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(54) Tower crane, self-assembling, with folding and telescoping tower, and foldable jib

(57) A self-mounting tower crane having a load arm (50) made up of portions (24,25,26,27,28,29,30,31) hinged together, and a tower, arranged on a base (32) with a fifth wheel (33), equipped with mechanisms which allow unfolding and folding of the crane through a series of flexible ties (34). The arm (50) comprises a first main portion (24), hinged (at 13) to the tower and to a first secondary portion (25) and a second main portion (27); a second secondary portion (26), a third main portion (30), a fourth secondary portion (29), a third secondary portion (28), a fifth secondary portion (31) and actuator means (60,62,108,110) for the unfolding and folding up of the first, second and third main portion (24,27 and 30), and means (68,70;109,111) for locking the main portions in position with the arm unfolded.

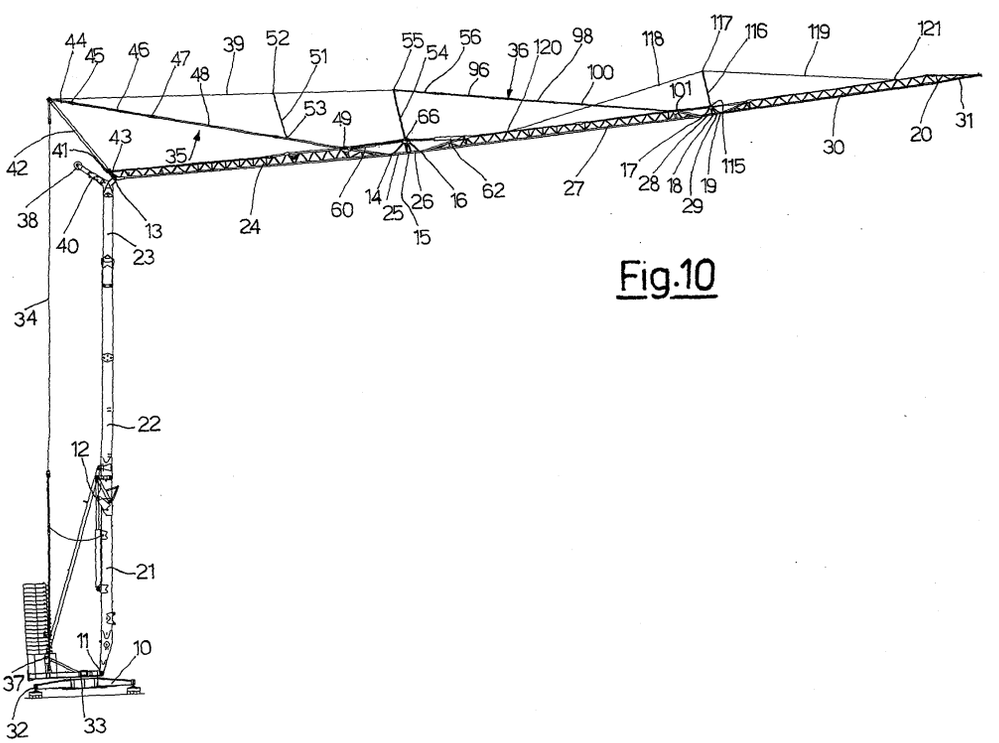

Fig.10

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Description

[0001] The present invention refers to a self-mounting tower crane with a fold-away and telescopic tower and an arm with many fold-away portions.

[0002] Self-mounting tower cranes are known having a composite structure in which the vertical element known as the tower is made up of a pair of portions of structure hinged together and the horizontal element, known as the arm, is also made up of one or more portions hinged together. The portions of the vertical element, with the crane folded up, are horizontal and compact one on top of another, whereas with the crane mounted they are vertical and aligned with one another to realise the tower of the crane. The portions of the horizontal element, with the crane folded up, are horizontal and folded upon themselves and over the portions of the vertical element, whereas, with the crane mounted, they are horizontal and aligned with one another to realise the arm of the crane.

[0003] There are various systems which allow the passage from the crane dismounted position, with portions of tower and of arm folded and horizontal , to the crane mounted position with portions of tower aligned and vertical and portions of arm aligned and horizontal; the maximum height which can be reached by the upper end of the tower, and therefore of the arm of the crane connected to said end, is however equal to the maximum length of the two portions of tower connected together in a hanged manner. This constitutes a limit to the possibility of use of the crane thus constructed since there is not the possibility of reaching heights greater than the sum of the lengths of the two portions of tower. At the same time, for transportation reasons of the dismounted crane, the portions of arm cannot have a maximum length that much exceeds the length of the portions of tower whereas the overall height of the portions of tower and of the portions of arm lying on top of each other cannot exceed a certain height, thus limiting the number of the heights of the individual portions of arm that can be placed on top of each other.

[0004] In known cranes the lifting of the arm into the position of use, which with the crane dismounted is rested over the pair of folded portions of tower, is carried out in the alignment and straightening steps of the tower through a suitable transmission of screw-down jacks and ties; this determines substantial flexing stresses in the two portions of tower and in the various types of members which may be used for the mounting of the tower.

[0005] The quoted technical problems have been avoided with the realisation of a tower crane with a self-mounting composite structure with a fold-away and telescopic tower and an arm with many portions; such a crane, object of Italian patent application no. MI2001A000116 and European patent no. 02075195.4, has allowed a machine to be realised that is particularly simplified in structure and construction, of a large size with arm and tower unfolded and having a low bulk with arm and tower folded up, with simple, valid and easy use.

[0006] The results achieved with the construction of the crane object of the aforementioned patents are overcome and improved by realising, with the invention, a self-mounting tower crane with a composite structure with a fold-away and telescopic tower and an arm with many portions according to claim 1 which allows there to be, with tower and arm unfolded, a longer working length whilst still realising, with tower and arm folded up, a lower bulk than the maximum size allowed in the transportation steps. At the same time the invention allows a structure that is statically simpler and easier to construct to be realised.

[0007] Other relevant and detailed characteristics of the invention are object of the dependent claims.

[0008] Advantageously, in particular, the crane of the present invention has a tower with a composite structure realised in at least one pair of portions hinged together, consisting of structural elements or blocks with a square or rectangular section, and a third portion slotted into the upper portion of the hinged pair also consisting of a structural element or block with a square or rectangular section and having the possibility of being extracted when the two hinged portions are vertical and aligned so that the upper end of the tower thus realised can reach a height greater than the height that can be reached with just the pair of hinged portions.

[0009] Moreover, the substantially reduced height of the individual portions of the arm and their particular shape allow, with the crane folded up, a number to be laid over each other such as to allow, with the crane mounted, a substantial arm length to be reached which is greater than that which can be reached with other known cranes of the same type.

[0010] Moreover, since in the crane of the invention the extracting of the third portion of tower takes place after the alignment in vertical position of the pair of hinged portions and only in such an extracting step there is the lifting of the arm into the position of use, the purpose of reducing the flexing stresses in the two hinged portions of tower and in the members used for the mounting of the tower is achieved.

[0011] The characteristics and advantages of a self-mounting tower crane with a composite structure with a fold-away and telescopic tower and an arm with many portions according to the invention shall become clearer from the following description, given as an example and not for limiting purposes, of an embodiment with reference to the figures in which:

Figures 1 to 5 are top side schematic views of the self-mounting crane according to the invention in which the mounting of the tower is essentially shown,

Figures 6 to 9 are top side schematic views in which the unfolding of the upper arm of the crane of figure

1 is shown,

Figure 10 shows a scaled down top side view of the crane in completely mounted position,

Figures 11 and 12 represent the articulated joint between the first main portion of the arm, the first and the second secondary portion of the arm and the second main portion of the arm in an intermediate step of aligning the arm and actual alignment of the arm, respectively,

Figures 13 and 14 represent the articulated joint between the second main portion of the arm, the third and fourth secondary portion of the arm and the third main portion of the arm in an intermediate step of aligning the arm and actual alignment of the arm, respectively,

Figures 15 and 16 represent the terminal of the arm and a possible embodiment of the articulated joint between the third main section of the arm and the terminal, with the crane dismounted and in mounting or use step, respectively,

Figures 17 and 18 show a second embodiment which differs from the first for the greater length of the telescopic portion of the tower, where the different mounting succession should be noted.

[0012] It should be specified that, besides the quoted Italian patent no. MI2001A000116 which clearly illustrates the embodiment of a crane in its totality, the tower, which is, however, an integral part of the invention, is also the object of two Italian patent applications nos. MI2000A002661 and MI2000A001062 which clearly illustrate two embodiments of the tower itself.

[0013] Having said that, it should be observed how a crane according to the invention is constructed with a tower as described above with an arm in many portions having sections of limited height, supported by screw-down jacks and ties so that at least three main portions of the arm, with the crane dismounted with arm and tower folded up, can be laid on top of each other and with two hinged tower elements, so that the overall height of the crane, dismounted and folded upon itself, is relatively contained and such as not to jeopardise the possibility of transporting it. In such a way, according to the present invention, besides reaching a substantial height and giving the other advantages inherent to the particular nature of the tower, it is thus possible, unfolding all of the portions of the arm, to reach a substantial length of the arm itself, with this substantially improving the possibilities of use of the machine.

[0014] It can be seen, in particular in figure 1, how the crane is in completely folded position with the lower base 10 rested upon the ground. Figures 2 and 3 represent the crane with the tower partially mounted up to that which is shown in figure 4 where the two portions of tower are aligned and a third portion is still completely slotted in them. Figure 5 also shows the two portions of tower aligned and the third portion completely extracted, whereas the portions of the arm are partially folded upon themselves. Figures 6, 7, 8 and 9 are schematic views of the crane according to the invention with the arm, the ties and the tip in three successive steps of unfolding until that which is shown in figure 10, where the crane completely mounted in work position, is reached. Figures 11 and 12 represent the articulated joint between the first main portion of the arm, the two intermediate secondary portions and the second main portion of the arm, respectively, in an intermediate step of aligning the arm and with the arm actually aligned. Figures 13 and 14 represent the articulated joint between the second main portion of the arm, the two secondary intermediate portions and the third main portion of the arm in an intermediate step of aligning the arm and actual alignment of the arm, respectively. Figures 15 and 16 show the terminal of the arm in the partially folded position which it takes up when the crane is dismounted and in the unfolded position aligned with the third main portion of the arm which it takes up when the crane is mounted or in use step.

[0015] As shown in the figures, the invention refers to a self-mounting tower crane with a composite structure which has the portions of the tower and of the arm hinged together at horizontal pivots indicated with 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20. It is made up of a tower consisting of two portions 21 and 22, hinged together at 12, and a third portion 23 slotted into - and able to be extracted from - the upper portion 22 of the two hinged portions. The load arm 50 is made up of a first main portion 24 one of the ends of which is hinged at 13 at the level of its longerons below the upper end of the extractable portion of the tower 23, of a first secondary portion 25 of relatively short length one of the ends of which is hinged at 14 at the level of its longerons below the free end of the first main portion 24, of a second secondary portion 26 of relatively short length one of the ends of which is hinged at 15 at the level of its longerons below the free end of the first secondary portion 25, of a second main portion 27 one of the ends of which is hinged at 16 at the level of its longerons below the free end of the second secondary portion 26, of a third secondary portion 28 of relatively short length one of the ends of which is hinged at 17 at the level of its longerons below the free end of the second main portion 27, of a fourth secondary portion 29 of relatively short length one of the ends of which is hinged at 18 at the level of its longerons below the free end of the third secondary portion 28, of a third main portion 30 one of the ends of which is hinged at 19 at the level of its longerons below the free end of the fourth secondary portion 29, of a fifth secondary portion or terminal 31 one of the ends of which is hinged at 20 at the level of its longerons below the free end of the third main portion 30.

[0016] All of the portions of the arm have a substantially reduced height in order to be able to be placed on top of each other, with the crane dismounted, in a number of at least three main portions; only the first main portion 24 has, in its front part near to the hinge 14, a

greater height in order to also allow the installation of the translation ratiomotor of the trolley. The lower portion of the tower 21 is in turn hinged at 11 in a lower end thereof to a base structure, per se known and wholly indicated with 32, equipped with a rotation fifth wheel 33, said fifth wheel being integral with the lower base 10. The base structure 32 usually foresees command means of the unfolding and of the refolding of the entire crane, not specifically indicated, which act through the flexible tie 34 which extends along the side of the tower essentially on the opposite side to the arm and the flexible ties 35, 36, 39, 118 and 119 which extend above the portions of the arm.

[0017] The ties form, with the portions of the base structure of the structure of the crane, an articulated quadrilateral.

