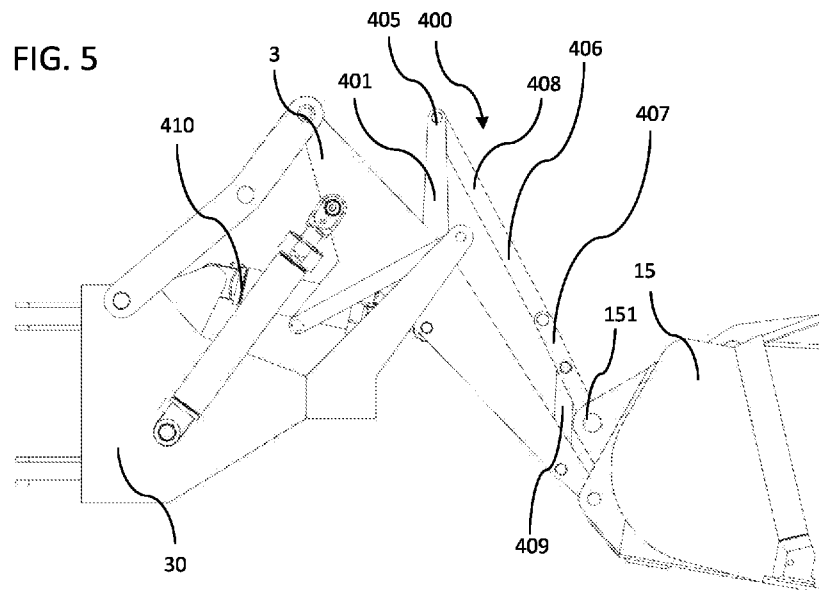




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(57) Abstract: A lifting arrangement for a construction machine, optionally a loader, having a frame arrangement with a front frame portion (30) and a rear frame portion (20), said lifting arrangement being mountable to said front frame portion (30), comprising a main arm (3), which is provided with a pivot connector (4) at a proximate end thereof and an equipment connector (5) at a distal end thereof, a main arm support means (6) for pivot supporting said pivot connector (4) of said main arm (3), wherein said main arm support means (6) is movable in a direction which includes at least a component in the front-rear direction with respect to said frame arrangement, wherein the lifting arrangement is configured such that the equipment connector (5), upon pivoting said main arm (3) between a lowered position and a lifted position, follows a substantially vertical path, the lifting arrangement further comprising a tilting arrangement (400) for tilting an equipment (15) mounted to the equipment connector (5) of the main arm (3), the tilting arrangement (400) comprising a kinematic chain (406) for attachment to a tilting connector (151) of the equipment (15) mounted to the equipment connector (5) of the main arm (3).

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## VERTICAL LIFTING ARRANGEMENT FOR CONSTRUCTION MACHINE

Technical Field

The present invention relates to a lifting arrangement for a construction machine comprising 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 the pivot connector of the main arm. The construction machine may be a loader, optionally a wheel loader. The lifting arrangement is configured such that the equipment connector, upon pivoting said main arm between a lowered and a lifted position, follows a substantially vertical path. The lifting arrangement further comprises a tilting arrangement for tilting an equipment connected to the equipment connector of the main arm. The equipment may be a bucket.

Background of the invention

Vertical lift loaders are construction machines that comprise a front frame portion and a rear frame portion, which are articulately interconnected for providing an articulating steering. Such loaders comprise a lifting arrangement that is supported by the front frame portion of said articulating frame arrangement and is articulated together with said front frame portion with respect to said rear frame portion upon steering.

The lifting arrangements of vertical lift loaders allow an equipment, e.g. a bucket, to be moved between a lowered position and a lifted position. The peculiarity of these vertical lifting arrangements is that the movement pattern of said equipment between said lowered and said lifted positions follows a substantially vertical path. This reduces the maximum distance from the bucket centroid to the front axle of the loader, thereby increasing the maximum loading capacity while maintaining the vehicle's weight.

The lifting arrangements for such vertical lift loaders typically comprise a tilting arrangement for tilting the equipment, which is connected to the lifting arrangement. Known tilting arrangements for vertical lift loaders are of the Z-bar type. In these arrangements, a lever is articulately supported by the main arm, wherein an upper end of the lever is connected to a tilting cylinder and a lower end thereof is connected to a tilting link. The tilting cylinder is provided above the main arm and the tilting link crosses the main arm from the lower end of the lever below the main arm to a tilting connector of the equipment above the main arm. By actuating the tilting cylinder, a tilting movement of the equipment can be initiated via lever and tilting link.

The drawback of these known vertical lifting arrangements is their inherent characteristic to restrain maximum loading capacity.

Summary of the invention

It was therefore the object of the present invention to provide a vertical lifting arrangement with a tilting arrangement, allowing for an increased loading capacity.

The invention is based on the idea that maximum loading capacity of a vertical lifting arrangement for a given vehicle weight is mainly determined by the distance between the bucket's centroid and the vehicle's front axle. This distance can be influenced by the amount of bucket tilting, as such tilting influences the position of the bucket's centroid. Furthermore, the location of the bucket's centroid at a lowered position of the lifting arrangement is key for the equipment movement path, as it sets an anchor point for the minimal distance of the bucket's centroid to the front axle of the loader. Accordingly, at the lowered position, the bucket should be tilted towards the construction machine as far as possible to move its centroid close to the vehicle's front axle.

However, the Z-bar type tilting arrangements constrain the bucket rollback at the lowered position due to interference of the tilting link of the tilting arrangement with the front axle and front wheel of the construction machine, respectively. This is mainly attributed to the fact that a larger rollback of the bucket implies a larger shift of the lower end of the lever of the tilting arrangement towards the front axle and front wheel, respectively.

The present invention exploits this idea by providing, in a first aspect, a lifting arrangement for a construction machine having a frame arrangement with a front frame portion and a rear frame portion, said lifting arrangement being mountable to said front frame portion. The construction machine may be a loader, for example a wheel loader. The lifting arrangement comprises 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.

The lifting arrangement is 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 lowered position in the context of this invention is preferably the lowest position of the equipment connector in normal operating conditions of the lifting arrangement. Further, the lifted position of the equipment connector is preferably the highest position of the equipment connector in normal operating conditions of the lifting arrangement. Furthermore, a substantially vertical path 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.

Furthermore, the lifting arrangement comprises a tilting arrangement for tilting an equipment mounted to the equipment connector of the main arm. The equipment may be a bucket. However, also other types of equipment are possible in this regard. The tilting arrangement comprises a kinematic chain for attachment to a tilting connector of the equipment mounted to the equipment connector of the main arm, a tilting actuator, and a connector connecting the kinematic chain and the tilting actuator. The kinematic chain is positioned above and the tilting actuator is positioned below the main arm in said lowered position of the main arm. The kinematic chain comprises a tilting link and a connecting link, which are pivotably connected to each other. With the above configuration a so-called reverse Z-shape of the tilting arrangement is achieved. In the context of the present invention this implies that the tilting link does not extend below the main arm such that there is no risk of interference of the tilting link with the front axle and the front wheel of the construction machine in all normal operating conditions of the lifting arrangement, respectively. Preferably, the entire tilting link is situated above the main arm in this lowered position. Furthermore, the kinematic chain, i.e. the tilting link and the connecting link, may be positioned above the main arm in all normal operating conditions of the lifting arrangement. Since the kinematic chain comprises the tilting link and the connecting link pivotably connected to each other it is possible to tilt the equipment by retracting the tilting actuator in the lifted position without a possibility of collision between the main arm and the kinematic chain. For further enhancing this effect it is also possible that the tilting link is made of multiple parts.

In the context of the present invention, directional terms refer to a situation in which the lifting arrangement is mounted to a construction machine.

According to the present invention, the lifting arrangement is constructed such that the tilting arrangement does not restrain bucket rollback in the lowered position of the lifting arrangement. This is achieved by providing the kinematic chain, which is connectable to the equipment, above the main arm, thereby preventing an interference of the kinematic chain and the front axle. Accordingly, compared to the prior art, in the lowered position, the bucket centroid can be moved closer to the front axle of the construction machine, thereby increasing loading capacity while maintaining the vehicle's weight. Thus, the lifting arrangement according to the present invention allows for exploitation of the full loading capacity potential thereof by comprising a tilting arrangement as outlined above. The tilting arrangement according to the present invention therefore exhibits a synergy with vertical lifting arrangements.

According to an embodiment of the lifting arrangement, the connector is a lever, which is pivotably supported by the main arm. The lever comprises an upper connector provided above and a lower connector provided below the main arm. The lever may be supported, in lengthwise direction of the main arm, in the upper half of the main arm. Furthermore, the distance from the upper connector of the lever to the support of the lever may be larger than the distance from the lower connector of the lever to the support of the lever. This embodiment allows for a compact arrangement of the lifting arrangement. Furthermore, the lever allows for the implementation of a transmission ratio into the tilting arrangement of the lifting arrangement.

According to an embodiment of the lifting arrangement, the tilting link connects the tilting connector of the equipment to the connecting link which is connected to the upper connector of the lever. The kinematic chain is completely provided above the main arm in the lowered position of the lifting arrangement. Optionally, the kinematic chain is completely provided above the main arm in all normal operating conditions of the lifting arrangement. The advantage of this embodiment is that the complete tilting arrangement may be provided above the main arm up to the position of the lever, thereby totally removing it from the region around the front axle to allow large bucket rollbacks in the lowered position.

