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(54) Self-erecting crane

(57) A jib (10) for a crane (1) is foldable between an operation arrangement and a transportation arrangement, wherein in the operation arrangement a first jib element (13) and a second jib element (14) are coaxially arranged concerning a longitudinal axis (25) of the unfolded jib (10), wherein in the transportation arrangement the jib (10) is folded such that the first jib element axis (73) and the second jib element axis (74) are arranged parallel and spaced apart to each other, and wherein a first hinge axis (34; 49; 56; 66) of a jib connecting unit (17; 47; 54; 62) and a second hinge axis (35; 50; 57; 67) of the jib connecting unit (17; 47; 54; 62) are oriented transversally to a first jib connecting axis (20) and to a second jib connecting axis (22), respectively.

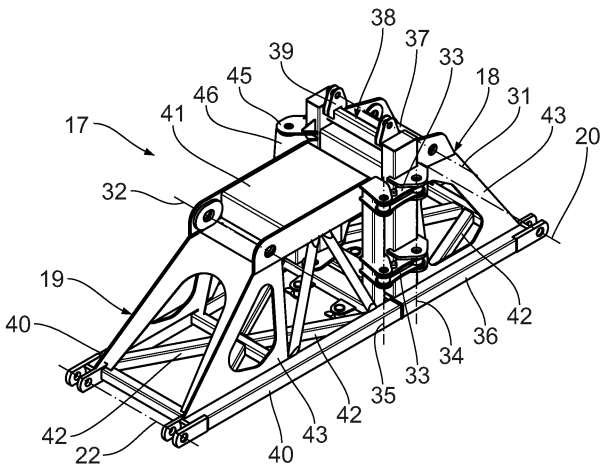

Fig. 5

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Description

[0001] EP 0 870 726 B 1 discloses a self-erecting crane with a sideways foldable jib in a transport position of the crane. A jib is foldable and comprises an intermediate folding jib element. However, the folding of the jib is limited due to the kinematics of the intermediate folding jib element.

[0002] It is a further aspect of the invention to provide a self-erecting crane with a foldable jib such that folding the jib between a transportation arrangement and an operation arrangement is enhanced.

[0003] This object is achieved according to the invention by a self-erecting crane comprising the features of claim 1.

[0004] According to the invention, it was recognized that the folding of a jib of a self-erecting crane is enhanced having a jib connecting unit comprising a first and a second jib connecting element which are articulated to each other at at least one vertical hinge axis. The at least one hinge axis is situated at least partially inside of the jib connecting unit. In particular, the hinge axis intersects a lower boom plane section of the first jib connecting element or of the second jib connecting element. The lower boom plane sections of the corresponding jib connecting elements in particular build a rectangular base having lower booms. In particular, the hinge axis intersects at least one of the lower booms. Thus, the hinge axis is not situated on one of the sides of the jib connecting unit. It is possible that the at least one hinge axis is situated completely inside the jib connecting unit. In particular, the hinge axis intersects the rectangular base and a rectangular roof built by an upper boom plane section. Since the hinge axis is integrated in the jib connecting unit, the stiffness of the jib connecting unit is enhanced.

[0005] Further, flexibility concerning the articulation of the jib connecting elements to each other is not affected. The jib connecting unit enables stable, secure and flexible folding of the jib.

[0006] A self-erecting crane according to claim 2 provides further flexibility for the handling of the jib connecting elements of the jib connecting unit. Since an additional, intermediate hinge axis is provided, the two hinge elements can be articulated at said intermediate hinge axis. An additional degree of freedom for kinematics of the hinge elements is provided.

[0007] A self-erecting crane according to claim 3 enables an offset of the first jib element and the second jib element along the longitudinal axis such that the first jib element and the second jib element are spaced apart from each other along the longitudinal axis.

[0008] A self-erecting crane according to claim 4 enables enhanced stiffness of the hinge elements since the intermediate hinge axis is coaxially arranged to a fixing axis of the hinge elements. The fixing axis enables fixing of the first jib connecting element with the second jib connecting element, in particular in the operation arrangement. Thus, the intermediate hinge axis provides multiple functionality.

[0009] A self-erecting crane according to claim 5 enables blocking of the articulation of the two hinge elements to each other around the intermediate hinge axis. For that purpose, each of the two hinge elements comprises a blocking bore, wherein in the offset arrangement of the two hinge elements said blocking bores are aligned concentrically. Thus, it is possible to block articulation of the two hinge elements by connecting said elements with a connecting element, such as a bolt. Then, the articulation around the intermediate hinge axis is prevented.

[0010] A self-erecting crane according to claim 6 enhances the handling of the jib, in particular during an operation, i. e. in operation arrangement of the jib. At least one fixing means is provided at the jib elements of the jib. Said fixing means can be realized by bores to be aligned concentrically in the operation arrangement of the jib such that the aligned bores are to be fixed with a bolt. However, other fixing means can be provided as well. In particular, said fixing means, in particular the bores to be aligned are arranged spaced apart from the first hinge axis and the second hinge axis. In particular, the bores are aligned concentrically to a fixing axis, wherein said fixing axis oriented parallel to the first hinge axis and the second hinge axis.

[0011] Embodiments of the invention will be described in more detail below with the add of the drawings:

Fig. 1 shows a side view of a self-erected crane in an operation arrangement

Fig. 2 an isometric view of the crane in fig. 1 in a transportation arrangement,

Fig. 3 a front view of the crane in fig. 2,

Fig. 4 a side view of a jib connecting unit according to a first embodiment of the invention.

Fig. 5 an isometric view of the jib connecting unit in fig. 4,

Fig. 6 a top view of a jib connecting unit in fig. 4,

Fig. 7 a top view corresponding to fig. 6 with the jib connecting unit in a transformation position,

Fig. 8 a top view corresponding to fig. 6, 7 in a further transformation position,

Fig. 9 a top view corresponding to fig. 6 to 8 in a transportation arrangement of the jib connecting unit,

Fig. 10 a side view of a jib connecting unit according to a further embodiment of the invention,

Fig. 11 a top view of the jib connecting unit in fig. 10

in the operation arrangement,

Fig. 12 a top view of the jib connecting unit corresponding to fig. 11 in a transformation position,

Fig. 13 a top view of the jib connecting unit corresponding to fig. 11, 12 in an other transformation position,

Fig. 14 a top view of the jib connecting unit corresponding to fig. 11 to 13 in an other transformation position,

Fig. 15 a top view of the jib connecting unit corresponding to fig. 11 to 14 in the transportation arrangement,

Fig. 16 a side view of a jib connecting unit according to a further embodiment of the invention,

Fig. 17 a top view of the jib connecting unit in fig. 16 in an operation arrangement,

Fig. 18 an isometric view of the jib connecting unit in fig. 16,

Fig. 19 a top view of the jib connecting unit corresponding to fig. 17 in a transformation position,

Fig. 20 a top view of the jib connecting unit corresponding to fig. 17 and 19 in a transportation arrangement,

Fig. 21 a side view a jib connecting unit according to a further embodiment of the invention,

Fig. 22 a top view of the jib connecting unit in fig. 21 in an operation arrangement,

fig. 23 an isometric view of the jib connecting unit in fig. 21,

Fig. 24 a top view of the jib connecting unit corresponding to fig. 22 in an offset arrangement,

Fig. 25 a top view of the jib connecting unit corresponding to fig. 22 and 24 in a transformation arrangement,

Fig. 26 a top view of the jib connecting unit corresponding to fig. 22, 24 and 25 in an other transformation position and

Fig. 27 a top view of the jib connecting unit corresponding to fig. 22 and 24 to 26 in a transportation arrangement.

[0012] Fig. 1 shows a side view of a self-erected crane 1. The crane 1 comprises a basic structure 2 with an undercarriage 3 which is supported on a ground 4 via struts 5. The basic structure 2 further comprises an upper carriage 6 to which a counter weight arrangement 7 comprising several stackable counter weights 8 is attached. A mast 9 is connected to the upper carriage 6 of the basic structure 2. The mast 9 is oriented vertically concerning the ground 4. The mast 9 comprises a mast longitudinal axis 24. The mast longitudinal axis 24 is vertically oriented. The mast 9 comprises several lattice sections arranged along the mast longitudinal axis 24. It is possible to provide the mast 9 telescopically, wherein a lower section of the mast comprises a larger cross sectional area than an upper section of the mast such that the upper section can be stacked into the lower section for space-saving arrangement of the mast 9 in a transportation arrangement.

[0013] At the tip of the mast 9 a jib 10 is articulated around a horizontal axis 11. The jib 10 is luffable around the horizontal axis 11. Thus, the horizontal axis 11 is also called luffing axis. A corresponding luffing plane is vertically oriented. The luffing plane is the drawing plane of fig. 1.

[0014] The jib 10 is slacked via slacking means 12 at the counter weight arrangement 7. The jib 10 comprises a first jib element 13, a second jib element 14, a third jib element 15 and a fourth jib element 16. The first jib element 13 comprises a first jib element axis 73. The second jib element 14 comprises a second jib element axis 74. The first jib element 13 is articulated at the horizontal axis 11 with the mast. The first jib element is also called jib foot element. The first jib element 13 and the second jib element 14 are connected via a connecting unit 17 with a first jib connecting element 18 and a second jib connecting element 19. The jib connecting unit 17 is explained in detail later.

[0015] The first jib element 13 is directly articulated at a first jib connecting axis 20 with the first jib connecting element 18. The first jib connecting axis 20 is arranged in the region of lower booms of the first jib element 13. In the region of upper booms of the first jib element 13 it is connected to the first connecting element 18 via a first telescopic cylinder 21.

[0016] The second jib element 14 is directly articulated at a second jib connecting axis 22 with the second jib connecting element 19. The second jib connecting axis 22 is horizontally oriented. The second jib connecting axis 22 is arranged in an area next to the lower booms of the second jib element 14. In an area of upper booms of the second jib element 14, the second jib element 14 is connected to the second jib connecting element 19 via a second telescopic cylinder 23.

[0017] The jib 10 comprises a longitudinal axis 25. In the arrangement of the crane 1 in fig. 1 the crane can be operated, in particular for lifting and lowering a load. The arrangement in fig. 1 is the so-called operation arrangement of the crane 1. In the operation arrangement of the crane 1 the jib 10 is unfolded, i. e. the first jib element

13, the second jib element 14, the third jib element 15 and the fourth jib element 16 are disposed along the longitudinal axis 25. In the operation arrangement, the first jib element 13 and the second jib element 14 are coaxially arranged concerning the longitudinal axis 25. The first jib element axis 73 is coincident with the longitudinal axis 25. The second jib element axis 74 is coincident with the longitudinal axis 25. As can be seen from fig. 1, the longitudinal axis 25 provides an inclination concerning the horizontal plane of about 5°. It is also possible to arrange the jib 10 in another luffing position, in particular with a luffing angle in a range between 0° to 25°, concerning the horizontal plane.

[0018] For lifting and lowering a load with the crane 1 a travelling trolley 29 is provided. The travelling trolley 29 is provided at lower booms of the jib 10. In particular, the travelling trolley 29 is guided at the lower booms of the jib 10. The travelling trolley 29 is driven by trolley motor 30 via cables.

[0019] The second jib element 14 is connected to the third jib element 15 via a first connecting element 26. The third jib element 15 and the fourth jib element 16 are connected with each other via a second connecting element 27. The fourth jib element 16 comprises a cross sectional area such that it can be nested onto the third jib element 15. In particular, the fourth jib element 16 has an essentially U-shaped cross section with an opening of the U at an upper end. When articulating the fourth jib element 16 at the second connecting element 27 counterclockwise in fig. 1 the fourth jib element 16 can be set on top of the third jib element 15, wherein the lattice elements of the third jib element 15 are disposed inside the open cross section of the fourth jib element 16. Thus, folding of the fourth jib element 16 onto the third jib element 15 does not lead an enlargement of the height of the jib 10.

[0020] In fig. 2 and 3 a folded arrangement of the crane 1 and in particular of the jib 10 is illustrated. The fourth jib element 16 is nested on the third jib element 15 as described above. The third jib element 15 and the fourth jib element 16 are connected via the second connecting element 27. Further, the second jib element 14 is connected via the vertically arranged first connecting element 26 with the third jib element 15. As shown in fig. 2, the third jib element 15 together with the fourth jib element 16 are arranged on the second jib element 14. Since the third jib element 15 is folded on the second jib element 14 using the first connecting element 26, the fourth jib element 16 is arranged between the second jib element 14 and the third jib element 15. That means that the third jib element 15 is in the transportation arrangement according to fig. 2 articulated with 180° around a horizontal axis of the first connecting element 26 and is therefore in a reversed arrangement. The second jib element 14 is connected via the jib connecting unit 17 to the first jib element 13. The first jib element 13 is arranged behind the second jib element 14, third jib element 15 and fourth jib element 16 as illustrated in fig. 2. That means that the first jib element 13 and the second jib element 14 are not arranged on top of each other but besides each other.

[0021] As best seen in fig. 3, the first jib connecting element 18 and the second jib connecting element 19 are articulated with respect to each other. The first jib element 13 is arranged on top of the mast 9. The mast longitudinal axis 24, the first jib element axis 73 and the second jib element axis 74 are arranged at corners of a triangle 28 which is schematically illustrated in fig. 3. In particular, the mast 9, first jib element 13 and the second jib element 14 are not stacked on each other such that their corresponding axes 24, 73, 74 are arranged along one direction. Thus, it is possible to dispose the second jib element 14 besides the mast 9 and the first jib element 13. The height of the crane 1 in the transportation arrangement as illustrated in fig. 2 and 3 is reduced.

[0022] A first embodiment of the jib connecting unit 17 is illustrated in fig. 4 to fig. 9. The jib connecting unit 17 comprises the first jib connecting element 18 and the second jib connecting element 19. The first jib connecting element 18 provides openings arranged concentrically to the first jib connecting axis 20. Additional openings are provided concentrically to a first cylinder hinge axis 31.

