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(54) Benævnelse: **METHOD AND MEANS FOR ESTABLISHING ACCESS TO THE MAIN PARTS IN THE NACELLE ON A WIND TURBINE.**

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TITLE: METHOD AND MEANS FOR ESTABLISHING ACCESS TO THE MAIN PARTS IN THE NACELLE ON A WIND TURBINE.

The present invention relates to a method for establishing access to the removal and installation of the main shaft, gearbox, generator and other main parts located in the nacelle of a wind turbine, the roof remains localized on the nacelle, and guide mechanisms to perform the invention.

When carrying out service and repair work on large wind turbines, there is a need to be able to get access to mount and dismount vital and relatively heavy parts of the wind turbine, which is located in the interior of the nacelle. These parts are for example the main shaft, gearbox, generator and other major parts, which not can be transported up and down through the wind turbine tower, and where either the use of cranes or crane winch between the nacelle and a station on the ground, to handle said parts, which require that there is access to the nacelle from above. This access has often been obtained by simply removing the nacelle roof (the roof), and the hoist it down to earth by the use of a mobile crane and hoist the roof in place after completion of servicing / repair of the windmill. This requires, however, the presence of a mobile crane, which is relatively expensive operation since the crane charged at the hourly rental. In cases where there used winches for the transport of the heavy parts from the nacelle and the ground surface, the handling of the nacelle roof be a difficult operation due the relatively bulky design of the roof, hence the need to operate with alternative solutions.

EP 1 677 001 (GAMESA EOLICA S A SOC UNIPERSO) discloses a system for removing the cover roof from a wind turbine which includes the following steps: the assembly of an elevator and a boom on the rail beams of the frame forming the nacelle, the lifting of the cover roof, its lengthwise movement and 90° turn. In this position the roof is anchored to a boom mounted on the rail beams, which turning on its axis separate the roof from the nacelle and next proceed to lowering it to the ground. The are two tools used to remove the cover roof: a tool capable of hoisting, moving and turning the nacelle cover, and an other tool for its lowering. Both tools are anchored to the rail beams of the nacelle.

An alternative option could be to mount the roof on the nacelle with a hinge connection, and with hydraulically operated pistons, for example in combination with exchange mechanisms whereby the roof could be opened as seen at smaller turbine types. However, such solutions require the installation of fixed installations in a nacelle, in which is already scarce space, and the solution is relatively expensive compared to the number of times where such installation is required.

Thus there is a need for an alternative solution to the above problem which is both flexible and which is universally applicable for convertibles on the nacelles of different sizes and types of wind turbines.

It is the object of the invention to provide a solution where the roof remains on the nacelle top, but at the same time establish access to the removal and installation, as well as hoisting up and down of a wind turbine main shaft, gearbox, generator and other major parts are arranged in the nacelle on wind turbines.

This object is achieved by a method for establishing access to the removal and installation of the main shaft, gearbox, generator and other main parts located in the nacelle of a wind turbine, where the nacelle roof remains on the nacelle and comprising the following operations;

-mounting at least two sets of pairs of opposing guide transfer mechanisms on the inner side of the nacelle respectively near the front end closest to the shaft, and the rear end, the upwardly facing free ends of which comprises at least one roller,

-displacement of the free ends of the guiding transfer means to abutment with the abutment flange of the roof relative to the nacelle base by jacks or winches,

-displacement of the roof in backwards direction, away from the front end to a position where a part of the roof is cantilevered over the rear edge of the nacelle.

This provides the possibility to perform a rearward displacement of the nacelle roof to an extent, which results in providing sufficient access to remove major parts of the interior of the nacelle by means of winches, without the use of an actual crane.

However, if the rearwards displacement of the roof, of some reasons are wished to be performed to an extent, where the center of gravity of the roof is lying outside the rear edge of the cabriolet, or the roof needs to be secured in case of wind gusts, following steps should be added to the method according to the invention;

-displacement of a counter holding roller located in the level above the roller (s) and the abutment flange of the roof in position above the abutment flange of the roof at each guide transfer mechanism,

- further displacement of the roof in backwards direction, away from the front end to a position where a part of the roof is cantilevered over the rear edge of the nacelle.

A guide transfer mechanism, for mounting on the inner surface of a nacelle with a roof and/or mounting to the static stable parts of a wind turbine arranged in the nacelle, for lifting and displacement of the roof on the nacelle of wind turbines for use in the practice of the method of claim 1 is characterized in, that the guide transfer mechanism comprises a console and a therein vertical displaceable cooperating first member, said console comprising mounting facilities for mounting the console in the inside of the nacelle and/or static stable parts of the wind turbine arranged in the nacelle, and said console comprising a first horizontally orientated frame section, with a second integrated vertically orientated, downwards extending, tube shaped part, for receiving and guiding of said vertical displaceable cooperating first member, the first lower end of which is adapted to cooperate with lifting means for displacement of the first member, and the other upper end of which comprises at least a first roller, or roller set, the upwards facing carrying surface is located in the same horizontal plane and mounted on horizontally oriented shaft(s).

Hereby is achieved the advantage that the guide transfer mechanisms used for lifting and displacement of the roof, can be mounted on any wind turbine and removed again after use, that is, to the universal application principle is ensured. The advantage is also that by displacement of the vertically oriented displaceable first means in the upward direction by means of a jack, winch, a pulley block or other suitable means it is obtained that the roll or roll set in the upper free end of the displaceable member is brought into abutment with the downwardly facing side of the flange of the roof, and a continued upward displacement of the member will result in that the roof come to rest on the roll or roll set, or, more correct expressed, the rollers of each of the four supporting points, whereby the roof can be displaced some backward, in the direction away from the hub of the wind turbine, in a carefully controlled movement, possibly guided by pulleys, winches, lashing straps, or similar equipment, thus ensuring that the roof do not run off the rolls, and dropped.

The guide transfer mechanisms can be transported from the surface to the nacelle inside the wind turbine tower may be designed in light metal or composite material in order to reduce weight accordingly, which will facilitate its handling and fitting.

With the intent of ensuring that the displacement of the roof should not be exaggerated so that it is dropped, the guide transfer mechanism further comprises a second roll, or counter hold, mounted on a horizontally oriented shaft, located at a level above the first roll or roll set, said second roller or counter hold is displaceable between a passive retracted position, where the roller or counter hold is located outside the first rolling bearing surface, and an advanced, active lockable position where the second roller or the counter hold is positioned at a level above the first roll or roll set's bearing surface.

By placing the counter hold or roll in the active projecting locked position, it is achieved that the displacement of the roof is limited by the second roller or counter hold, so that the displacement is limited to the point where the roller or the counter hold comes in abutment with the inner surface of the front end of roof, and simul-

taneously controlled displacement of the roof parallel to the nacelle. Moreover, the counter holds ensures the roof does not tilt over his center of gravity and thus the lost. The counter hold or roller also ensures the roof against gust of wind.

With the intent to maximize stability during displacement of roof, the guide transfer mechanism according to the invention may comprise locking means between the tube shaped part and the cooperating first member for attachment of the vertically displaceable first member in a preferred position.

