (S8) comprises assembling a different front frame portion (5; 5'), to which the different lifting arrangement (52) is mounted, to said rear frame portion (3).

4. The method according to Claim 2 or 3, further comprising a step (S1) of disconnecting a supply and/or control line from the front frame portion (2), and a step (S11) of connecting said supply and/or control line to the different front frame portion (5; 5').

5. The method according to any one of Claims 2 to 4, further comprising a step (S2) of disconnecting a steering cylinder (43) from the front frame portion (2), and a step (S10) of connecting said steering cylinder (43) to the different front frame portion (5; 5').

6. The method according to any one of Claims 2 to 5, further comprising a step (S2) of disconnecting a driving shaft (44) from the front frame portion (2), and a step (S9) of connecting said driving shaft (44) to the different front frame portion (5; 5').

7. The method according to any one of Claims 2 to 6, further comprising a step (S5) of detaching a front axle arrangement (21) from the front frame portion (2), and a step (S6) of mounting said front axle arrangement (21) to the different front frame portion (5; 5').

8. The method according to Claims 6 and 7, wherein the driving shaft (44) is connected to the front axle arrangement (21) mounted to said different front frame portion (5; 5').

9. The method according to any one of Claims 2 to 8, further comprising a step (S4) of detaching a boom control valve (424) from the front frame portion (2), and a step (S7) of mounting said boom control valve (424) to said different front frame portion (5; 5').

10. The method according to any one of Claims 3 to 9, further comprising a step of providing an adapter for at least one of the assembling step (S8), mounting steps (S6, S7), and connecting steps (S9, S10, S11).

11. Method according to any one of claims 1 to 10, wherein the different lifting arrangement (52) comprises:

a main arm (521), which is provided with a pivot connector (523) at a proximate end thereof and an equipment connector (522) at a distal end thereof;

a main arm support means (526) for pivotably supporting said pivot connector (523) of said main arm (521), wherein said main arm support means (526) is movable in a direction which includes at least a component in a front-rear direction with respect to said frame arrangement (2, 3);

wherein the second lifting arrangement (52) is configured such that the equipment connector (522), upon pivoting said main arm (521) between said lowered position and said lifted position, follows a substantially vertical path.

12. Method according to claim 11, wherein the different lifting arrangement (52) further comprises a guiding means (527) engaged to said main arm (521) at a guided portion (5211) of said main arm (521) positioned between said pivot connector (523) and said equipment connector (522), wherein upon pivoting said main arm (521) between said lowered position and said lifted position, said guiding means (527) guides the main arm (521) such that said equipment connector (522) follows a substantially vertical path.

13. Method according to claim 11, wherein the different lifting arrangement (52) further comprises a main arm actuating element (525) engaged to said main arm (521) and an auxiliary actuating element (527') engaged to said main arm support means (526) for moving said second equipment connector (522) between said lowered position and said lifted position, a determining means for determining a lifting related quantity reflecting a position of said equipment connector (522) with respect to said frame arrangement (2, 5'), and a control means for controlling an operation of said main arm actuating element (525) and said auxiliary actuating element (527') based on the determined lifting related quantity, such that a path of said equipment connector (522) upon moving between said lowered and said lifted position follows a substantially vertical path.


S1
Disconnect supply and control lines from front frame portion
S2
Disconnect steering cylinders and driving shaft from front frame portion
S3
Disassemble front and rear frame portions of radial lift construction machine
S4
Detach boom control valve from front frame portion
S5
Detach front axle arrangement from front frame portion
S6
Mount front axle arrangement to vertical lift front frame portion
S7
Mount boom control valve to vertical lift front frame portion
S8
Assemble vertical lift front frame portion with radial lift rear frame portion
S9
Connect driving shaft to front axle arrangement
S10
Connect steering cylinders to front frame portion
S11
Connect supply and control lines to front frame portion