[0018] The two hinged portions of the tower 21 and 22 pass from the horizontal position one on top of another, figure 1, to the almost vertical and aligned position, figure 4, gradually taking up a series of intermediate positions, two of which are represented in figures 2 and 3.

[0019] In the intermediate position represented in figure 2 the flexible tie 34, consisting of one or more portions, is hinged at 37 to the base structure 32, rests upon the large roller 38 placed at the end of a tip 40, said tip being rigidly connected to the upper end of the portion of tower 23, and rests upon a roller 41 hinged to the end of the first portion of arm 24 at the level of the upper longeron. As better highlighted in figure 3, the other end of the tie 34 is connected in a hinged manner to the ties 35 and 39 and to the end of the tip 42, said tip in turn being connected in a hinged manner at 43 to the upper end of the tower 23. With the two hinged portions of tower 21 and 22 progressively rising the tie 34 progressively tends to go into traction. Before the tie 34 goes into traction tending to make the tip 42 rotate about the hinge 43, through the effect of the progressive lifting of the two portions of tower 21 and 22, it is necessary to unfold the second portion 27 of the arm and the third portion 24 of the arm moving them away from the first portion 24 of the arm by a space necessary and sufficient to allow the rotation of the tip 42 about the hinge 43 without the end of said tip 42 interfering with the third portion 30 of the arm. The ways of unfolding all of the portions of the arms are described later on.

[0020] When, through the progressive lifting of the two portions of tower 21 and 22, the tie 34 goes into traction, the tip 42 tends to rotate about the hinge 43 taking the tie 35 into traction until it is taut, said tie consisting of three portions of which the first 44 of a short length is connected to the tip 42, the second portion 46 of a length substantially equal to the length of the tip 42 is connected at 45 to the first portion 44, the third portion 48 is connected at 47 to the second portion 46 and, at the other end, is connected at 49 to the first main portion of the arm 24 at the height of the upper longeron of the portion.

[0021] When the tie 34 is taut through the effect of the rotation of the tip 42 it is suitable to fold the second portion 27 of the arm and the third portion 30 of the arm until they are rested upon the tie 35. Continuing with the unfolding of the two portions of tower 21 and 22, when said two hinged portions of tower 21 and 22 are aligned in vertical position or slightly inclined from the opposite side to the tie 34 as indicated in figure 4, the portion of tower 23 is completely slotted in the portion of tower 22; the load arm 50, hinged at 13 to the upper end of the portion of tower 23, is arranged vertically and almost resting upon the portions 21 and 22 of the tower; the ties 34 and 35 are taut.

[0022] In the final mounting step of the tower of the crane the portion of tower 23 is extracted from the hinged portion of tower 22, as indicated in figure 5, and the command devices of such extracting are illustrated in the two patent applications nos. MI2000A002661 and MI2000A001062 quoted above. With the portion of tower 23 being extracted, the traction applied by the ties 34 and 35 makes the load arm 50 rotate about the hinge 13, said load arm 50 rising until the horizontal or slightly raised position is reached towards the opposite end of the tower indicated in figure 5, when the portion of tower 23 is completely extracted from the portion of tower 22; conventional devices ensure the locking of the portion of tower 23 in the position of maximum extracting in which the crane can be used to lift loads.

[0023] On the upper part of the first secondary portion 25 of the arm 50 an end of a screw-down jack 54 is hinged at 66, the other end of the screw-down jack 54 being hinged at 55 to the end of the flexible tie 36 and to the end of the flexible tie 39, consisting of a metal cable. At about two thirds of its overall length the tie 39 is integral with the end 52 of a screw-down jack 51, the other end of said screw-down jack being fixed in a hinging manner at 53 to the portion 48 of the tie 35.

[0024] The details of the devices which determine the alignment of the first secondary portion 25 of the arm 50 with the first main portion 24, of the second main portion 27 with the second secondary portion 26 and of the secondary portion of the arm 26 with the secondary portion 25 are better illustrated in figures 11 and 12.

[0025] A plate 57 carrying a slot in a suitable position is integral with the first secondary portion 25 of the arm, whereas a plate 58 carrying a hole in a suitable position is integral with the second secondary portion 26 of the arm. A jack 90 inserted in the hole of the plate 58 and in the slot of the plate 57 allows the first secondary section 25 of the arm and the second secondary section 26 of the arm to rotate about the hinge 15 in the slack allowed by the jack 90 inserted in the slot of the plate 57 and in the hole of the plate 58.

[0026] A hydraulic actuator 60 is hinged at 61 to the upper structure of the first main portion of the arm 24, the other end of the hydraulic actuator 60 being hinged at 59 to the plate 57 of the first secondary portion 25 of the arm. A second hydraulic actuator 62 is hinged at 64

to the second main portion of the arm 27, the other end of the hydraulic actuator 62 being hinged through the jack 90 to the plate 58 of the second secondary portion 26 of the arm. A pair of connecting rods of different lengths 68 and 70 are hinged together at 69, the other end of said connecting rod 70 being hinged at 71 to the first main portion of the arm 24 and the other end of said connecting rod 68 being hinged at 67 to the plate 57 of the first secondary portion of the arm 25.

[0027] Figures 6 and 7 show two intermediate steps of the alignment of the first secondary portion 25 of the arm 50 to the first main portion 24 of the arm 50, of the alignment of the second main portion 27 with the second secondary portion 26 of the arm 50 and of the alignment of the portions 26 and 27 with the portions 24 and 25.

[0028] The thrust exerted by the hydraulic actuator 60 makes the first secondary portion 25 of the arm rotate about the hinge 14 arranged at the end of the first main portion 24 of the arm; in the same way, the thrust exerted by the actuator 62 makes the second main portion 27 of the arm rotate about the hinge 16 arranged at the end of the second secondary portion 26 of the arm. Rotating the first secondary portion 25 of the arm about the hinge 14 determines the rotation of the second secondary portion 26, said second secondary portion 26 being connected, in a hinged manner at 15, to the first secondary portion 25 and with the possibility of rotating about said hinge 15 in the slack allowed by the jack 90 inserted in the slot of the plate 57 and in the hole of the plate 58. By rotating the first secondary portion 25 of the arm about the hinge 14 the connecting rods 68 and 70 rotate about the hinge 69 which connects them to an end, whereas the other end of the connecting rod 68 connected at 67 to the upper part of the secondary portion 25 of the arm displaces following the rotary movement of the first secondary portion 25 of the arm about the hinge 13 and whereas the other end of the connecting rod 70 rotates about the hinge 71 which connects it to the first main portion 24 of the arm.

[0029] Figure 7 shows an intermediate step of the alignment of the first secondary portion 25 with the first main portion 24, of the alignment of the second main portion 27 with the second secondary portion 26 and of the alignment of the portions 26 and 27 with the portions 24 and 25, a step in which the third main portion 30 of the arm has been partially moved away from the second main portion 27 of the arm with means which shall be described later on and in order to allow the unfolding of the tie 36 without interference with the third portion 30 of the arm. The flexible tie 36 consists of a first rigid portion 56 of a length about equal to the length of the screw-down jack 54, said portion 56 being hinged through a slot at 55 to the screw-down jack 54 and to the flexible tie 39. The other end of the first portion 56 of the tie 36 is hinged at 91 to the end of a short tie 92; the other end of said short tie 92 is hinged at 93 to the end of a second short tie 94; the other end of said short tie 94 is hinged at 95 to the second portion 96 of the tie 36 of a relatively long length. The sliding permitted by the slot made at 55 on the end of the first portion 56 of the tie 36 has the purpose of easing the unfolding or folding of the portions of the tie 33 during the unfolding or folding of the arm 50. The other end of the second portion 96 is connected in a hinged manner at 97 to a third portion 98 of the tie 36; the opposite end of the third portion 98 is connected in a hinged manner at 99 to the fourth portion 100 of greater length, the other end of which is connected in a hinged manner at 101 to the end of the second main portion 27 at the height of the upper longeron.

[0030] Through the rotation of the first secondary portion 25 of the arm 50 about the hinge 14 at the end of the first main portion 24, through the rotation of the second secondary portion 26 about the hinge 15 at the end of the first secondary portion 25 in the slack allowed by the jack 90 inserted in the slot of the plate 57 and in the hole of the plate 58 and through the rotation of the second main portion 27 about the hinge 16 at the end of the second secondary portion 26 of the arm 50, the tie 36 tends to go into traction and the tip 54, through the force exerted by said tie 36, tends to lift rotating about the hinge 66; continuing the rotation of the portion 25 about the hinge 14, of the portion 26 about the hinge 15, of the portion 27 about the hinge 16 and of the tip 54 about the hinge 66 the tie in metal cable 39 also tends to go into traction, said traction in turn determining the rotation of the tip 52 about the hinge 53, said tip 51 being integral at 52 with the tie 39.

[0031] Figure 8 illustrates the final position of alignment of the portions 24, 25, 26 and 27 of the arm 50 whereas figure 12 better illustrates the details of the portions 24, 25, 26 and 27 connected from the hinges 14, 15 and 16. When the actuator 60 is about to reach its end stop position and the first secondary portion 25 of arm is aligned with the first main portion 24, the connecting rod 70 connected in the hinge 71 to the first main portion 24 of arm and the connecting rod 68 connected in the hinge 67 to the first secondary portion 25, both of the connecting rods 70 and 68 being connected together by the hinge 69, go into traction preventing the further rotation of the first secondary portion 25 about the hinge 14 carrying out the function of supporting said first portion 25; the attachment hinges 61 and 59 of the actuator 60 have the holes slightly slotted or oversized, with this allowing the actuator 60 to reach the final position without any longer transmitting any force to the secondary portion 25 and without carrying out any structural supporting function of the portion 25.

[0032] When the connecting rods 70 and 68 have gone into traction, the rotation downwards of the first secondary portion 25 with respect to the first main portion 24 about the hinge 14 is prevented by the traction of said connecting rods 70 and 68; with respect to the forces directed downwards, the group consisting of the first main portion 24 and the first secondary portion 25 is therefore a single isostatic reticular structure with hinges at the joints.

[0033] When the actuator 62 reaches its end stop position, the second main portion 27 of the arm 50 has completed the rotation about the hinge 16 aligning itself with the second secondary portion 26 of the arm 50; the actuator 62, connected in a hinged manner at one end thereof to the second secondary portion 26 of the pin 90 inserted in the hole of the plate 58 and connected in a hinged manner at the other end thereof at 64 to the second main portion 27, carries out, in an end stop position, the function of a rigid shaft giving the group consisting of the second secondary portion 26 and the second main portion 27 the characteristics of a single isostatic reticular structure with hinges at the joints.

[0034] The isostatic group consisting of the portions 24 and 25 of the arm 50, connected at an end thereof in the hinge 13 to the top of the portion 23 of the tower, is supported in a suitable position by the traction of the ties 35 and 34 and by the tip 42 which prevent the rotation of the group consisting of the portions 24 and 25 about the hinge 13. The isostatic group consisting of the portions 26 and 27, connected at its rear end in the hinge 15 to the front end of the group consisting of the portions 24 and 25, can rotate about the hinge 15 in the slack allowed by the sliding of the pin 90, integral with the group consisting of the portions 26 and 27, in the slot of the plate 57 integral with the group consisting of the portions 24 and 25; said isostatic group consisting of the portions 26 and 27 is supported in a suitable position by the traction of the ties 36 and 39 and by the tip 54 which prevent the rotation of the group consisting of the portions 26 and 27 about the hinge 15.

[0035] Once the final position of alignment illustrated in pages 7 and 8 is reached, one proceeds with the alignment of the remaining portions 28, 29, 30 and 31 with the portions 24, 25, 26 and 27 illustrated in an intermediate step in page 9 until the completely unfolded crane is obtained. The details of the devices which determine the alignment of the third secondary portion 28 of the arm 50 with the second main portion 27, of the third main portion 30 with the fourth secondary portion 29 and of the secondary portion 29 with the secondary portion 28 are better illustrated in figures 13 and 14.

[0036] A plate 102 carrying a slot in a suitable position is integral with the third secondary portion 28 of the arm whereas a plate 103 carrying a hole in a suitable position is integral with the fourth secondary portion 29 of the arm. A jack 104 inserted in the hole of the plate 103 and in the slot of the plate 102 allows the fourth secondary section 29 and the third secondary section 28 of the arm to rotate about the hinge 18 in the slack allowed by the jack 104 inserted in the slot of the plate 102 and in the hole of the plate 103.