Hereby is achieved that the vertically displaceable member is lockable with the roll or roll set at a preferred level, and thus there is provided a stable support of the rollers or roller sets on which the roof can be displaced. The locking means may for example consist in through-holes in the vertical tubular member and the sliding body which can be made to overlap by adjusting the displacement of the body with jacks, winches, pulley blocks, etc. after which a locking bolt is introduced through the overlapping holes and secured with a locking ring, split or similar. Then slacken the means used for the displacement of the body, then roll/roll set is supported by the locking bolt.

With the intention further to stabilize the rear guide transfer mechanisms, the first horizontally oriented frame section may further comprises cooperating mounting facilities at the first end of the horizontally oriented frame section, and with respect to the first frame part longitudinal axis, obliquely extending support beams, the other end of which includes mounting facilities for mounting for fitting on an inner adjacent side of the nacelle.

This provides better stability of the rear transfer mechanisms against twisting, provided that the roof during the displacement is influenced by wind or other forces which do not run parallel to the longitudinal axis of the nacelle.

In a particular embodiment of the guide transfer mechanism according to the invention, the vertically displaceable cooperating first member comprise a jack, for

displacement of the first member in the vertical direction, guided in the vertically oriented tubular member.

The embodiment will inevitably cause the guide transfer mechanism becomes heavier to handle, but can in some cases be advantageous.

In a further embodiment of the guide transfer mechanism according to the invention, the first lower end of the vertically displaceable cooperating first member comprise a groove cut wheel which cooperates with a winch, a pulley block or lashing straps belonging to the guide transfer mechanism, the ends of which are attachable to a bracket, and passed through the groove cut wheels for the displacement of the first member in the vertical direction guided in the vertical tubular member.

The invention is briefly described in the following with reference to the accompanied drawings, wherein;

Fig. 1 is a view of a nacelle on a wind turbine seen from above, where the roof is closed,

Fig. 2 is a view of the nacelle in Fig. 1 seen from above, but with the roof displaced backwards according to the method according to the invention,

Fig. 3 is a perspective view of Fig. 2,

Fig. 4 is a perspective detail section view of the nacelle shown in Fig. 2 and Fig. 3 seen obliquely from behind, and where the roof is transparent,

Fig. 5 shows a first embodiment of a guide transfer mechanism for mounting on statically stable structural components mounted near the front end of the nacelle, to perform the method according to the invention,

Fig. 6 is a detail perspective view of the embodiment of a guide transfer mechanism shown in Fig. 5,

Fig. 7 shows a second embodiment of a guide transfer mechanism for mounting on the nacelle sides, mounted near the rear end of the nacelle,

Fig. 8 is a first detail perspective view of the embodiment of a guide transfer mechanism shown in Fig. 7,

Fig. 9 is a second detail perspective view of the embodiment of a guide transfer mechanism shown in Fig. 7 and Fig. 8, and

Fig. 10 is a detail perspective view of the second upper end of the guide transfer mechanism according to the invention.

Fig. 1 is a view of the nacelle 2 on a wind turbine 4 seen from above where the roof 6 is closed. The nacelle has a front end 8 and a rear end 10, and a center axis 12. In the view the roof is made transparent.

In Fig. 2, which is a view of the nacelle 2 shown in Fig. 1, the roof is displaced backwards above the rear end 10 of the nacelle so the main shaft 14 and the gearbox 16 etc. of the wind turbine is exposed.

In Fig. 3 which is a perspective view of the nacelle shown in Fig. 1 and Fig. 2 where the nacelle 2 and the roof 6 is made transparent, appears how the roof 6 is raised and carried respectively on a first set of guide transfer mechanisms 18, 18´, mounted on statically stable structural components 20 in the nacelle 2 close to the front end 8 of the nacelle, and a second set of guide transfer mechanisms 22, 22´mounted on the parallel long sides 24, 24´of the nacelle and with support beams 26 mounted on the rear side 28 of the nacelle.

In Fig. 4, which is a perspective section view of the nacelle 2 seen obliquely from behind and above, it appears more in detail how the first set of guide transfer mechanisms 18, 18´is mounted to mechanical stable structural components 20 close to the front end 8 of the nacelle, and how the second set of guide tranfer mechanisms 22, 22´is mounted on the parallel sides 24, 24´of the nacelle 2.

In Fig. 5 is disclosed a detail section showing how the first guide transfer mechanism 18 is mounted to a mechanical stable structural component 20 in the nacelle 2. The mounting facilities 28 consists in the shown embodiment of a stiffened angle frame 30, the vertical oriented leg 32 of which is connected with a first horizontally oriented frame part 34 near the nacelle wall 24, and the horizontally

oriented angle leg 36 via spacers 38 and bolts 40 introduced through mating holes 41 in the angle leg 36, is fixed to the mechanically stable structural member 20.

As it further appears from Fig. 5, more clearly from Fig. 6, which is a perspective view of an embodiment of the first guide transfer mechanism 18, 18´, it´s design is seen more in detail. The guide transfer mechanism 18, 18´comprises the first horizontally oriented frame section 34 which is attached to the angle frame 30.

In Fig. 7 is shown a second embodiment 22, 22´of the guide transfer mechanism suited for mounting on respectively the inner long sides 24, 24´ of the nacelle 2 and on the inner rear wall 28 of the nacelle. This embodiment of the guide transfer mechanism comprises besides the first horizontally oriented frame section 34 with mounting facilities 66 for mounting on the nacelle sides 24, 24´, further an oblique extending frame part 68, the free end of which 70 includes mounting facilities 71 on the rear wall 28 of the nacelle 2. This will provide this second embodiment 22, 22´of the guide transfer mechanism the required stability to withstand the forces to be transferred to the nacelle sides when the roof 2 is displaced backwards and forwards.

Common for the shown embodiments of the guide transfer mechanisms 18, 18´ and 22, 22´ is that a second integrated vertically oriented tube shaped part 42 is downwards extending from the first integrated frame part 34, said second integrated vertically orientated tube shaped part 42 being designed for receiving and guiding a vertically displaceable first member 44 , the first lower end 46 in the shown embodiment is provided with a groove cut wheel 48 arranged to cooperate with lifting means (not shown) for displacement of the first member 44, guided inside the vertically oriented tube shaped part 42. The lifting means may in connection with the shown embodiment consist of a pulley block, a lashing with a tighten mechanism, the ends of which is attached to cross pins 50 arranged on each side of the tube shaped part 42 on the frame 34. By guiding the wire of the winch, the chain of the pulley block, or the lashing strap down and around the groove cut wheel 48, and subsequently tighten the wire, chain or the lashing strap with the

suitable tighten mechanisms, there is performed a displacement of the first member 44 in vertical direction.

The second upper end 52 of the vertical displaceable member 44 comprises in the embodiment shown, a set of rolls comprising three rolls 54, whose upwardly facing support surface 55 is located in the same horizontal plane and mounted on horizontally oriented shafts 56 It is the roller upwardly facing supporting surfaces 55, which at an upwardly-oriented displacement of the vertically displaceable member 44 is brought into abutment with the flange 58 on the lower side 60 of the roof 6 (see also Fig. 10) and, by continued displacement of the member 44 upwards by the lifting means, the roof 6 is lifted free of nacelle edge and can subsequently be displaced carried on rollers 54.