According to an embodiment of the lifting arrangement, the tilting arrangement may comprise a guiding link. One end of the guiding link is pivotably supported by the main arm and the other end thereof is pivotably supported by the kinematic chain. The guiding link allows for large tilting forces transmitted to the equipment via the kinematic chain, as it directs the tilting force introduced into the kinematic chain into the tilting direction.

According to an embodiment of the lifting arrangement, the guiding link is pivotably connected to the tilting link. The kinematic chain may also comprise more than two links.

According to an embodiment of the lifting arrangement, the lifting arrangement further comprises an equipment, the equipment being a bucket. The bucket comprises a main arm connector, which is connected to the main arm, and a tilting connector, which is connected to the tilting link of the tilting arrangement of the lifting arrangement. The tilting connector of the bucket is situated above the main arm connector.

Furthermore, the tilting actuator of the lifting arrangement according to an embodiment of the present invention may comprise a tilting cylinder for actuation of a tilting movement of an equipment connected to the main arm. The tilting actuator is however not limited to a cylinder and may for example also be an electrical motor driving a lead screw. The tilting actuator is coupled to the tilting link. However, this coupling must not be a direct coupling but several parts may be provided between the tilting cylinder and the tilting link. Preferably, the tilting cylinder is situated below the main arm in all normal operating conditions of the lifting arrangement. This embodiment leads to the advantage that a very compact lifting arrangement may be provided.

The tilting cylinder may be connected to the lower connector of the lever. This embodiment implies that the lever may be utilized for transferring a tilting force from the tilting cylinder to the equipment. As the lever may implement a transmission ratio, this embodiment exhibits high flexibility. Furthermore, the first part of the tilting arrangement positioned below the main arm is the tilting cylinder, which is however located upstream of the lever when viewed from the equipment and therefore outside the region of the front axle. Accordingly, this embodiment allows for the utilization of a lever in the tilting arrangement with the accompanying advantages while not affecting bucket rollback in the lowered position of the lifting arrangement.

According to an embodiment of the lifting arrangement, the tilting cylinder is connectable to the front frame portion of said frame arrangement. In other words, one end of the tilting cylinder may be connected to the front frame portion of said frame arrangement. The other end of the tilting cylinder is preferably connected to the lower connector of the lever. This embodiment allows for relatively light main arm and main arm support means designs, as the tilting cylinder is supported by the frame arrangement of the construction machine.

According to a further embodiment of the lifting arrangement, the tilting cylinder is connected to the main arm support means. In other words, one end of the tilting cylinder may be connected to the main arm support means. The other end of the tilting cylinder is preferably connected to the lower connector of the lever. This embodiment leads to the advantage that the mounting of the lifting arrangement on a construction machine is facilitated, as the tilting cylinder does not have to be attached thereto.

The 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 connectable to the front frame portion of said frame arrangement. The guiding means provides a relatively simple mechanical way of realizing a vertical lifting arrangement.

The 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 the lowered position and the lifted position, a determining means for determining a lifting related quantity reflecting a position of said equipment connector with respect to said front frame arrangement, and a control means for controlling an operation of said main arm actuating element and said auxiliary arm 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 and auxiliary actuating means, the determining means and the control for controlling the actuation means based on the output of the determining means allow for the provision of a vertical lifting arrangement.

In a second aspect, the present invention relates to a construction machine, optionally a loader, having an articulating frame arrangement consisting of a front frame portion and a rear frame portion, which are articulately interconnected for providing an articulating steering, comprising a lifting arrangement according to one of the previously described embodiments. The loader may be a wheel loader. Furthermore, the lifting arrangement may be supported by said front frame portion of said articulating frame arrangement such that it is articulated together with said front frame portion with respect to said rear frame portion upon steering. Concerning the advantages of the construction machine according to this second aspect, it is referred to the advantages indicated above in connection with the lifting arrangement.

Brief description of the drawings

- Figure 1 illustrates a construction machine equipped with a vertical lifting arrangement according to a first embodiment in a lowered position;
- Figure 2 illustrates a construction machine equipped with a vertical lifting arrangement according to the first embodiment in an intermediate position;
- Figure 3 illustrates a construction machine equipped with a vertical lifting arrangement according to the first embodiment in a lifted position;
- Figure 4 illustrates a first embodiment of the tilting arrangement of the vertical lifting arrangement of the construction machine according to the first embodiment in perspective view;
- Figure 5 illustrates the tilting arrangement of Fig. 4 in side view in a lowered position;
- Figure 6 illustrates schematically the tilting arrangement of Fig. 4 in side view in a lifted position;
- Figure 7 illustrates a second embodiment of the tilting arrangement of the vertical lifting arrangement of the construction machine according to the first embodiment in perspective view;
- Figure 8 illustrates the tilting arrangement of Fig. 7 in side view.
- Figure 9 illustrates a construction machine equipped with a vertical lifting arrangement according to a second embodiment in a lowered position;
- Figure 10 illustrates a construction machine equipped with a vertical lifting arrangement according to the second embodiment in an intermediate position;
- Figure 11 illustrates a construction machine equipped with a vertical lifting arrangement according to the second embodiment in a lifted position;
- Figure 12 illustrates components of the control system applied to the lifting arrangement according to the second embodiment;
- Figure 13 illustrates a third embodiment of the tilting arrangement of the vertical lifting arrangement of the construction machine according to the second and first embodiment in perspective view.

Detailed description of embodiments

In the following, embodiments of the present invention are explained in detail based on the drawings. It is noted that the below discussed embodiments can be combined with each other and the invention is not specifically restricted to the structure and arrangement of the specific embodiments and modifications discussed below.

GENERAL OVERVIEW

The present invention relates to a lifting arrangement comprising a tilting arrangement which is applicable to construction machines in general. In the following embodiments, the lifting arrangement is illustrated and explained as structure of a construction machine which is embodied as wheel loader. However, the specific application of the lifting arrangement according to the present invention is not limited to the application to a wheel loader. Rather, the lifting arrangement according to the present invention can be applied to drivable construction machines of any type such as loaders having wheels or crawler track chains or even a combination of both. Moreover, the steering type is not limited to the below discussed optional articulating steering arrangement. Rather, the lifting arrangement is applicable to construction machines having any type of steering arrangements such as articulating steering arrangements, skid steering arrangements or any other type.

The construction machine to which the lifting arrangement according to the present invention is applicable is briefly explained based on the illustration of Figure 1. Figure 1 shows the construction machine 1 in a simplified side view. Elements which are not essential for the invention are omitted. Figure 1 does not illustrate the tilting arrangement of the lifting arrangement of the construction machine. Embodiments of the tilting arrangement of the construction machine are illustrated in Figures 4-7.

The construction machine 1 comprises a front frame portion 30 and rear frame portion 20. In the example according to Figure 1, a pair of front wheels 301 is mounted to the front frame portion 30 and a pair of rear wheels 201 is mounted to the rear frame portion 20. The front frame portion 30 is mounted to the rear frame portion 20 with an articulating steering arrangement 40. The articulating steering arrangement 40 is well known to the skilled person and comprises one or multiple bearings for providing an articulating mount between the front frame portion 30 and the rear frame portion 20 with a pivoting axis being 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. The articulating steering arrangement 40 provides a tilting between the front frame portion 30 and the rear frame portion 20 in order

to provide a steering by changing the angle enclosed between the rotation axis of the front wheels 301 and the rotating axis of the rear wheels 201. The articulating steering arrangement 40 can be driven by a not illustrated actuator, such as a hydraulic actuator. The type and structure of the articulating steering arrangement 40 is not essential to the invention and can be adapted as required.

The construction machine 1 according to the example shown in Figure 1 comprises an operator's cab 203 which is mounted to the rear frame portion 20. Inside the operator's cab 203, space for the operator is provided and the required operating and control elements which are not illustrated are accessible by the operator. The operator's cab 203 comprises not illustrated windows in order to provide visibility of the surrounding field for the operator.

An engine compartment 202 is provided at the rear frame portion 20 which 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. The power source is used to provide power for driving the front wheels 301 and/or the rear wheels 201 as well as for providing power for actuators besides other elements of the construction machine.

The front frame portion 30 extends in the forward direction with respect to the rear frame portion 20. In the present example, the front frame portion 30 is located in front of the operator's cab 203 and the engine compartment 202. However, the application of the lifting arrangement according to the present invention is not limited to the construction machine 1 having such an arrangement.

Upon a steering operation, the front frame portion 30 tilts with respect to the rear frame portion 20, the operator's cab 203 and the engine compartment 202. However, it is also possible to provide a modified steering arrangement such as a single wheel steering, front wheel steering or rear wheel steering while the articulating steering arrangement is omitted or provided only as option.

In the following, the lifting arrangement according to the present invention is explained in three embodiments, wherein the lifting arrangement is mounted to the front frame portion 30 of the above explained exemplary construction machine 1 embodied as wheel loader.

#### FIRST EMBODIMENT

The lifting arrangement according to the first embodiment will now be explained with reference to Figs. 4 to 6. The lifting arrangement comprises a main arm 3 having a pivot connector 4 at a proximate end and an equipment connector 5 at a distal end thereof. The pivot connector 4 is pivotally supported at a main arm support means 6 which includes a main arm support link 6a in the present embodiment. The main arm support link 6a has a first end 12 and a second end 13, the first end 12 being pivotally connected to the pivot connector 4 of the main arm 3 and the second end 13 being pivotally connected to an element of the front frame portion 30. The connection between the pivot connector 4 of the main arm 3 and the first end 12 of the main arm support link 6a can be provided as bearing arrangement of a suitable type in order to provide a sliding rotation of the main arm 3 with respect to the main arm support link 6a.

