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(54) ELEVATOR SYSTEM

(57) An elevator system comprising an elevator cabin guided by or around one or more substantially rigid guiding elements, a travelling cable for supplying energy to the elevator cabin, and a pulley mounted on a pulley frame, wherein the pulley with the pulley frame are movably suspended on the travelling cable, wherein the system further comprises one or more transverse elements each having one end attached to the pulley frame and the other end adapted to be slidably arranged with respect to one or more of the rigid guiding elements. A wind turbine comprising such an elevator system is further described.

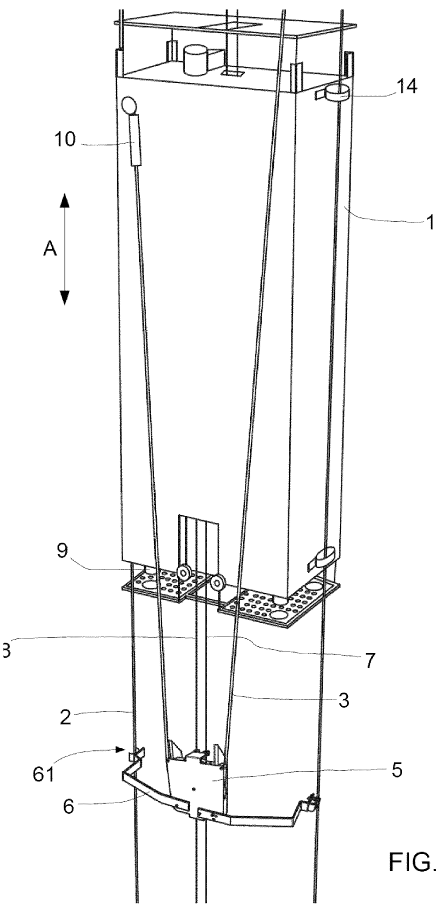

FIG. 1

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Description

[0001] The present disclosure relates to elevator systems, for example service elevator systems. In some examples, the elevator systems may be configured for use in wind turbine towers. The present disclosure further relates to wind turbines comprising such elevator systems.

BACKGROUND ART

[0002] Modern wind turbines are commonly used to supply electricity into the electrical grid. Wind turbines generally comprise a rotor with a rotor hub and a plurality of blades. The rotor is set into rotation under the influence of the wind on the blades. The rotation of the rotor shaft drives the generator rotor either directly ("directly driven") or through the use of a gearbox. The operation of the generator produces the electricity to be supplied into the electrical grid.

[0003] When maintenance works are required inside wind turbines, hoists are often used in the form of elevator-like structures where a lift platform or a cabin for the transportation of people and/or equipment is hoisted up or down within the wind turbine tower. Wind turbines are often provided with working platforms arranged at various heights along the height of the tower with the purpose of allowing workers to leave the cabin and inspect or repair equipment where intended. These sorts of elevator systems are also known in other applications, such as e.g. factories, construction sites, and all sorts of towers.

[0004] Elevator systems in general include an elevator car being suspended within a hoistway by ropes, cables or belts. In some systems, e.g. some electric elevators, a counterweight may be provided, depending on e.g. the available space. Other systems such as hydraulic elevators normally do not comprise a counterweight. Typically, elevator systems include a moving or travelling cable for supplying electric power to the elevator cabin and/or for signal communication between components associated with the elevator car/cabin and a control panel provided in a fixed location relative to the hoistway. The control panel may be provided at any height up in the hoistway. In order to avoid coiling of the travelling cable when the cabin is placed at the lowest level of the hoistway, an intermediate travelling cable fixation point may be chosen, most frequently at a height which is halfway up in the hoistway. Therefore, when the elevator car is below this height, the travelling cable is thus suspended downwards. And when the elevator car is above this height, the travelling cable is thus carried upwards.

[0005] In use, there may be circumstances in which a travelling cable may begin to move and sway within an elevator hoistway or the cable can become tangled up in itself. This is most prominent in high slender structures, such as e.g. tower of larger (MW class) wind turbines, in which the tower may move significantly.