As is apparent from FIG. 5, Figs. 6 Fig. 7, Fig. 8 Fig.9 and Fig. 10 comprises the guide transfer mechanism further another roll or a counter hold 62, mounted on a horizontally oriented shaft 64 located in a level of the first roll set 54, the second roller or counter hold 62 is displaceable between a passive retracted position, in which the reel / counter hold 62 is located outside the first roll set's support surface 55, and a forward, active position in which the second roller / counter hold 62 is positioned at a level above the supporting surface 55 of the first roller set 54.

Common to the embodiments of the guide transfer mechanism 18 18' and 22, 22' also applies to include locking means 70 between the vertically oriented tubular member 42 and the vertically displaceable first member 44 for retaining of the vertically displaceable first member 44 in a preferred position. The locking means 70 consist in the shown embodiments in that, the vertical tubular portion 42 and the displaceable member 44 comprises through-holes 72, 74 which can be made to overlap by adjusting the displacement of the body 44 with jacks, winches and pulley blocks etc. (not shown) after which a locking bolt 76 which is secured with a locking ring, split or similar (not shown) is introduced through the overlapping holes 72, 74. Then the lifting means used for the displacement of the body is slackened, after which roll set 54 is supported by the bolt 76.

Access to mounting and de-mounting main shafts 14, gearbox 16, generator and other main parts arranged in the nacelle 2 on a wind turbine, without removing the roof 2 from the nacelle 2 comprises the following operations;

-mounting at least two sets of pairs of opposing guide transfer mechanisms 18, 18´, 22, 22´, the upwardly facing free ends 52 of which comprises at least one roller 54, on the inner side of the nacelle close to respectively near the front end (the shaft end) and the rear end.

-displacement of the free ends 52 of the guide transfer mechanisms 18, 18´,22, 22´ to abutment with the abutment flange 58 of the roof by jacks or winches,

-displacement of a counter holding roller 62 located in the level above the roller (s) 54 and the abutment flange 58 of the roof in position above the abutment flange 58 of the roof at each guide transfer mechanism18, 18´, 22, 22´,

-displacement of the roof 2 in backwards direction, away from the front end 8 of the nacelle 2 to a position where a part of the roof 2 is cantilevered over the rear edge 10 of the nacelle.

Upon completion work in the nacelle the roof 2 is displaced on the rollers 54, back to the original position, where after the vertically displaceable member 44 on the guide transfer mechanisms 18, 18 ', 22, 22' are lowered to the starting position and subsequently, the roof is attached to the nacelle, and finally the guide transfer mechanisms 18, 18 ', 22, 22' are removed.

Finally it should be noted that the inventor has recognized that the guide transfer mechanism may be embodied in other designs than those described above and shown in the accompanying drawings. For example, could each guide transfer mechanism 18, 18 ', 22, 22' be equipped with an integrated jack, and the number of rolls 54 and counter holds 62 may be more or less than the number disclosed, but this does not alter the essential inventive aspect to provide access to the removal and installation of the main shaft, gearbox, generator and other main parts located in the nacelle of a wind turbine, without removal of the nacelle roof from the nacelle, by providing the nacelle 2 with a number of guide transfer mech-

anisms 18, 18 ', 22, 22 'with supporting rollers 54, on which the roof 2 can be displaced sufficiently backward to be establish the appropriate access, as well as with lockable counter hold 62 for retaining and control of the displacement of the roof.

PATENTKRAV

1. Fremgangsmåde til etablering af adgang til at fjerne og installere hovedaksler (14), gearkasse (16), generator og andre hoveddele placeret i en nacelle (2) af en vindmølle (4), hvor nacelle taget (6) forbliver på nacellen (2) og som omfatter følgende operationer:

-montere mindst to sæt bestående af par af modstående overførselsstyremekanismer (18, 18´, 22, 22´), på indersiden (24, 24´, 28) af nacellen nær den forreste ende (8) af nacellen nærmest akslen, og den bagerste ende (10) af nacellen, respektivt, hvor de opadvendende frie ender (52) af hver overførselsstyremekanismeomfatter mindst en første rulle (54),

- forskydning af de opadvendende frie ender (52) af overførselsstyremekanismerne til de anlægger mod anlægsflangen (58) af taget relativt til nacellebasen ved brug af jdonkrafte eller spil,

- forskydning af taget (6) i en bagudrettet retning, væk fra den forreste ende (8) af nacellen til en position hvor en del af taget er udkraget over den bagerste kant (10) af nacellen.

2. Fremgangsmåde ifølge krav 1, der omfatter følgende operationer;

- forskydning af en modholdsrulle eller et modhold (62) placeret i niveauet over den første rulle(r) og anlægsflangen (58) af taget i en position over anlægsflangen (58) af taget ved hver overførslesstyremekanisme (18, 18´, 22, 22´),

- yderligere forskydning af taget (6) i en bagudrettet retning, væk fra den forreste ende (8) til en position hvor en del af taget er udkraget over den bagerste kant (10) af nacellen.

3. Overførselsstyremekanisme, til montering på den indre overflade af en nacelle (2) med et tag (6) og/eller montering til statisk stabile dele (20), af en vindmølle, arrangeret i nacellen (2), til at løfte og forskyde taget (6) på nacellen (2) af vindmøllen (4) til brug i udøvelsen af fremgangsmåden ifølge krav 1, hvor overførselsstyremekanismen (18, 18´, 22, 22´) omfatter en konsol (34, 42) og et deri lodret forskydeligt samvirkende første element (44), hvor konsolen (34, 42)

omfatter monteringsfaciliteter (32, 36, 38, 40, 66, 68, 71) til montering af konsolen indvendigt i nacellen (2) og/eller statisk stabile dele (20) af vindmøllen anbragt i nacellen (2), og omfatter en første horisontalt orienteret rammesektion (34), med en anden integreret lodret orienteret rørformet del (42), der rager nedad, til at modtagelse og styring af det lodret forskydelige samvirkende første element (44), hvis første nedre ende (46) er tilpasset til at samvirke med løfte midler til forskydning af det første element (44), og den anden øvre ende (52) der omfatter mindst en første rulle (54), eller rullesæt, hvis opadvendende bærende overflade (55) er placeret i det horisontale plan og monteret på mindst en horisontalt orienteret aksel (56), hvor overførselsstyremekanismen videre omfatter en anden rulle eller modhold (62), monteret på en horisontalt orienteret aksel (64), placeret på et niveau over den første rulle eller rullesæt (54), hvor den anden rulle eller modhold (62) er forskydeligt mellem en passiv, tilbagetrukket position, hvor rullen eller modholdet (62) er placeret udenfor den bærende overflade (55) af den første rulle eller rullesæt (54), og en fremskreden, aktiv position, hvor den anden rulle/modholdet (62) er placeret i et niveau over den bærende overflade af den første rulle eller rullesættet (54).