[0023] The second jib connecting element 19 provides openings concentrically arranged concerning the second jib connecting axis 22. Further openings are provided concentrically around a second cylinder hinge axis 32. The jib connecting axes 20, 22 and the cylinder hinge axes 31, 32 are oriented parallel to each other. In particular, said axes 20, 22, 31 and 32 are horizontally oriented. Said axes 20, 22, 31 and 32 are oriented perpendicular to the longitudinal axis 25 of the jib 10.

[0024] The first jib connecting element 18 is connected with the second jib connecting element 19 via two hinge elements 33. Each hinge element 33 is provided as a connecting rod articulated at a first hinge axis 34 with the first jib connecting element 18 and articulated at a second hinge axis 35 with the second jib connecting element 19. The first hinge axis 34 and the second hinge axis 35 are arranged to each other with a lateral offset D to each other, wherein said offset D is oriented perpendicular to said first hinge axis 34 and to said second hinge axis 35. In particular, the lateral offset D is oriented parallel to the longitudinal axis 25 of the jib 10.

[0025] Both, the first jib connecting element 18 and the second jib connecting element 19 each comprises a cross section oriented perpendicular to the longitudinal axis 25, wherein said cross section is of trapezoid shape. The trapezoid comprises a bottom in form of a lower first boom plane section defined by two lower first booms 36 extending along the longitudinal axis 25. A roof of the trapezoid is provided in form of an upper first boom plane section. The upper first boom plane section is provided by an upper first plate element 37. The first cylinder hinge axis 31 intersects the upper first plate element 37. The first jib connecting axis 20 intersects each of the lower first booms 36 at free ends facing the first jib element 13. The upper first plate element 37 comprises an inclination

concerning an horizontal plane.

[0026] At an upper end 38 of the first jib connecting element 18 receiving means 39 are provided for receiving rope guiding means, e. g. rope discs, or for receiving structural parts of the jib, e.g. struts.

[0027] The second jib connecting element 19 comprises lower second booms 40 defining a lower second boom plane section. Further, an upper second plate element 41 defines an upper second boom plane section. The upper second boom plane section may comprise at least partially an inclination. The trapezoid of the second jib connecting element 19 has a bottom in form of the lower second boom plane section and a roof in form of an upper second boom plane section.

[0028] The upper first boom plane section has a width W_{U1}. The lower first boom plane section has a width W_{L1}. The lower second boom plane section comprises a width $W_{L2.}$ The upper second boom plane section comprises a width W_{U2}. As best seen from fig. 6 width W_{U1} of the upper boom plane section of the first jib connecting element 18 is nearly identical to the width W_{U2} of the upper boom plane section of the second jib connecting element 19. Further, the width W_{L1} of the lower boom plane section of the first jib connecting element 18 is nearly identical to the width W_{L2} of the lower boom plane section of the second jib connecting element 19. The widths W_{U1}, W_{U2} of the upper boom plane sections of the jib connecting elements 18, 19 each are more narrow than the widths W_{L1}, W_{L2} of each corresponding lower boom plane section.

[0029] Each of the lower boom plane sections comprises several stiffening struts 42. The lower first boom plane sections are each connected with the corresponding upper first plate elements 37, 41 with stiffening plates 43. The stiffening plates 43 each comprise a window for reduction of the material amount and therefore for reduction of the weight.

[0030] As best seen from fig. 6 both, the first hinge axis 34 and the second hinge axis 35 intersect the corresponding lower boom plane section. According to the first embodiment of the invention, the first hinge axis 34 and the second hinge axis 35 intersect at least the lower booms 36, 40.

[0031] Each of the hinge elements 33 comprises a stopping pin 44 in order to provide a defined positioning of the first jib connecting element 18 relative to the second jib connecting element 19.

[0032] The hinge elements 33 are concentrically arranged concerning the first hinge axis 34 and the second hinge axis 35. The two hinge elements 33 are spaced apart from each other along the first hinge axis 34 and along the second hinge axis 35.

[0033] The first jib connecting element 18 provides a first fixing means 45 and the second jib connecting element 19 comprises a second fixing means 46. Both fixing means 45, 46 comprise an opening, wherein said openings 45, 46 are aligned with each other in the operation arrangement of the jib connecting unit 17 as illustrated in fig. 4 to 6. Thus, the first jib connecting element 18 and the second jib connecting element 19 can be fixed to each other e. g. by using a bolt in the aligned bores of the fixing means 45, 46 such that an articulation of the first jib connecting element 18 relative to the second jib connecting element 19 along at least one of the hinge axis 34, 35 is prevented.

[0034] In the following, a transformation of the crane 1 and in particular of the jib connecting unit 17 from the operation arrangement in fig. 6 to the transportation arrangement in fig. 9 is described.

[0035] For understanding the whole self-erecting process of the crane 1 is to be understood that starting from the operation arrangement of the crane 1 with the linear, unfolded arrangement of the jib 10, the jib elements 13 to 17 are disposed coaxially to the longitudinal axis 25. Starting the folding means folding the fourth jib element 16 with the second connecting element 27 onto the third jib element 15. Further, the third jib element 15 together with the folded fourth jib element 16 are folded via the first connecting element 26 onto the second jib element 14. Thus, a labyrinth-like arrangement of the second jib element 14, the third jib element 15 and the fourth jib element 16 results as shown in fig. 2. Further, the second jib element 14 together with the third jib element 15 and the fourth jib element 16 are articulated around the second connecting axis 22 from a nearly horizontal arrangement in fig. 1 counterclockwise for approximately 90°. This articulation is provided by the second telescopic cylinder 23. In a similar manner the first telescopic cylinder 21 is used to articulate the first jib element 13 at the first jib connecting axis 20 towards the jib connecting unit 17 clockwise for approximately 90° such that in the folded arrangement of the jib 20 the first jib element 13 and the second jib element 14 are arranged such that the telescopic cylinders 21, 23 are neighboring. This folding is a first folding step, wherein the first jib element 13 and the second jib element 14 are folded concerning the jib connecting unit 17. The folding takes place in a vertical plane around the first jib connecting axis 20 and the second jib connecting axis 22.

[0036] A second folding step is provided by the jib connecting unit 17 itself. The second folding step provides a folding in a horizontal plane and in particular out of said vertical plane. The jib connecting unit 17 is also called a bi-fold hinge connecting element for a jib boom.

[0037] In particular, the second folding step is illustrated in fig. 6 to 9. Starting from the fixed arrangement of the jib connecting unit 17 in fig. 6, the fixation is released by releasing the bolt fixing the fixing means 45, 46. Thus, it is possible to articulate the second jib connecting element 19 at the second hinge axis 35. A 90° rotational transformation position is given in fig. 7. Then, the second jib connecting element 19 together with the two hinge elements 33 are rotated around the first hinge axis 34 in a counterclockwise direction according to fig. 8. A final position of the second jib connecting element 19 is illustrated in fig. 9, wherein the first jib connecting element

18 and the second jib connecting element 19 are arranged next to each other and parallel to each other. Since the hinge elements 33 are essentially oriented perpendicular to each longitudinal axis of the first jib connecting element 18 and the second jib connecting element 19, both jib connecting elements 18, 19 are disposed to each other with a maximum lateral offset which is identical to the lateral offset D of the hinge axis 34, 35 as indicated in fig. 6. It is possible to provided further pivoting of the first jib connecting element 18 and/or the second jib connecting element 19 concerning the hinge elements 33 such that the lower first booms 36 and the lower second booms 40 are arranged closer to each other and in particular are in contact with each other. As it is illustrated in fig. 9, it is possible to pivot the first jib connecting element 18 to the left, wherein the parallel orientation of the first jib connecting element 18 to the second jib connecting element 19 is maintained. It is also possible to pivot the first jib connecting element 18 to the right and also maintain the parallel orientation of the jib connecting elements 18, 19 to each other. Maintaining the parallel orientation of the jib connecting elements 18, 19 means that the corresponding facing sides of the jib connecting elements 18, 19 at which the jib connecting elements 18, 19 are connected in the operation arrangement are oriented parallel to each other. However, the facing sides of the jib connecting elements 18, 19 may be arranged in different vertical planes having a lateral offset concerning the longitudinal axis 25 which is perpendicular to each of the vertical planes. A margin of an offset in a direction parallel to the longitudinal axis 25 is approximately two times the lateral offset D. As indicated in fig. 9 the jib connecting elements 18, 19 are arranged to each other such that the hinge element 33 are oriented perpendicular to the longitudinal axis 25. It is possible to maintain for instance the first jib connecting element 18 in the position according to fig. 9 and to rotate the second jib connecting element 19 together with the hinge element 33 around the first hinge axis 34, wherein the main orientation of the second jib connecting element 19 which is parallel to the first jib connecting element 18 is maintained. Such rotation is possible until the second jib connecting element 19 with the lower second boom 40, i.e. the upper one in fig. 9, is in direct contact with the lower first boom 36 of the first jib connecting element 18, i.e. the lower one in fig. 9.

[0038] It is also possible to pivot the second jib connecting element 19 together with the hinge element 33 around the first jib connecting axis 34 counterclockwise until the lower booms 36, 40 contact each other.

[0039] Obviously, it is also possible to maintain the second jib connecting element 19 in position and to provide a rotation of the first jib connecting element 18 together with the hinge element 33 around the second hinge axis 35. A lateral difference, i.e. the margin of the offset in the direction parallel to the longitudinal axis 25 of the vertical plane in both arrangements as already explained above is approximately two times the lateral offset D.

[0040] A further embodiment of a jib connecting unit of a jib according to the invention is illustrated in fig. 10 to 15. Components that correspond to those as described in previous figs. 1 to 9 have identical reference signs.

[0041] The jib connecting unit 47 differs from the jib connecting unit 17 essentially in that only one hinge element 48 is provided. The hinge element 48 is provided as a connecting rod, but having an enlarged height along a first hinge axis 49 compared to the connecting rods 33. Thus, the single piece hinge element 48 has an enhanced stiffness concerning the two separate hinge elements 33 of the first embodiment.

[0042] Further, the hinge element 48 is integrated in the jib connecting unit 47 such that the first hinge axis 49 and the second hinge axis 50 intersect not only the lower booms 36, 40 of the corresponding lower boom plane sections, but an intermediate section arranged between two parallel corresponding booms 36 and 40, respectively.

[0043] A further difference concerning the first embodiment of the jib connecting unit 17 is the upper second plate element 51 which clearly comprises an inclination concerning a horizontal plane.

[0044] In addition, the first jib connecting axis 52 and the second jib connecting axis 53 are provided with a height-offset concerning the lower booms 36, 40. However, the jib connecting axis 52, 53 are arranged in region of the lower boom plane sections.

[0045] In the following, the second folding step, i. e. the folding of the jib connecting unit 47 is described concerning figs. 11 to 15. Starting from the fixed arrangement in the operation arrangement in fig. 11, the fixation of the first fixing means 45 and the second fixing means 46 is released. As illustrated in fig. 12, it is possible to provide a transversal offset of the first and the second jib connecting elements. That means that both jib connecting elements 18, 19 are arranged along the longitudinal axis 25 but not coaxially concerning said axis 25. Said arrangement is achieved by pivoting the hinge element 48 counterclockwise around the second hinge axis 50. In a next transformation step the hinge element 48 is pivoted around the first hinge axis 49 on the one hand and also around the second hinge axis 50 on the other hand. After that, the second jib connecting element 19 is pivoted together with the hinge element 48 around the first hinge axis 49 in a 90° position (fig. 14). In a last transformation step the second jib connecting element 19 is pivoted around the second hinge axis 50 only in a parallel arrangement of the both jib connecting elements (fig. 15). As previously explained concerning the first embodiment of the jib connecting unit of the invention, also the second embodiment provides an offset of the jib connecting elements relative to each other. However, the amount of the offset is reduced, since the hinge axis 49, 50 are provided deeper inside the corresponding cross sectional areas.

[0046] A further embodiment of a jib connecting unit of a jib according to the invention is illustrated in figs. 16 to

20. Components that correspond to those as described in previous figs. 1 to 15 have identical reference signs.

[0047] A jib connecting unit 54 according to a further embodiment of the invention comprises one single hinge element 55. The hinge element 55 is attached to the first connecting element 18 and the second jib connecting element 19 such that the first hinge axis 56 and the second hinge axis 57 are provided inside the corresponding lower boom plane sections, respectively. The fixing axis at which the first fixing means 58 and the second fixing means 59 articulated with each other is disposed in an intermediate plane of the jib connecting element 54. Said intermediate plane is vertically oriented and contains the longitudinal axis 25 of the jib 10. The main difference of the jib connecting element 54 regarding previously described embodiments is the hinge element 55. From an upper end a lower horizontally extending plate two positioning pins 60 are vertically extending. The positioning pins 60 are of importance for the transformation procedure as described in the following.

[0048] Starting from the operation arrangement of the jib connecting element 54 in fig. 17, the second jib connecting element 19 is articulated with the hinge element 55 around the first hinge axis 56 into the arrangement as shown in fig. 19. An articulation around the first hinge axis 56 is automatically stopped when one of the positioning pins 60 reaches a corresponding recess 61 of the first jib connecting element 18. Thus, further articulation of the hinge element 55 around the first hinge axis 56 counterclockwise is prevented. For further transformation of the jib connecting unit 54 than the second jib connecting element 19 is articulated around the second hinge axis 57 into a position of the transportation arrangement in fig. 20. Said transportation arrangement is reached when the second positioning pin 60 is disposed in a second recess 61 of the second jib connecting element 19. Thus, the transportation arrangement of fig. 20 is secured by the position pins 60 each arranged in a corresponding recess 61. However, it is possible to articulate the second jib connecting element 19 together with the hinge element 55 around the first hinge axis 56 clockwise or to articulate the first jib connecting element 18 together with the hinge element 55 around the second hinge axis 57 counter clockwise such that the first jib connecting element 18 and the second jib connecting element 19 are arranged side by side with contact between the lower booms 36 and 40.