Fig. 1

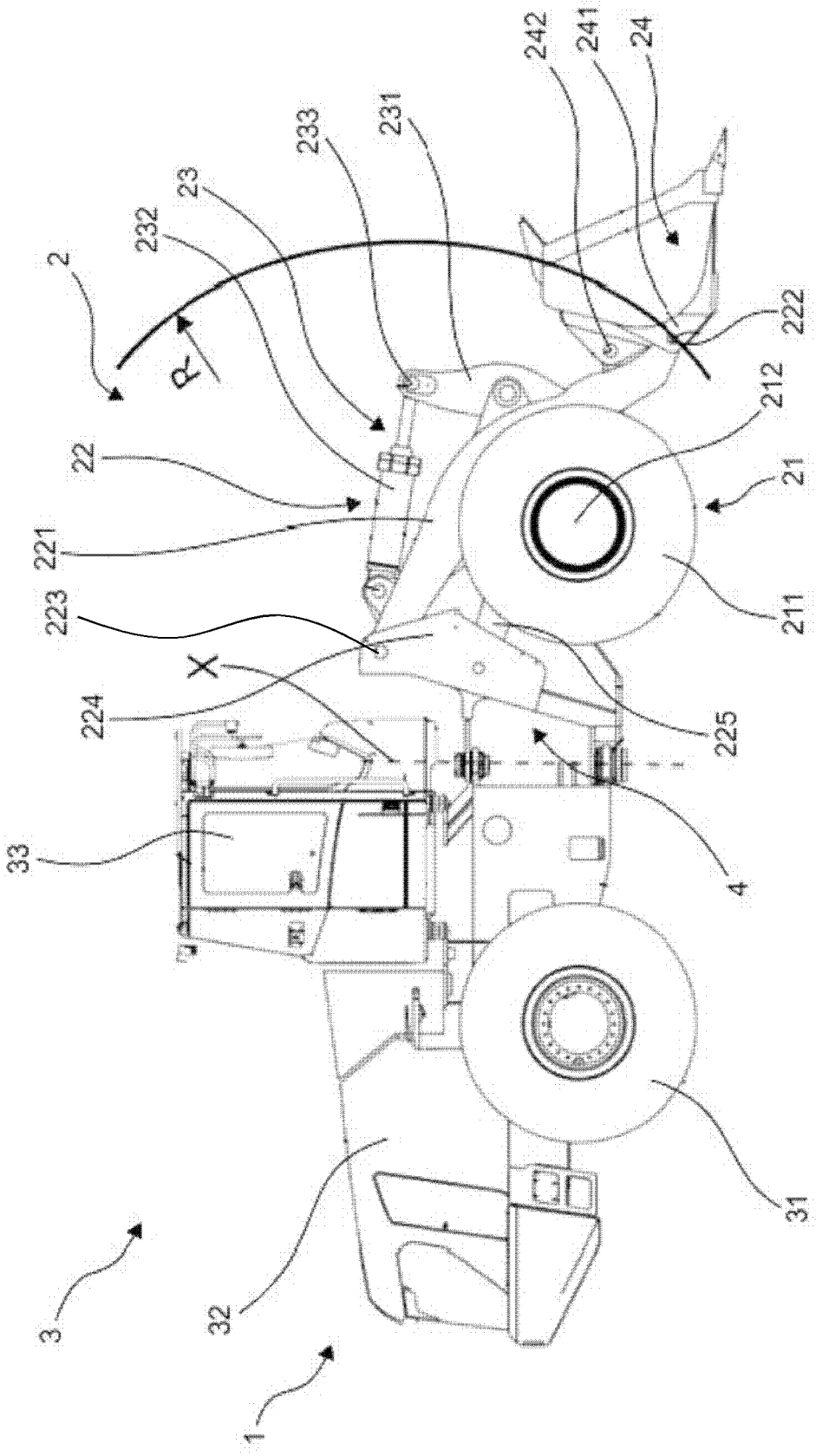

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Fig. 2

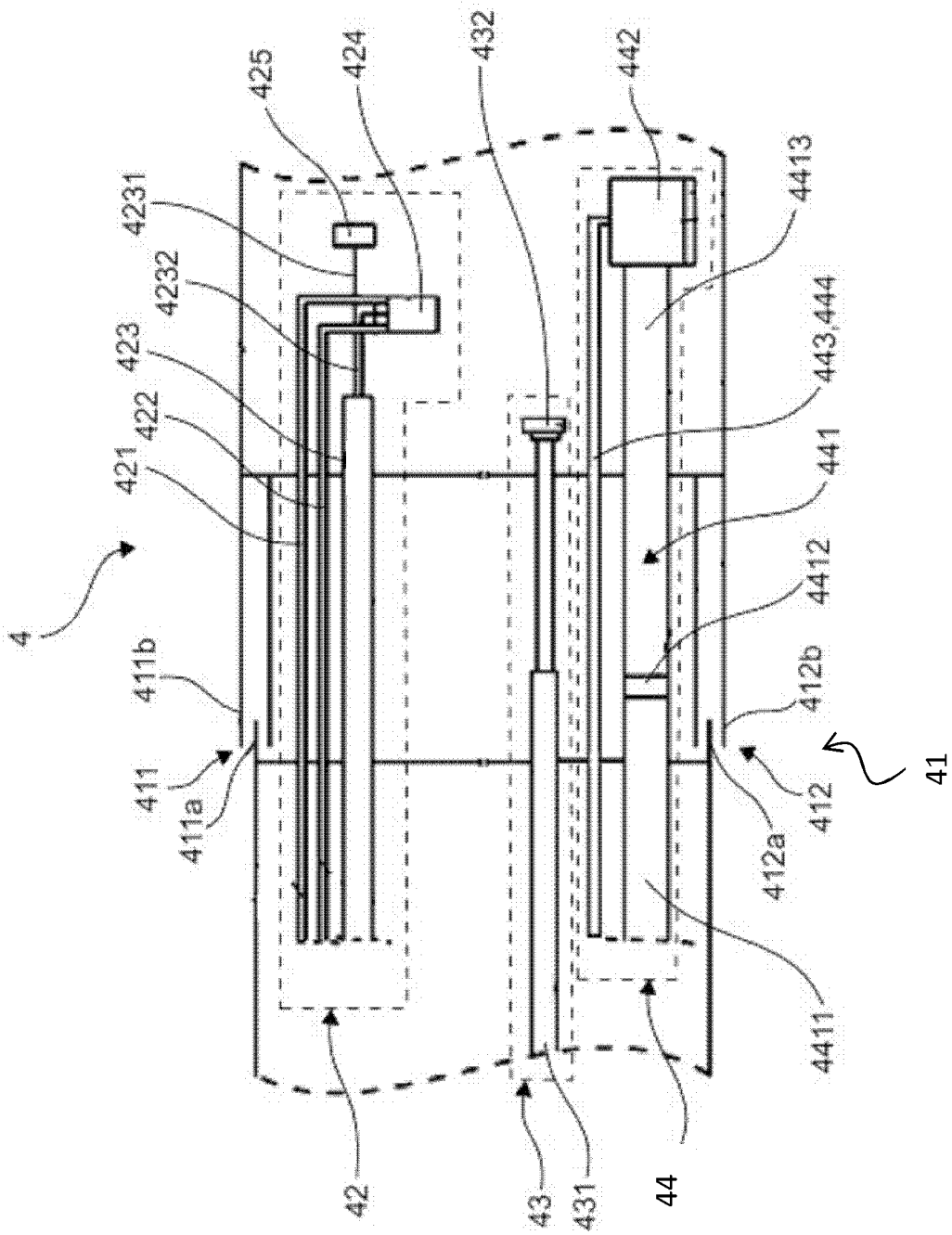