[0037] A hydraulic actuator 110 is hinged at 105 to the upper structure of the second main portion 27 of the arm 50, the other end of the hydraulic actuator 110 being hinged at 106 to the plate 102 of the third secondary portion 28 of the arm. A second hydraulic actuator 108 is hinged at 107 to the third main portion 30 of the arm, the other end of the hydraulic actuator 108 being hinged through the jack 104 to the plate 103 of the fourth secondary portion 29 of the arm. A pair of connecting rods of different lengths 109 and 111 are hinged together at 112, the other end of the connecting rod 109 being hinged at 113 to the second main portion of the arm 27 and the other end of the connecting rod 111 being hinged at 114 to the plate 102 of the third secondary portion 28.

[0038] On the upper part of the third secondary portion 28 of the arm 50 an end of a screw-down jack 116 is hinged at 115, the other end of the screw-down jack 116 being hinged at 117 to the ends of two flexible ties 118 and 119, preferably metal cables, the other end of said tie 118 being hinged at 120 to the second main portion 27 of the arm 50 near to the hinge 61 at the height of the upper longeron of the portion 27 and the other end of the tie 119 being hinged at 121 to the third main portion 30 of the arm 50 near to the hinge 20 at the height of the upper longeron of the portion 30.

[0039] Figure 9 shows an intermediate step of the alignment of the third secondary portion 28 of the arm 50 with the second main portion 27 of the arm 50, of the alignment of the third main portion 30 with the fourth secondary portion 29 of the arm 50 and of the alignment of the portions 29 and 30 with the portions 27 and 28.

[0040] The thrust exerted by the hydraulic actuator 110 makes the third secondary portion 28 of the arm rotate about the hinge 17 arranged at the end of the second main portion 27 of the arm; in the same way the thrust exerted by the actuator 108 makes the third main portion 30 of the arm rotate about the hinge 19 arranged at the end of the fourth secondary portion 29 of the arm. Rotating the third secondary portion 28 of the arm about the hinge 17 determines the rotation of the fourth secondary portion 29, said fourth secondary portion 29 being connected, in a hinged manner at 18, to the third secondary portion 28 and with the possibility to rotate about said hinge 18 in the slack allowed by the jack 104 inserted in the slot of the plate 102 and in the hole of the plate 103. By rotating the third secondary portion 28 of the arm about the hinge 17, the connecting rods 109 and 111 rotate about the hinge 112 which connects them at one end, whereas the other end of the connecting rod 111 connected at 114 to the upper part of the third secondary portion 28 of the arm displaces following the rotary movement of the third secondary portion 28 of the arm about the hinge 17 and whereas the other end of the connecting rod 109 rotates about the hinge 113 which connects it to the second main portion 27.

[0041] Through the rotation of the third secondary portion 28 of the arm 50 about the hinge 17 at the end of the second main portion 27, through the rotation of the fourth secondary portion 29 about the hinge 18 at the end of the third secondary portion 28 in the slack allowed by the jack 104 inserted in the slot of the plate 102 and in the hole of the plate 103 and through the rotation of the third main portion 30 about the hinge 19 at the end of the fourth secondary portion 29 of the arm

50, the tie 119 tends to go into traction and the tip 116, through the force exerted by said tip 119, tends to lift rotating about the hinge 115; by further continuing the rotation of the portion 28 about the hinge 17, of the portion 29 about the hinge 18, of the portion 30 about the hinge 19 and of the tip 116 about the hinge 115 the tie 118 also tends to go into traction.

[0042] Figure 10 illustrates the final position of alignment of the portions 27, 28, 29 and 30 of the arm 50 and the arrangement of the ties 118 and 119, whereas figure 14 better illustrates the details of the portions 27, 28, 29 and 30 connected from the hinges 17, 18 and 19. When the actuator 110 is about to reach its end stop position and the third secondary portion 28 of the arm 50 is aligned with the second main portion 27, the connecting rod 109 connected in the hinge 113 to the second main portion 27 of the arm and the connecting rod 111 connected in the hinge 114 to the third secondary portion 28, both connecting rods 109 and 111 being connected together by the hinge 112, go into traction preventing the further rotation of the third secondary portion 28 about the hinge 17 and carrying out the function of supporting said first portion 28; the attachment hinges 105 and 106 of the actuator 110 have the holes slightly slotted or oversized, with this allowing the actuator 110 to reach the final position without transmitting any force any longer to the secondary portion 28 and without carrying out any longer the structural function of supporting the portion 28.

[0043] When the connecting rod 109 and 111 have gone into traction, the rotation downwards of the third secondary portion 28 with respect to the second main portion 27 about the hinge 17 is prevented by the traction of said connecting rods 109 and 111; with respect to the forces directed downwards, the group consisting of the second main portion 27, the third secondary portion 28 and the second secondary portion 26, isostatically integral with the other end of the second main portion 27, is therefore a single isostatic reticular structure with hinges at the joints.

[0044] When the actuator 108 reaches its end stop position, the third main portion 30 of the arm 50 has completed the rotation about the hinge 19 aligning itself with the fourth secondary portion 29 of the arm 50; the actuator 108, connected in a hinged manner at one end thereof to the fourth secondary portion 29 of the pin 104 inserted in the hole of the plate 103 and connected in a hinged manner at the other end thereof at 107 to the third main portion 30, carries out, in an end stop position, the function of a rigid shaft giving the group consisting of the fourth secondary portion 29 and the third main portion 30 the characteristics of a single isostatic reticular structure with hinges at the joints.

[0045] The isostatic group as defined above consisting of the portions 26, 27 and 28 of the arm 50, connected at one end thereof in the hinge 15 to the end of the first secondary portion 25, is supported in a suitable position by the traction of the tie 36 which prevents the rotation of said group 26, 27 and 28 about the hinge 15. The isostatic group consisting of the portions 29 and 30 of the arm 50, connected at one end thereof in the hinge 18 to the front end of the group consisting of the portions 26, 27 and 28, can rotate about the hinge 18 in the slack allowed by the sliding of the pin 104, integral with the group consisting of the portions 29 and 30, in the slot of the plate 102 integral with the group consisting of the portions 22, 27 and 28; said isostatic group consisting of the portions 29 and 30 is supported in a suitable position by the traction from the tie 118, integral at one end with the hinge 120 and at the other end with the hinge 117, by the tie 119, integral at one end with the hinge 121 and at the other end with the hinge 117 and by the tip 116 which prevent the rotation of the group consisting of the portions 29 and 30 about the hinge 18.

[0046] The joint between the third portion 30 of the arm 50 and the terminal 31 has the function of allowing the complete folding of all of the elements of the arm without interference between the structural parts in the final step of said folding; in the top side view of the folded crane represented in figure 1, it should be noted how the terminal 31 must have the possibility of folding slightly upwards rotating about the hinge 20, whereas in the scaled down top side view of the completely mounted crane represented in figure 10, it should be noted how in the use step of the crane the terminal 31 must be aligned with the other portions of the arm 50. Figure 15 represents one of the possible solutions to allow the terminal 31 to be arranged, respectively, in a position aligned with the other portions of the arm 50 when the crane is mounted and in use conditions; figure 16 represents how the same solution can allow the terminal 31 to fold upwards when the crane is dismounted and folded.

[0047] The terminal 31 is hinged at one end and at the height of the lower longerons at 20 to the third main portion 30 of the arm; a perforated plate 125 is integral with the same end of the terminal 31 at the height of the upper longeron whereas a short connecting rod 122 is hinged at 123 to the front end of the third main portion 30 of the arm at the height of the upper longeron. A jack 124 inserted in the hole of the plate 125 and in the slot of the connecting rod 122 allows the terminal 31 to rotate with respect to the third main section 30 of the arm about the hinge 20 and in the slack allowed by the length of the slot, in such a way that the terminal 31 can fold for a short portion upwards when, with the crane folded, the terminal 31 rests upon other structural elements of the arm of the crane or can align itself with the other portions of the arm when, with the crane mounted, the terminal's own weight or the pull exerted by the conventional load-lifting cable fixed at the fixed end 126 to the end of the terminal 31, make the terminal rotate downwards.

[0048] With this the procedure for mounting the crane with the complete folding of the tower first of all and then of the arm has been described. It must, first of all, be specified that in the case of a greater height of the crane,

the portion of tower that can be extracted and the flexible ties on the side of the tower have a greater length. In this case the mounting foresees differences in the succession of the various operations and the tower assumes its completely raised position with side tie pulled, before the unfolding of the load arm begins. During the extracting of the upper portion of tower that can be extracted, the folded arm slides on the tower structure thanks to the presence of a suitably adapted trolley 80 (the details of figures 17 and 18 highlight such a situation). Moreover, it must be specified that the crane object of the present invention can be used, as well as with the arm 50 completely unfolded as illustrated above and for the purpose of increasing its versatility of use, also without the terminal 31 or with the third main portion 30 folded and resting upon the tie 36 or even with the second main portion of the arm 27 and the third main portion of the arm 30 folded upon themselves and resting upon the tie 35 in the configuration illustrated in figure 5.

[0049] The mounting procedure of the crane with the complete folding of the arm first of all and then of the tower implies the carrying out of the operations described for the mounting with the sequence order reversed.

[0050] A tower crane with a composite structure and automatic mounting has been realised in which the tower consists of at least three portions and the arm consists of many portions which can be folded and unfolded in the same direction of rotation.

[0051] It can be understood what are the advantages of the crane of the present invention. The tower in at least three portions, of which two are hinged and a third is telescopic, allows the double result can be achieved of having a crane of substantial height when unfolded and of a small size when folded in transportation configuration. Equally, the reduced height of the portions of the arm and their particular alternation of connection through hinges between the main portions, of a relatively long length, and the secondary portions, of a relatively short length, allow an arm to be realised of a substantial length with the crane unfolded and of a height that is so low as to allow the bulk size for the transportation of the crane not to be exceeded.

Claims

1. Self-mounting tower crane having portions of said structure hinged together at pivots, comprising a load arm (50) made up of many portions (24, 25, 26, 27, 28, 29, 30, 31) hinged together, and a tower made up of at least one pair of portions (21, 22) hinged together (at 12) and at least one portion (23) slotted in and able to be extracted from one of the portions (21, 22) of the hinged pair, said tower being equipped with mechanisms which allow the mounting in vertical position and the dismounting in horizontal position of the two portions of tower hinged together and which allow the extracting and reslotting of the third portion of tower in one of the two portions of the hinged pair, said tower in turn being hinged (at 11) at a lower end to the base structure (32) equipped with a rotation fifth wheel (33) and above which command means of the unfolding and folding of said crane are foreseen which act through a series of flexible ties (34) which extend along the side of said tower and essentially on the opposite side to said load arm (50) and which are hooked above said load arm, said ties forming, with the portions of base structure and with the portions of said tower, an articulated quadrilateral, with ties (35, 36, 39, 118, 119) being foreseen which collaborate with said arm (50), in which there are foreseen:

   - a first main portion (24), which is hinged (at 13) on one side to said tower and which in a front part thereof near to a hinge (14) for connection to a first secondary portion (25) is greater in height,
   - a first secondary portion (25) on one side hinged (at 14) to the first main portion (24),
   - a second main portion (27) of constant height,

   characterised in that said arm (50) also foresees:

   - that said first secondary portion (25) at the other side is hinged (15) to an end of a second secondary portion (26), said second secondary portion (26) being hinged (at 16) to said second main portion (27),
   - a third main portion (30), which at one end is hinged (at 19) to a fourth secondary portion (29) in turn hinged at the other end (at 18) to a third secondary portion (28) which in turn, at the other end, is hinged (at 17) to said second main portion (27),
   - a fifth secondary portion (31) which, at one end, is hinged (at 20) at the level of its lower longerons to a free end of said third main portion (30),
   - actuator means (60, 62, 108, 110) for the unfolding and folding up of said first, second and third main portion (24, 27 and 30),
   - means (68, 70; 109, 111) for restoring the structural integrality between said first and second main portion (24, 27) and, respectively, between said second and third main portion (27, 30) in the position with the arm unfolded.

2. Tower crane according to claim 1, **characterised in that** said means for restoring the structural integrality between said first and second main portion (24, 27) are a pair of connecting rods (68, 70), which on one side are hinged together (at 69) and on the other side one (70) is hinged (at 71) to said first main portion (24) and the other (68) is hinged (at 67) to

said first secondary portion (25) of the arm (50), and ties (35, 36, 39) arranged between a tip (42) arranged at the end of said tower and said second main portion (27) in association with a further tip (54).

3. Tower crane according to claim 1, **characterised in that** said actuator means (60, 62; 108, 110) for the unfolding and folding between said first, second and third main portion (24, 27, 30) are hydraulic cylinders.