[0049] A further embodiment of a jib connecting unit of a jib according to the invention is illustrated in figs. 21 to 27. Components that correspond to those as described in previous figs. 1 to 20 have identical reference signs.

[0050] The main difference of the jib connecting unit 62 concerning previously described embodiments is the feature that a first hinge element 63 and a second hinge element 64 are provided, wherein said two hinge elements 63, 64 are articulated at an intermediate hinge axis 65. That means the first hinge element 63 is articulated at the first hinge axis 66 with the first jib connecting element 18. The second hinge element 64 is articulated at the second hinge axis 67 with the second jib connecting element 19. Both hinge elements 63, 64 are pivotally connected with each other around the intermediate hinge axis 65. In the operation arrangement of the jib connecting unit 62 as illustrated in figs. 21 to 23 the intermediate hinge axis 65 is coaxially arranged to a fixing axis at which the first fixing means 68 of the first jib connecting element 18 and the second fixing means 69 of the second jib connecting element 19 are fixed with each other. Thus, the operation arrangement of the jib connecting unit 62 is also a connecting arrangement in which the first jib connecting element 18 and the second jib connecting element 19 are directly connected to each other. By releasing the fixation of the first fixing means 68 with the second fixing means 69 it is possible to provide relative displacement of the first jib connecting element 18 and the second jib connecting element 19 to each other.

[0051] An articulation of the first and the second hinge elements 63, 64 enables an offset arrangement of the jib connecting unit 62 as illustrated in fig. 24. The offset arrangement provides an axial offset A. the offset is oriented along the longitudinal axis 25.

[0052] The offset arrangement is reached when the first hinge axis 66, the second hinge axis 67 and the intermediate hinge axis 65 are disposed on straight line 70. Said virtual line 70 is parallel to the longitudinal axis 25. In this offset arrangement blocking bores 71 which are provided in both, the first hinge element 63 and the second hinge element 64 are coaxially aligned. It is possible to connect the first hinge element 63 and the second hinge element 64 with a non-shown connecting element such as a bolt. Thus, the first hinge element 63 and the second hinge element 64 are connected with each other at the intermediate hinge axis 65 and at the blocking bores 71. Thus, an articulation of the first hinge element 63 concerning the second hinge element 64 is not longer enabled when using the connecting element in the blocking bores 71. The first hinge element 63 and the second hinge element 64 together build a common hinge element 63, 64 which comprises enhanced stiffness concerning the first hinge element 63 and the second hinge element 64 articulated at the intermediate hinge axis 65.

[0053] In the offset arrangement as illustrated in fig. 24 the intermediate hinge axis 65, the blocking bores 71 and the second fixing means 69 are arranged on a line 72 which essentially perpendicular to the line 70 and the longitudinal axis 25. However, it is not necessary to provide such aligned arrangement.

[0054] After transformation of the jib connecting unit 62 from the operation arrangement in figs. 21 to 23 to the offset arrangement as illustrated in fig. 24 a further transformation of the jib connecting unit 62 is enabled using the blocked common hinge element 63, 64. Starting from the offset arrangement in fig. 24, the second jib connecting element 19 is articulated at the second hinge axis 67 counterclockwise. After that the second jib connecting element 19 together with the common hinge element 63,

64 is articulated at the first hinge axis 66 counterclockwise relative to the first jib connecting element 18. In a last step the second jib connecting element 19 is articulated at the second hinge axis 67 counterclockwise such that the first jib connecting element 18 and the second jib connecting element 19 are oriented parallel, i. e. such that the lower booms 36 and 40 are oriented parallel. As illustrated in fig. 27 it is possible to arrange the common hinge element 63, 64 in a position such that the line 70 is not perpendicular to the longitudinal axis 25.

Claims

1. A self-erecting crane, comprising a foldable jib (10) having at least a first jib element (13), a second jib element (14) and a third jib element (15), a jib connecting unit (17; 47; 54; 62) connecting the first jib element (13) and the second jib element (14), wherein the second jib element (14) and the third jib element (15) of the folded jib (10) is arranged on a side of a mast (9) of the crane (1) in a transportation position,
wherein the jib connecting unit (17; 47; 54; 62) further comprises

a) a first jib connecting element (18) having a rectangular base, wherein said first jib connecting element (18) is connected to the first jib element (13) in the area of lower booms (36) at a transverse first jib connecting axis (20) and wherein said first jib connecting element (18) is connected to the first jib element (13) via a first telescopic cylinder (21) to upper booms of the first jib element (13),
b) a second jib connecting element (19) having a rectangular base, wherein said second jib connecting element (19) is connected to the second jib element (14) in the area of lower booms (40) at a transverse second jib connecting axis (22) and wherein said second jib connecting element (19) is connected to the second jib element (14) via a second telescopic cylinder (23) to upper booms of the second jib element (14),
c) a hinge element (33; 48; 55; 63, 64) joining the first jib connecting element (18) to the second jib connecting element (19), wherein the hinge element (33; 48; 55; 63, 64) determines at least one vertical hinge axis (34, 35; 49, 50; 56, 57; 66, 67), and
d) non-permanent fixing means (45, 46; 58, 59; 68, 69) for interlocking the jib connecting element (18) with the second jib connecting element (19) in an operation position of the crane (1),

characterized in that
the at least one hinge axis (34, 35; 49, 50; 56, 57; 66, 67) is situated at least partially inside the jib connecting unit (17; 47; 54; 62).

2. The self-erecting crane according to claim 1, **characterised by** two hinge elements (63, 64) being articulated at an intermediate hinge axis (65).

3. The self-erecting crane according to claim 2, **characterised in that** the two hinge elements (63, 64) are displaceable between a connecting arrangement and an offset arrangement, wherein in the connecting arrangement the first jib connecting element (18) and the second jib connecting element (19) are directly connected to each other, and wherein in the offset arrangement the first jib connecting element (18) and the second jib connecting element (19) are spaced apart from each other along the longitudinal axis (25) with an axial offset (A).

4. The self-erecting crane according to claim 3, **characterised in that** the intermediate hinge axis (65) is coaxially arranged to a fixing axis at which the first jib connecting element (18) and the second jib connecting element (19) are fixed with each other, in particular in the operation arrangement.

5. The self-erecting crane according to claim 3 or 4, **characterised in that** each of the two hinge elements (63, 64) comprises a blocking bore (71), wherein in the offset arrangement said blocking bores (71) are aligned coaxially and are connected by a connecting element such that articulation around the intermediate hinge axis (65) is prevented.

6. The self-erecting crane according to one of the preceding claims, **characterised in that** the first jib connecting element (18) and the second jib connecting element (19) each provide at least one fixing means (45, 46; 58, 59; 68, 69) to be fixed to each other, in particular in the operation arrangement of the jib (10).

7. The self-erecting crane according to one of the claims 2 to 5, **characterized in that** a first hinge element (63) is articulated at a first hinge axis (66) with the first jib connecting element (18) and a second hinge element (64) is articulated at a second hinge axis (67) with the second jib connecting element (19), wherein in the offset arrangement the first hinge axis (66), the second hinge axis (67) and the intermediate hinge axis (65) are disposed on a straight line (70).

8. The self-erecting crane according to claim 7, **characterized in that** the line (70) is parallel to a longitudinal axis (25) of the jib (10).

9. The self-erecting crane according to one of the preceding claims, **characterized in that** the at least one

hinge axis (34, 35; 49, 50; 56, 57; 66, 67) intersects a lower boom plane section of the first jib connecting element (18) or of the second jib connecting element (19).

10. The self-erecting crane according to claim 9, **characterized in that** the lower boom plane section builds a rectangular base having lower booms (40), wherein the at least one hinge axis (34, 35; 49, 50; 56, 57; 66, 67) intersects at least one of the lower booms (40).

11. The self-erecting crane according to one of the preceding claims, **characterized in that** the at least one hinge axis (34, 35; 49, 50; 56, 57; 66, 67) is situated completely inside the jib connecting unit (17; 47; 54; 62).

12. The self-erecting crane according to one of the preceding claims, **characterized in that** the at least one hinge axis (34, 35; 49, 50; 56, 57; 66, 67) intersects a rectangular base built by a lower boom plane section and a rectangular roof built by an upper boom plane section.

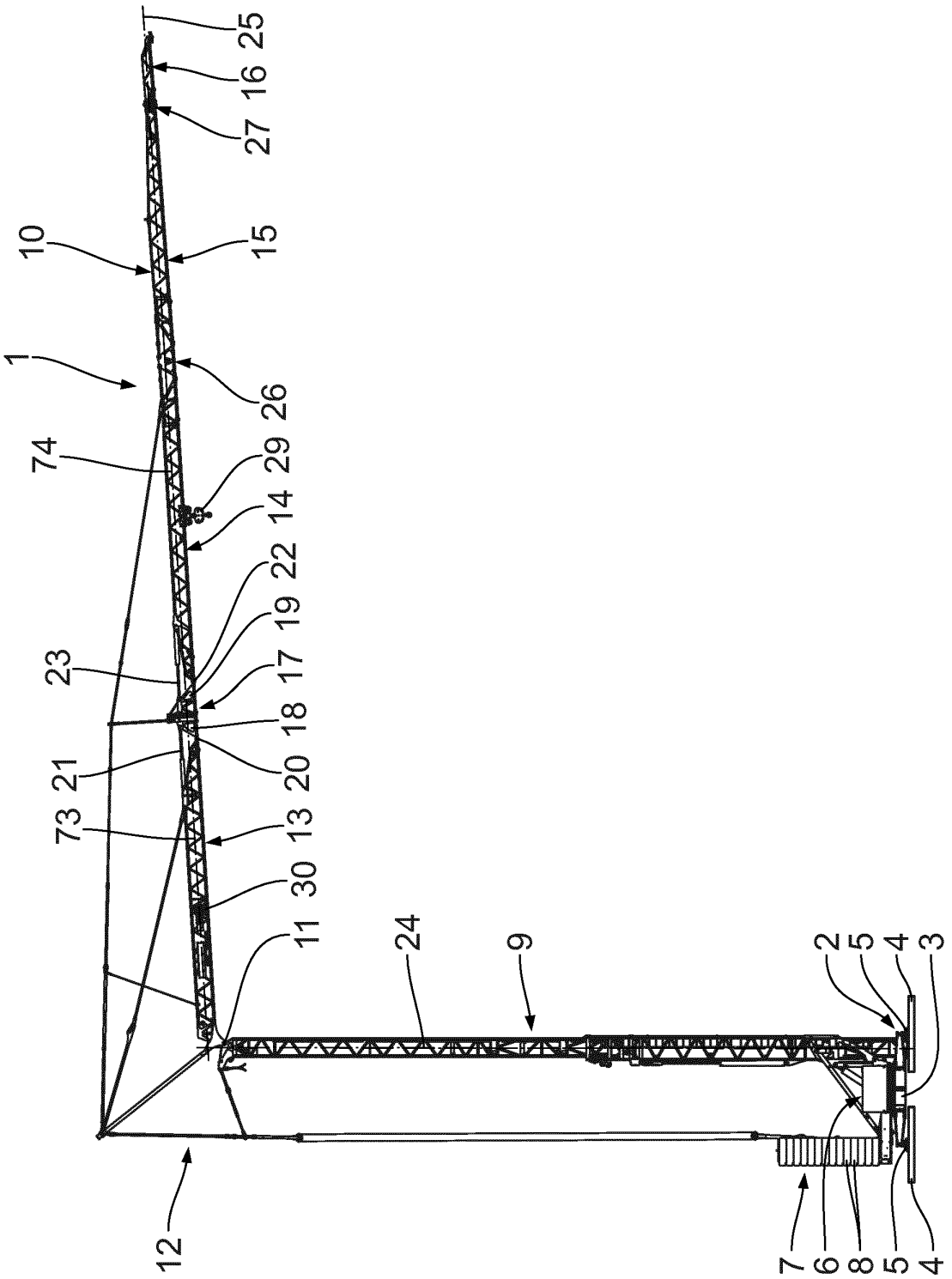
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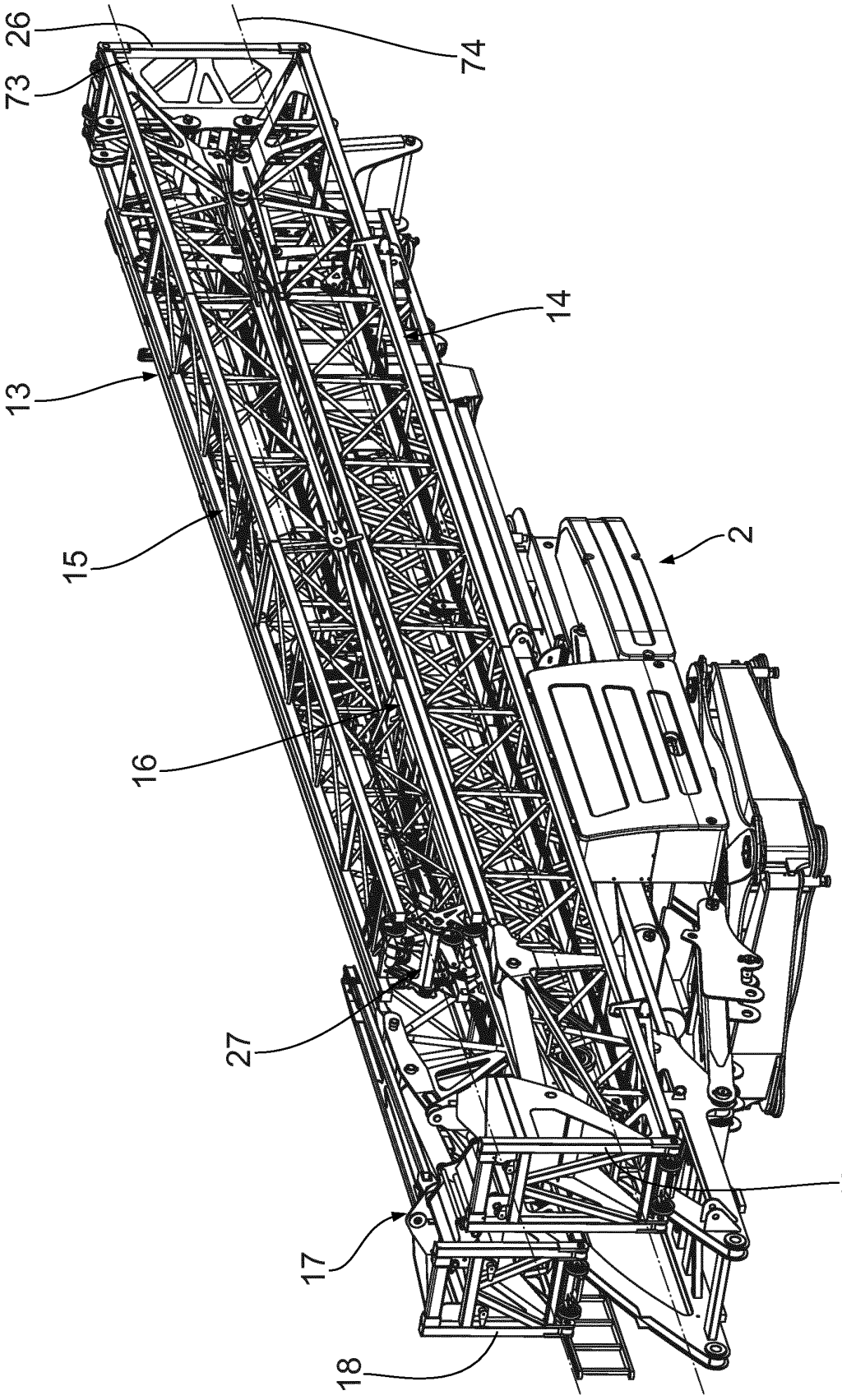
Fig. 1