The main arm support link 6a is pivotally mounted to the front frame portion 30 at its second end 13. In order to provide such a pivotable mount of the main arm support link 6a to the front frame portion 30, a rotating bearing of a suitable type is arranged for providing the pivotable movement of the main arm support link 6a with respect to the front frame portion 30.

The main arm support link 6a is arranged such that a rotation or pivoting movement of the main arm support link 6a provides a movement of the first end 12 in a direction which at least includes a component in the front-rear direction of the construction machine 1. For this reason, the main arm support link 6a is directed in an upwards direction with a specific inclination from the vertical direction in the situation in Fig. 1.

The main arm 3 comprises a guided portion 10 which is provided between the pivot connector 4 and the equipment connector 5. In the present embodiment, the guided portion 10 is also offset by a predetermined amount from a line connecting the pivot connector 4 and the equipment connector 5. However, this offset is not essential for the present invention and rather a preferred arrangement.

The lifting arrangement according to the present invention further includes a guiding means 7 which includes in the embodiment shown in Figure 1 a guiding arm 7a having a first end 8 and a second end 9. The first end 8 is pivotally mounted to the front frame portion 30 and the second end 9 is pivotally mounted to the main arm 3 at the guided portion 10. The second end 9 is pivotally mounted to a bearing of a suitable type provided in the area of the guided portion 10 of the main arm 3 in order to provide a

pivotable movement of the guiding arm 7a relative to the main arm 3. On the other hand, the first end 8 is pivotably mounted to the front frame portion with a bearing of a suitable type in order to provide a pivotable movement of the guiding arm 7a with respect to the front frame portion.

An actuator 11 is provided in the lifting arrangement. The actuator has a first end 11b which is pivotably mounted to the front frame portion 30 and a second end 11a which is pivotably mounted to the main arm 3. The actuator is embodied as linear actuator such as a hydraulic actuator in the present embodiment but not limited thereto. Upon operating the actuator 11, the distance between the first end 11b and the second end 11a can be changed e.g. by introducing pressurized fluid into pressure chambers of the actuator 11.

At the equipment connector 5 of the main arm 3, a bucket 15 is provided which is an example of equipment which can be mounted to the main arm. The bucket comprises a main arm connector for connection to the equipment connector 5 of the main arm 3 and a tilt connector 151 for tiltably operating the bucket. The tilt connector 151 is provided above the main arm connector. The tilting arrangement of this first embodiment for tilting the bucket 15 is not illustrated in Figures 1-3 and will be explained in further detail below.

In the exemplary arrangement shown in Figure 1, the guiding arm 7a is directed rearwards with respect to the first end 8 of the guiding arm 7a. In Figure 1, the lifting arrangement is shown in a position which is defined as lowered position in which the bucket is positioned at a lowermost position in which the bucket is able to admit material to be lifted and touches the ground. It is, however, possible to provide a lifting range which extends below the ground limit if needed.

In the following, an operation of the lifting arrangement according to the present invention is explained in detail based on the illustrations of Figures 1-3.

In Figure 1, the lifting arrangement is illustrated in the lowered position. In this situation, the main arm is rotated downwards as illustrated in Figure 1. This is achieved by retracting the actuator 11 which is provided for operating the main arm 3. The position of the main arm 3 is determined by the linkage between the guiding arm 7a and the main arm support link 6a. In other words, the position of the pivot connector 4 of the main arm 3 can be changed by changing the rotational position of the main arm support link 6a, whereas the guiding arm 7a determines, due to its rotational connection between the front frame portion 30 and the guided portion 10 of the main arm 3, the position of the pivot connector 4 depending on the rotational position of the main arm 3. As such, the lifting arrangement provides a link-based transmission which uniquely determines the position of the main arm 3.

Upon actuating the actuator 11, the main arm 3 is rotated in the clockwise direction in Figure 1. With this rotation, the main arm 3 is rotated with respect to the main arm support link 6a. At the same time, the guiding arm 7a is rotated in the counter clockwise direction. When the guiding arm 7a rotates in the counter clockwise direction, the guided portion 10 of the main arm 3 is forced along a circular path due to the constant distance between the first and second ends 8, 9 of the guiding arm 7a. The circular path provided by the rotation of the guiding arm 7a is bulged towards the main arm support means including, in the present embodiment, the main arm support link 6a.

Figure 2 shows the lifting arrangement of Figure 1 in an intermediate position which is lifted from the lowered position by a predetermined amount. As can be seen, the guiding arm 7a is rotated from the position shown in Figure 1 in the counter clockwise direction. In this context, the position of the second end 9 of the guiding arm 7a 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 3 has rotated in the clockwise direction and the bucket 15 mounted to the equipment connector has lifted by a predetermined amount. Due to the fact, that the guided portion 10 of the main arm 3 is forced in the rearward direction by the predetermined movement path of the second end 9 of the guiding arm 7a, the main arm support link 6a is rotated in the clockwise direction about its second end 13 which is mounted to the front frame portion 30. Therefore, the position of the first end 12 of the main arm support link 6a is moved together with the pivot connector 4 of the main arm 3 in the rearward direction with respect to the construction machine.

Upon a further operation of the actuator 11, the main arm 3 is further rotated in the clockwise direction and reaches a lifted position shown in Figure 3. In this position, the bucket 15 mounted to the equipment connector 5 of the main arm 3 has reached a position which is higher than the intermediate position shown in Figure 2. This position is the maximum lift position of the bucket 15 which can be achieved with the embodiment shown in Figures 1-3. Upon further rotating the main arm 3 in the clockwise direction, the guiding arm 7a is further rotated in the counterclockwise direction and forces the guided portion 10 of the main arm 3 further along the circular path. As the second end 9 of the guiding arm 7a has moved forward with respect to the position shown in Figure 2, the

main arm support link 6a is rotated in the counterclockwise direction from the position shown in Figure 2. Therefore, the position of the first end 12 supporting the pivot connector 4 of the main arm 3 is further forward compared to the position thereof shown in Figure 2.

Based on the above operation, the bucket 15 can be moved from the lowered position shown in Figure 1 to the lifted position shown in Figure 3 through the intermediate position shown in Figure 2. Based on the inventive arrangement comprising the guiding arm 7a and the main arm support link 6a, the equipment connector 5 is forced along a predetermined movement path which is shown as path P in the drawings. In the present illustration, the path P is formed with an S-shape but basically follows a substantially vertical path throughout the movement of the equipment connector from the lower most position to the upper most position. The substantially vertical path may be a J-shaped path. In particular, the path P deviates from a circular path which is achievable with prior art lifting arrangements in which the pivot connector 4 of the main arm 3 is immovably and stationary with respect to a frame portion of the construction machine 1. According to the present invention, the movement of the pivot connector 4 of the main arm is achieved by providing the movable support means 6 and the guiding means 7 which forces the main arm 3 to a specified movement pattern leading to a basically vertical movement range of the equipment connector 5.

Furthermore, the lifting arrangement according to this first embodiment comprises a tilting arrangement 400 for tilting the bucket 15 connected to the equipment connector 151 of the main arm 3. Figures 4-5 illustrate a first embodiment of this tilting arrangement 400. The tilting arrangement 400 comprises a lever 401, which is pivotably supported by the main arm 3. Specifically, the main arm 3 comprises a pivot connector 402 for supporting the lever 401. The pivot connector 402 may be provided at a connection piece 403, which extends between two parallel main arm carriers. The connection piece 403 may be provided in the middle of the main arm length extension. Preferably, the pivot connector 402 for supporting the lever 401 is provided at the upper end, i.e. the end which faces towards the wheel loader, of the connection piece 403. In this preferred embodiment, the pivot connector 402 may be provided in the upper half of the length extension of the main arm 3.

The lever 401 comprises a lower connector 404, which is positioned below the main arm 3, and an upper connector 405, which is positioned above the main arm 3. Preferably, the distance from the upper connector 405 of the lever 401 to the pivot connector 402 for supporting the main arm 3 is larger than the distance from the lower connector 404 to the pivot connector 402. Thus, the lever 401 according to this preferred embodiment exhibits a transmission ratio. In other words, due to the different distances from upper 405 and lower connectors 404 to the pivot connector 402 for supporting the lever 401, a relatively small movement path of the lower connector 404 with a relatively large force leads to a relatively large movement path of the upper connector 405 with a relatively small force.

Furthermore, the tilting arrangement 400 comprises a kinematic chain 406. The kinematic chain 406 is connected to the upper connector 405 of the lever 401 and the tilt connector 151 of the bucket 15. Thus, the kinematic chain 406 transmits a movement of the upper connector 405 of the lever 401 to the tilt connector 151 of the bucket 15. In this embodiment, the kinematic chain 406 comprises a tilting link 407 and a connection link 408, which are pivotably connected to each other. The length of the connection link 408 may be more than twice the length of the tilting link 407. The tilting link 407 is further connected to the tilt connector 151 of the bucket 15. The connection link 408 is further connected to the upper connector 405 of the lever 401. The complete kinematic chain 406 is provided above the main arm 3. Specifically, in all normal operating conditions of the lifting arrangement, the kinematic chain 406 never extends into a region below the main arm 3. Thus, there is no risk of interference between the tilting link 407/the kinematic chain 406 and the front axle and front wheel 301 of the construction machine, respectively. Accordingly, the tilting arrangement 400 according to this embodiment does not restrain bucket rollback in any normal operating condition of the lifting arrangement due to its provision above the main arm 3.