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Fig. 3

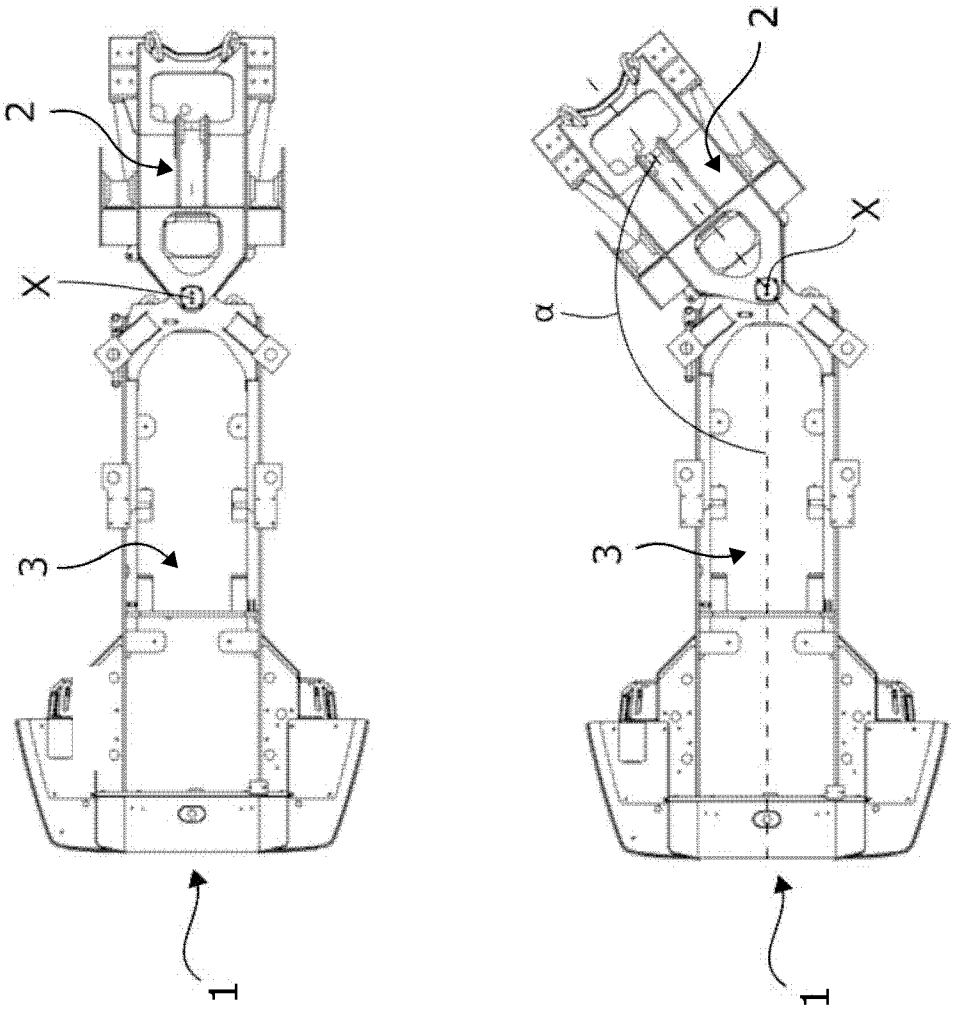


Fig. 4

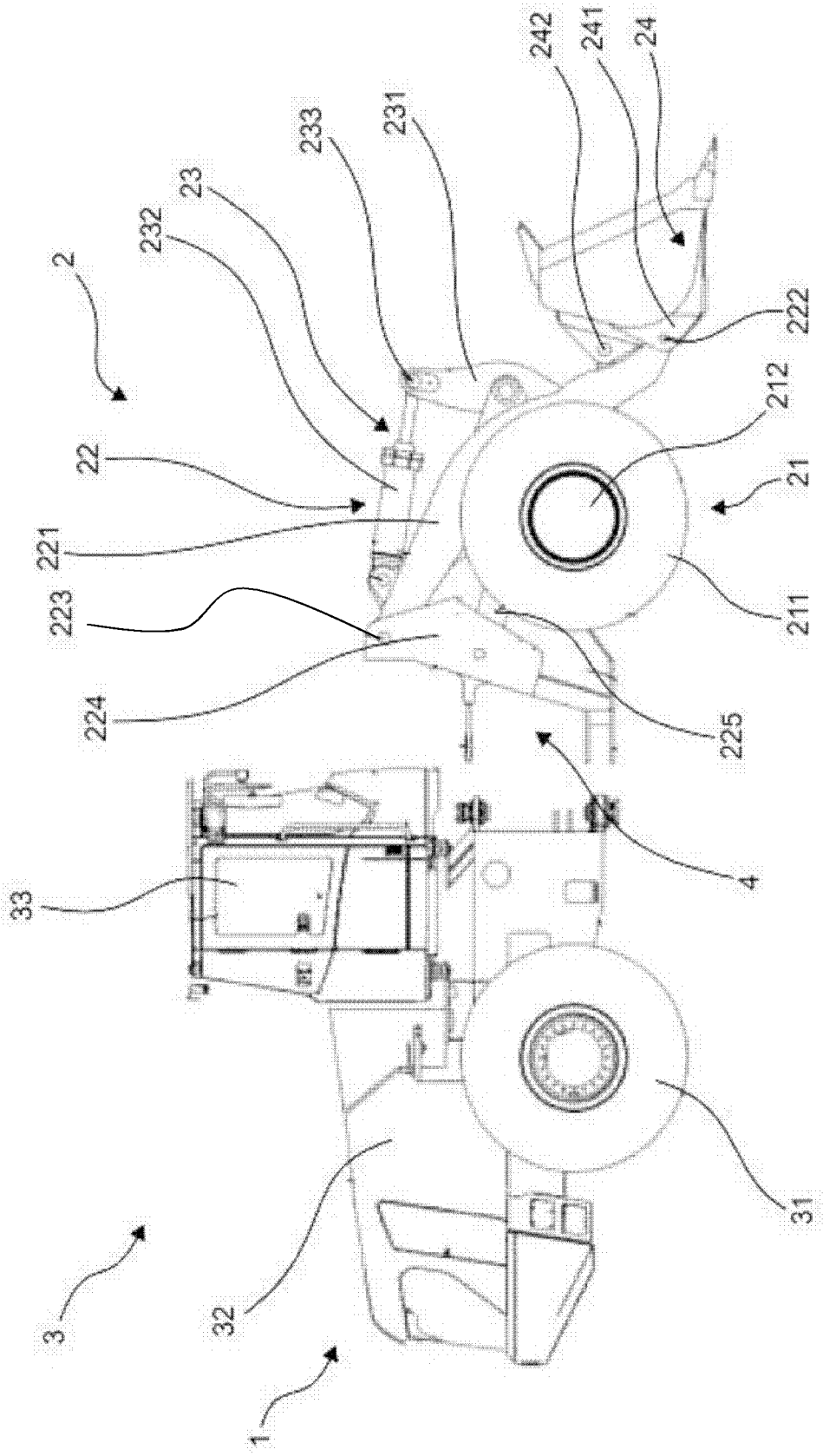