4. Tower crane according to claim 1, **characterised in that** said ties which collaborate with said load arm (50) comprise a first tie (35) consisting of three portions, of which a first portion (44), of short length, is connected to a tip (42) which is arranged hinged (at 43) to an end of said tower, a second portion (46), of a length substantially equal to the length of said tip (42), and a third portion (48) is connected (at 49) to said first main portion (24) of the arm (50) at the height of the upper longeron, and a second tie (36, 39) arranged between said tip (42) and said second main portion (27).

5. Tower crane according to claim 4, **characterised in that** it foresees a further tip (54) arranged between said second tie (36, 39) and said secondary portion (25) of the arm (50) .

6. Tower crane according to claim 4, **characterised in that** at least one portion (39) of said second tie (36, 39) consists of a flexible metal cable.

7. Tower crane according to claim 1, **characterised in that** said means for restoring the structural integrality between said second and third main portion (27, 30) are a pair of connecting rods (109, 111), which on one side are hinged together (at 112) and on the other side one (109) is hinged (at 113) to said second main portion (27) and the other (111) is hinged (at 114) to said third secondary portion (28) of the arm (50), and ties (118, 119) arranged between said second main portion (27) on one side and said third main portion (30) on the other side, both in association with a further intermediate tip (116).

Fig.1

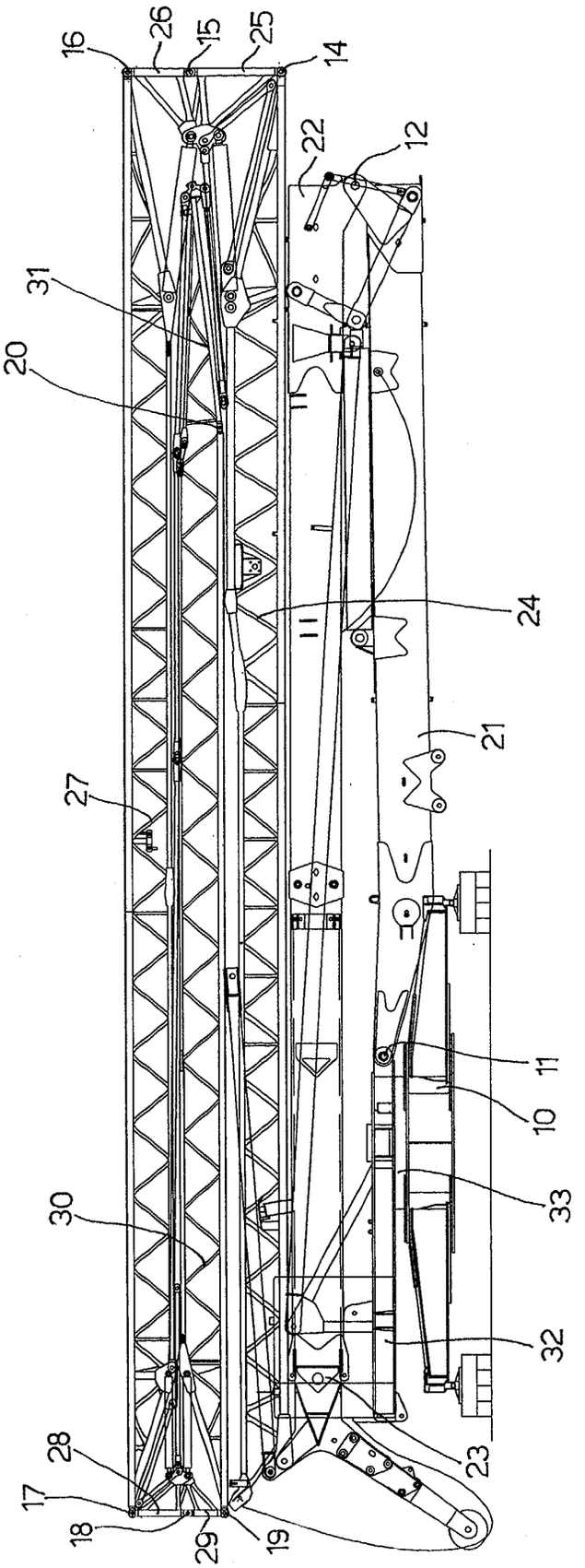

Fig.2

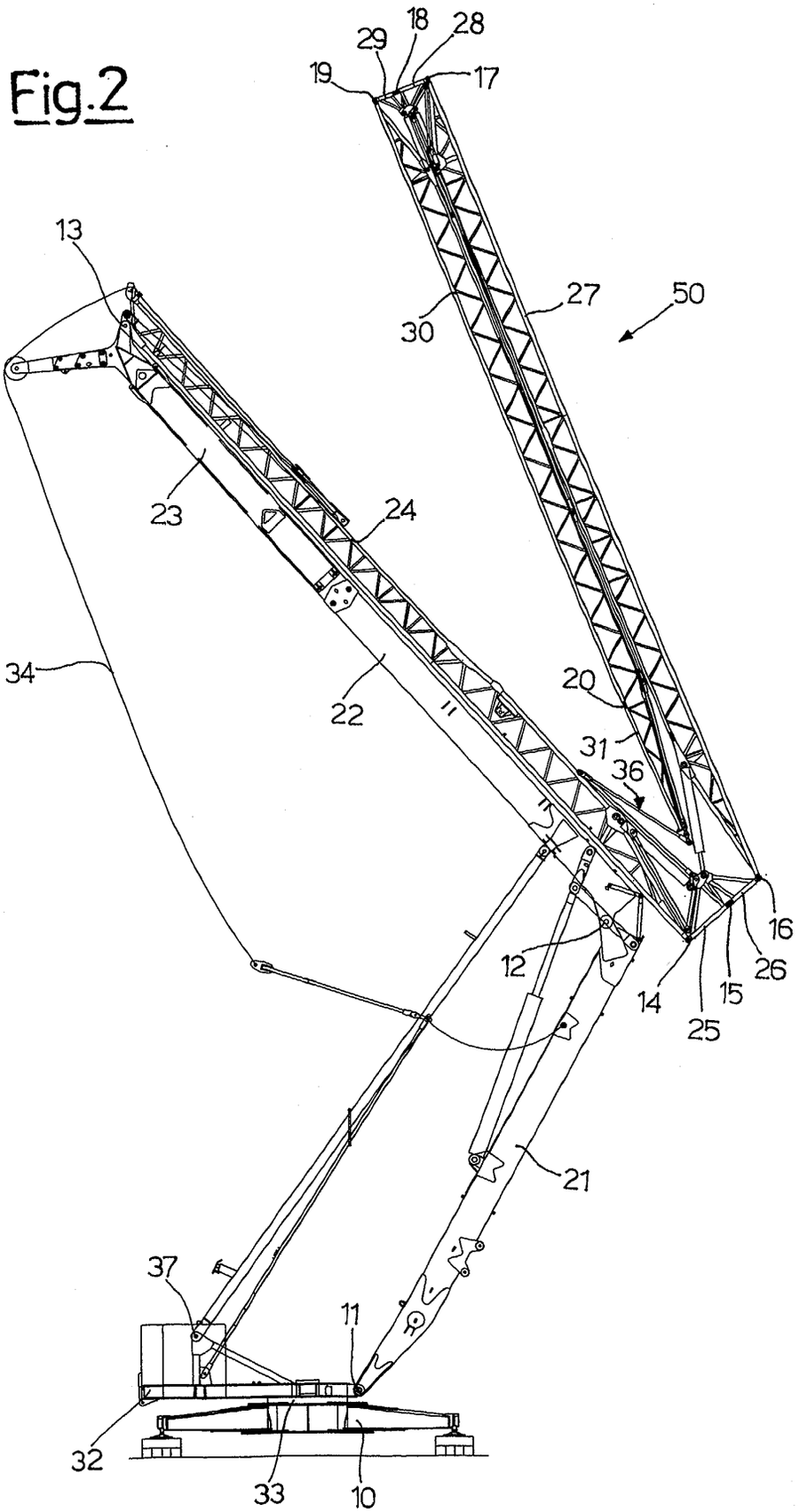
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Fig.3

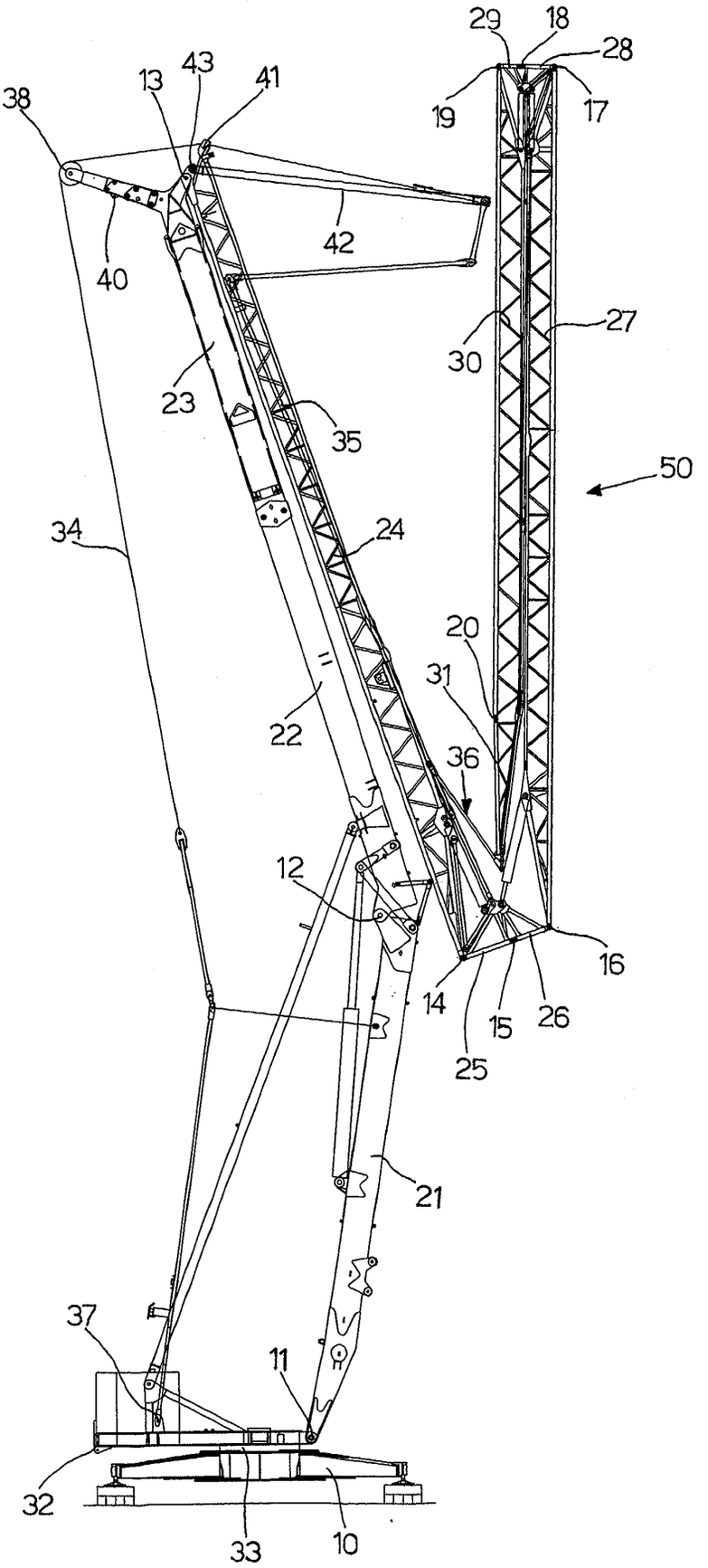
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Fig.4