4. Overførselsstyremekanisme (18, 18´, 22, 22´) ifølge krav 3, k e n d e t e g n e t v e d a t, den omfatter låsemidler (72, 74, 76) mellem den rørformede del (42) og det lodret forskydelige samvirkende første element (44) til fastgørelse af det lodret forskydelige første element (44) i en foretrukken position.

5. Overførselsstyremekanisme (18, 18´, 22, 22´) ifølge krav 3 eller 4, k e n d e t e g n e t v e d a t, den første horisontalt orienterede rammesektion (34) videre omfatter samvirkende monteringsfaciliteter ved den første ende af den horisontalt orienterede ramme sektion (34), og respektivt til den første rammedels langsgående akse, vinkelret strækkende støttebjælker (68), hvis anden ende (70) inkluderer monteringsfaciliteter (71) til montering på en idre tilstødende side (28) af nacellen (2).

6. Overførselsstyremekanisme (18, 18´, 22, 22´) ifølge et hvilket som helst af krave 3-5, k e n d e t e g n e t v e d a t, det lodret forskydelige første element

(44) omfatter en donkraft til forskydning af det første element i en lodret retning, styret i den lodret orienterede rørformet del (42).

7. Overførselsstyremekanisme (18, 18´, 22, 22´) ifølge et hvilket som helst af krave 3-6, k e n d e t e g n e t v e d a t, den første nedre ende (46) af det forskydeligt samvirkende første element (44), omfatter en sporskåret hjul (48) der samvirker med et spil, en taljeblok eller surrestropper tilhørende overførselsstyremekanismen, hvis frie ender kan fastgøres til et beslag, og føres gennem det sporskårne hjul (48) for at forskyde det første element (44) i den lodrette retning styret i det lodrette rørformede element (42).