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Fig. 5

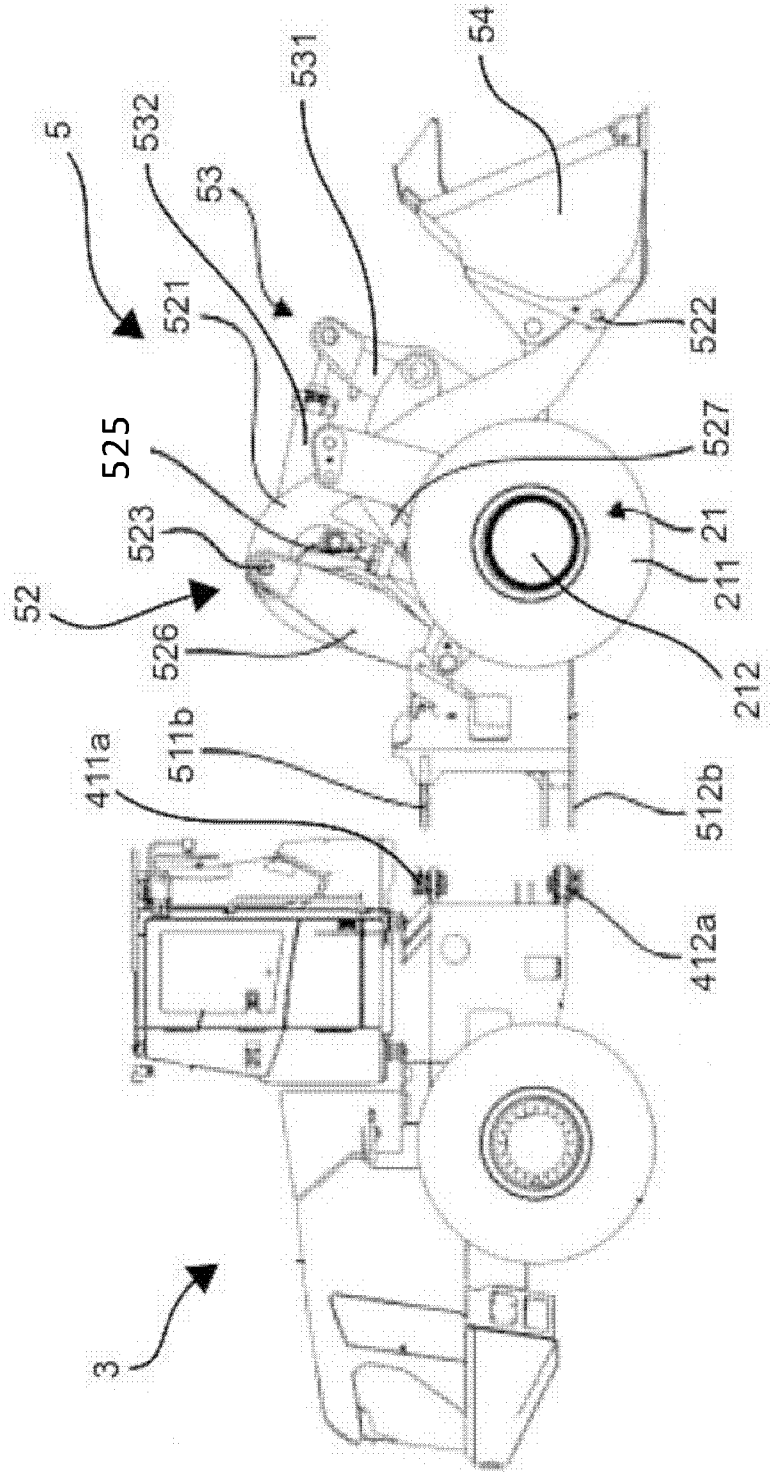

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