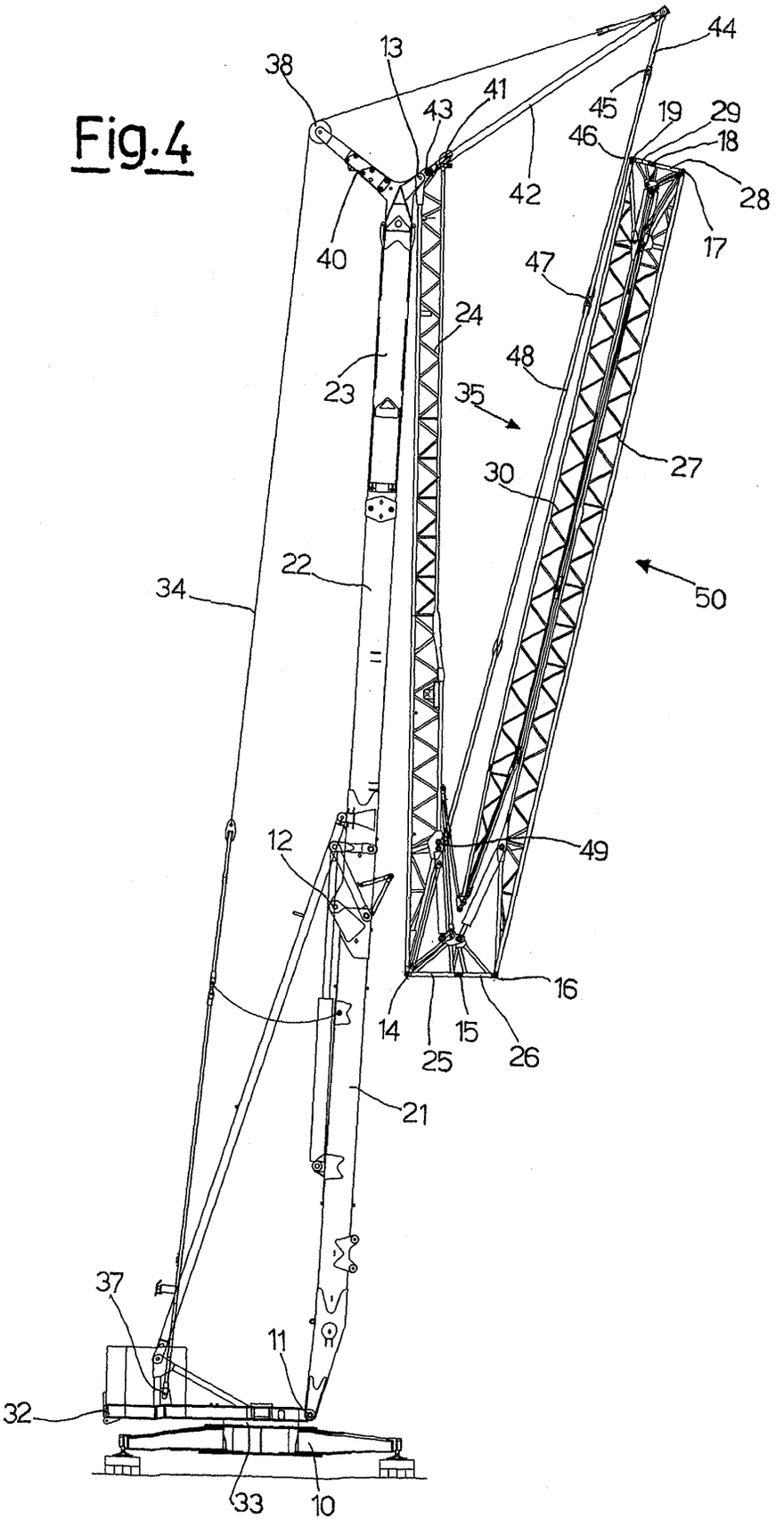
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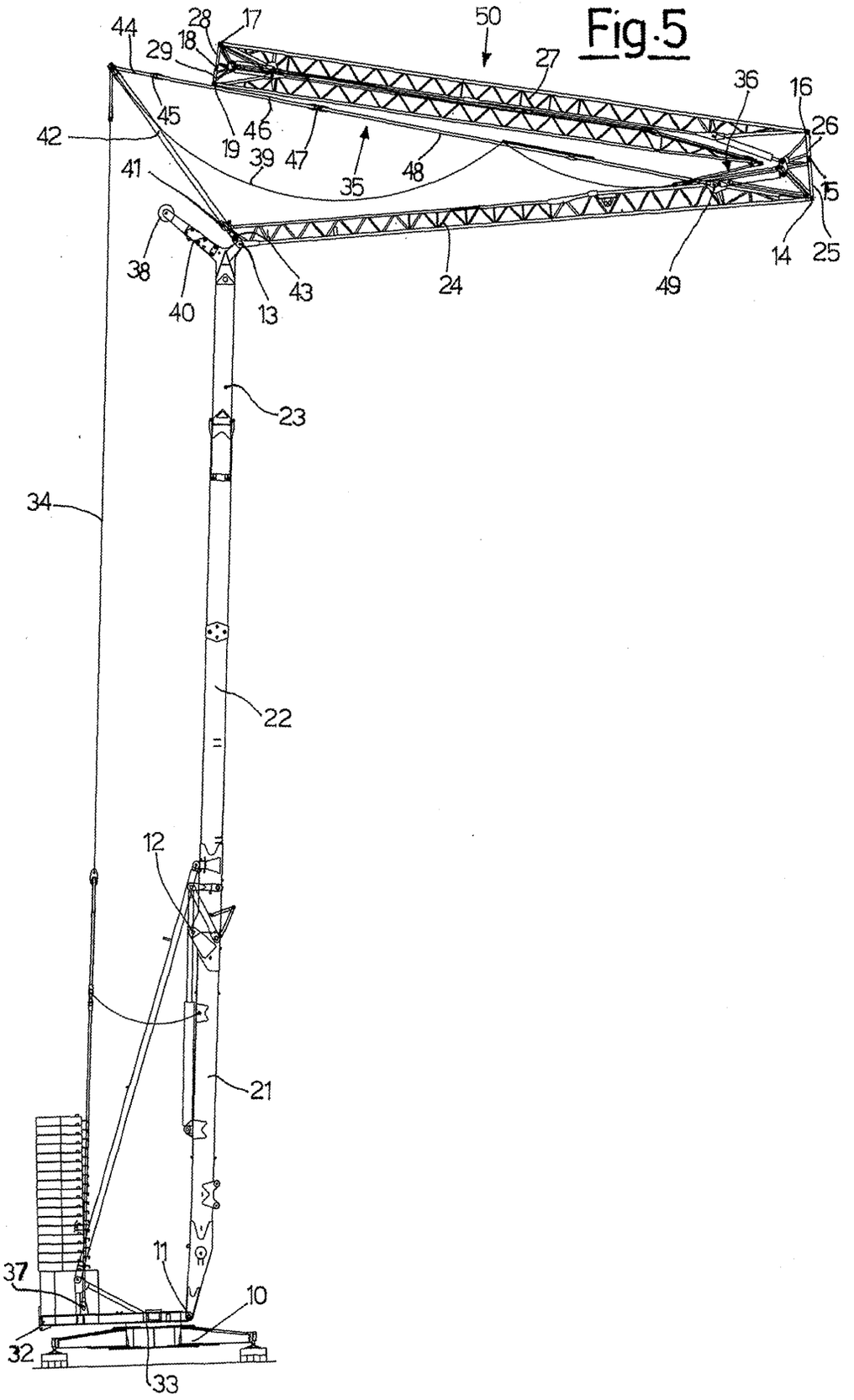
Fig.5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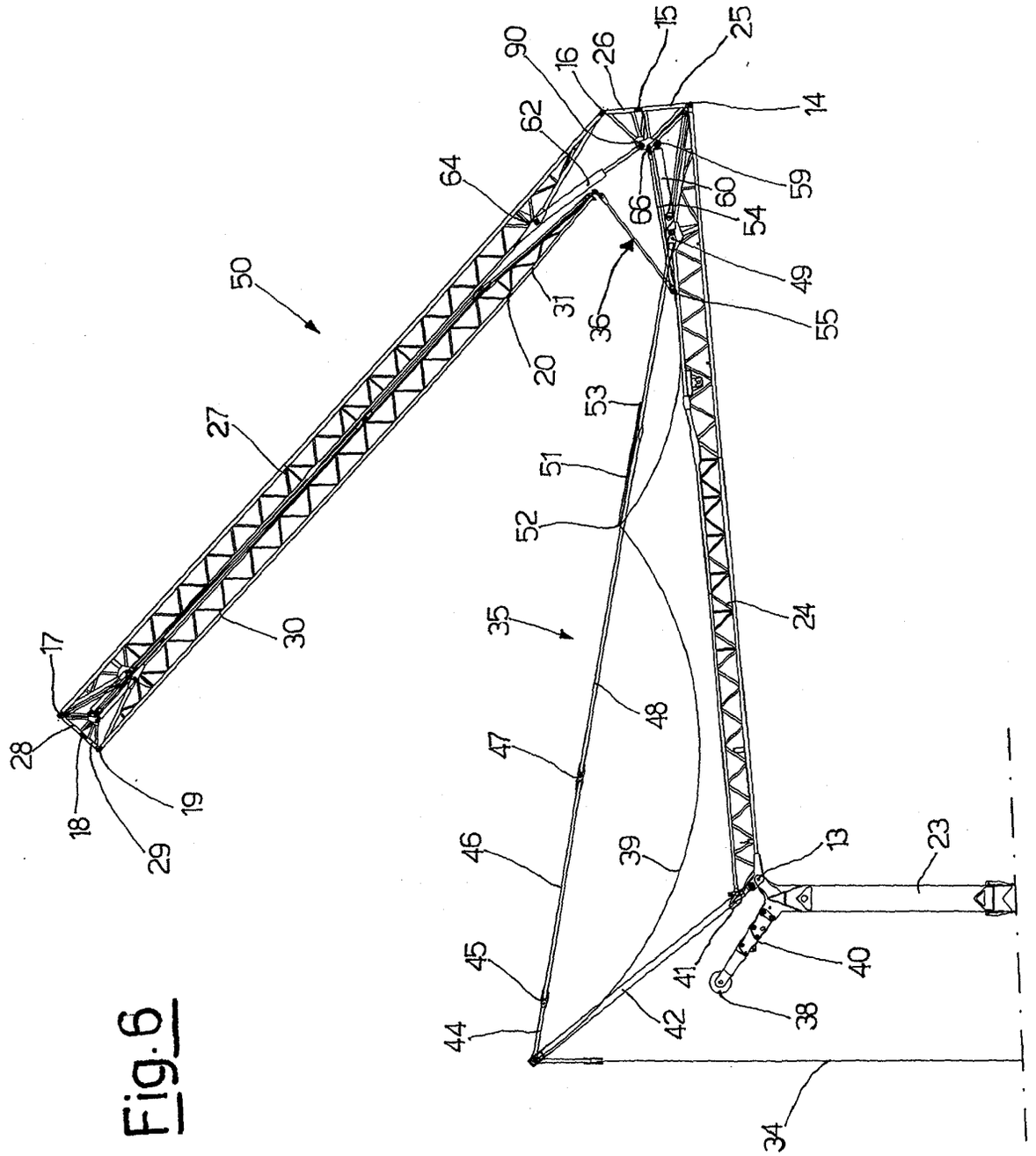
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Fig.6

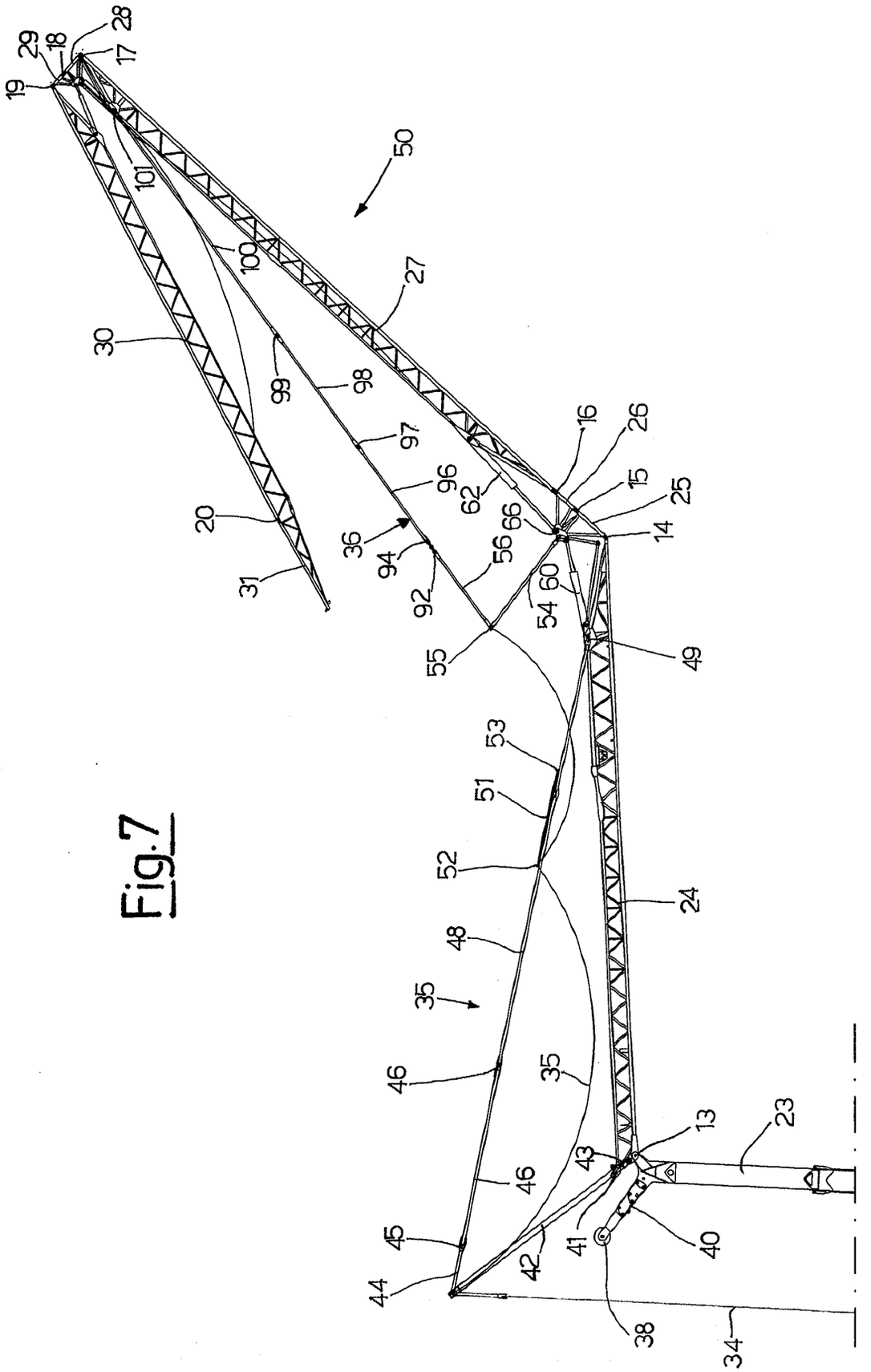
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Fig.7