[0006] In such tall structures in general, elevator ropes and cables, which may include hoist ropes, compensation ropes, governor ropes, and travelling cables, may also vibrate in harmony with the wind induced sway of the structure and other dynamic factors affecting the structure. Particularly in wind turbines, several loads such as for example aerodynamic forces associated with the wind, rotor rotation, etc. may act on the structure. These loads may further be increased in offshore wind turbines by the forces exerted by waves, currents and tides. It is thus desirable that elevator cabins arranged inside wind turbine towers run controlled by lines, cables or any other rigid guiding element extending all the way from the top to the bottom of the wind turbine tower.

[0007] The aforementioned loads can produce vibrations and sway of the ropes and cables which may cause fatigue and wear, excessive noise, and the increased possibility of tangling thus potentially shortening the lifetime of the cables and complicating normal operation of the elevator system.

[0008] Document JP6278968 describes a moving cable stabilizer for an elevator comprising a guide member installed in a vertical direction between the elevator car and an internal surface of the hoistway, a feed roller support, a support arm attached to the roller support and slidably attached to the guide member and two or more feed rollers arranged in parallel in an axial direction and rotatably attached to the feed roller support. One drawback associated with this cable stabilizer is that it is rather complex and the part count is high.

[0009] As such there is a need for reliable and effective elevator systems that are able to reduce travelling cables' sway and tangling and which also reduces or eliminates at least some of the afore-mentioned drawbacks.

SUMMARY

[0010] In accordance with a first aspect, an elevator system is provided. The elevator system comprises an elevator cabin guided by or guided around one or more substantially rigid guiding elements, a travelling cable for supplying energy to the elevator cabin, and a pulley mounted on a pulley frame. The pulley with the pulley frame is movably suspended on the travelling cable and the system further comprises one or more transverse elements each having one end attached to the pulley frame and the other end adapted to be slidably arranged with respect to one or more of the rigid guiding elements.

[0011] According to this aspect, in use, i.e. when the elevator cabin goes up and down, the travelling cable is carried upwards and downwards. Since the pulley and the pulley frame are movably suspended from the travelling cable, in use, the pulley with the pulley frame can self-travel along the travelling cable. Such a motion of the pulley and pulley frame on the travelling cable straightens the travelling cable at all possible positions. Furthermore, the provision of a transverse element having one end attached to the pulley frame and the other end slidably arranged with respect to one or more of the rigid guiding elements together with the motion of the pulley frame along the travelling cable entails a slide of the transverse element along such rigid guiding elements. The transverse elements thus act as a spacer between the pulley frame which slides on the travelling cable and the rigid guiding elements. This can substantially stabilize the travelling cable's position even when loads producing vibrations and sway of the cables are acting. Tangling up of the travelling cable in itself can also thus be avoided or substantially reduced with the provision of such spacers, i.e. transverse elements. The travelling cable is thus subjected to less stress therefore extending its lifetime.

[0012] At the same time, guiding elements which are already present in the system are used. No additional guiding elements are necessary. Furthermore, the provision of transverse elements substantially as hereinbefore described is quite simple to implement. It can therefore be easily retrofit into existing elevator installations having travelling cables with a pulley suspended from the travelling cable. Moreover, it is a solution that may be fitted in a relatively small area as it is the hoistway dimension of an elevator system.

[0013] Throughout the present disclosure, pulley is to be understood as covering any form of wheel or roller that guides or redirects a cable along its circumference. Pulley herein thus covers e.g. sheaves with a specific groove around its circumference between two flanges, but also any other form of cable guiding wheel.

[0014] In summary, a system substantially as hereinbefore described ensures that the ability of the travelling cable to move in the horizontal plane, i.e. in a plane substantially perpendicular to the up and down movement of the elevator cabin is reduced.

[0015] Such systems may be adapted or configured for a particular application, such as e.g. a wind turbine tower.

[0016] In some embodiments, the rigid guiding element may be a ladder arranged on an inner surface of a hoistway of the elevator system and the transverse elements may be adapted to be slidably arranged with respect to the ladder. In others, the rigid guiding element may be a guide rail arranged on an inner surface of a hoistway of the elevator system and the transverse elements may be adapted to be slidably arranged with respect to the guide rail. In yet further embodiments, the rigid guiding element may be a pair of taut cables running laterally from the elevator cabin and the transverse elements may be adapted to be slidably arranged with respect to at least one of the taut cables. Combinations of these embodiments may also be possible.