In addition, the tilting arrangement 400 according to this embodiment comprises a guiding link 409. The guiding link 409 is pivotably supported by the main arm and the tilting link 407 of the kinematic chain 406. The guiding link 409 ensures a specific movement pattern of the tilt connector 151, thereby allowing for large tilting forces. The guiding link 409 may be supported at the lower end, i.e. the end that faces away from the construction machine, of the connection piece 403 of the main arm 3.

Furthermore, the tilting arrangement 400 comprises a tilting cylinder 410 for actuation of a tilting movement of the bucket 15. The tilting cylinder 410 is connected to the lower connector 404 of the lever 401 and extends from this lower connector 404 towards the construction machine. In this embodiment, the tilting cylinder 410 is completely provided below the main arm 3. Furthermore, in this embodiment, the tilting cylinder 410 is connected to the front frame portion 30 of the articulating frame arrangement. Thus, the main arm 3 and the main arm support means 6 do not have to carry the weight of the tilting cylinder 410 upon movement of the bucket 15 between lowered and lifted position.

For tilting the bucket 15, the tilting cylinder 410 is actuated, thereby moving the lower connector 404 of the lever 401 to which it is connected. The movement of the lower connector 404 leads to a rotation of the lever 401 around the pivot connector 402, which moves the upper connector 405 of the lever in a direction opposite to that of the lower connector 404 movement. The movement of the upper connector 405 is transferred to the tilt connector 151 of the bucket 15 via the kinematic chain 406, thereby tilting the bucket 15. As all of the parts of the tilting arrangement 400, which may principally interfere with the front axle and/or front wheel 301 of the wheel loader, are located above the main arm 3, such an interference can be prevented. Thus, the tilting arrangement of the lifting arrangement according to the present embodiment does not restrain bucket roll back in any normal operating condition of the wheel loader, especially not in the lowered position.

As shown in Fig. 6, since the kinematic chain 406 comprises the tilting link 407 and the connecting link 408 pivotably connected to each other via a kinematic chain connector 411 it is possible to tilt the bucket 15 by retracting the tilting cylinder 410 in the lifted position. By retracting the tilting cylinder 410 in the lifted position the kinematic chain connector 411 moves upward away from the main arm 3 thereby avoiding collision of the kinematic chain 406 with the main 3.

### SECOND EMBODIMENT

Figs. 7-8 illustrate a lifting arrangement according to a second embodiment. The lifting arrangement according to the second embodiment comprises a tilting arrangement 400 substantially according to the first embodiment, therefore only differences between these embodiments will be outlined in the following.

The tilting arrangement 400 according to the second embodiment is configured identically to the tilting arrangement of the first embodiment with the exception that the tilting cylinder 410 is not connected to the front frame portion 30 of the articulating steering arrangement, but to the main arm support means 6. This facilitates the mounting of the lifting arrangement to the front frame portion 30 of the wheel loader since the tilting cylinder 410 does not have to be connected thereto.

The lifting arrangement according to the second embodiment and lifting procedure thereof is now explained in detail under reference to Figs. 9-12. Except for the differences outlined below, the lifting arrangement according to this second embodiment is configured as that of the first embodiment described above and therefore the explanations concerning the lifting procedure apply also to the first embodiment.

An auxiliary actuating element 21 embodied as linear actuator is provided in the lifting arrangement according to this second embodiment. The auxiliary actuating element 21 has a first end 21a and second end 21b, the first end 21a being pivotably mounted to said main arm support link 6a in the embodiment shown in Figure 9. The second end 21b of the auxiliary actuating element 21 is pivotably mounted to said main arm 3. Accordingly, the auxiliary actuating element 21 operates in order to vary the angle of inclination between the main arm support link 6a and the main arm 3. In other words, by extending the auxiliary actuating element 21, the angle enclosed by the main arm support link 6a and the main arm 3 is increased.

By actuating the main arm actuating element 11, the main arm 3 is rotated about a pivot center provided at the second bearing portion 13 of said main arm support link 6a. In other words, by extending the main arm actuating element 21, the main arm 3 is rotated together with the main arm support link 6a in the clockwise direction such that a lifting operation is achieved.

Reference is made to Figure 12, which discloses the elements of the control system used for the lifting arrangement according to this second embodiment of the invention. The shown control system is only an example and elements which are not essential for the invention are not shown in this illustration. The control system shown in Figure 12 is mounted in the construction machine at a suitable position. The basic element of the control system is a control means 60 which includes a CPU for performing control operations and other calculations which are required for operating the control system. Information can be obtained from a determining means 50 for determining a lifted related quantity reflecting a position of said equipment connector 5 with respect to the front frame arrangement 30. The determining means 50 can include sensors 51, 52, 51.A, 52A. The sensors can be embodied as linear sensors 51, 52 which provide information on the extension position of the linear actuators used for the main arm actuating element 11 and the auxiliary actuating element 21. Such sensors are well known to the skilled person and will be suitably selected from available types. As alternative, rotation sensors can be mounted to those elements of the lifting arrangement which experience a relative rotation between two elements, such as at the connection between the pivot connector 4 of the main arm 3 and the first bearing portion 12 of the main arm support link 6a or at the bearing portion supporting the second bearing portion 13 of the main arm support link 6a on the front frame portion 30. 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 with respect to the main arm support link 6a as well as the relative position of the main arm support link 6a with respect to the front frame portion 30. The determining means 50 using the above mentioned sensors transmits electric signals to the control means 60 which are further processed by the CPU as follows.

The CPU of the control means 60 communicates with a storage means 63 and is capable of obtaining information from the storage means and of transferring information to the storage means 63. The storage means 63 includes besides others information in the form of a set of data, such as functions or patterns.

Furthermore, an input section 61 communicates with the control means 60. The input section 61 is capable of transferring signals to the control means 60 which are e.g. triggered by the operator operating the construction machine. As alternative or in addition, the input section 61 can further communicate with additional control systems in order to provide an automatic trigger for transferring signals to the control means 60.

The control means 60 communicates with an output section 63 which is provided for controlling the actuating system of the lifting arrangement, in particular, the main arm actuating element 11 and the auxiliary actuating element 21. The output section 63 can be combined with a not illustrated solenoid section controlling pressures and/or flow rates of hydraulic fluid to and from the pressure chambers of the actuators in a known manner. Consequently, the output section 62 can transfer the signals provided from the control means 60 into actuating movements of the main arm actuating element 11 and the auxiliary actuating element 21.

The above indicated functions or patterns included in the storage means 63 is used for controlling the movement pattern of the equipment connector 5 of the lifting arrangement in the course of a lifting operation. According to the present embodiment, the control system provides a relationship between the movement of the main arm actuating element 11 and the movement of the auxiliary actuating element 21. In other words, the function or pattern included in the storage means 63 includes a relationship between the operating position of the main arm actuating element and the operating position of the auxiliary actuating element 21. The relationship can be continuous.

The operation of the control based lifting arrangement is explained in the following. Starting out from the situation in Figure 9, the operator manipulates a not illustrated operating element which is associated with the input section 61 in order to initiate a lifting operation for lifting the equipment connector 5 from the lowered position shown in Figure 9 to a lifted position shown in Figure 11 through an intermediate position shown in Figure 10. With the lifting arrangement shown in Figure 9, the main arm actuating element 11 is extended in order to rotate the main arm 3 together with the main arm support link 6a in the clockwise direction in the drawing. In the course of the operation of the main arm actuating element 11, the auxiliary actuating element 21 is retracted as can be derived from a comparison of Figure 9 with Figure 10. Based on this retraction of the auxiliary actuating element 21, the angle enclosed between the main arm 3 and the main arm support link 6a is decreased and the pivot connector 4 is withdrawn in the rearward direction with respect to the frame arrangement.

Upon further performing the lifting operation from the intermediate position shown in Figure 10, the main arm actuating element 11 is further extended in order to further rotate the main arm 3 in the clockwise direction in the drawing. In the course of the lifting operation between the intermediate position shown in Figure 10 towards the lifted position shown in Figure 11, the auxiliary actuating element 21 is again extended in order to increase the angle enclosed between the main arm 3 and the main arm support link 6a. By this, the pivot connector 4 moved in the forward direction with respect to the frame arrangement.

Based on the above cooperation of the main arm actuating element 11 and the auxiliary actuating element 21 in combination with the construction using the main arm support link 6a, a movement pattern of the equipment connector 5 can be provided which deviates from a circular path having a constant radius.

The above explained resulting movement pattern which can be derived from Figures 9-11, is achieved by using a closed loop control with signals from the sensors as input and signals from the output section 62 as output. Starting again out from the situation in Figure 9, the determining means 50 using the sensors continuously determines the extension positions of the main arm actuating element 11 and the auxiliary actuating element 21 under the precondition that linear sensors are used. By initiating the lifting operation, the sensor determining the extension position of the main arm actuating element 11 senses a predetermined extension and transmits this as a signal to the control means 60. The control means uses this signal and compares the obtained signal continuously with a selected function or pattern present the storage means. The function can be provided as a continuous function defining the relationship between the extension position of the main arm actuating element 11 and the extension position of the auxiliary actuating element 21 such that this comparison will result in a unique output of a target extension position of the auxiliary

actuating element 21. The output section 62 will control the solenoid section in order to set the auxiliary actuating element 21 to the position which corresponds to the target position obtained from the pattern in the storage means.