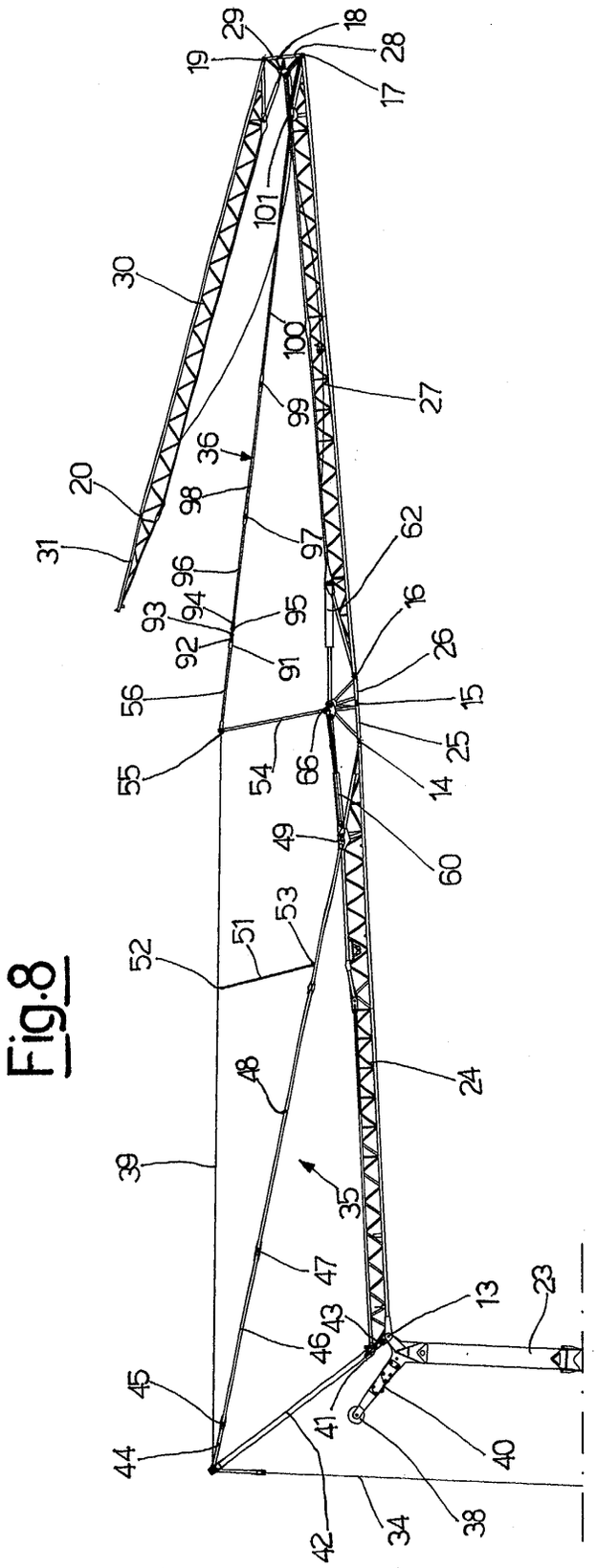
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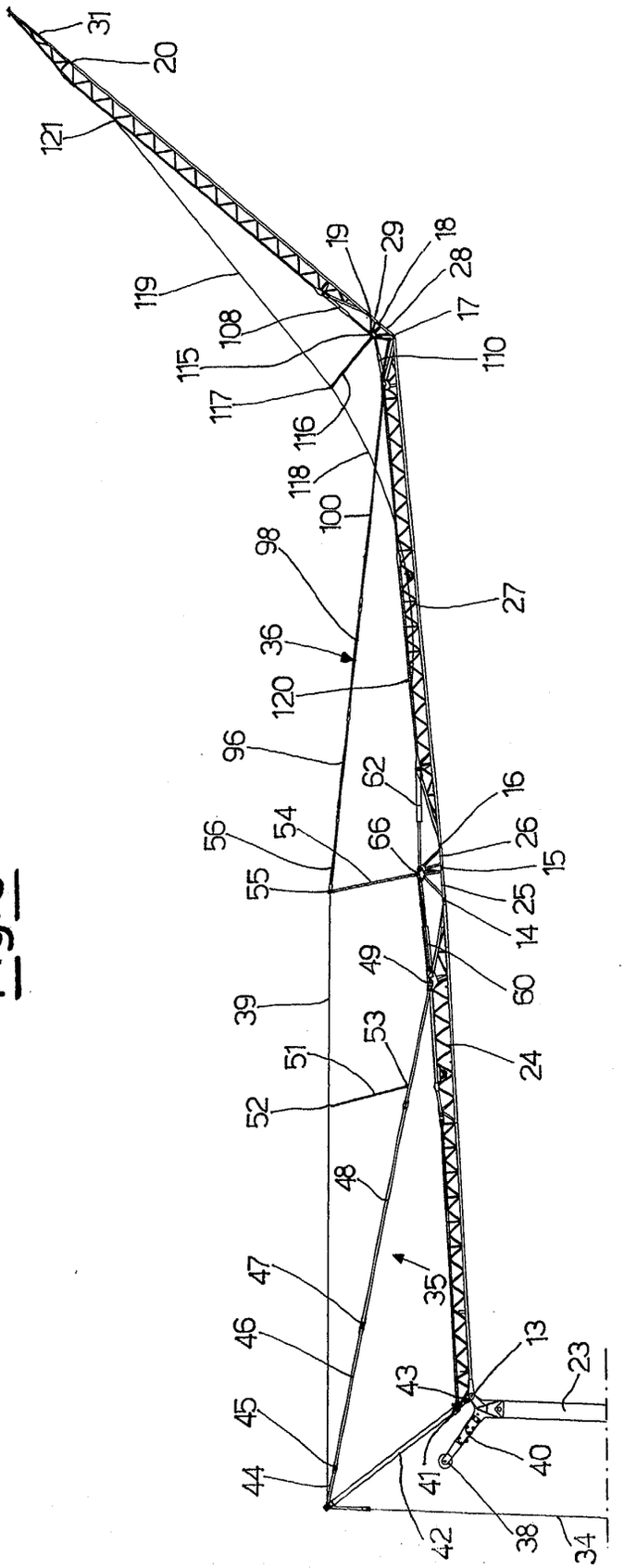
Fig.8

Fig.9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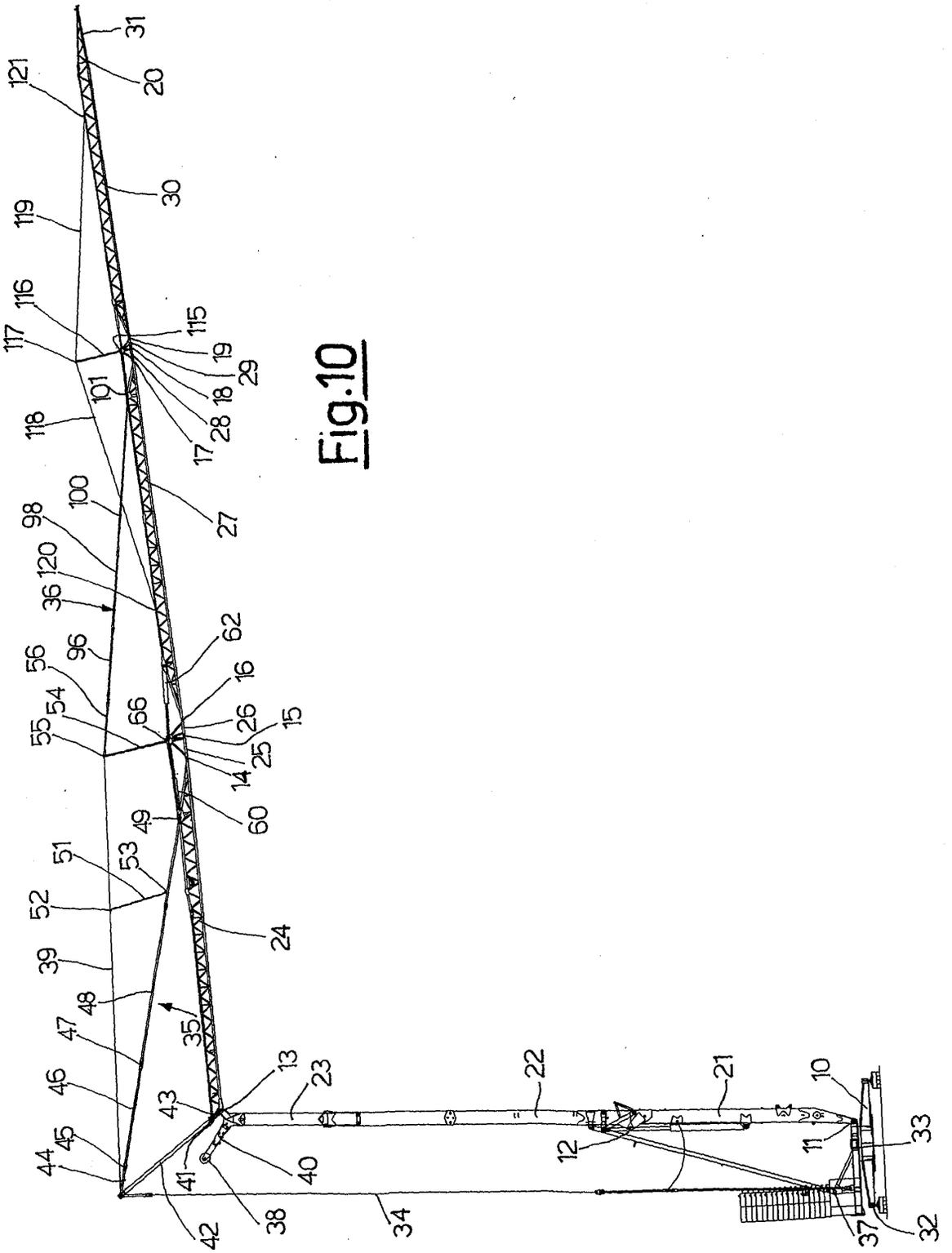
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Fig.10