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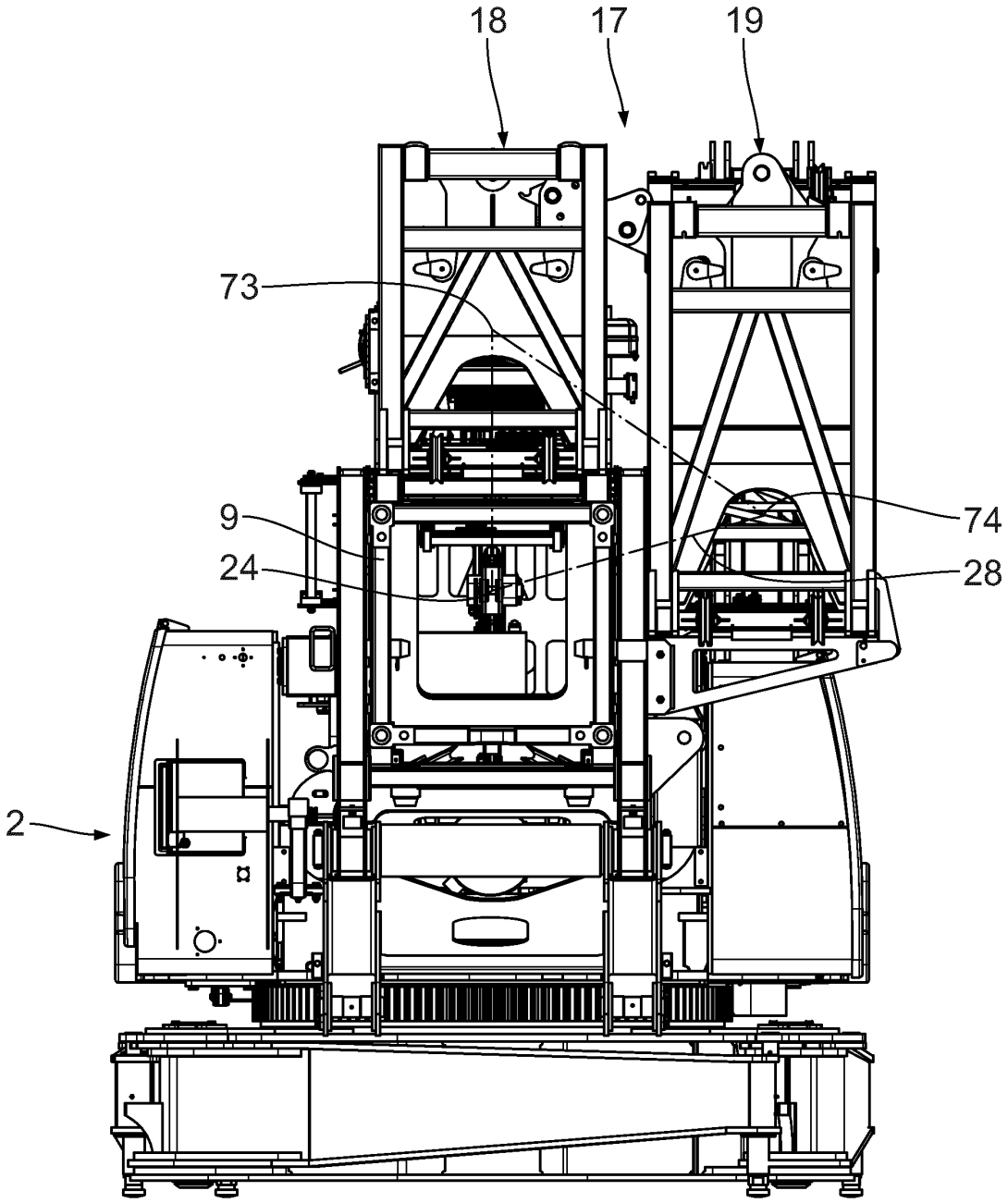

Fig. 3

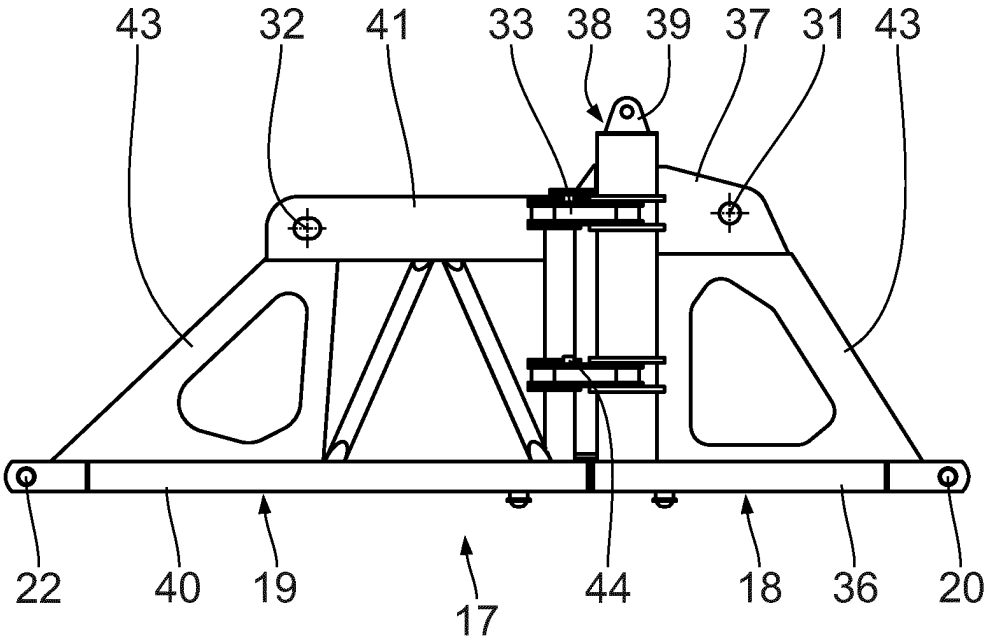
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Fig. 4

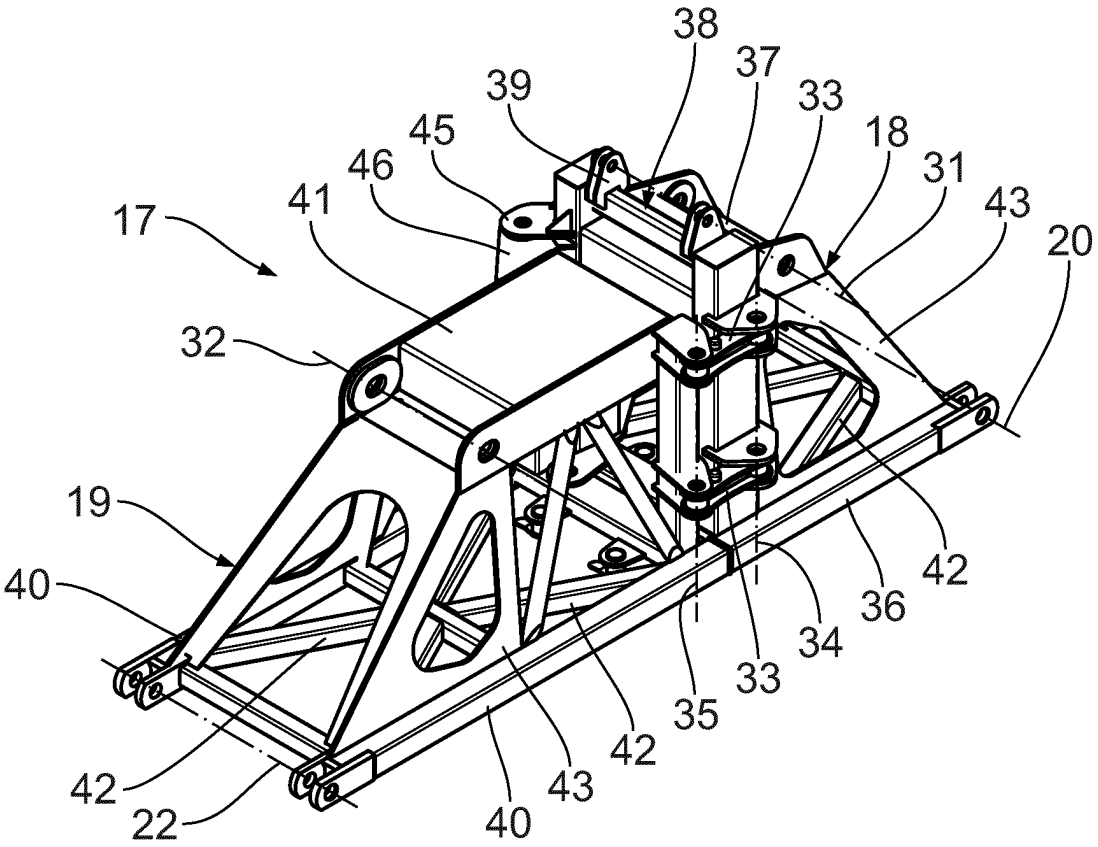
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Fig. 5