[0017] In some embodiments, an inner surface of a hoistway of the elevator system may be provided with a rack and the elevator cabin may be provided with a pinion arranged to mesh with the rack such that the elevator cabin can be driven by the rack and pinion engagement. In these cases, a motor driving the pinion may be arranged inside the elevator cabin. In other embodiments, one or more traction wire ropes may be used for driving the elevator cabin. In these embodiments, the pulley frame may further be adapted to be guided along at least one traction wire rope or a safety wire rope.

[0018] In some embodiments in which the rigid guiding element may be a pair of taut cables, the pulley frame may further be provided with runners arranged such that in use the runners can glide on the inner surface of a hoistway of the elevator system. This way, in use, when the pulley frame self-travels along the travelling cable it can also be guided on the inner surface of the hoistway of the elevator system by the runners and discontinuities such as the junctions between e.g. wind turbine tower's sections of such an inner surface can be easily overcame in a relatively smooth manner.

[0019] In some embodiments, the end of the transverse element that is adapted to be slidably arranged with respect to the rigid guiding element may be selected from the group consisting of a pair of rollers, an eyelet or a substantially C-shaped profile. In other embodiments, other ways of adapting the end of the transverse elements for being slidably arranged with respect to the rigid guiding elements may be foreseen.

[0020] A second aspect provides a wind turbine comprising an elevator system substantially as hereinbefore described arranged within a wind turbine tower.

[0021] Additional objects, advantages and features of embodiments of the invention will become apparent to those skilled in the art upon examination of the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Particular embodiments of the present invention will be described in the following by way of non-limiting examples, with reference to the appended drawings, in which:

Figure 1 shows a perspective of a service elevator system according to a first embodiment;

Figures 2a and 2b show two perspective views of a service elevator system according to a second embodiment;

Figure 3 shows a perspective of a service elevator system according to a third embodiment; and

Figures 4a - 4d show the pulley frame with transverse elements according to different embodiments.

DETAILED DESCRIPTION

[0023] Figure 1 shows an elevator system according to a first embodiment. The elevator system may comprise an elevator cabin 1 which may move up and down in the inside of a hoistway (not shown) driven by a traction wire rope 7. In alternative embodiments, more than one traction wire rope may be provided. A safety wire rope 8 may further be provided.

[0024] The elevator cabin 1 may be guided by a pair of taut cables 2 running laterally from the elevator cabin 1. The elevator cabin 1 may be provided with cable guiding means 14 that may be selected from the group consisting of a tubular part, a ring or an eyelet, a substantially C-shaped profile or similar. At least one cable guiding means 14 may be arranged at each side of the elevator cabin or two or more such means may be arranged at least in an upper and a lower location of each side of the elevator cabin.

[0025] The taut cables are under tension, and due to this tension they become relatively rigid and thus suitable as a cabke guiding means.

[0026] A travelling cable 3 may be provided for supplying energy to the elevator cabin 1. The travelling cable 3 may be connected to a power supply at one end (not shown) and to the elevator cabin 1 at the other end. A pulley 4 mounted on a pulley frame 5 may be arranged in a movably suspended manner on the travelling cable 3. One end of the travelling cable arrangement may be mounted at some point along the hoistway. In case of an elevator system for a wind turbine it may be attached at the tower. The other end of the travelling cable arrangement may be connected to the elevator cabin. The height at which the travelling cable arrangement is mounted may be at approximately half the total height of the hoistway, or in this case, at approximately half the total height of the tower. The power supply may be provided at any height in the hoistway

[0027] Two transverse arms 6 may each extend laterally from the pulley frame 5. In the shown example, each transverse arm 6 may extend substantially perpendicular from an up and down direction of motion of the elevator cabin 1 (see arrow A). Each transverse arm 6 may extend towards one of the taut cables 2. A free end 61 of the transverse arms may be adapted to be slidably arranged with respect to the taut cable 2. In alternative embodiments only one transverse arm may be provided. An aspect of using a single transverse arm is that it may be less costly. Figures 4a-4d show the free ends of the transverse arms according to some different embodiments.