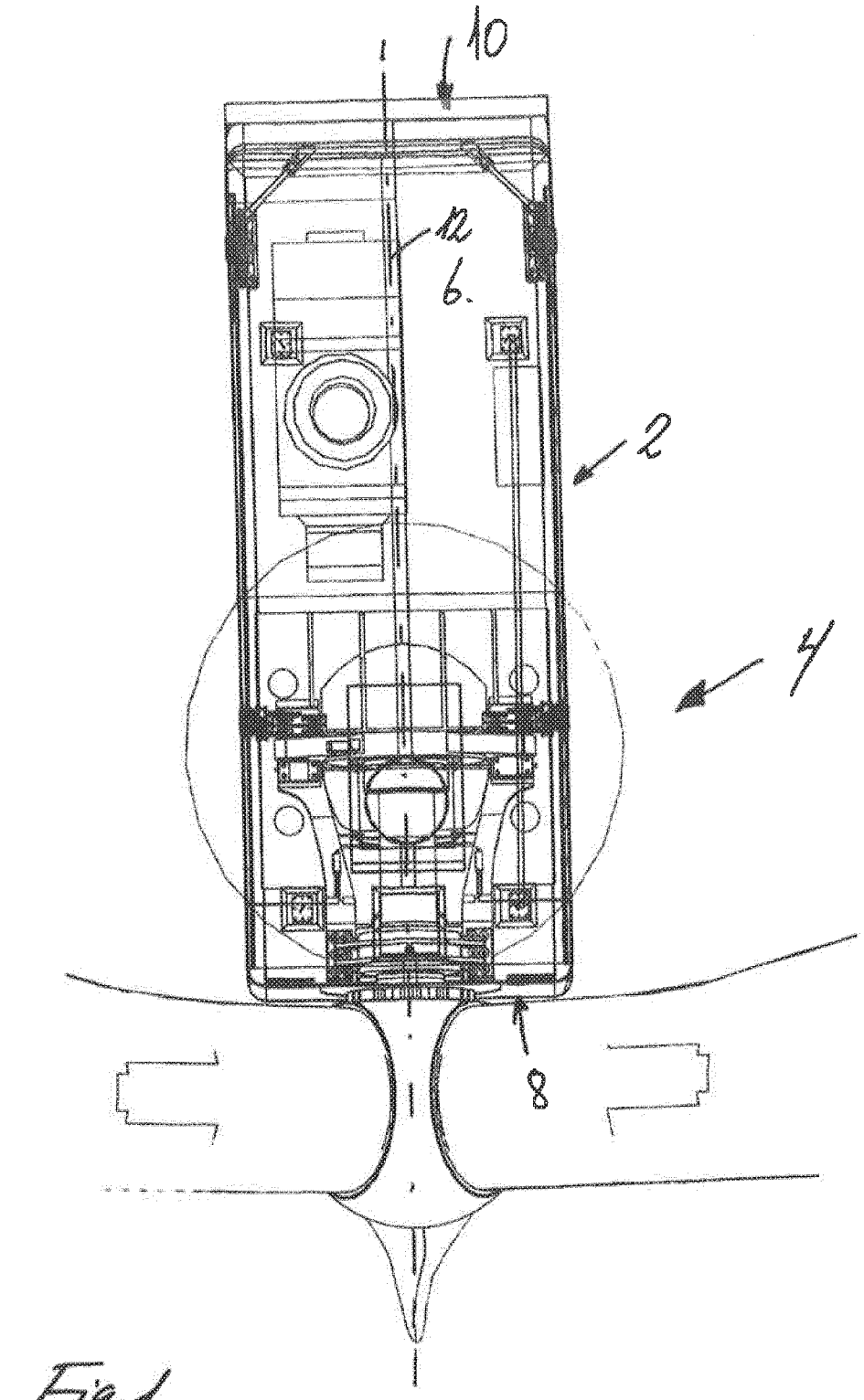

Fig. 1

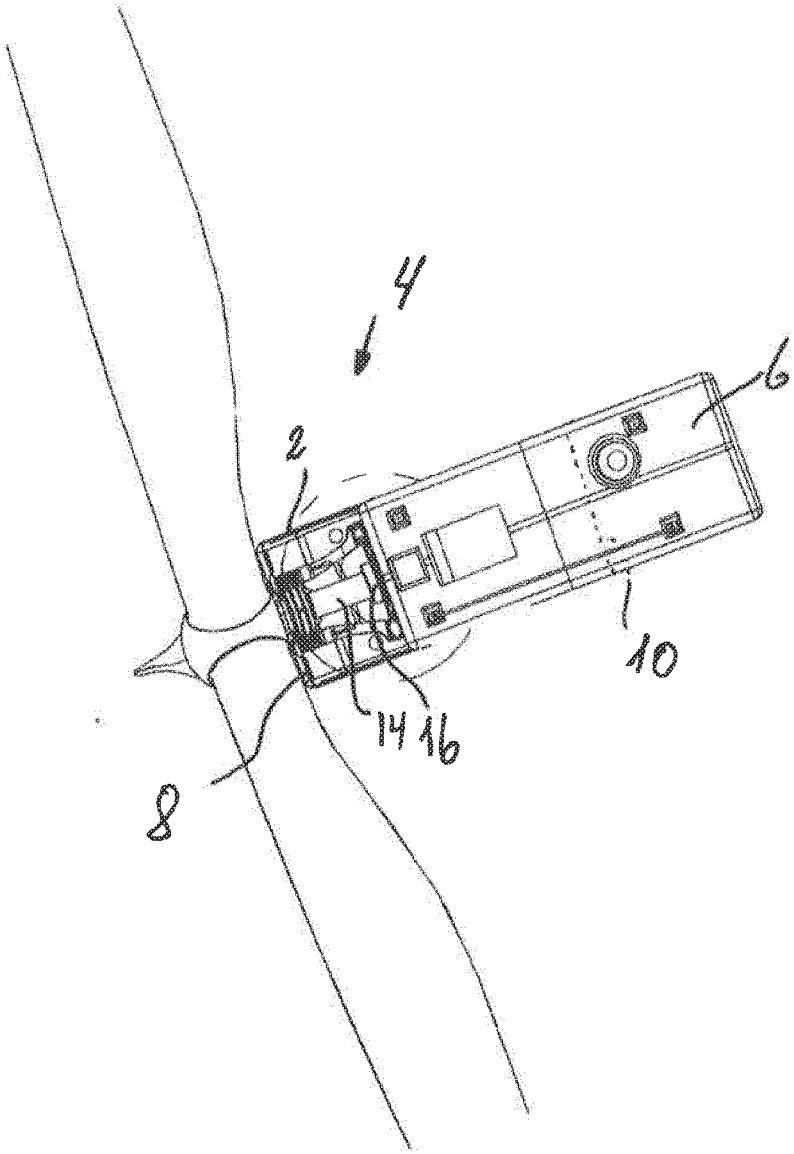

Fig.2

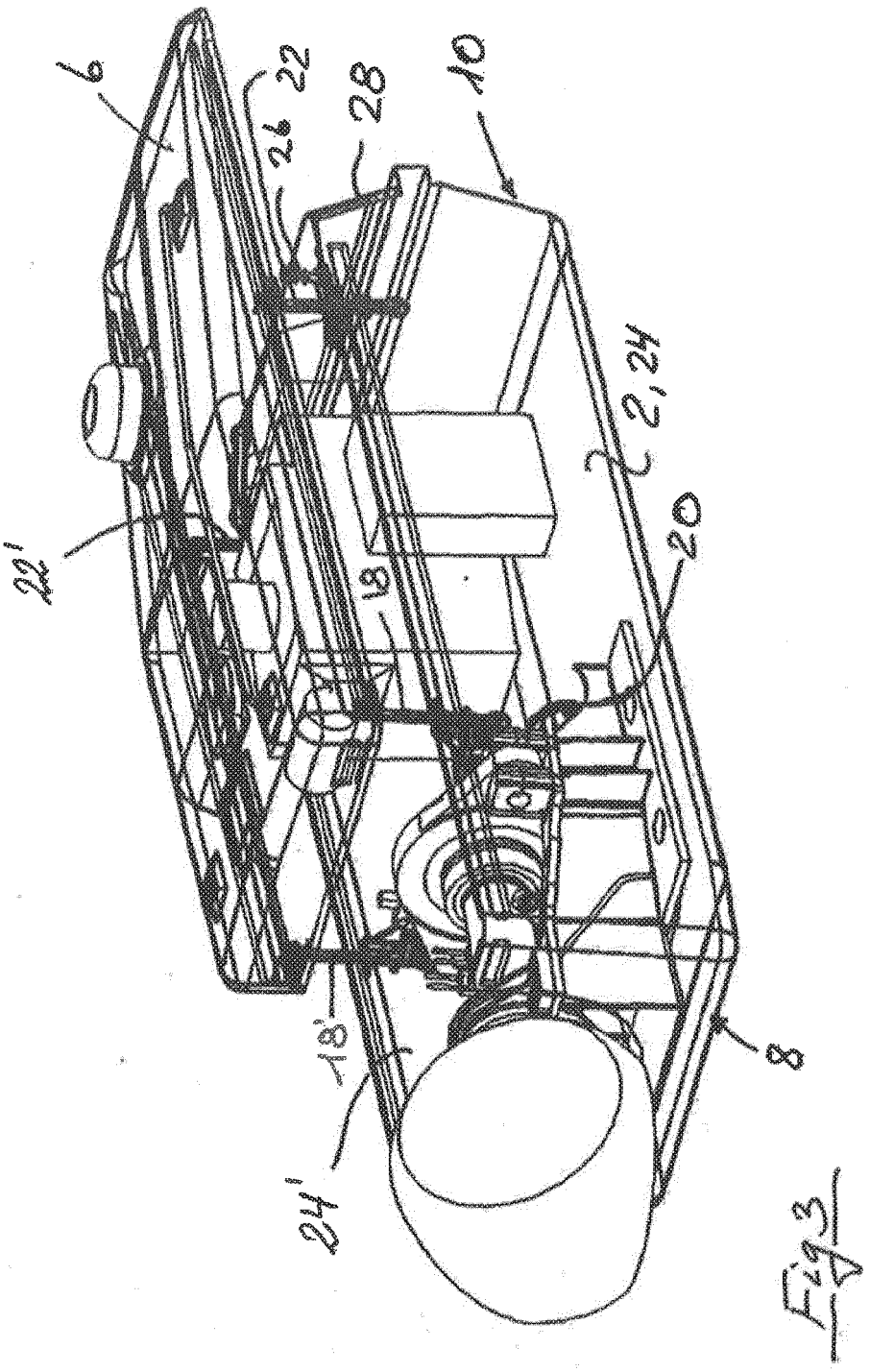