The above mentioned closed loop control is continuously performed by the control system such that there is always a unique relationship between the extension position of the main arm actuating element 11 and the extension position of the auxiliary actuation 20 element 21. According to the present embodiment, as stated above, the pattern or function can be set such that the movement pattern of the equipment connector can be predetermined in various ways.

Based on the above operation, the bucket 15 shown as example in Figure 9 can be moved from the lowered position shown in Figure 9 to the lifted position shown in Figure 11 through the intermediate position shown in Figure 10. Based on the control system and arrangement, the movement of the equipment connector 5 is controlled by the control system along a predetermined movement path which is shown as path P in the drawings. In the present illustration, the path P has an S-shape but basically follows a vertical path throughout the movement of the equipment connector from the lowered position to the lifted position. In particular, the path P deviates from a circular path which is achievable with prior art lifting arrangements in which the pivot connector 4 of the main arm 3 is immovably and stationary with respect to a frame portion of the construction machine 1 and the equipment connector 5 is stationary with respect to the main arm 3. According to the present embodiment, the movement of the pivot connector 4 of the main arm is achieved by providing the moveable main arm support means 6 and the auxiliary actuating element 21 in addition to the above discussed control system such that the main arm 3 is moved with a specified movement pattern such that a basically vertical movement range of the equipment connector 5 is achievable.

The lifting arrangement according to the second embodiment further comprises a tilting arrangement 400, which is not illustrated in Figs. 9-11. The tilting arrangement 400 is configured according to the first or second embodiment of the tilting arrangement 400 described in connection with the lifting arrangement of the first embodiment.

### THIRD EMBODIMENT

The lifting arrangement according to the third embodiment is now explained in detail with reference to Fig. 13. Fig. 13 illustrates the lifting arrangement according to the third embodiment on a left side in a lowered position and on a right side in a lifted position.

Except for the differences outlined below, the lifting arrangement according to the third embodiment is configured as that of the first and second embodiment described above. Therefore, also the explanations concerning the lifting procedure made above (see second embodiment) apply also to the third embodiment.

The third embodiment differs from the second embodiment in that a short self-level link 412 and long self-level link 413 have been added. The short self-level link 412 is attached to the main arm support link 6, and to both the long self-level link 413 and the tilting cylinder 410. The long self-level link 413 is attached to the front frame 30, and to both the short self-level link 412 and the tilting cylinder 410.

## CLAIMS

1. Lifting arrangement for a construction machine, optionally a loader, having a frame arrangement with a front frame portion (30) and a rear frame portion (20), said lifting arrangement being mountable to said front frame portion (30), comprising
 

a main arm (3), which is provided with a pivot connector (4) at a proximate end thereof and an equipment connector (5) at a distal end thereof,

a main arm support means (6) for pivotably supporting said pivot connector (4) of said main arm (3), wherein said main arm support means (6) is movable in a direction which includes at least a component in the front-rear direction with respect to said frame arrangement,

wherein the lifting arrangement is configured such that the equipment connector (5), upon pivoting said main arm (3) between a lowered position and a lifted position, follows a substantially vertical path,

the lifting arrangement further comprising a tilting arrangement (400) for tilting an equipment (15) mounted to the equipment connector (5) of the main arm (3), the tilting arrangement (400) comprising a kinematic chain (406) for attachment to a tilting connector (151) of the equipment (15) mounted to the equipment connector (5) of the main arm (3), a tilting actuator (410), and a connector (401) connecting the kinematic chain (406) and the tilting actuator (410),

wherein

the kinematic chain (406) is positioned above and the tilting actuator is positioned below the main arm (3) in said lowered position of the main arm (3),

characterized in that

the kinematic chain (406) comprises a tilting link (407) and a connecting link (408), which are pivotably connected to each other.
2. Lifting arrangement according to Claim 1, wherein the connector is a lever (401), which is pivotably supported by the main arm (3), the lever (401) comprising an upper connector (405) provided above and a lower connector (404) provided below the main arm (3).
3. Lifting arrangement according to Claim 2, wherein the tilting link (407) connects the tilting connector (151) of the equipment (15) to the connecting link (408) which is connected to the upper connector (405) of the lever (401).
4. Lifting arrangement according to Claim 3, wherein the tilting arrangement (400) further comprises a guiding link (409), one end of the guiding link (409) being pivotably supported by the main arm (3) and the other end thereof being pivotably supported by the kinematic chain (406).
5. Lifting arrangement according to Claim 4, wherein the guiding link (409) being pivotably connected to the tilting link (407) of the kinematic chain (406).
6. Lifting arrangement according to one of the preceding claims, further comprising an equipment (15), the equipment being a bucket, which comprises a main arm connector, which is connected to the equipment connector (5) of the main arm (3), and a tilting connector (151), which is connected to the tilting link (407) of the tilting arrangement (400), the tilting connector (151) being situated above the main arm connector.
7. Lifting arrangement according to one of the preceding claims, wherein the tilting actuator comprises a tilting cylinder (410) for actuation of a tilting movement of an equipment (15) connected to the equipment connector (5) of the main arm (3).
8. Lifting arrangement according to Claim 7, wherein the tilting cylinder (410) is situated below the main arm (3) in all normal operating conditions of the lifting arrangement.
9. Lifting arrangement according Claim 7 or 8 when directly or indirectly dependent on Claim 2, wherein the tilting cylinder (410) is connected to the lower connector (404) of the lever (401).

10. Lifting arrangement according to Claim 7, 8 or 9, wherein the tilting cylinder (410) is connectable to the front frame portion (30) of said frame arrangement or the main arm support means (6).
11. Lifting arrangement according to one of the preceding claims, further comprising a first self-level link (412) and a second self-level link (413) being longer than the first self-level link (412), wherein the first self-level link (412) is attached to the main arm support means (6), and to both the second self-level link (413) and the tilting actuator (410); and the second self-level link (413) is attached to the front frame portion (30), and to both the first self-level link (412) and the tilting actuator (410).
12. Lifting arrangement according to one of the preceding claims, further comprising a guiding means (7) engaged to said main arm (3) at a guided portion of said main arm positioned between said pivot connector (4) and said equipment connector (5), wherein upon pivoting said main arm (3) between said lowered position and said lifted position said guiding means (7) guides the main arm (3) such that said equipment connector (5) follows a substantially vertical path.
13. Lifting arrangement according to one of Claims 1 to 12, further comprising a main arm actuating element (11) engaged to said main arm (3) and an auxiliary actuating element (21) engaged to said main arm support means (6) for moving said equipment connector (5) between the lowered position and the lifted position, a determining means (50) for determining a lifting related quantity reflecting a position of said equipment connector (5) with respect to said front frame portion (30), and a control means (60) for controlling an operation of said main arm actuating element (11) and said auxiliary arm actuating element (21) based on the determined lifting related quantity, such that a path of said equipment connector (5) upon moving between said lowered and said lifted position follows a substantially vertical path.
14. Construction machine (1), optionally loader, having an articulating frame arrangement consisting of a front frame portion (30) and a rear frame portion (20), which are articulately interconnected for providing an articulating steering, comprising a lifting arrangement according to one of the preceding claims.
15. Construction machine (1) according to Claim 14, wherein the lifting arrangement is supported by said front frame portion (30) of said articulating frame arrangement and is articulated together with said front frame portion (30) with respect to said rear frame portion (20) upon steering.