[0028] In some cases, the transverse arms may be made with the pulley frame as an integral piece or they may be welded to the pulley frame. In other cases, they may be fixed to the pulley frame by e.g. screws or bolts.

[0029] In some embodiments, a ladder (not shown) may further be provided and the elevator cabin may be guided around the ladder by the taut cables.

[0030] In the example of figure 1, the pulley frame 5 may further be guided along the traction 7 and safety 8 wire ropes of the elevator system. In other cases, the pulley frame may be adapted to be guided along at least one of the traction and safety wire ropes. Figures 4a-4d show a pulley frame adapted to be guided along at least one of traction and safety wire ropes according to an embodiment.

[0031] In all examples wherein the pulley frame is guided along or guides further cables, such as safety ropes or traction ropes, these further cables may also benefit from the increased stability of the travelling cable arrangement. In the illustrated example, the two transverse arms help to reduce oscillations and movements of the travelling cable. If the travelling cable pulley is relatively fixed in space, then the corresponding portions of these further cables are also fixed in space. The movements of these further cables (for traction, safety etc.) may thus also be reduced.

[0032] The elevator cabin 1 may further be provided with feet 9 made for example of rubber, providing a distance between a bottom portion of the elevator cabin and a bottom platform floor when the elevator cabin reaches the bottom platform floor.

[0033] A cable stocking 10 may further be provided at each end of the travelling cable 2 for aiding cable hauling in use.

[0034] Figures 2a and 2b show two perspective views of a service elevator system according to a second embodiment. Figures 2a and 2b differ from figure 1 in that the elevator cabin 1 may be guided by a ladder 11 arranged on an inner surface of a hoistway (not shown) of the elevator system, for example an inner surface of a wind turbine tower. Figure 2b shows that at least two pairs of runners 111 may be provided at the elevator cabin 1 for guiding the elevator cabin on the ladder 11. In other embodiments more pairs of runners may be provided at the elevator cabin for guiding the cabin on the ladder.

[0035] In the example of figures 2a and 2b, the two transverse arms 6’ may comprise free ends 61’ comprising each a further pair of wheels or runners 62 for being slidably arranged with respect to the ladder 11. As mentioned before, in alternative embodiments only one transverse arm may be provided.

[0036] In the example of figures 2a and 2b traction and safety ropes are provided for hoisting and driving the elevator cabin 1. In this examples, these ropes may also benefit from the increased stability of the travelling cable. In alternative embodiments, the elevator cabin may comprise a drive belt for driving the elevator cabin along the ladder. The drive belt may have a plurality of climb pins arranged such that in use a climb pin engages with a rung of the ladder. In these cases, a motor that may be provided in the elevator cabin may drive the drive belt

[0037] In yet further embodiments, as shown in figure 3, an inner surface of a hoistway of the elevator system, e.g. an inner surface of a wind turbine tower may be provided with a rack 12 and the elevator cabin 1 may be provided with a pinion (not shown) arranged to mesh with the rack 12 such that the elevator cabin can be driven by the rack and pinion engagement.

[0038] The two transverse arms 6’ may comprise free ends 61’ comprising each a further pair of runners 62 for being slidably arranged with respect to the ladder 11 in a similar manner as explained before in connection with figures 2a and 2b. In alternative embodiments, only one transverse arm may be provided.

[0039] Figure 3 shows a perspective view of a service elevator system according to a third embodiment. Figure 3 differs from figure 1 in that the elevator cabin 1 may be guided by a ladder 11 arranged on an inner surface of a hoistway (not shown) of the elevator system in a similar manner as explained in connection with figures 2a and 2b. In the example shown in figure 3, the rack may be provided along one of the side rails of the ladder.