Fig 3

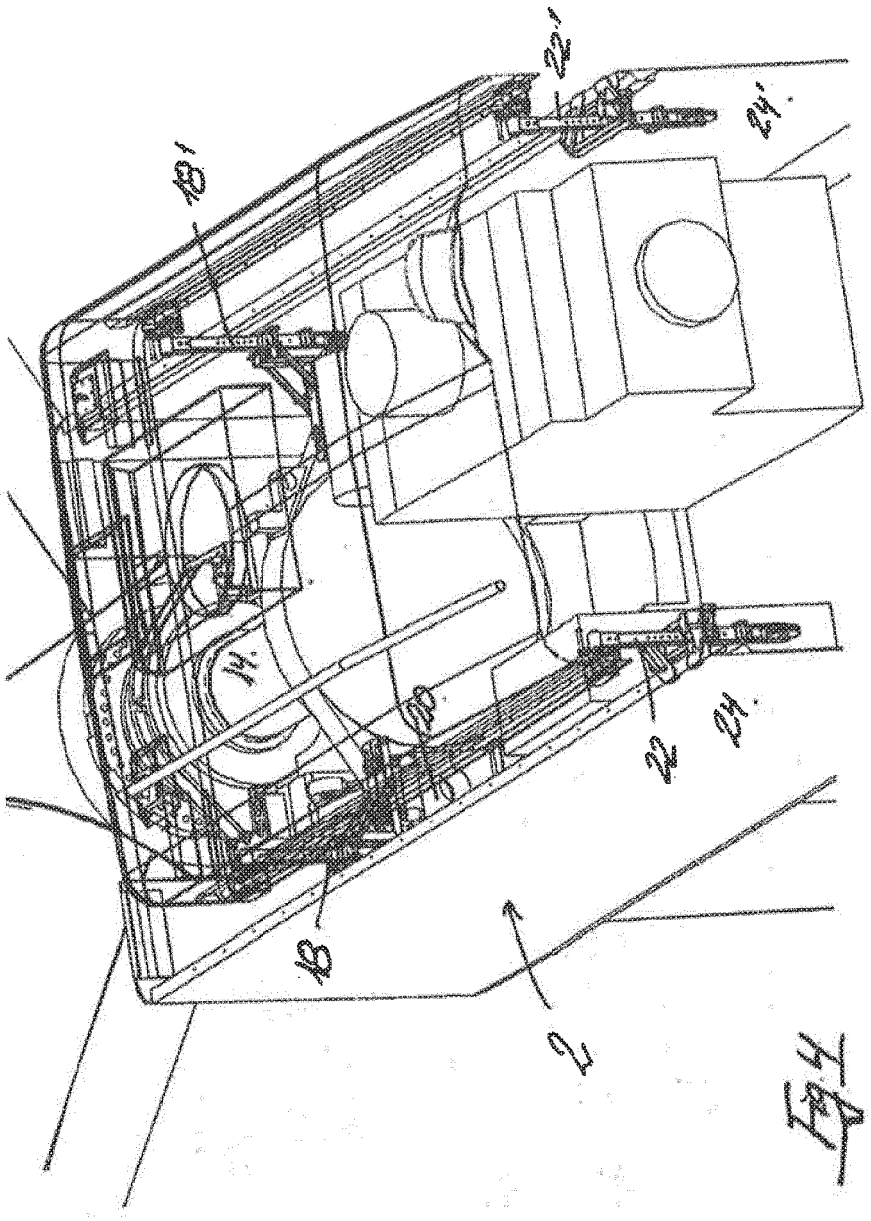

Fig 4

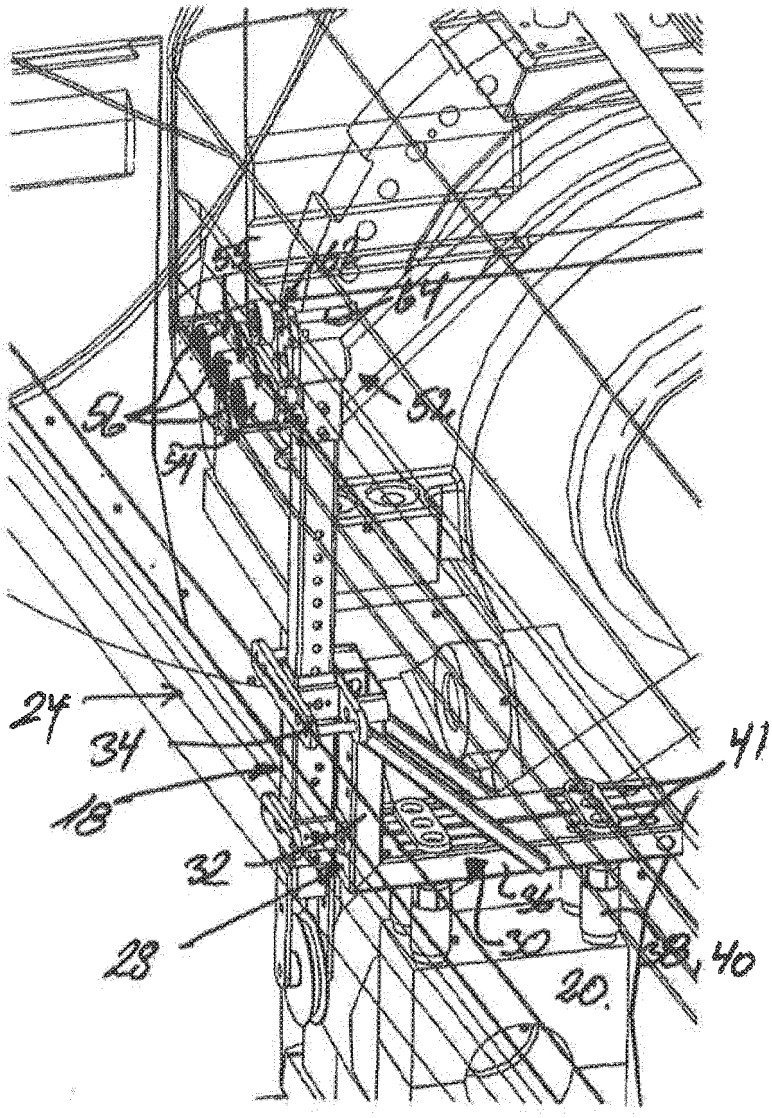

Fig. 5