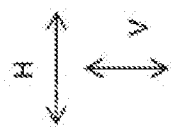


FIG. 2

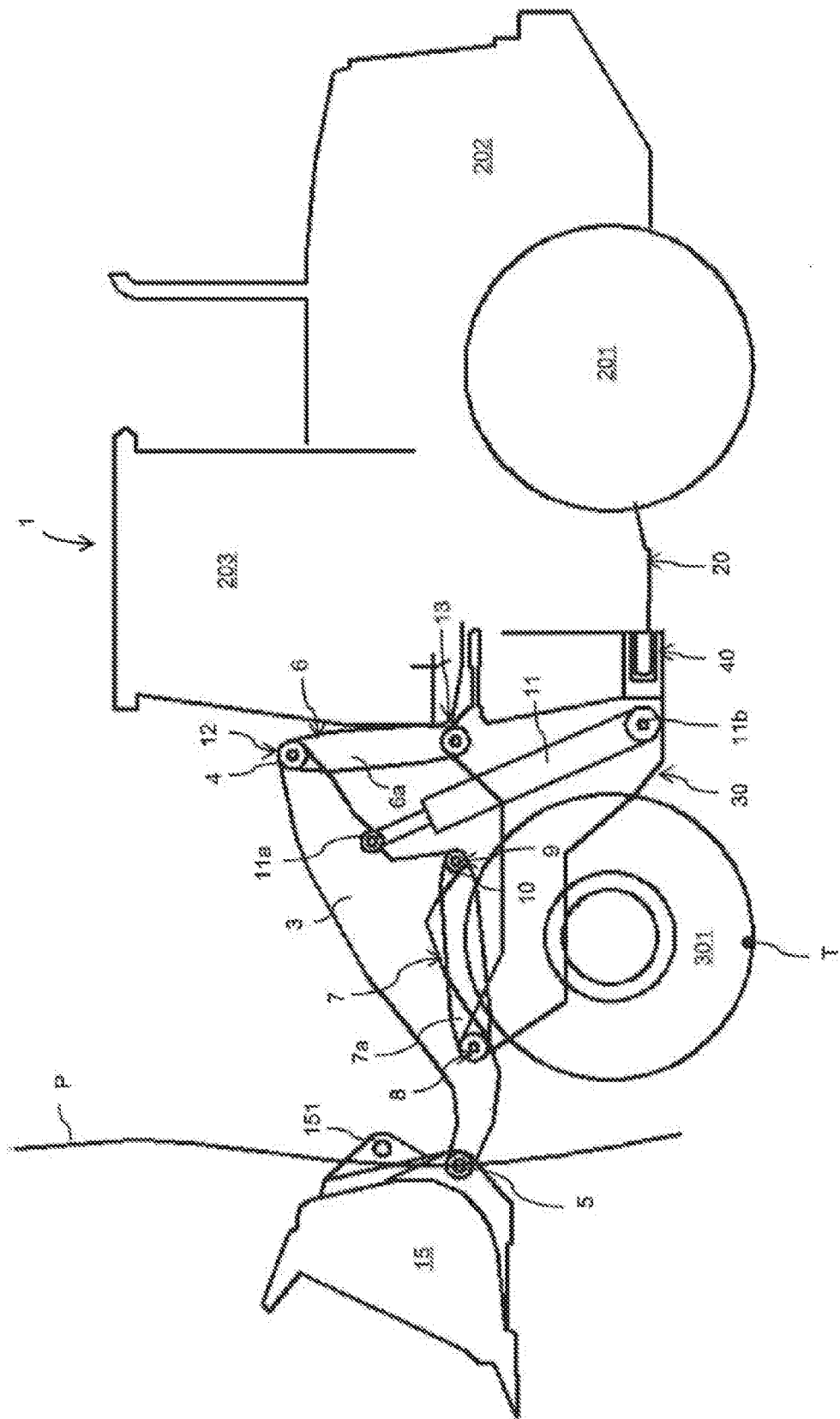




FIG. 4

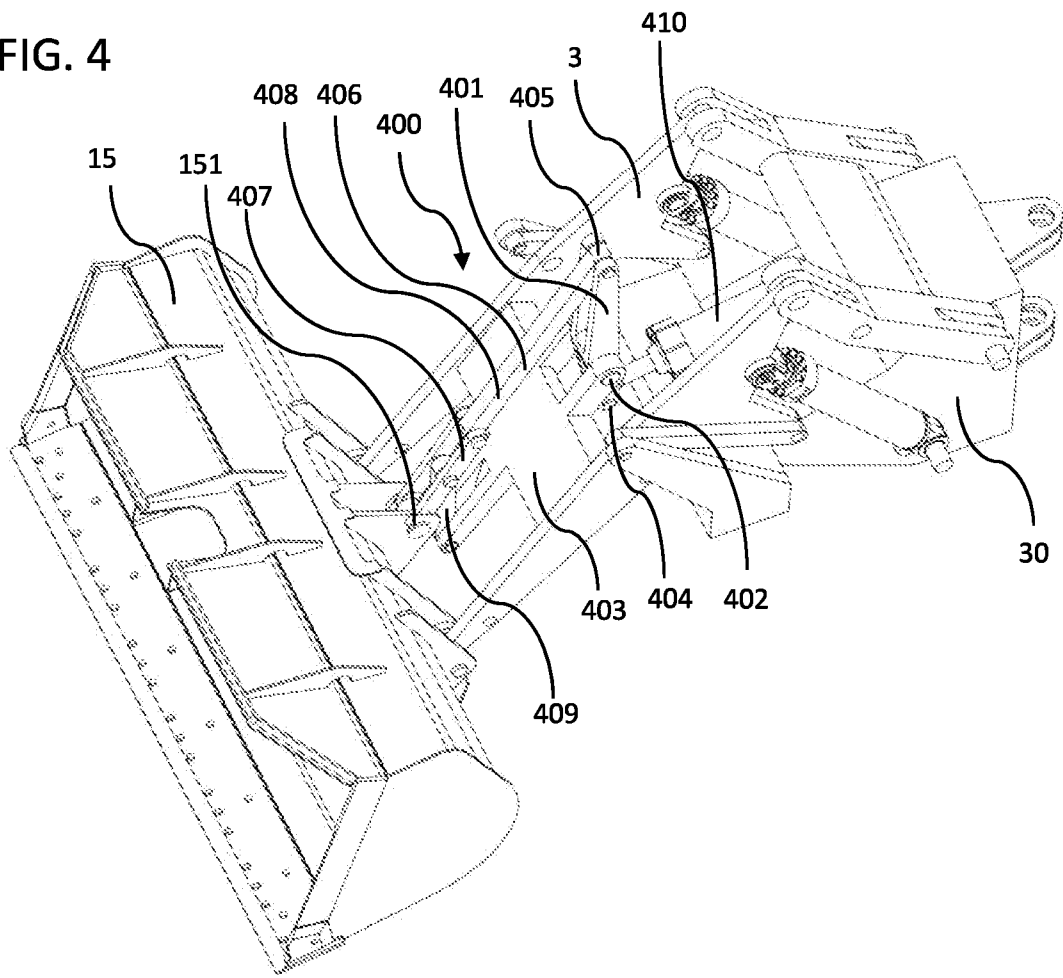


FIG. 5

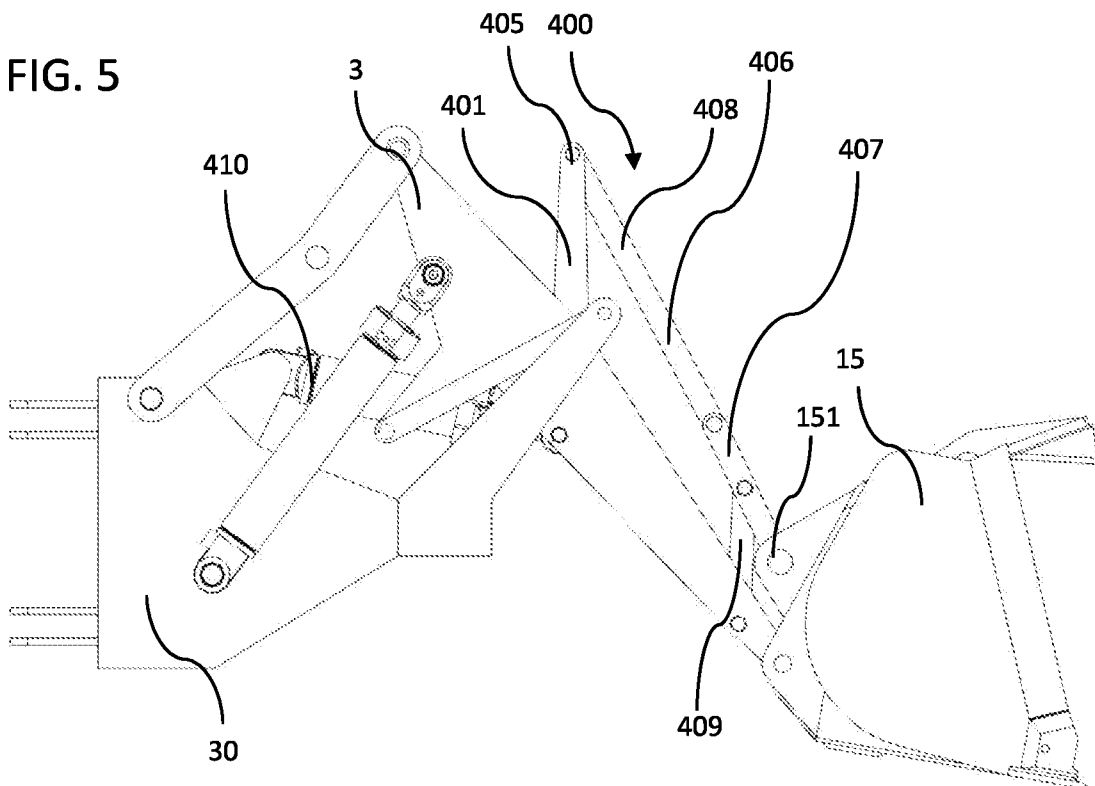