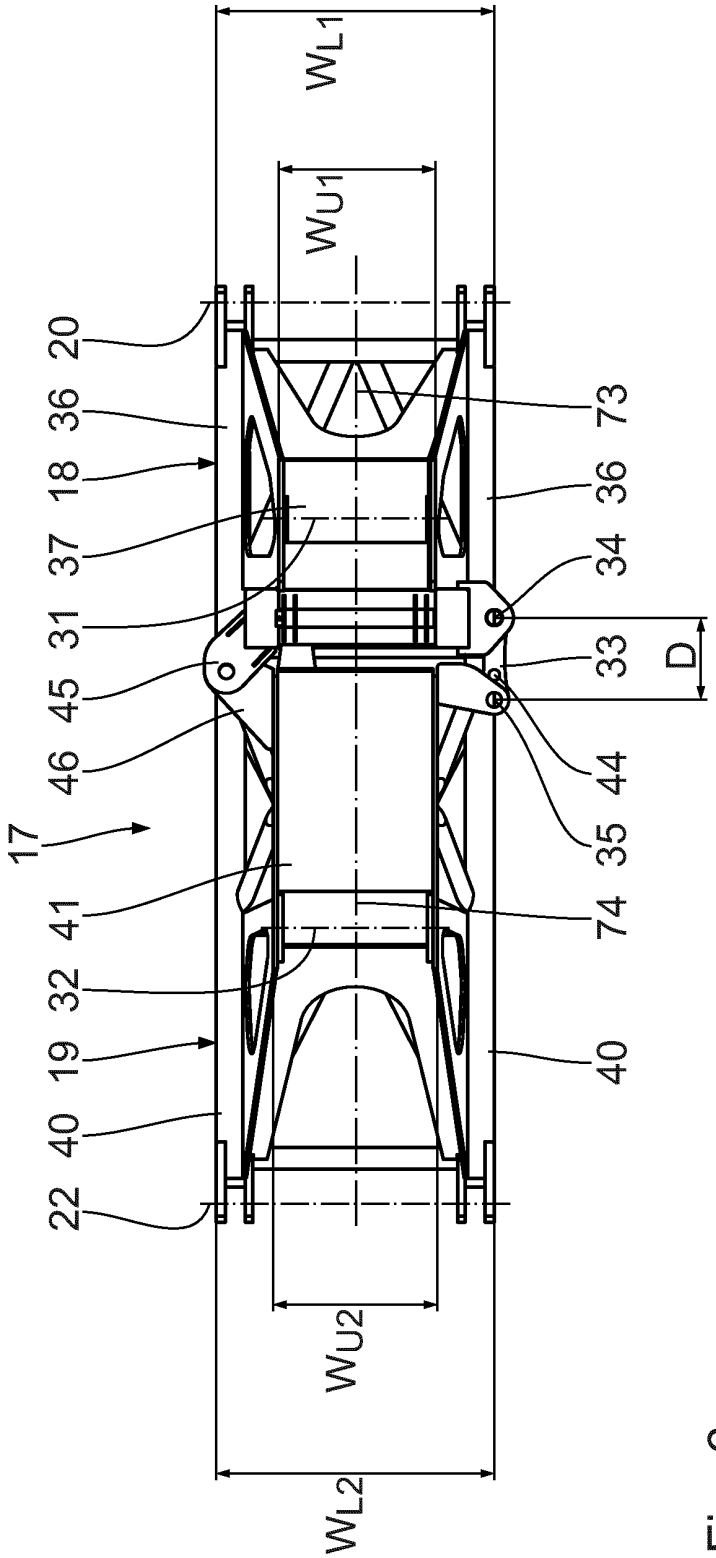
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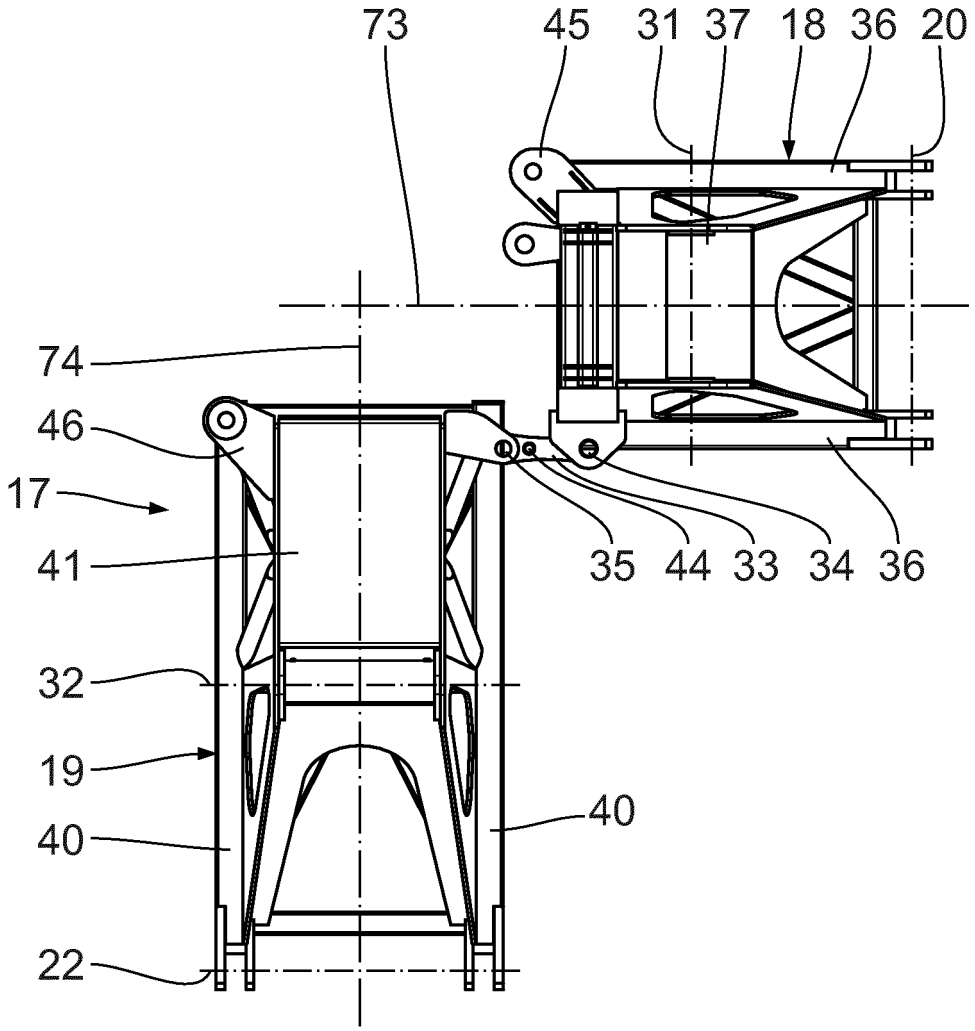
Fig. 6



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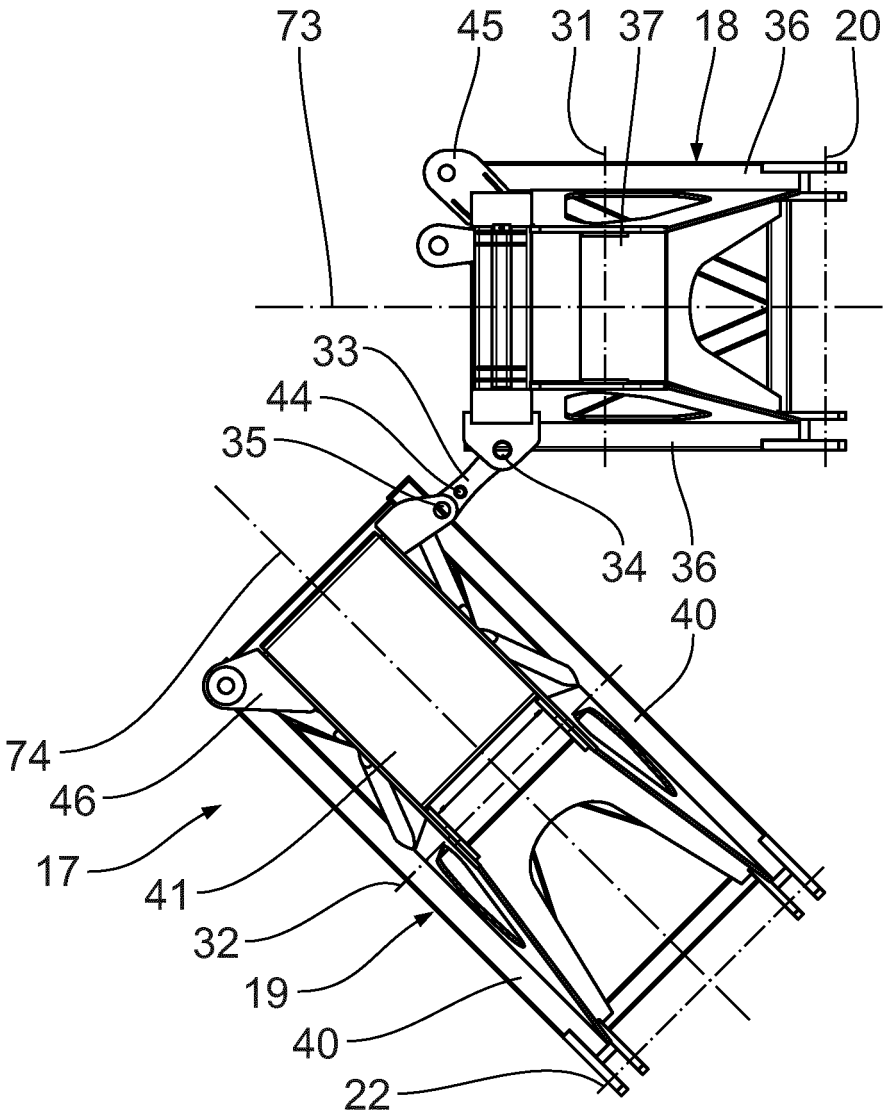

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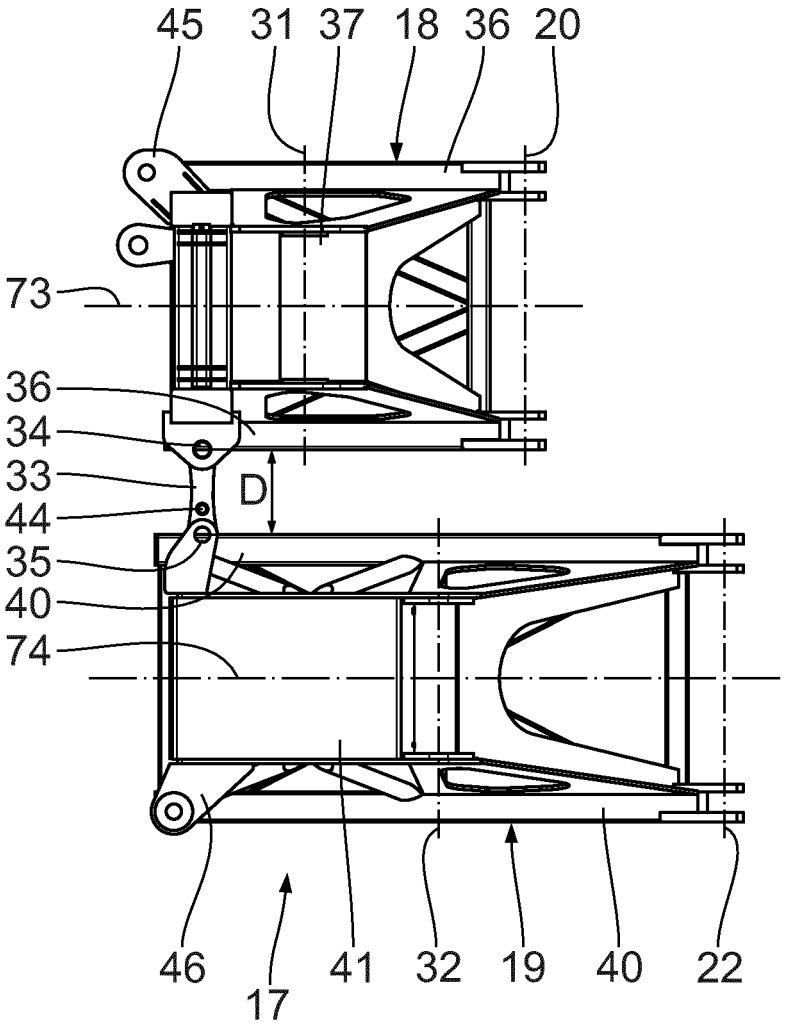

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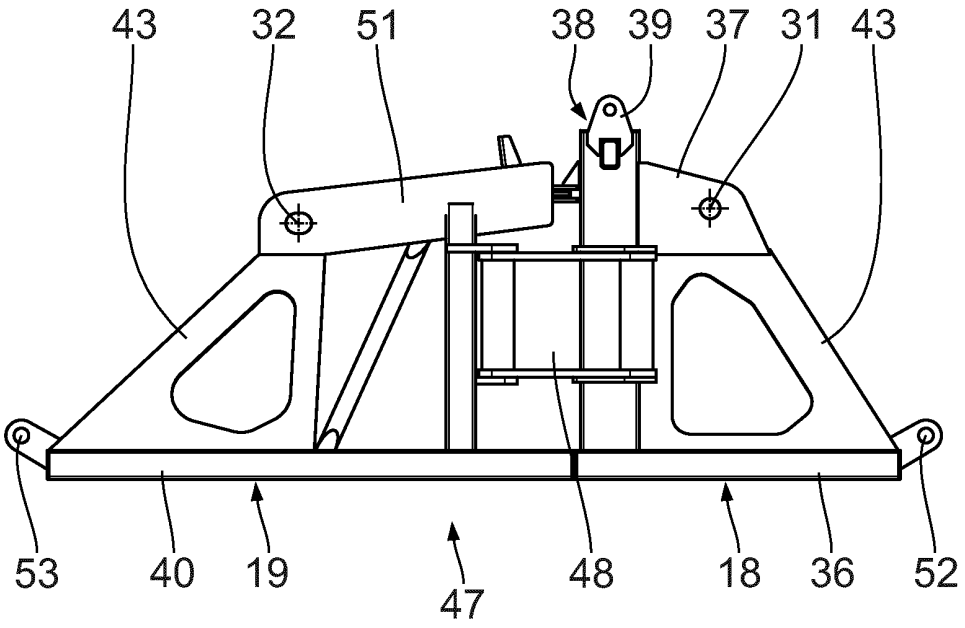
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Fig. 10