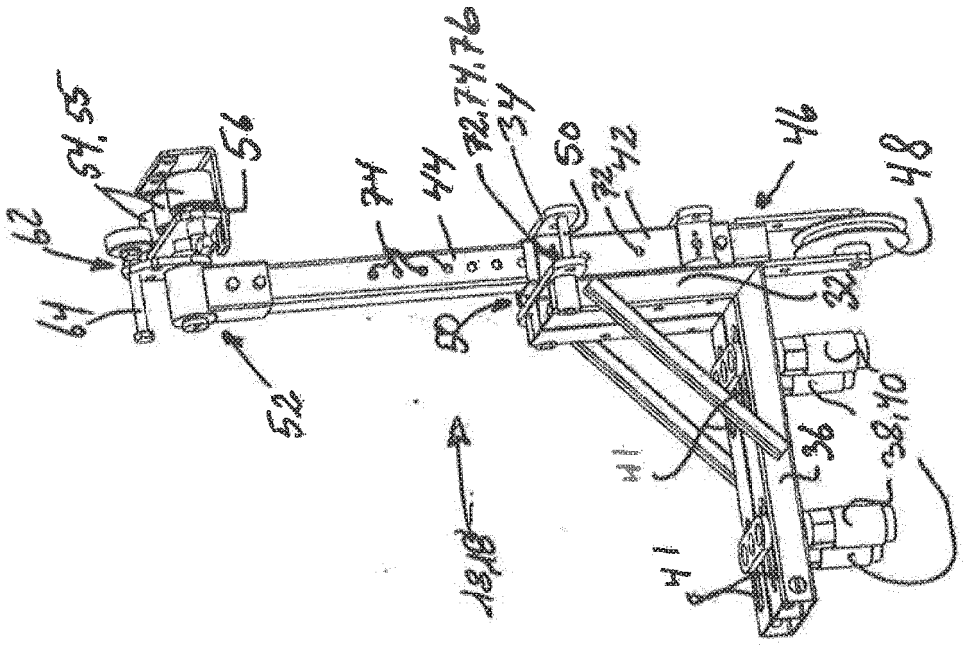

FIG. 1

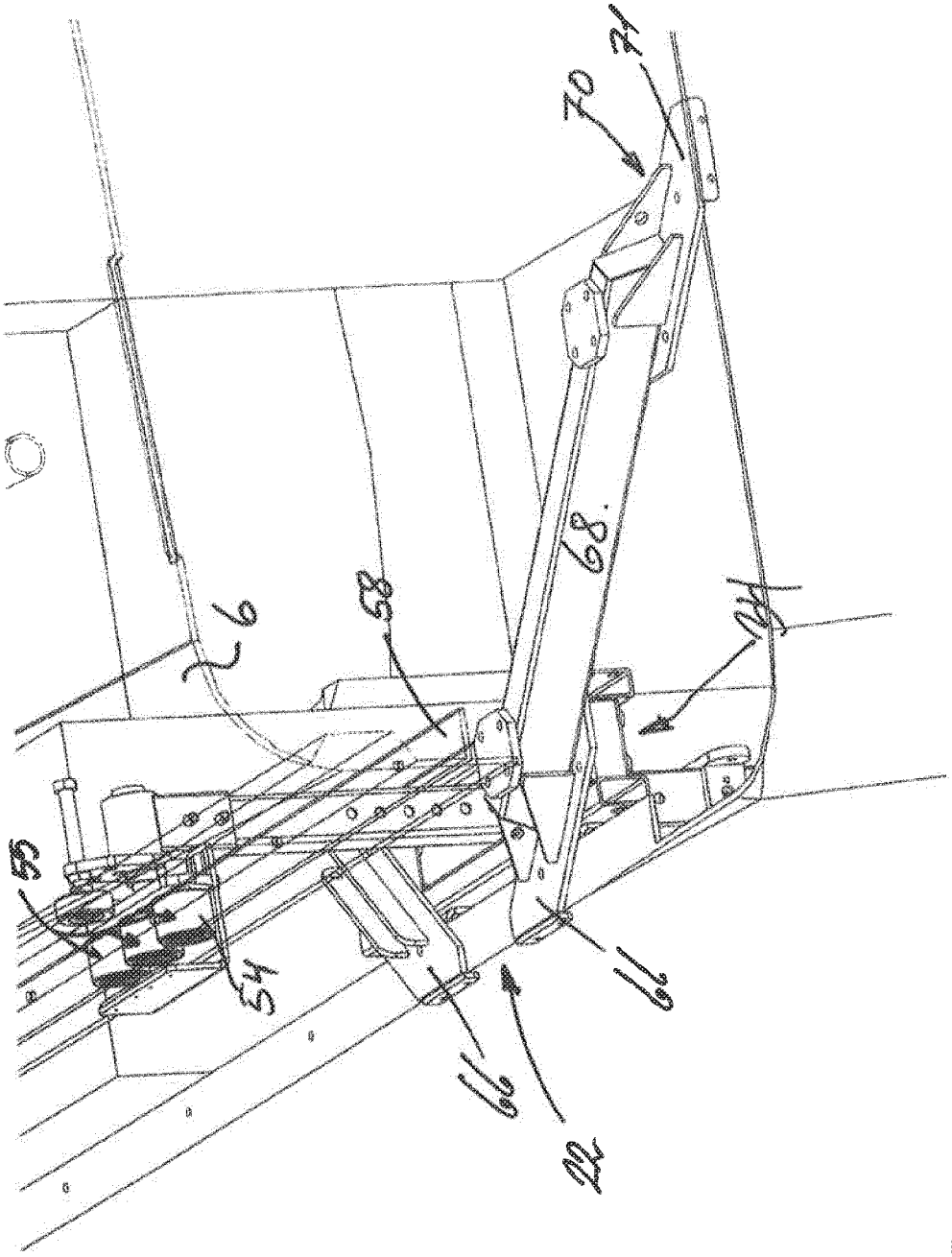

Fig. 7

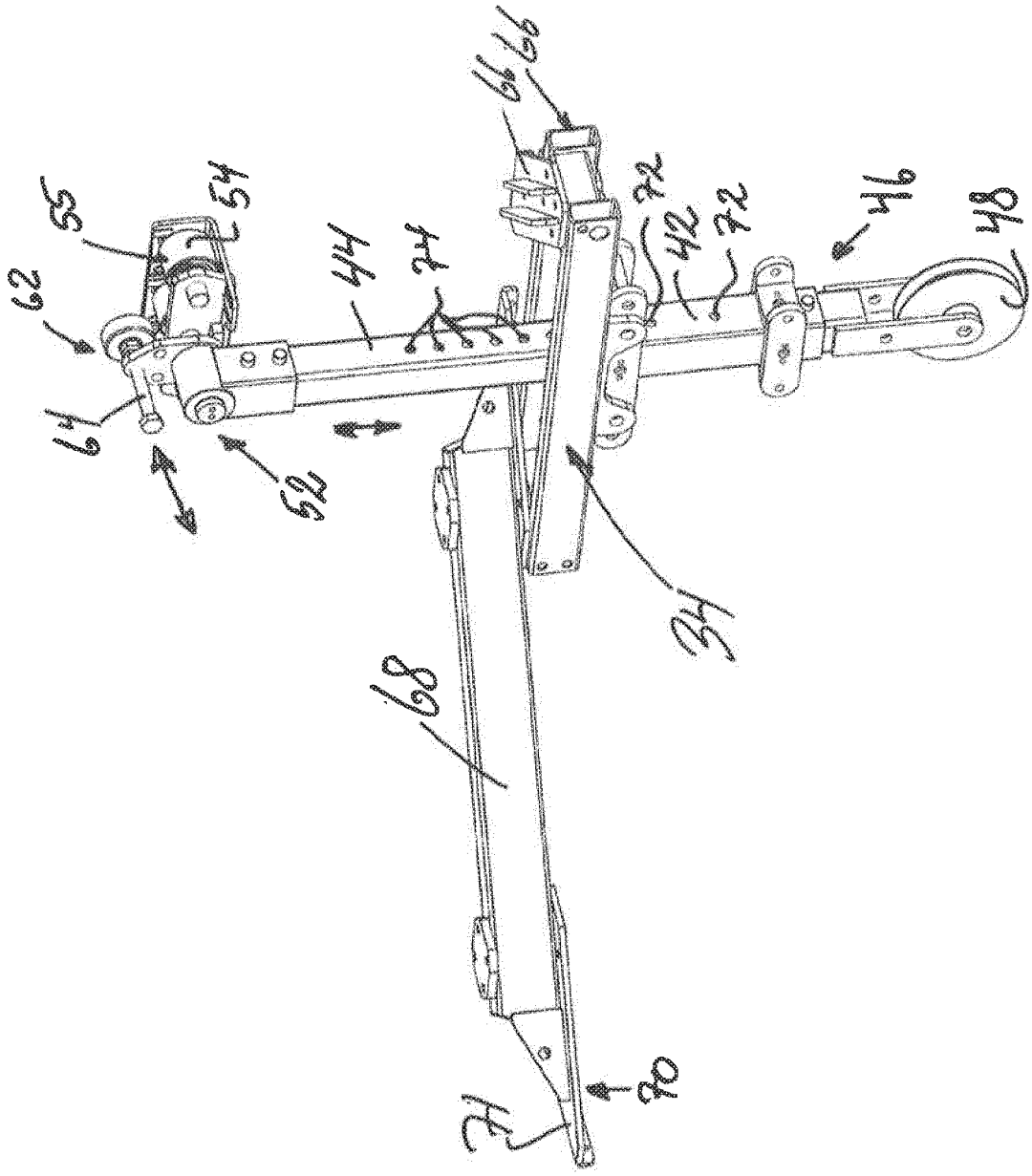