FIG. 7

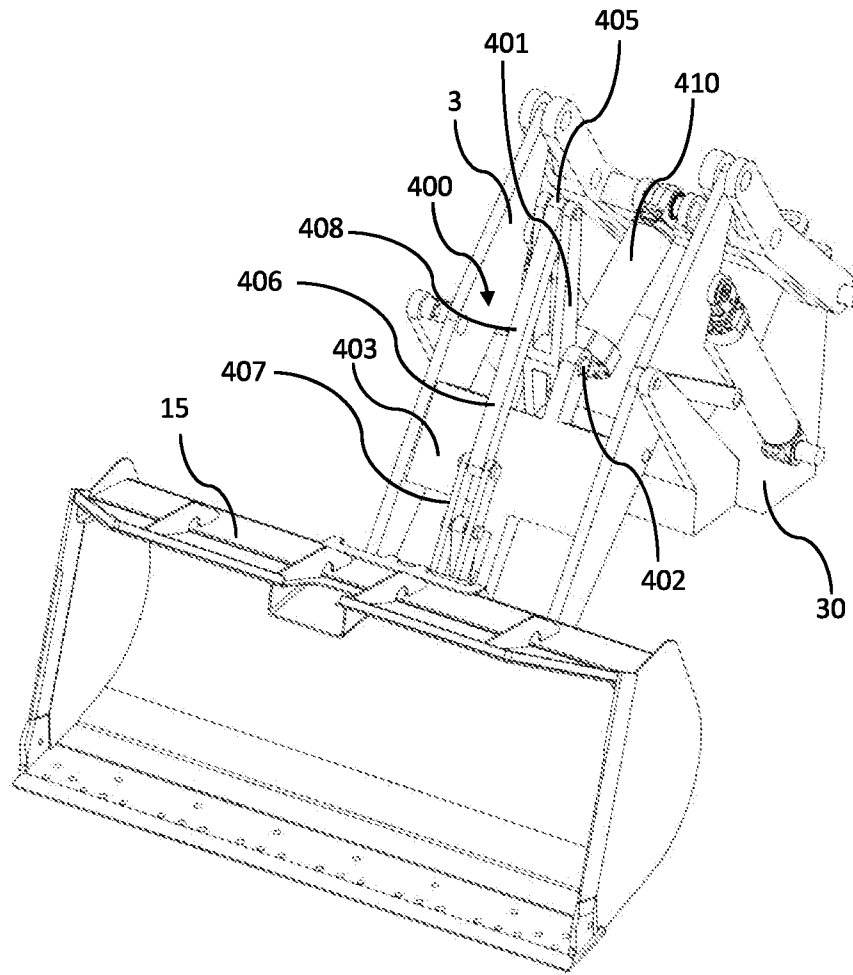
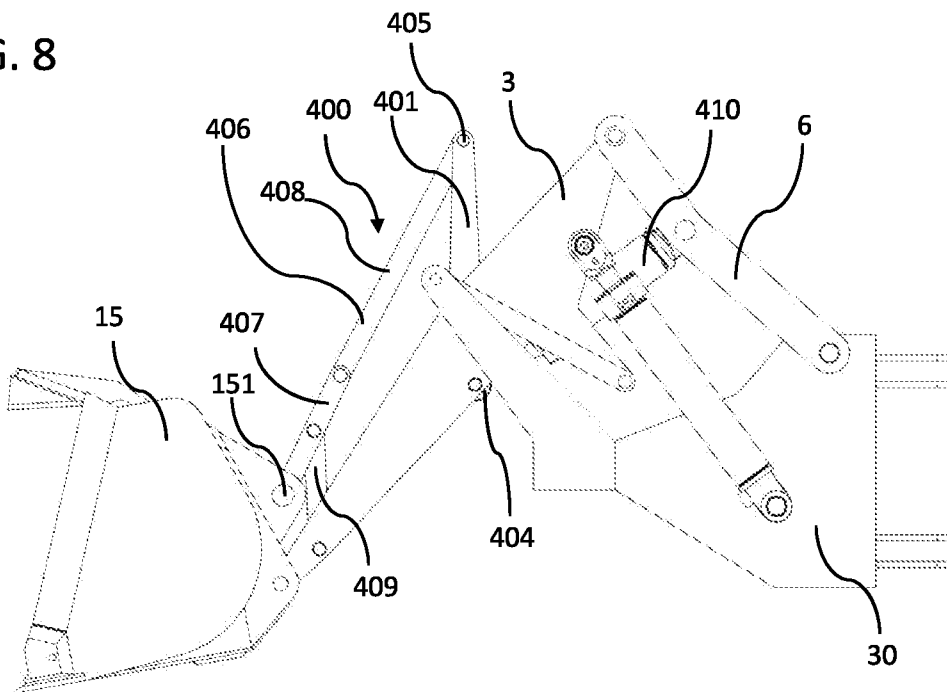


FIG. 8



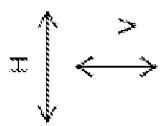
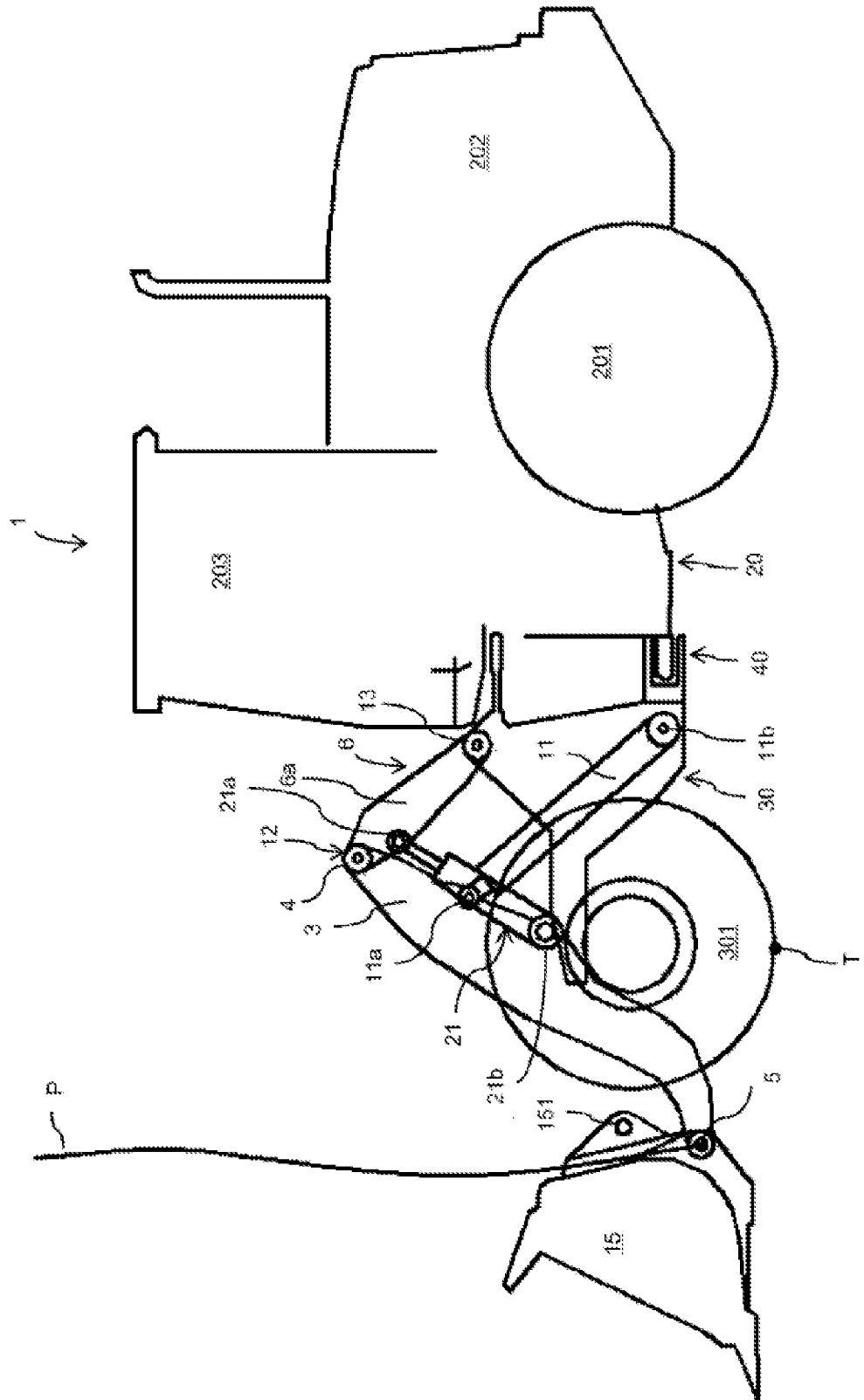