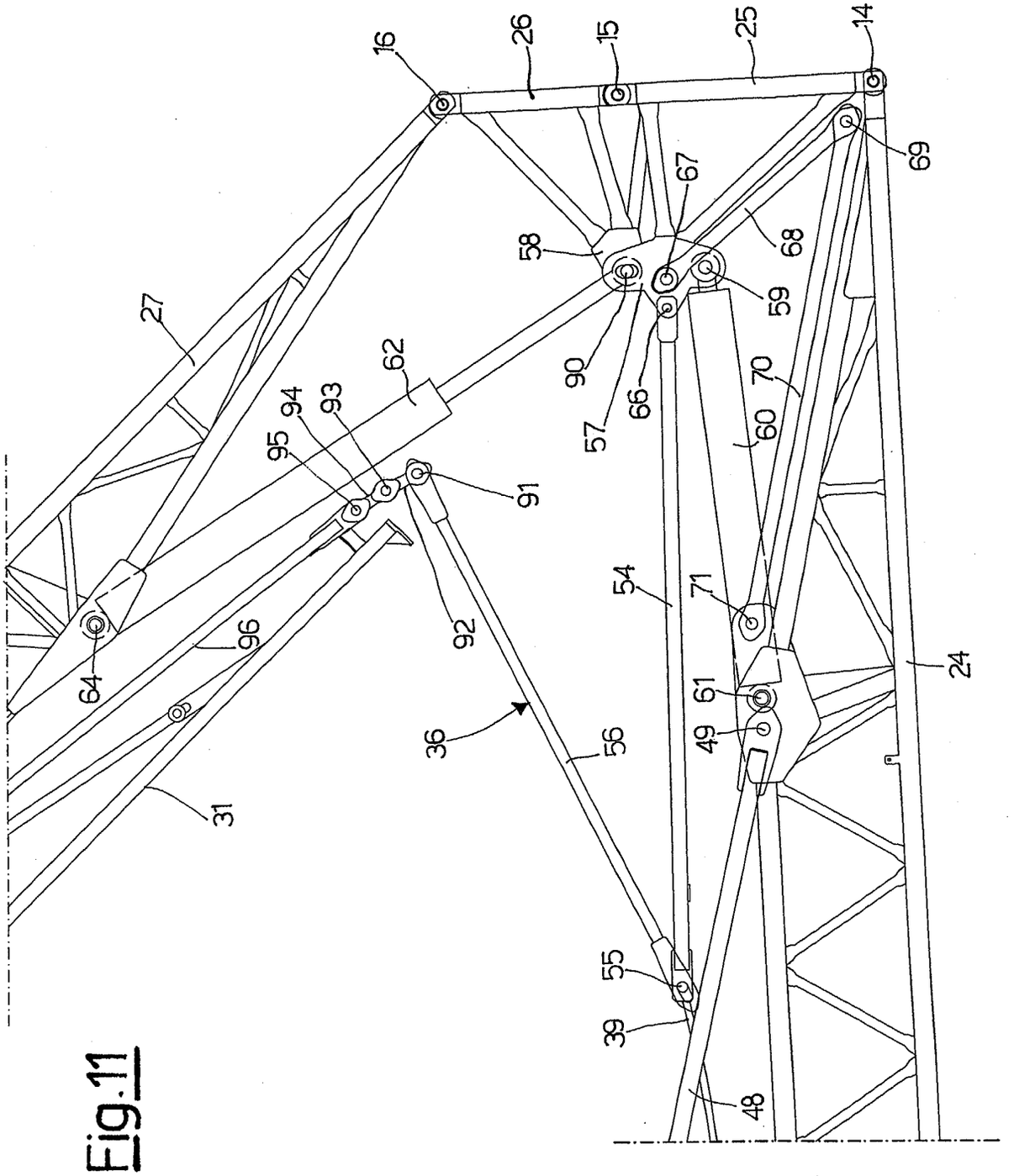
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Fig.11

Fig.12

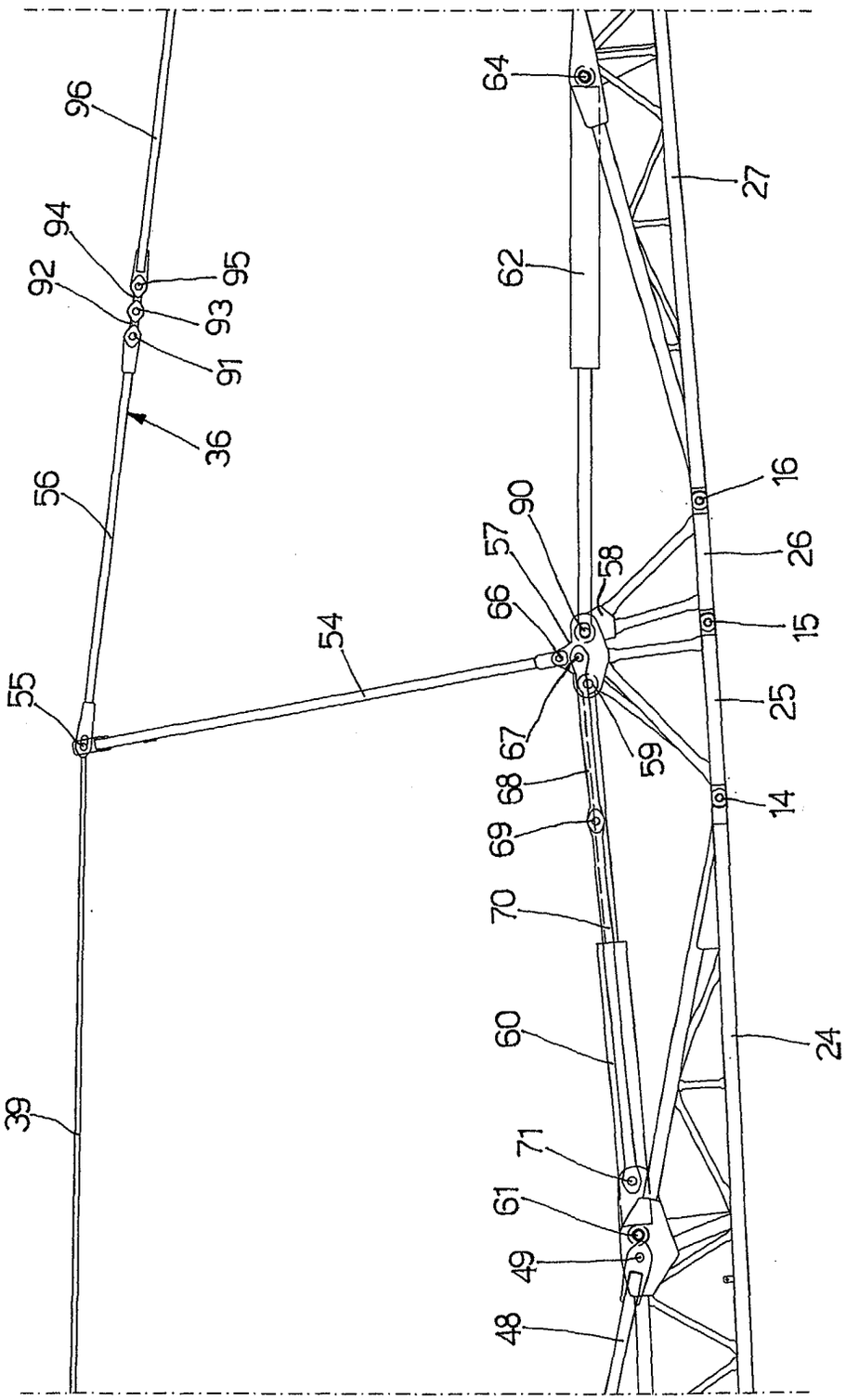
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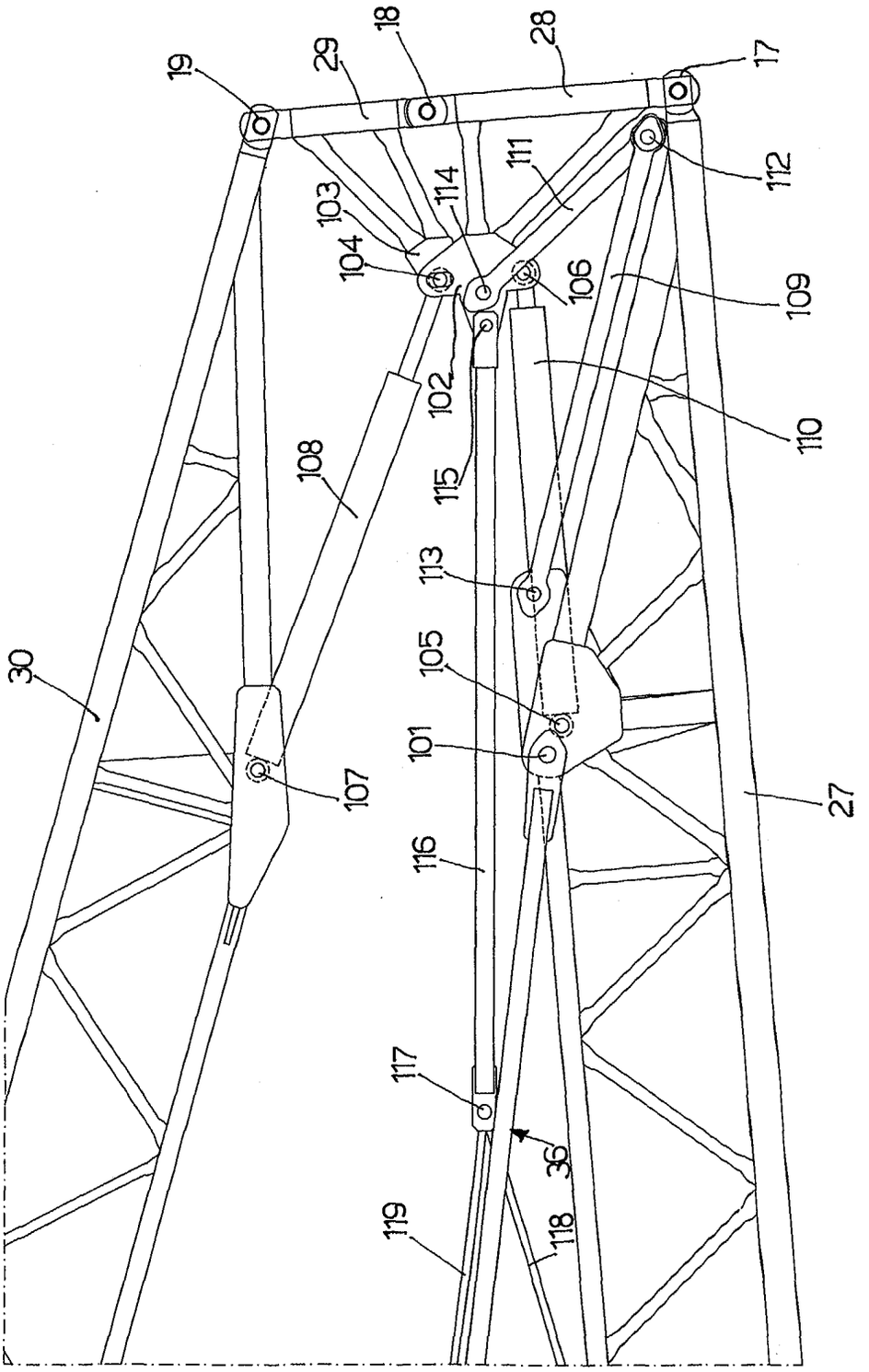
Fig.13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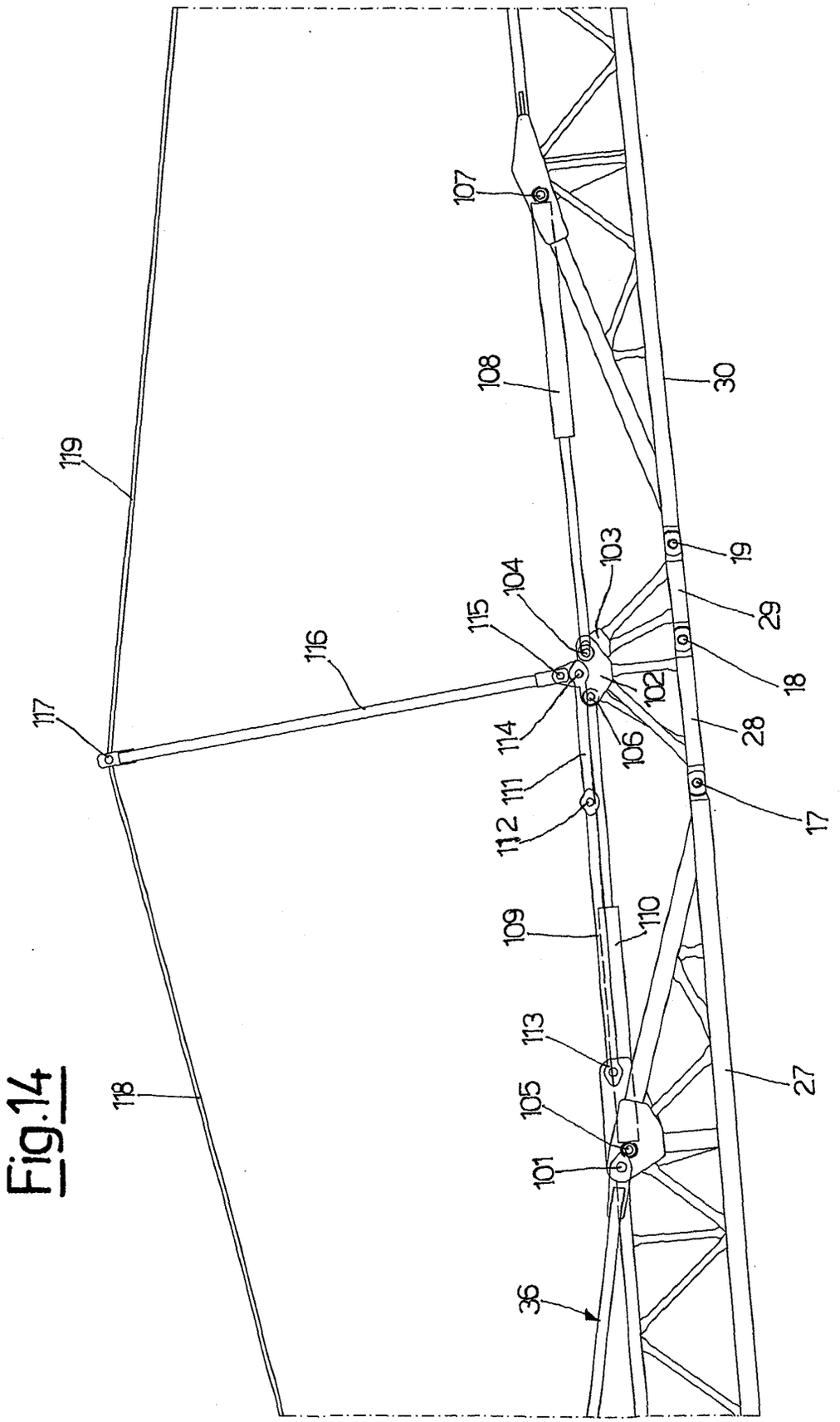
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Fig.14