[0040] In some cases in which the elevator cabin may be guided by a ladder or by a guide rail, the elevator cabin may further be adapted to guide the travelling cable at each side of the elevator cabin 1. In these cases the elevator cabin 1 may comprise at least one travelling cable guide 13 at each side. The guide 13 may be in the form of tubular part, a ring or an eyelet or a substantially C-shaped support. C-shaped supports may be particularly easily retrofitted in existing elevator systems as there is no need for a full dismantling of the travelling cable in order to be arranged inside a C-shaped support.

[0041] In alternative embodiments, the elevator cabin may be guided by a rail arranged on an inner surface of a hoistway of the elevator system, e.g. a wind turbine tower. In these cases the transverse elements may be adapted to be slidably arranged with respect to the rail e.g. by wheels or rollers adapted to engage with the rail. The guide rail may for example have a U-shaped section and the rollers or wheels may be engaged in that U-shaped section with a prescribed clearance allowing carrying out sliding movement. In alternative embodiments, the elevator cabin may move along a vertical path within a hoistway guided by two guide rails arranged at both sides of the width of the elevator cabin. In some of these cases a ladder (not shown) may further be provided and the elevator cabin may be guided around the ladder by the guide rail.

[0042] Optionally, the guide rails may carry a rack, with which a pinion arranged with the cabin can engage.

[0043] Figures 4a-4d show the pulley 4 arranged within the pulley frame 5 and transverse elements 6 according to different embodiments.

[0044] Figure 4a shows an embodiment in which only one transverse arm 6 is fixed to the pulley frame 5 by screws 51. The transverse arm 6 may comprise a free end 61 having a substantially C-shaped guide 60 that may be fixed to a free end 61 of the arm by a further screw 63. Other shapes or supports may also be foreseen for the free ends of the transverse arm as long as they may be adapted to be slidably mounted with respect to a cable, a ladder or a guide rail depending on circumstances.

[0045] The pulley frame 5 may further comprise at least one flange 52 provided with two holes 53 for guiding traction and/or safety ropes of the elevator system. In alternative embodiments other number of holes may be provided. In some cases the flange 52 may be integrally formed with the pulley frame 5. In others, it may be welded or it may be fixed with screws to the pulley frame. Figure 4a shows an embodiment in which top and lower flanges 52 may be integrally formed with the pulley frame 5. Each flange 52 may comprise two holes 53.

[0046] Figure 4b differs from figure 4a in that two transverse arms are provided. The rest is substantially similar to figure 4a. In figure 4b the two flanges 52 are clearly visible.

[0047] Figure 4c differs from figure 4b in that the pulley frame 5 further comprises runners that can glide or ride over the inner surface of the hoistway. In this case, four wheels 54 arranged in pairs (upper and lower pair of wheels) through a shaft 55 are provided. The wheels may help overcome any bumps or protrusions of the inner surface of the hoistway of the elevator system, e.g. the junctions between tower sections for the inner surface of a wind turbine tower wall.

[0048] Figure 4d differ from figures 4b and 4c in that each free end 61' of the transverse elements 6' comprises a pair of runners 62 arranged to slide along the taut cable 2 or the ladder (see figure 3). The pulley frame in this example, as well as in the examples of figures 4a and 4b, furthermore comprises wedge shaped guiding elements 56. As the pulley frame moves upwards en encounters e.g. a flange of a junction between two tower sections, the wedge shaped elements can help the pulley frame to slide over such a junction. Similar wedge shaped guiding elements may be provided at the bottom of the pulley frame for the same reasons. These wedge shaped guiding elements thus act as runners gliding along an inner surface of e.g. a wind turbine tower.

[0049] For reasons of completeness, various aspects of the invention are set out in the following numbered clauses:

Clause 1. An elevator system comprising:

an elevator cabin guided by or around one or more substantially rigid guiding elements,
a travelling cable for supplying energy to the elevator cabin, and
a pulley mounted on a pulley frame,
wherein the pulley with the pulley frame is movably suspended on the travelling cable,
wherein the system further comprises one or more transverse elements each having one end attached to the pulley frame and the other end adapted to be slidably arranged with respect to one or more of the rigid guiding elements.

Clause 2. The elevator system of clause 1, wherein the system comprises two transverse elements having one end attached to the pulley frame and the other end adapted to be slidably arranged with respect to one or more of the rigid guiding elements.