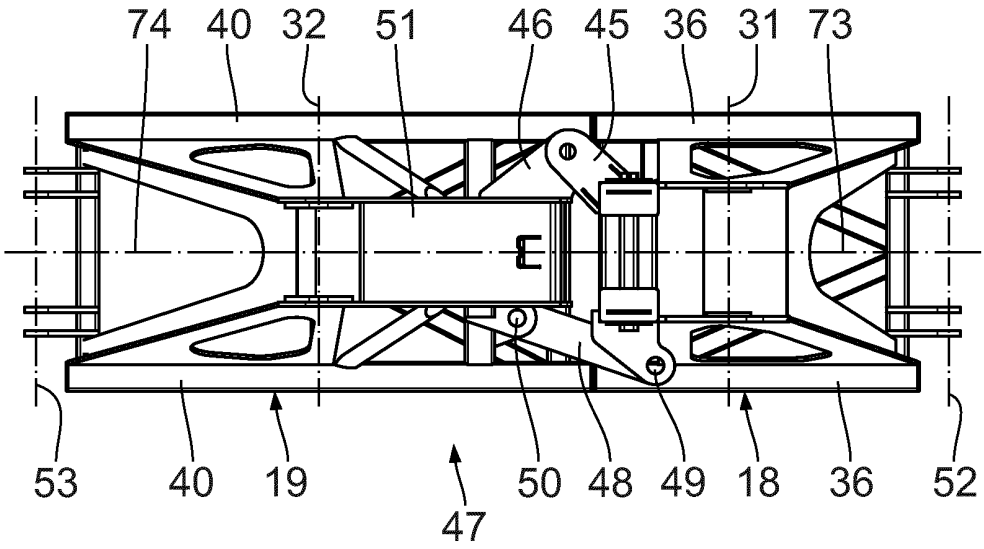
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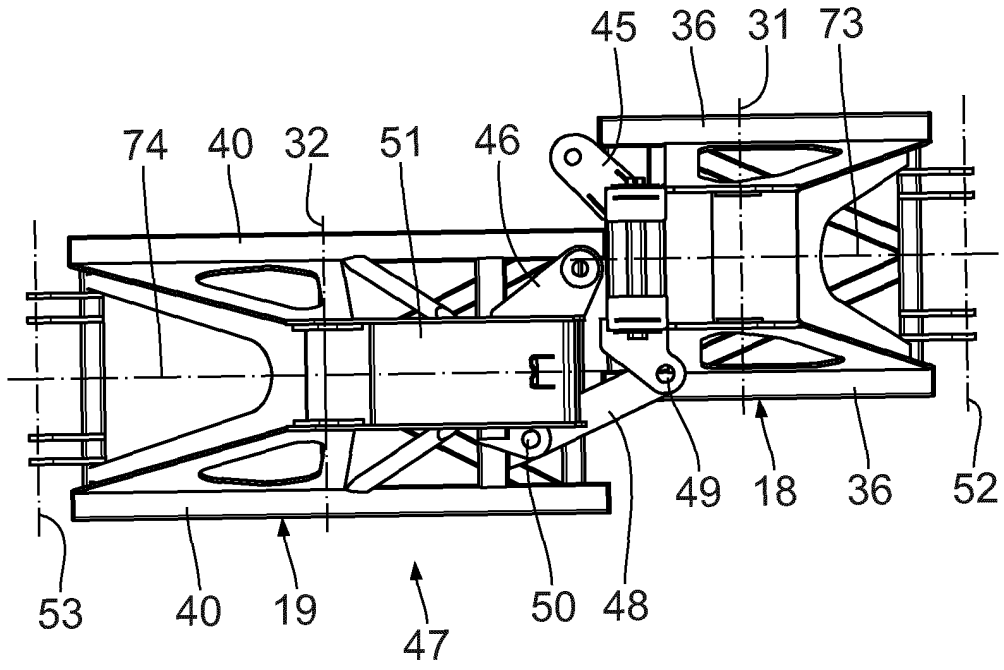
Fig. 11



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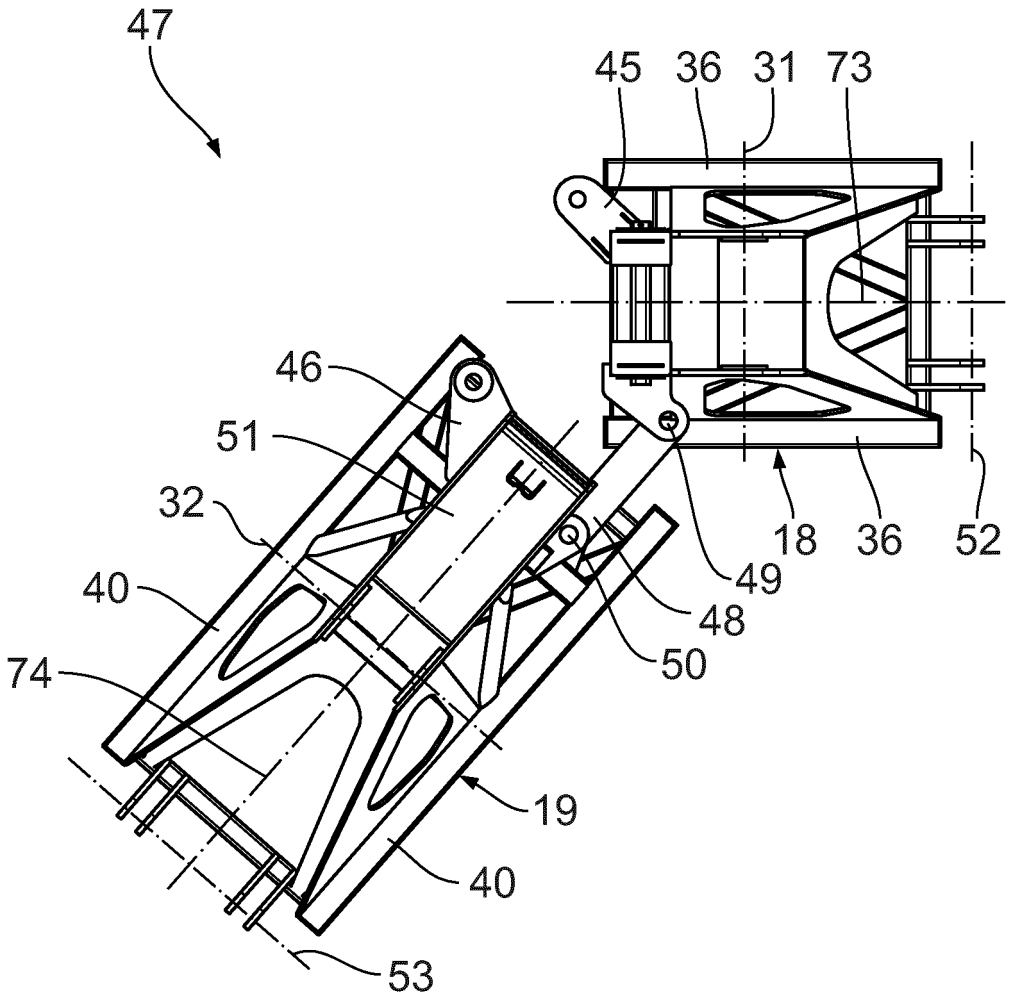

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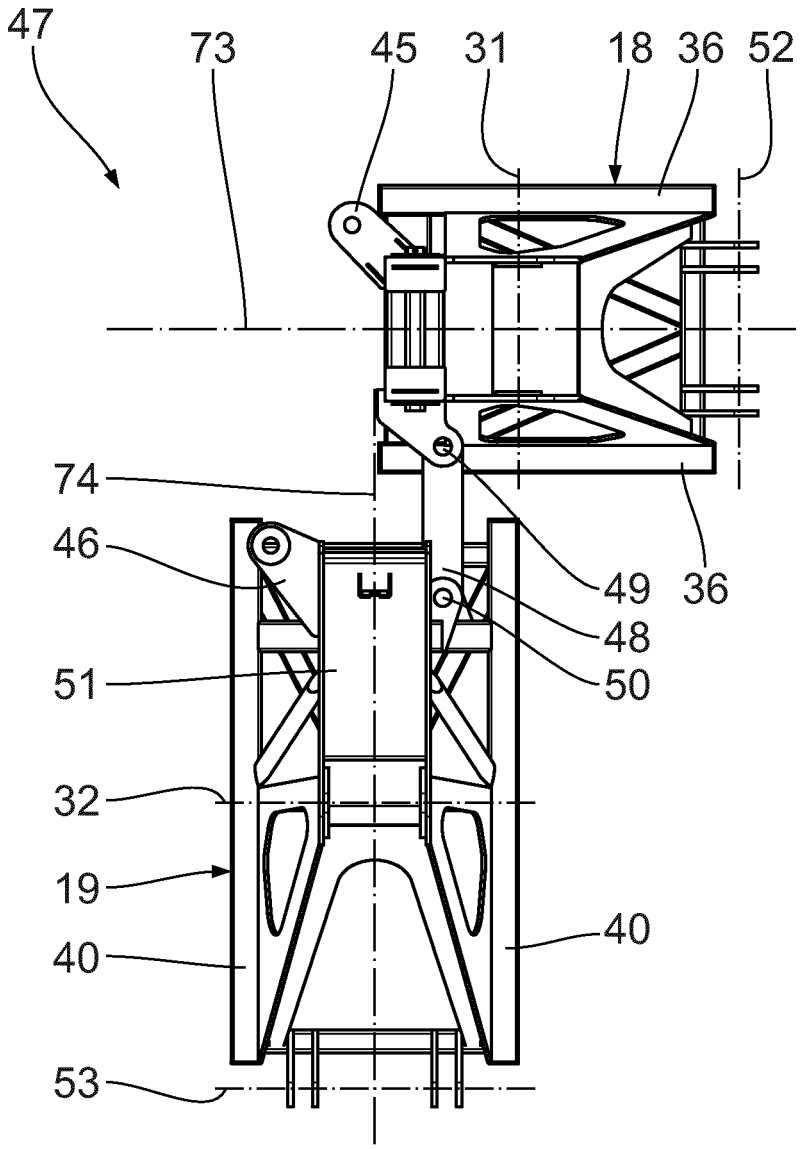

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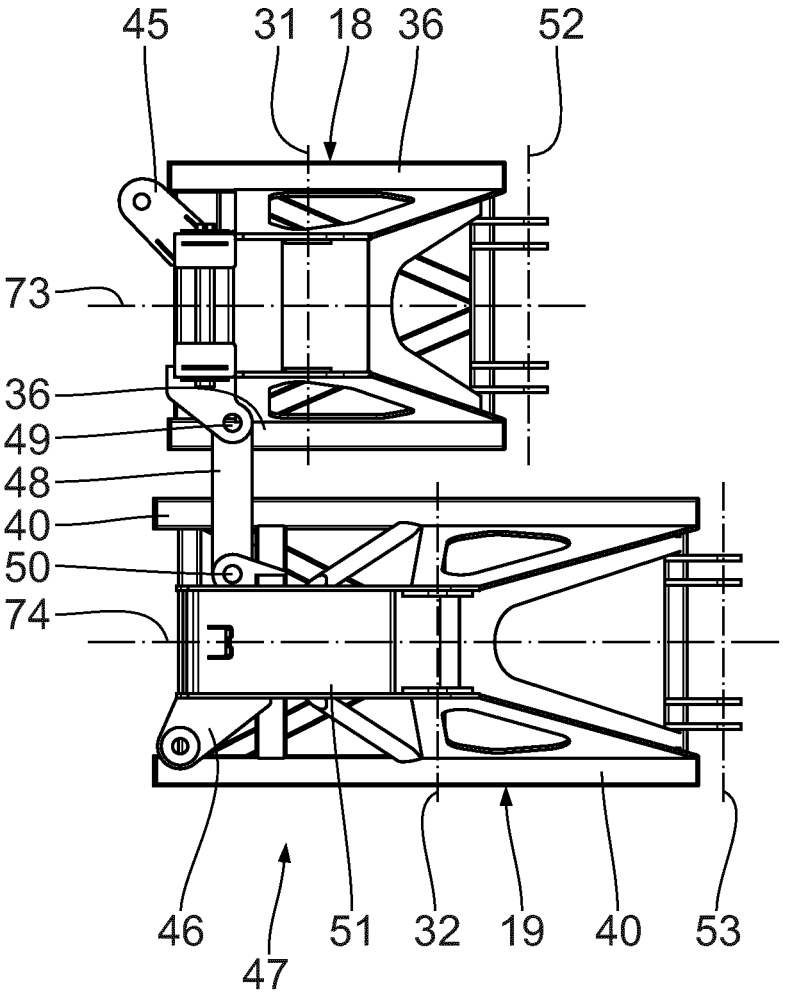

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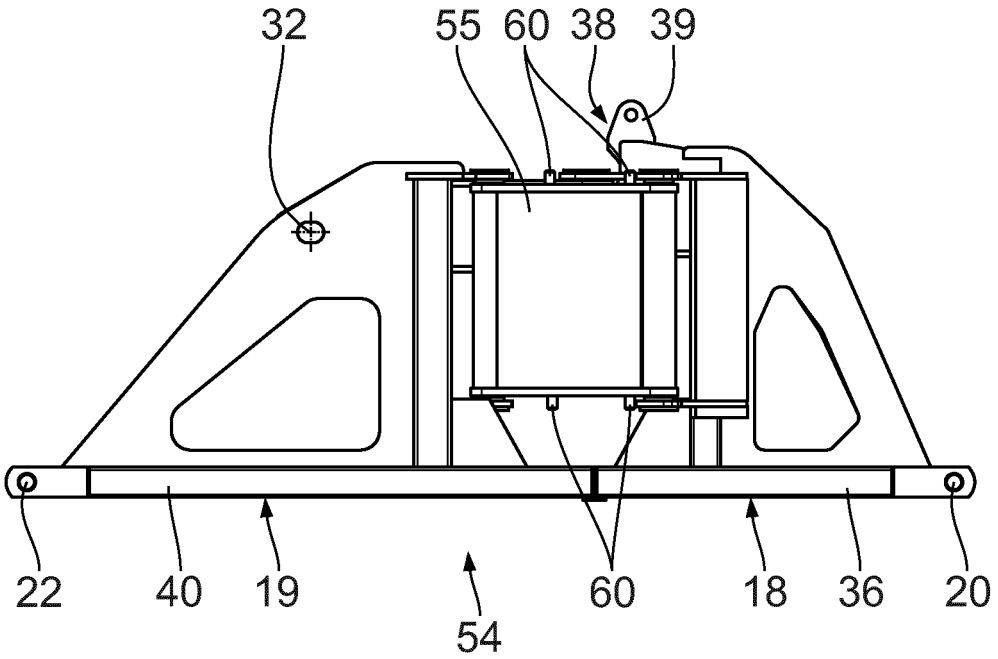
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Fig. 16