FIG. 9



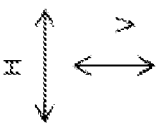


FIG. 10

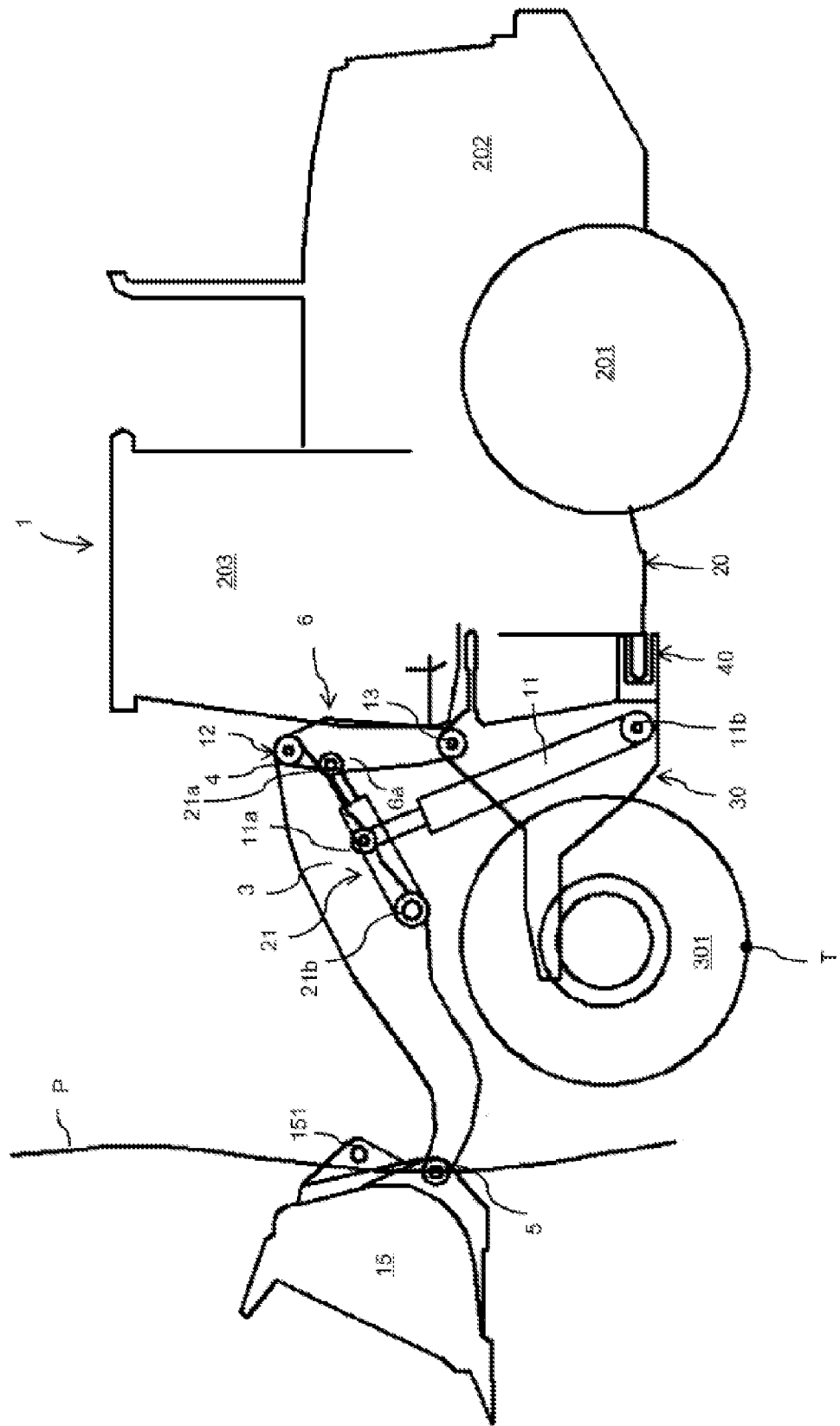
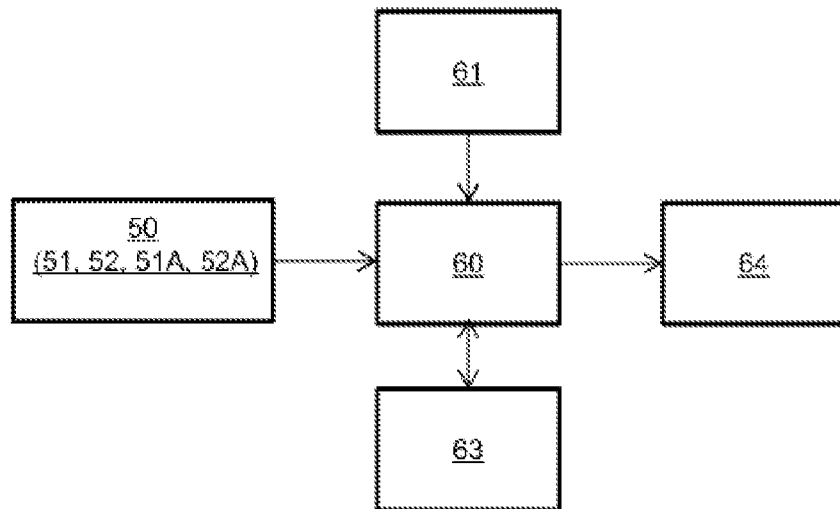




FIG. 12



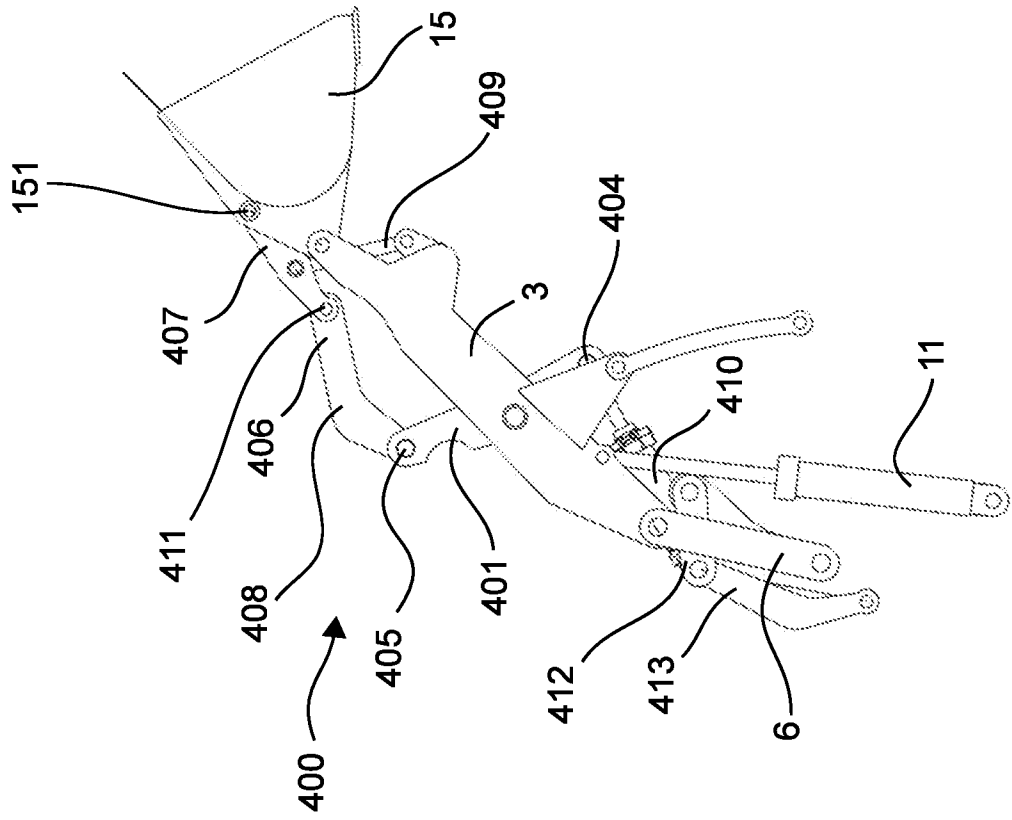
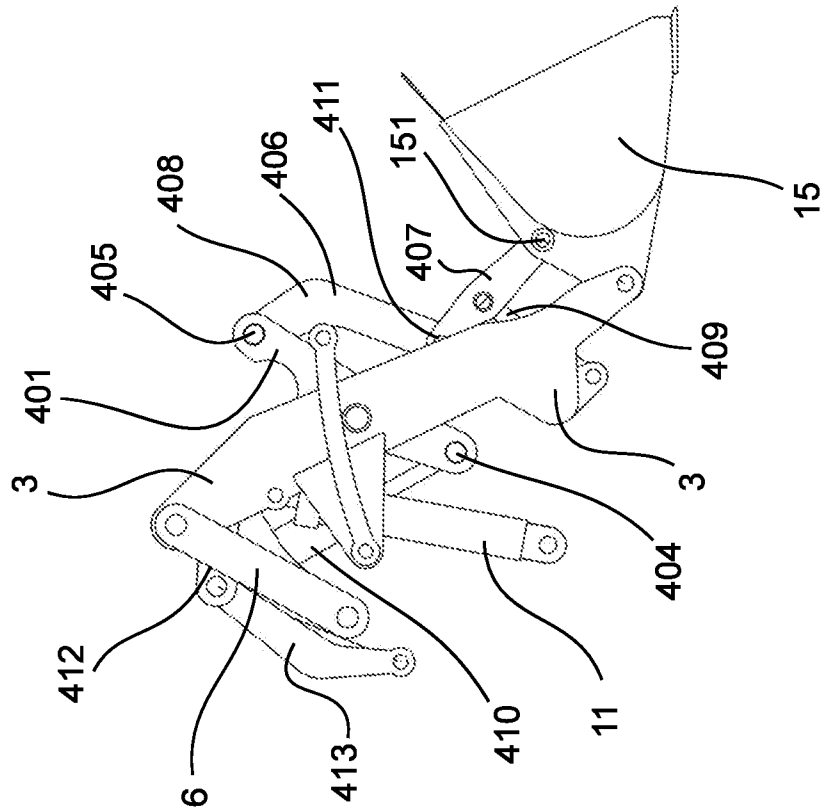


FIG. 13



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2018/117225

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
E02F 3/36(2006.01)i; B65G 65/04(2006.01)i; B66F 9/06(2006.01)i		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) E02F; B65G; B66F		
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) CPRSABS,CNKI,DWPI,SIPOABS,load,lift,arm,frame,tilt,chian,connector,link,hinge,guide,,cylinder		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
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 paragraphs17-24, figures1-2	1-15
X	CN 103790193 A (QINGDAO SHANDONG ENG MACHINERY MFG CO) 14 May 2014 (2014-05-14) See description paragraphs11, figures1-4	1-15
A	EP 3051032 A2 (GUANGXI LIUGONG MACHINERY CO) 03 August 2016 (2016-08-03) See the whole document	1-15
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A	US 3876101 A (CATERPILLAR TRACTOR CO) 08 April 1975 (1975-04-08) See the whole document	1-15
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "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 <b>11 February 2019</b>		Date of mailing of the international search report <b>06 March 2019</b>
Name and mailing address of the ISA/CN <b>National Intellectual Property Administration, PRC 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088 China</b>		Authorized officer <b>ZHAO,Xiaoming</b>
Facsimile No. (86-10)62019451		Telephone No. (86-10) 62085157

**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International application No.

**PCT/CN2018/117225**

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