Clause 3. The elevator system of any of clauses 1-2, wherein the rigid guiding element is a ladder arranged on an inner surface of a hoistway of the elevator system and the transverse elements are adapted to be slidably arranged with respect to the ladder.

Clause 4. The elevator system of any of clauses 1-2, wherein the rigid guiding element is a guide rail arranged on an inner surface of a hoistway of the elevator system and the transverse elements are adapted to be slidably arranged with respect to the guide rail.

Clause 5. The elevator system of any of clauses 1-2, wherein the rigid guiding element is a pair of taut cables running laterally from the elevator cabin and the transverse elements are adapted to be slidably arranged with respect to at least one of the taut cables.

Clause 6. The elevator system of any of clauses 3-5, wherein an inner surface of a hoistway of the elevator system is provided with a rack and the elevator cabin is provided with a pinion arranged to mesh with the rack such that the elevator cabin can be driven by the rack and pinion engagement.

Clause 7. The elevator system of any of clauses 3-5, wherein one or more traction wire ropes are provided for driving the elevator cabin and the pulley frame is further adapted to be guided along at least one traction wire rope or a safety wire rope of the elevator system.

Clause 8. The elevator system of clause 5, wherein the pulley frame is further provided with runners arranged such that in use the runners can ride or glide on the inner surface of a hoistway of the elevator system.

Clause 9. The elevator system of clause 8, wherein the runners comprise rollers, preferably two pairs of rollers.

Clause 10. The elevator system of clause 8, wherein the runners comprise wedge-shaped guiding elements.

Clause 11. The elevator system of any of clauses 1 - 10, wherein the end of the transverse element that is adapted to be slidably arranged with respect to the rigid guiding element is selected from the group consisting of a pair of rollers, an eyelet or a substantially C-shaped profile.

Clause 12. Wind turbine comprising an elevator system according to any of clauses 1 - 11 arranged within a wind turbine tower.

[0050] Although only a number of particular embodiments and examples of the invention have been disclosed herein, it will be understood by those skilled in the art that other alternative embodiments and/or uses of the invention and obvious modifications and equivalents thereof are possible. Furthermore, the present invention covers all possible combinations of the particular embodiments described. Thus, the scope of the present invention should not be limited by particular embodiments, but should be determined only by a fair reading of the claims that follow.

Claims

1. An elevator system for a wind turbine tower comprising:

   an elevator cabin (1) guided by a ladder (11) arranged on an inner surface of a hoistway of the elevator system,
   a travelling cable (3) for supplying energy to the elevator cabin (1), and
   a pulley (3) mounted on a pulley frame (5),
   wherein the pulley (4) with the pulley frame (5) is movably suspended on the travelling cable (3),
   wherein the system further comprises one or more transverse elements (6, 6’) each having one end attached to the pulley frame (5) and the other end (61, 61’) adapted to be slidably arranged with respect to the ladder.

2. The elevator system of claim 1, wherein the system comprises two transverse elements (6, 6’) having one end attached to the pulley frame (5) and the other end (61, 61’) adapted to be slidably arranged with respect to the ladder.

3. The elevator system of any of claims 1 - 2, wherein an inner surface of a hoistway of the elevator system is provided with a rack (12) and the elevator cabin (1) is provided with a pinion arranged to mesh with the rack (12) such that the elevator cabin can be driven by the rack (12) and pinion engagement.

4. The elevator system of any of claims 1 - 2, wherein one or more traction wire ropes (7) are provided for driving the elevator cabin (1) and the pulley frame (5) is further adapted to be guided along at least one traction wire rope (7) or a safety wire rope (8) of the elevator system.

5. The elevator system of any of claims 1 - 2, wherein the pulley frame (5) is further provided with runners (54) arranged such that in use the runners (54) can ride or glide on the inner surface of a hoistway of the elevator system.

6. The elevator system of claim 5, wherein the runners comprise rollers, preferably two pairs of rollers.

7. The elevator system of claim 5, wherein the runners comprise wedge-shaped guiding elements.

8. The elevator system of any of claims 1 - 7, wherein the end (61, 61') of the transverse element (6, 6') that is adapted to be slidably arranged with respect to the ladder (11) is selected from the group consisting of a pair of rollers (62), an eyelet or a substantially C-shaped profile (60).