Fig. 6

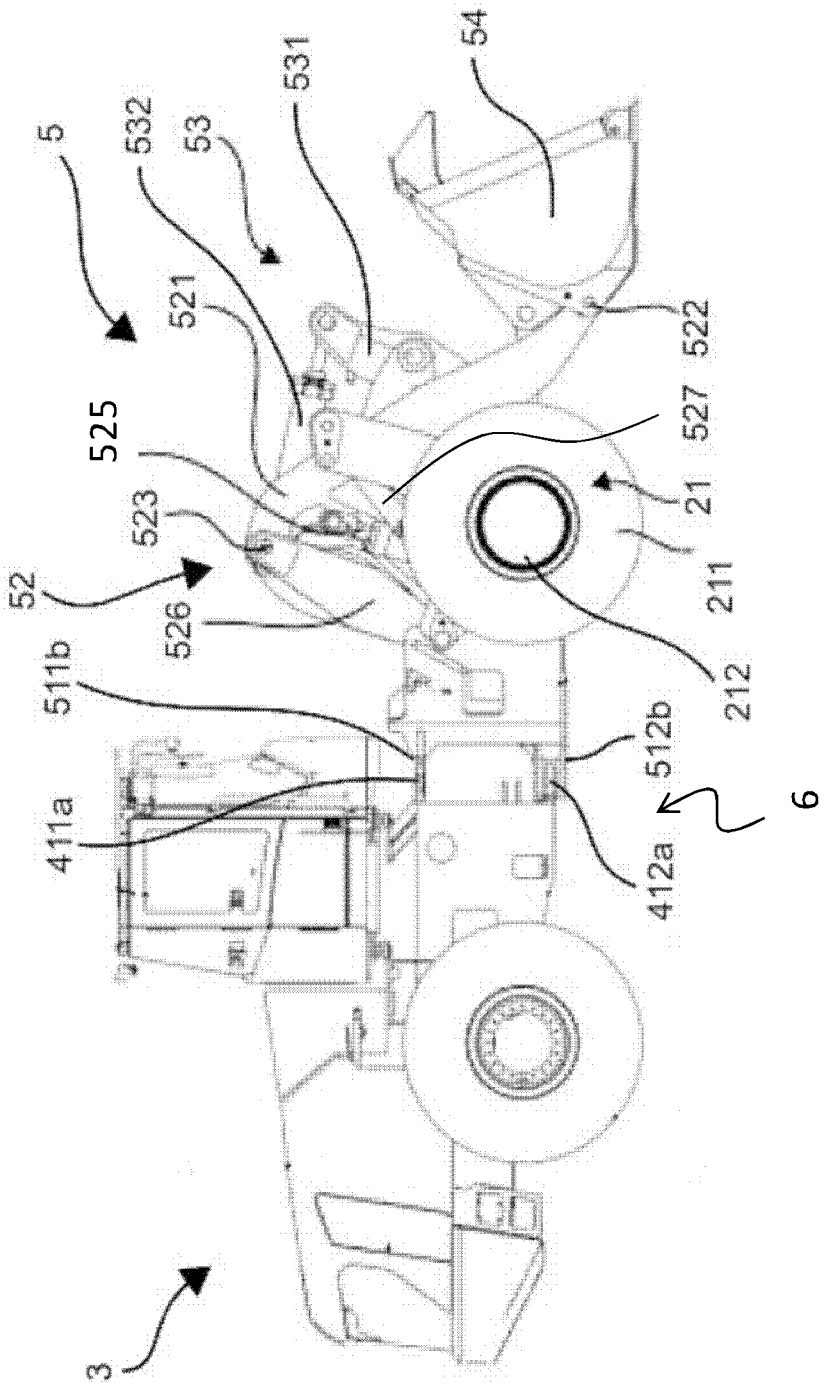

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Fig. 7

Fig. 8a