Fig.15

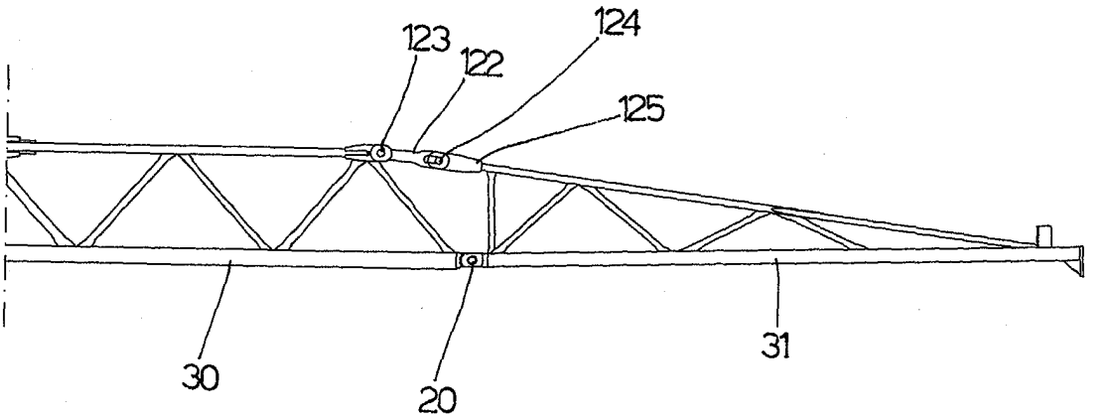
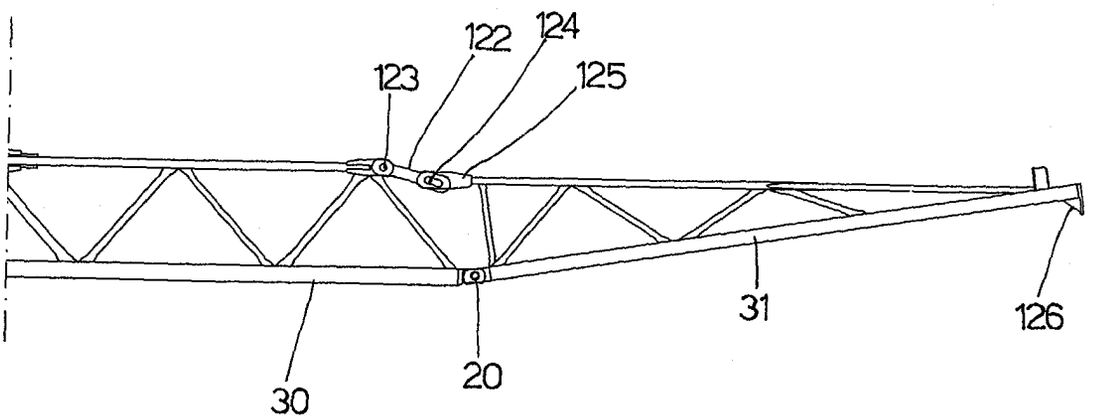


Fig.16



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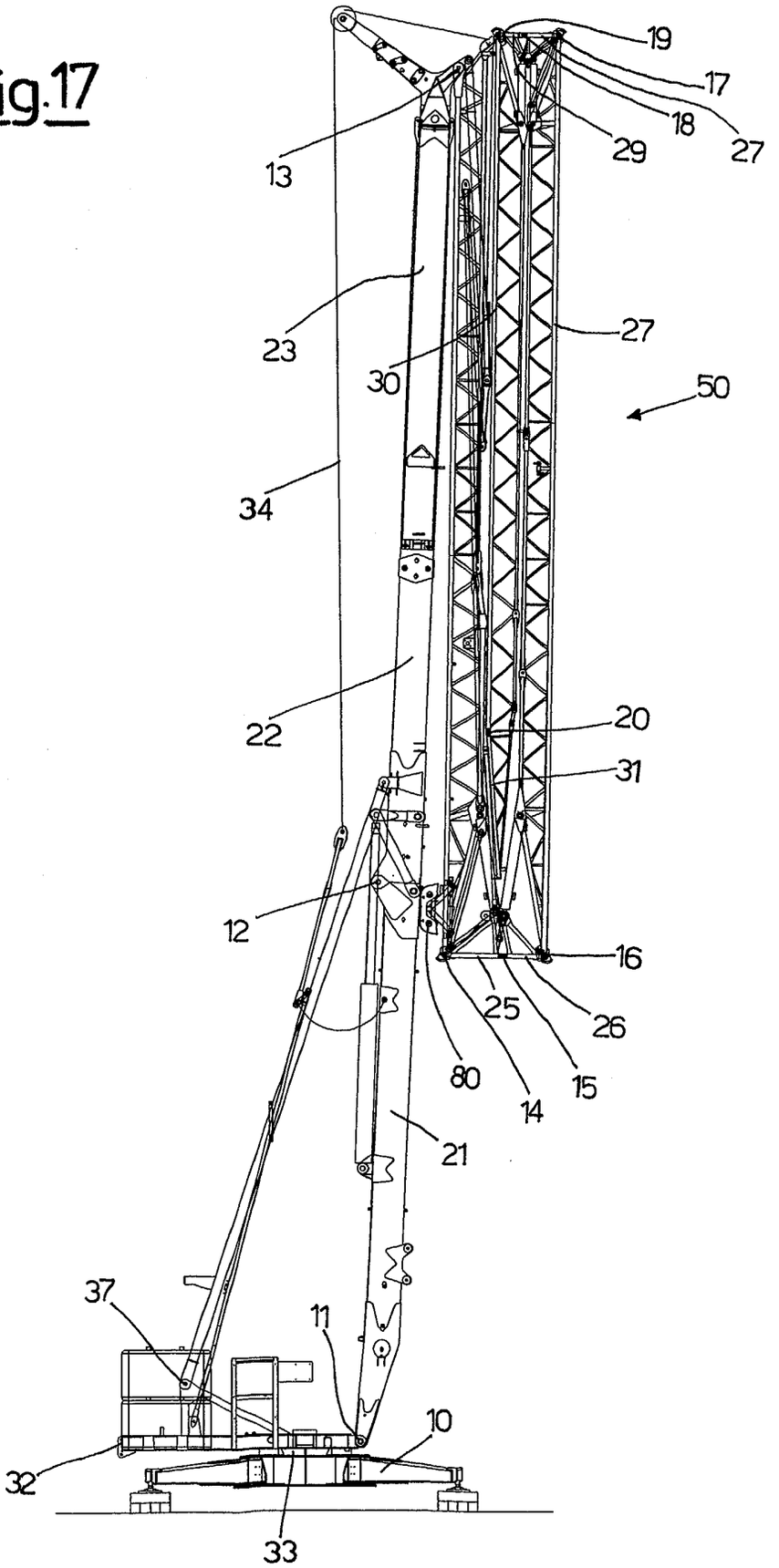
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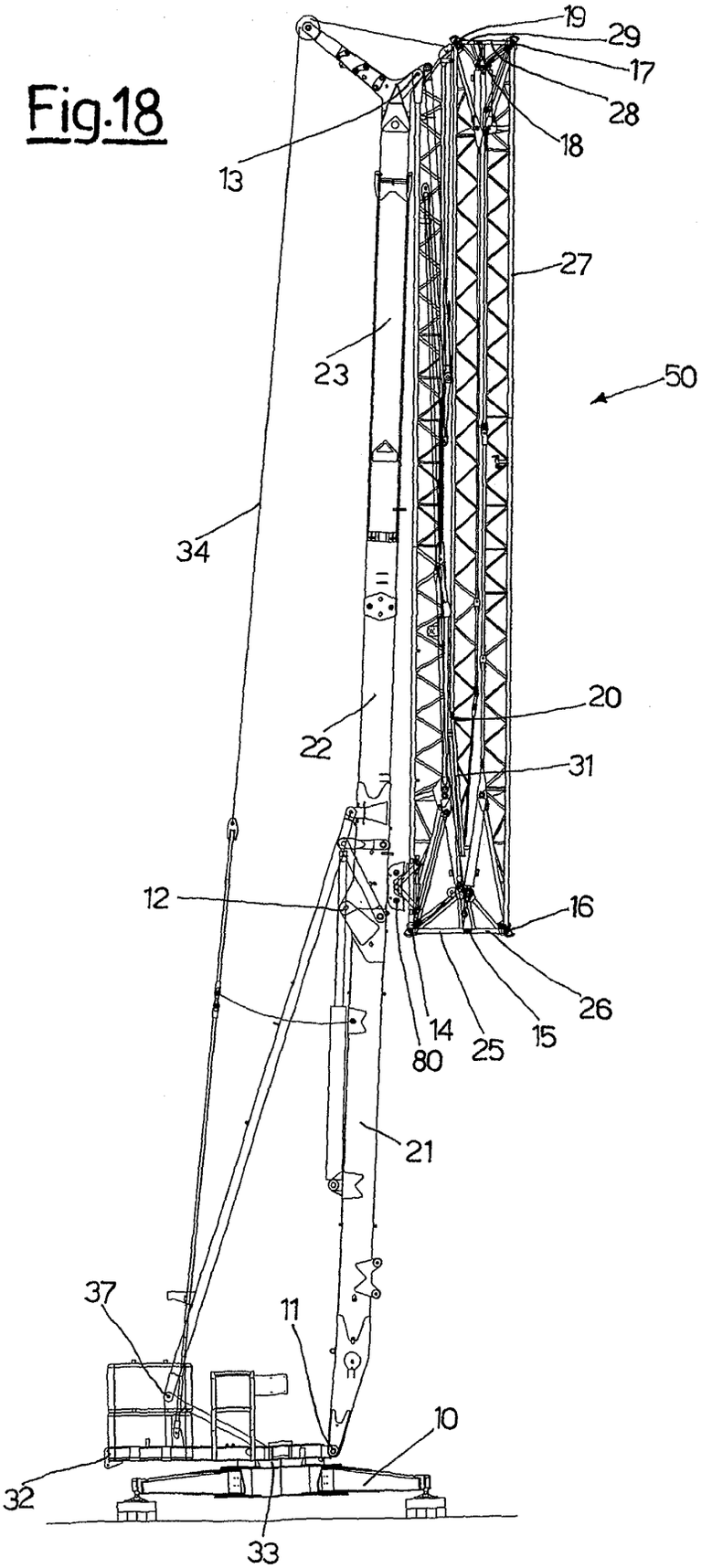
Fig.18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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 07 7915

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

B66C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 December 2003	Sheppard, B

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