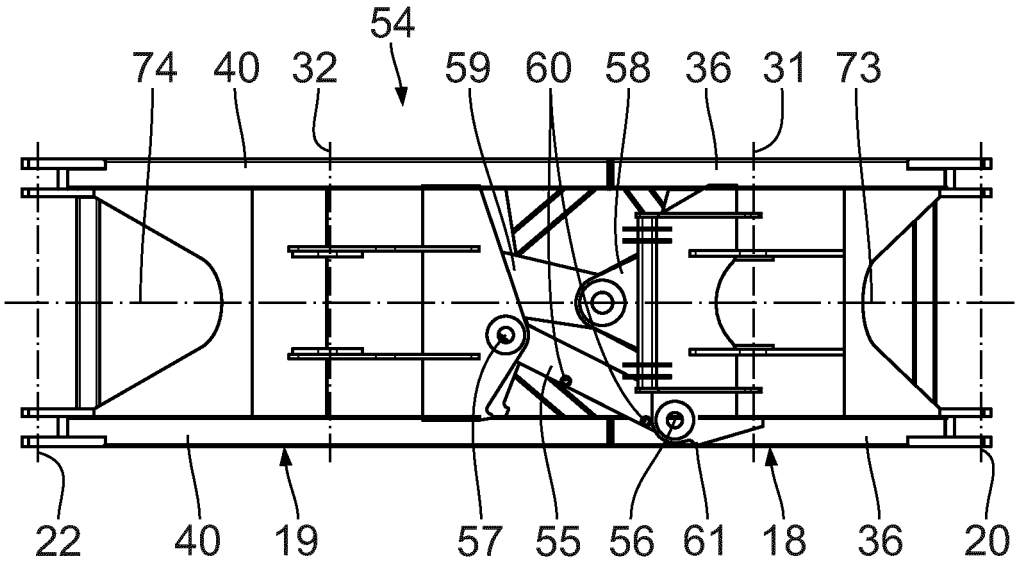
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Fig. 17

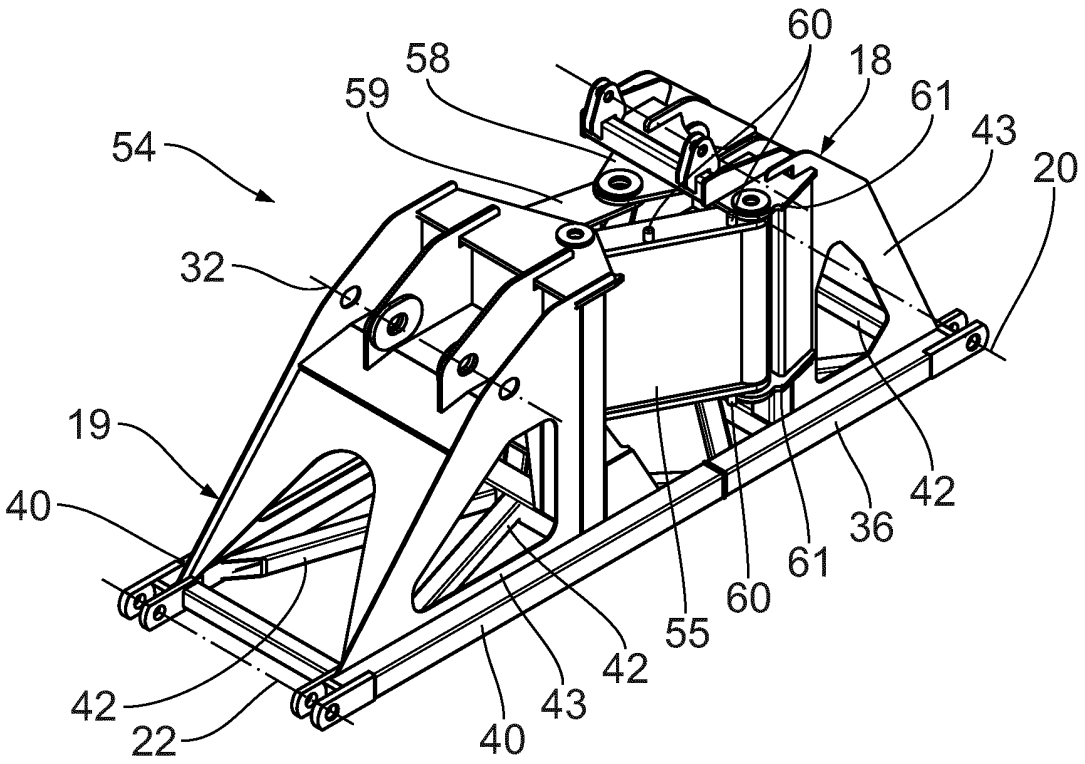
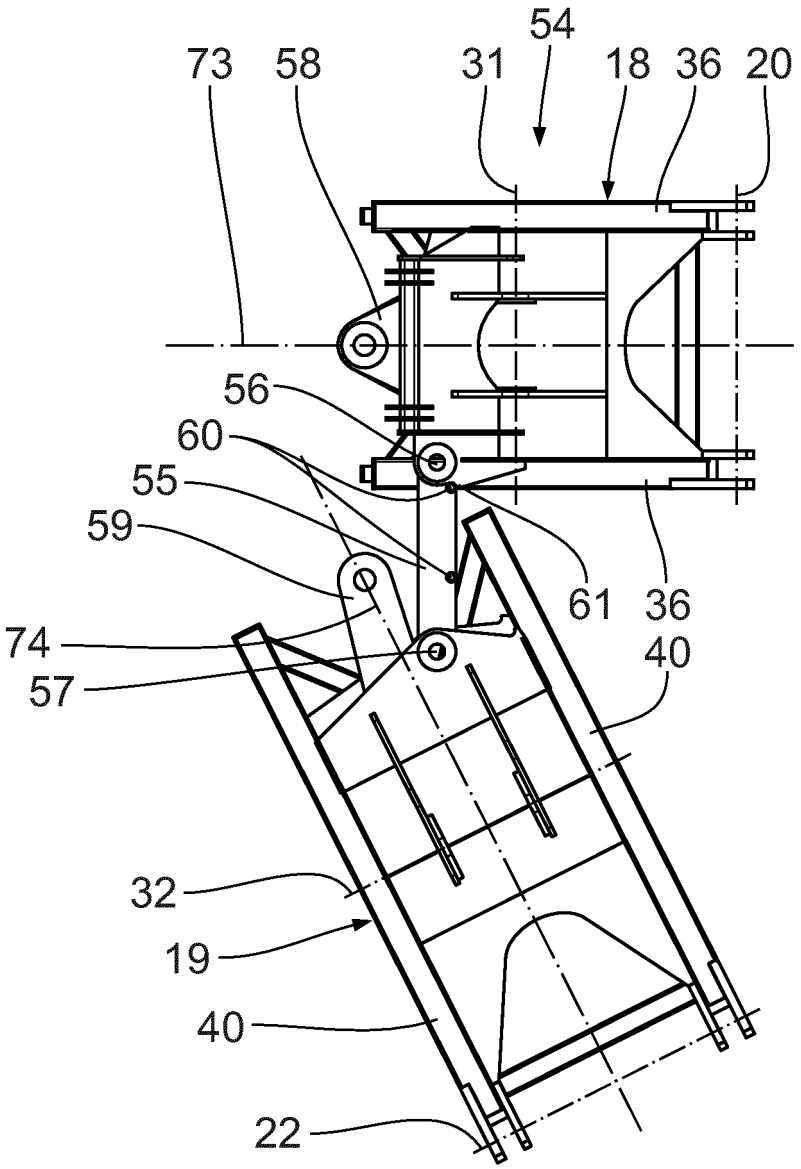


Fig. 18



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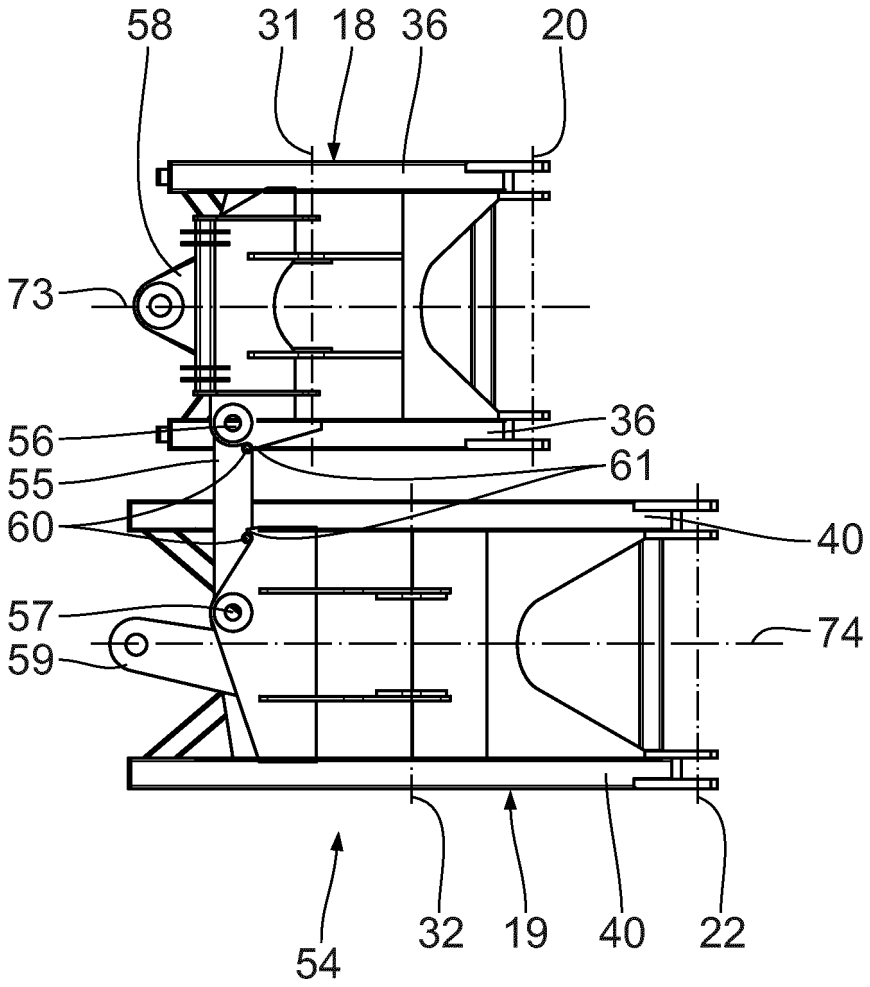

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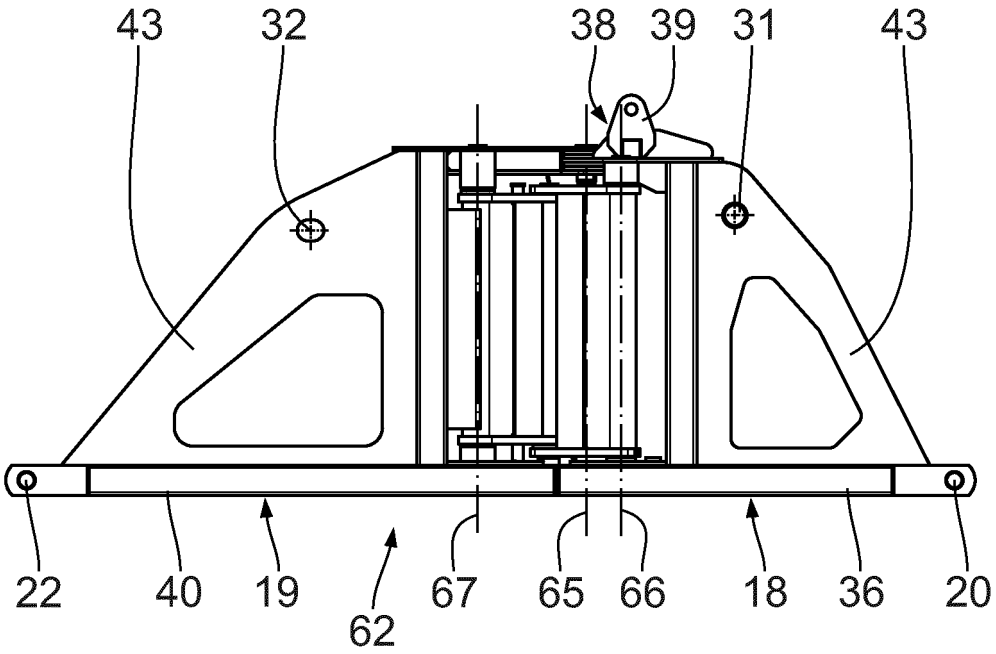
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Fig. 21