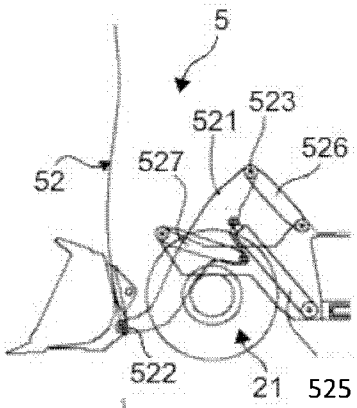


Fig. 9a

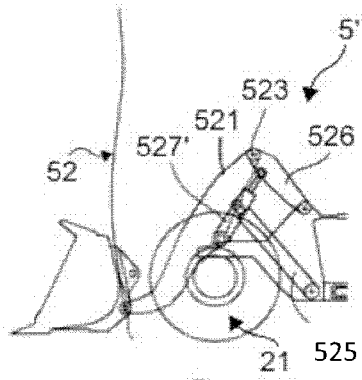


Fig. 8b

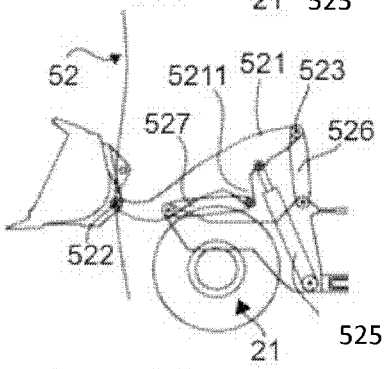