Fig. 8

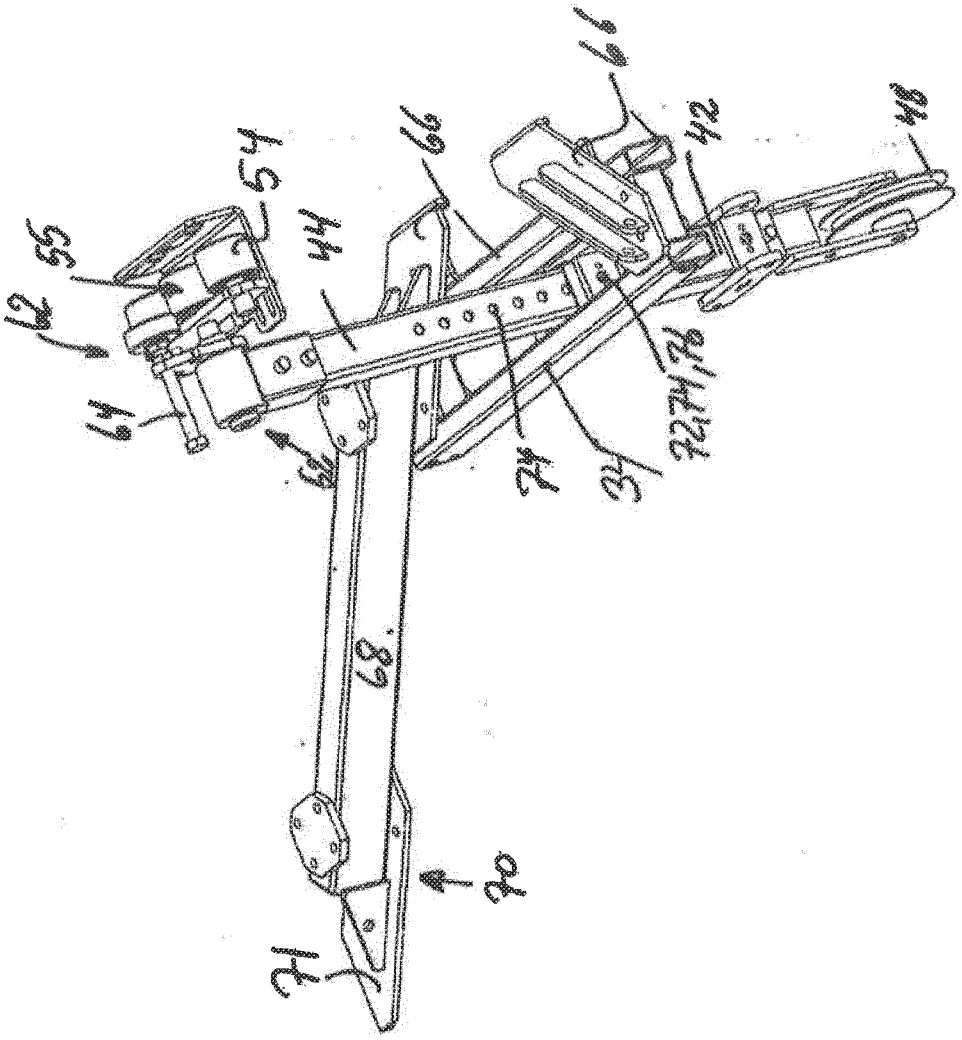

Fig. 2

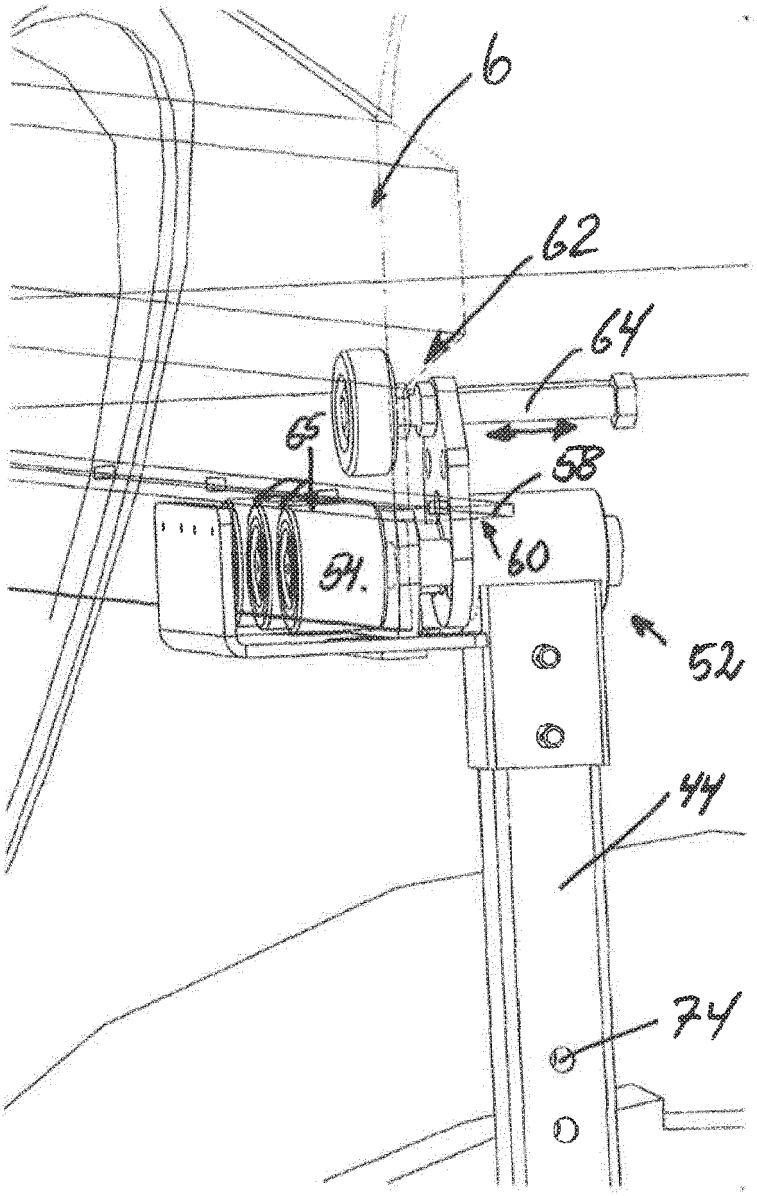

Fig. 10