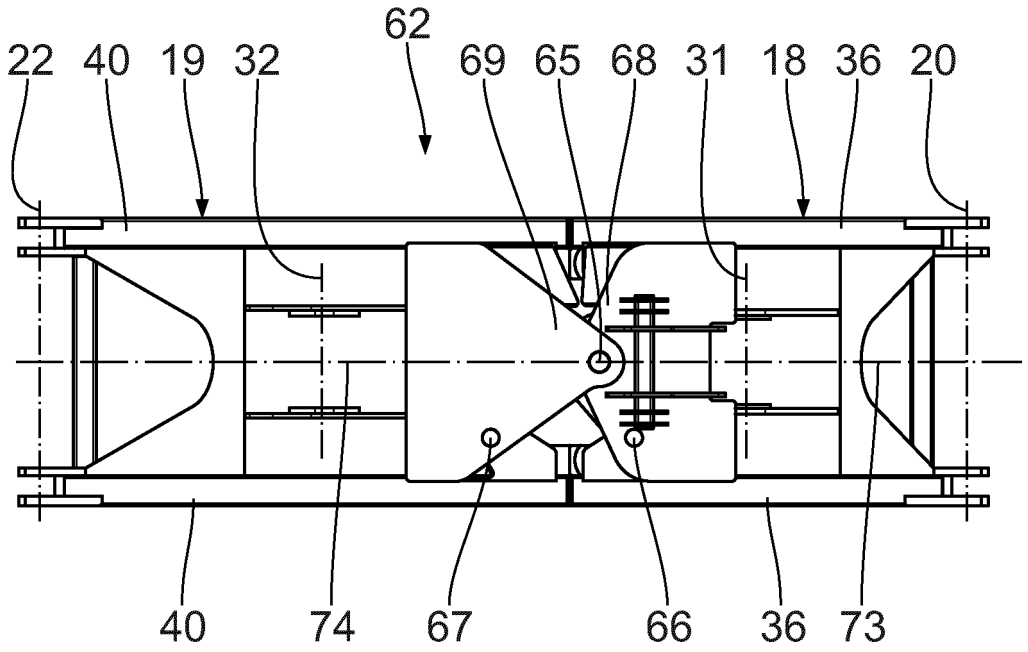
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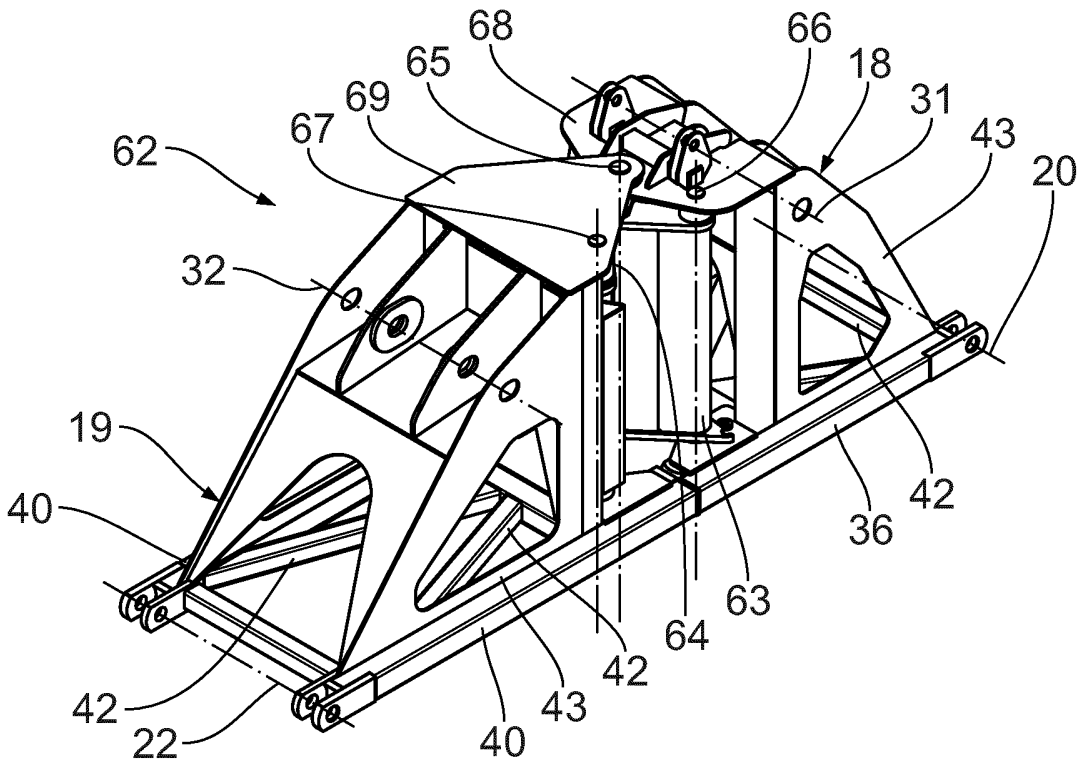
Fig. 22



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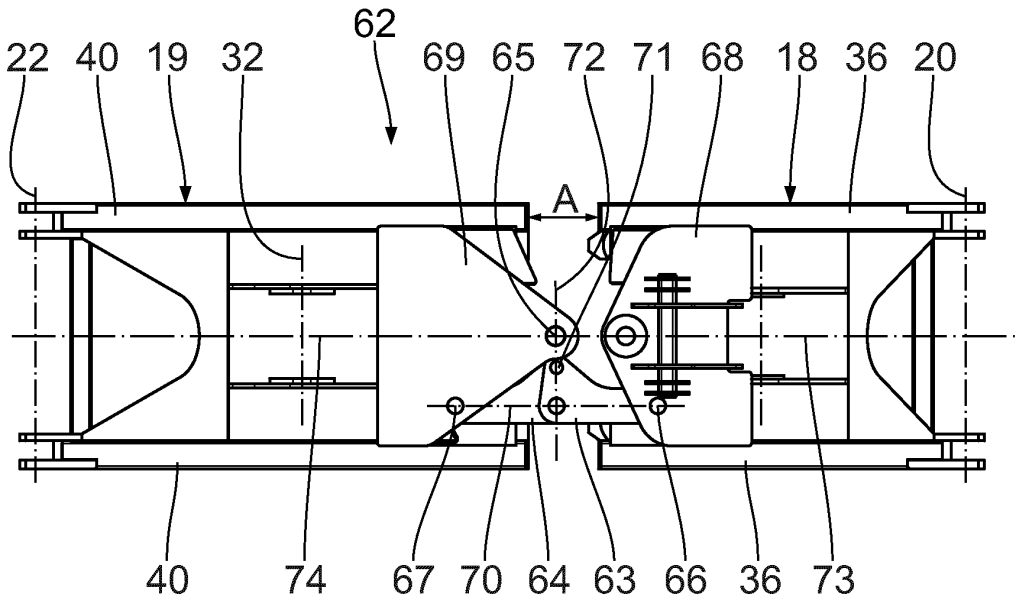
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Fig. 24

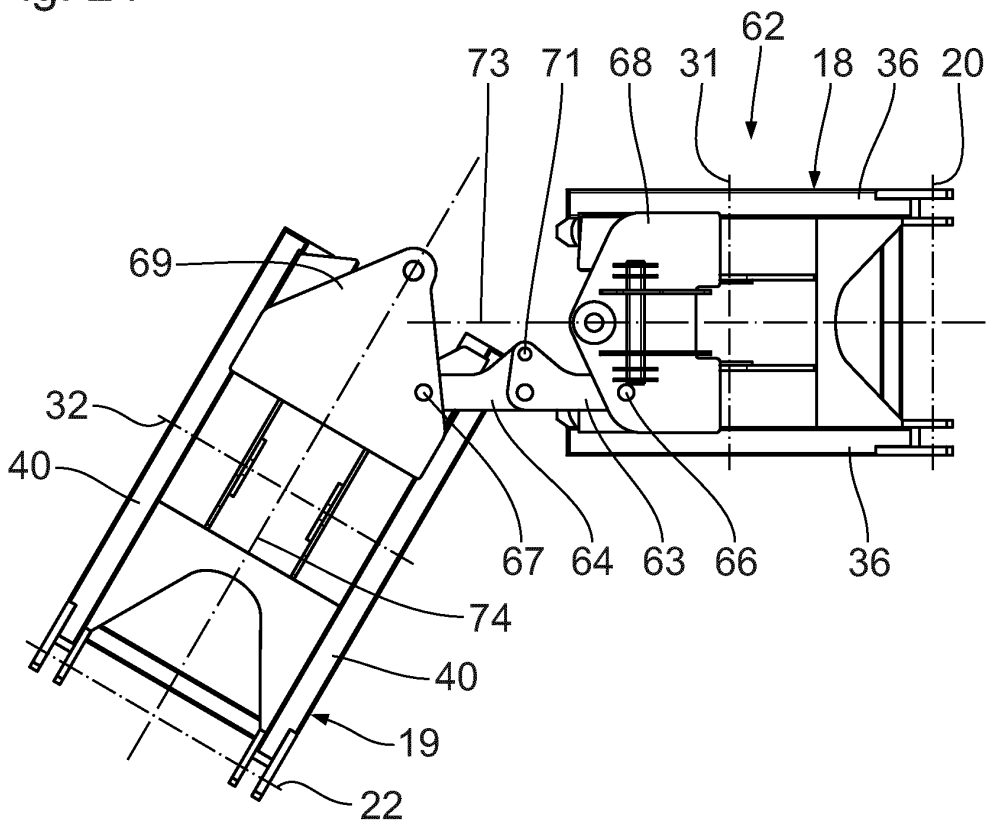
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Fig. 25

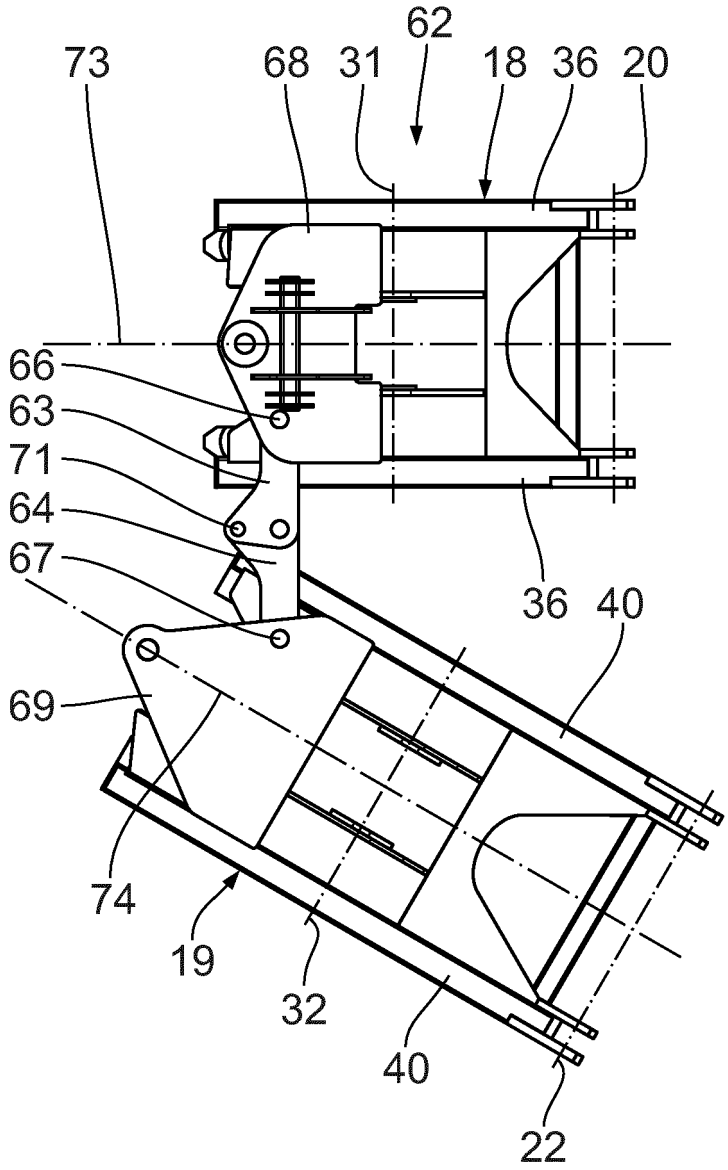

Fig. 26

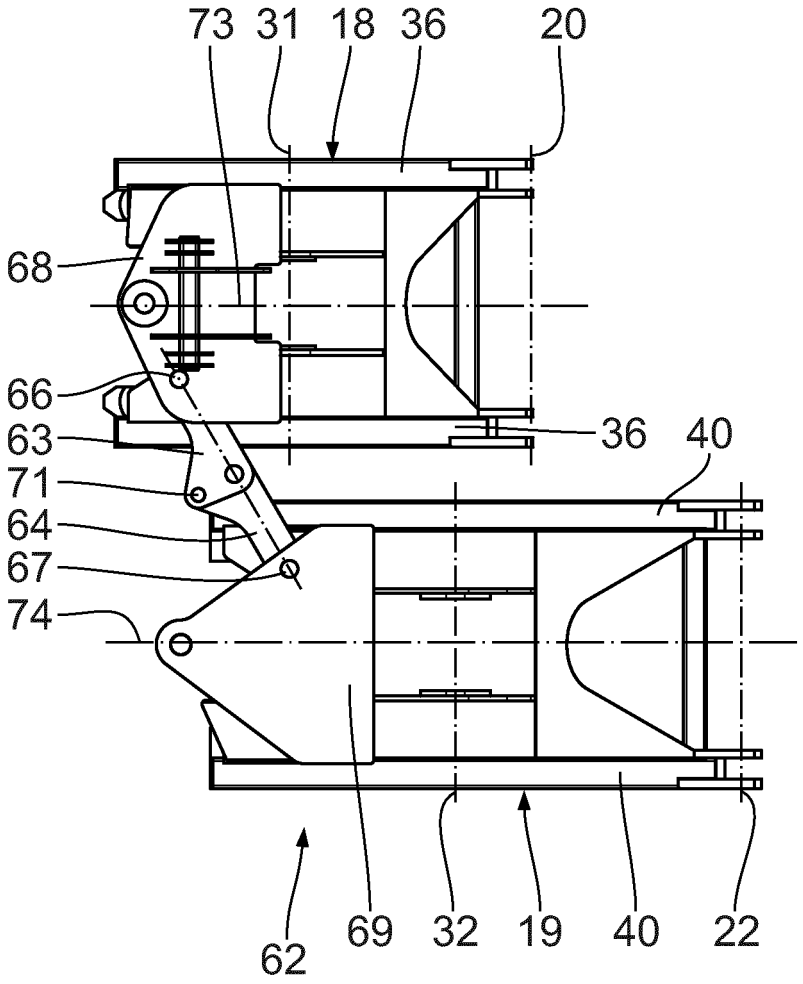

Fig. 27

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EUROPEAN SEARCH REPORT

Application Number
EP 13 16 5293

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	FR 2 594 427 A1 (FERRERI ANDREA [IT]) 21 August 1987 (1987-08-21) * abstract; figures 1-7 *	1-12	INV. B66C23/34
A	DE 93 16 113 U1 (LIEBHERR WERK BIBERACH [DE]) 16 February 1995 (1995-02-16) * figures 1-5 *	1-12	

TECHNICAL FIELDS SEARCHED (IPC)

B66C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	22 May 2013	Faymann, L

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22-05-2013

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FR 2594427 A1	21-08-1987	FR 2594427 A1	21-08-1987
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Patent documents cited in the description

- EP 0870726 B1 **[0001]**