Fig. 9b

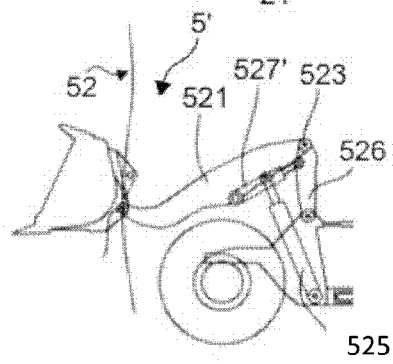


Fig. 8c

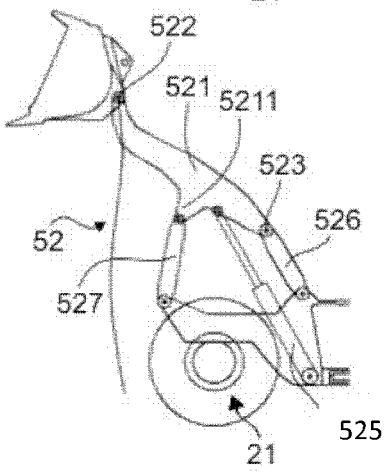
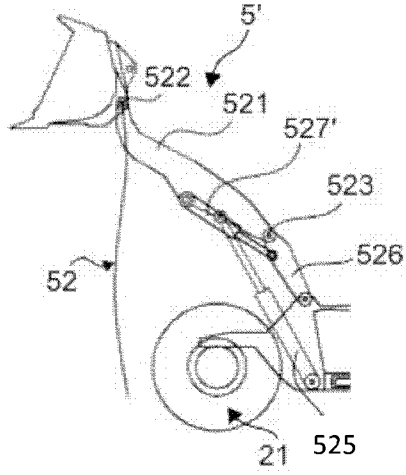


Fig. 9c



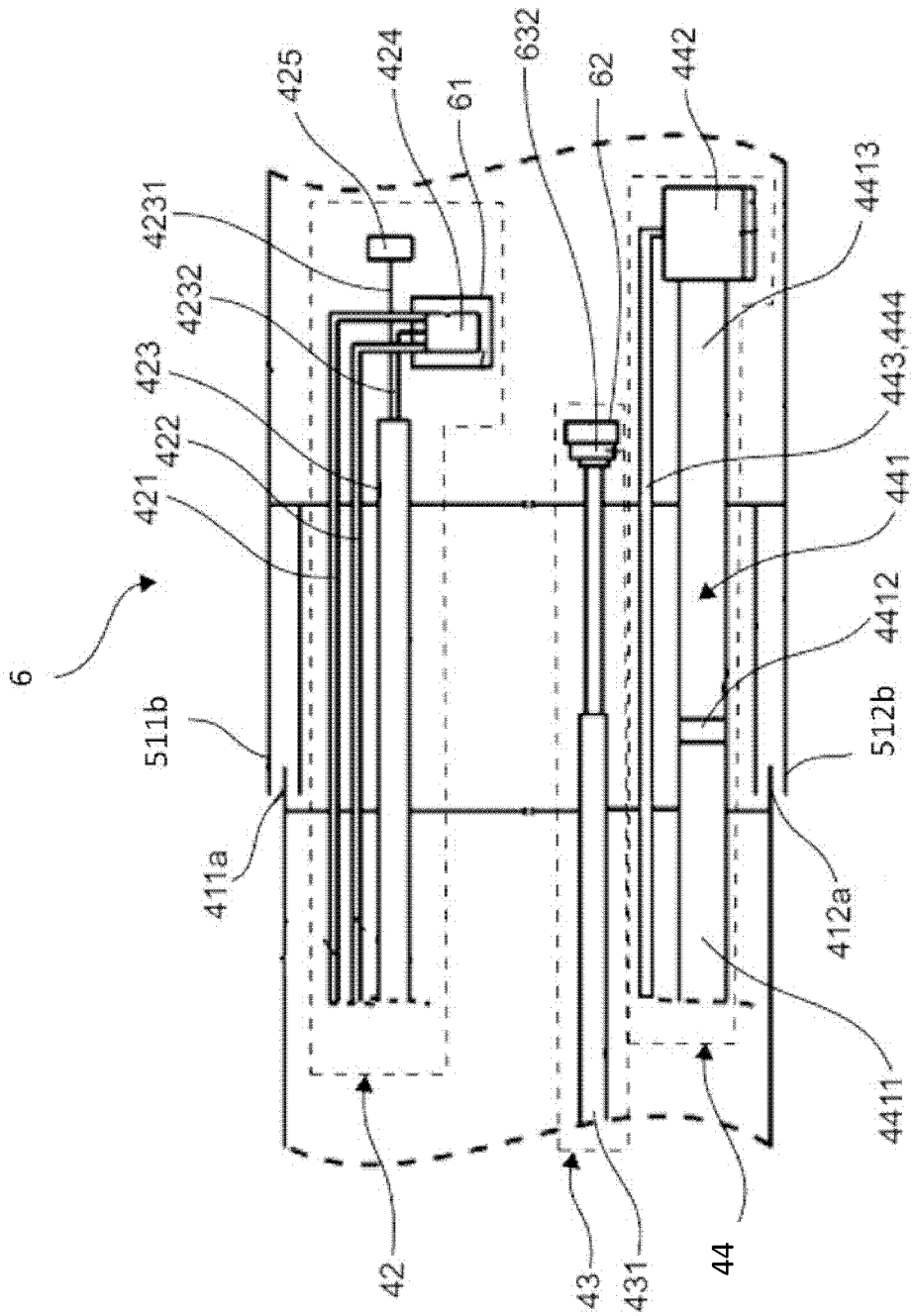

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511b
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Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/117229

A. CLASSIFICATION OF SUBJECT MATTER

E02F 3/28(2006.01)i; E02F 3/36(2006.01)i; E02F 3/42(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E02F3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

VEN, CNABS, CNTXT, CNKI: load, loader, lift, raise, arm, boom, frame, cylinder, drive, perpendicular, upright, mount, disassemble, assemble

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 103161185 A (XIAMEN XGMA MACHINERY CO LTD) 19 June 2013 (2013-06-19) See description paragraphs 17-24, figures 1-2	1-13
X	CN 103790193 A (QINGDAO SHANDONG ENG MACHINERY MFG CO) 14 May 2014 (2014-05-14) See description paragraph 11, figures 1-4	1-13
PX	CN 108301448 A (GUANGXI LIUGONG MACHINERY CO LTD) 20 July 2018 (2018-07-20) See the whole document	1-13
A	CN 201943096 U (NINGXIA HAICHEN MACHINERY CO LTD) 24 August 2011 (2011-08-24) See the whole document	1-13
A	CN 103485378 A (JIANGSU LIUGONG MACHINERY CO LTD) 01 January 2014 (2014-01-01) See the whole document	1-13
A	DD 235443 A1 (INST F BAUMECHANISIERUNG DRESD) 07 May 1986 (1986-05-07) See the whole document	1-13

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 February 2019	**21 February 2019**
Name and mailing address of the ISA/CN **National Intellectual Property Administration, PRC** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **LI,Ping** Telephone No. **62085276**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/117229

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5511932 A (NEW HOLLAND NORTH AMERICA INC) 30 April 1996 (1996-04-30) See the whole document	1-13

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/117229

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 103161185 A	19 June 2013	CN 103161185 B	23 December 2015
CN 103790193 A	14 May 2014	None	
CN 108301448 A	20 July 2018	None	
CN 201943096 U	24 August 2011	None	
CN 103485378 A	01 January 2014	None	
DD 235443 A1	07 May 1986	DE 3602912 A1	16 October 1986
US 5511932 A	30 April 1996	None	