9. Wind turbine comprising an elevator system according to any of claims 1 - 8 arranged within a wind turbine tower.

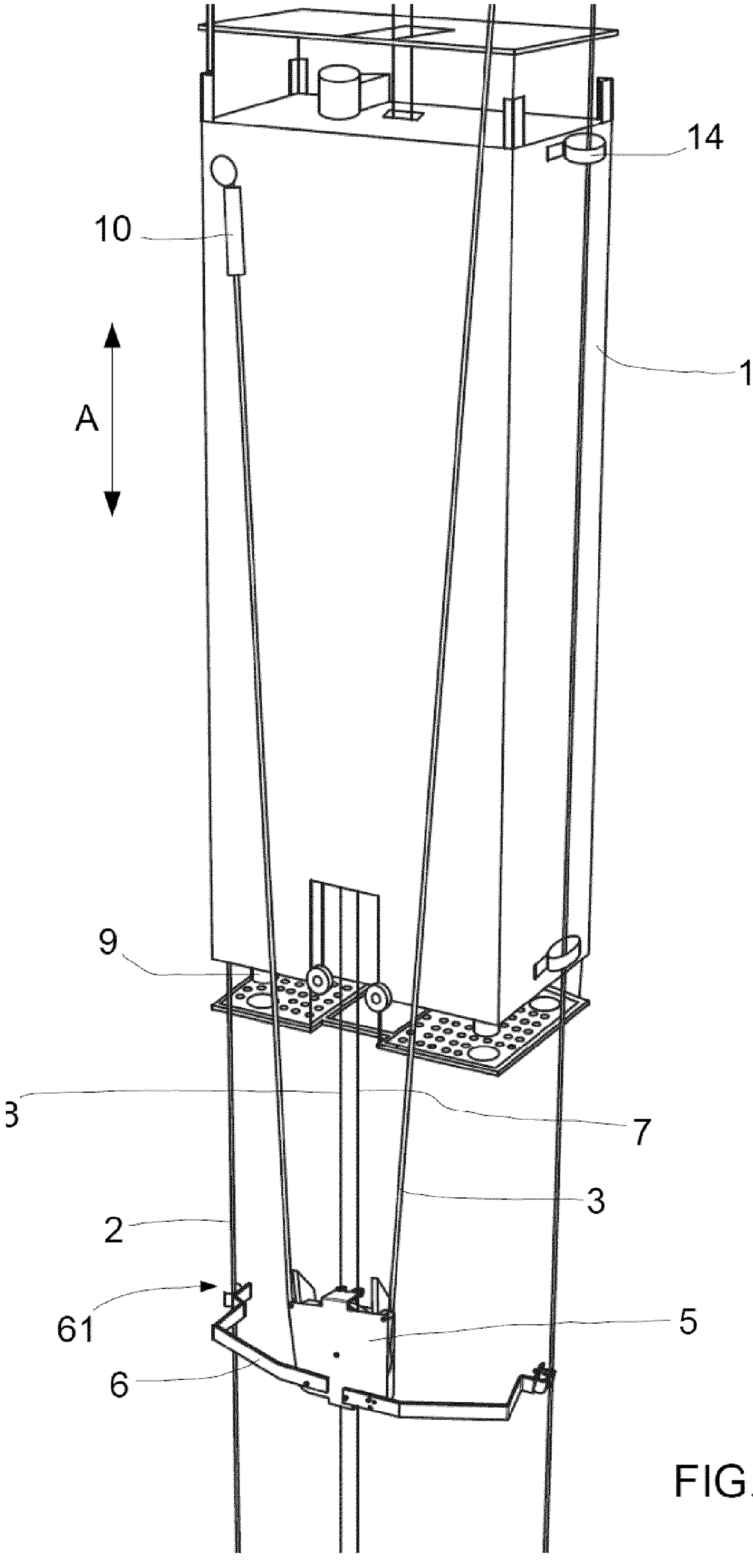

FIG. 1

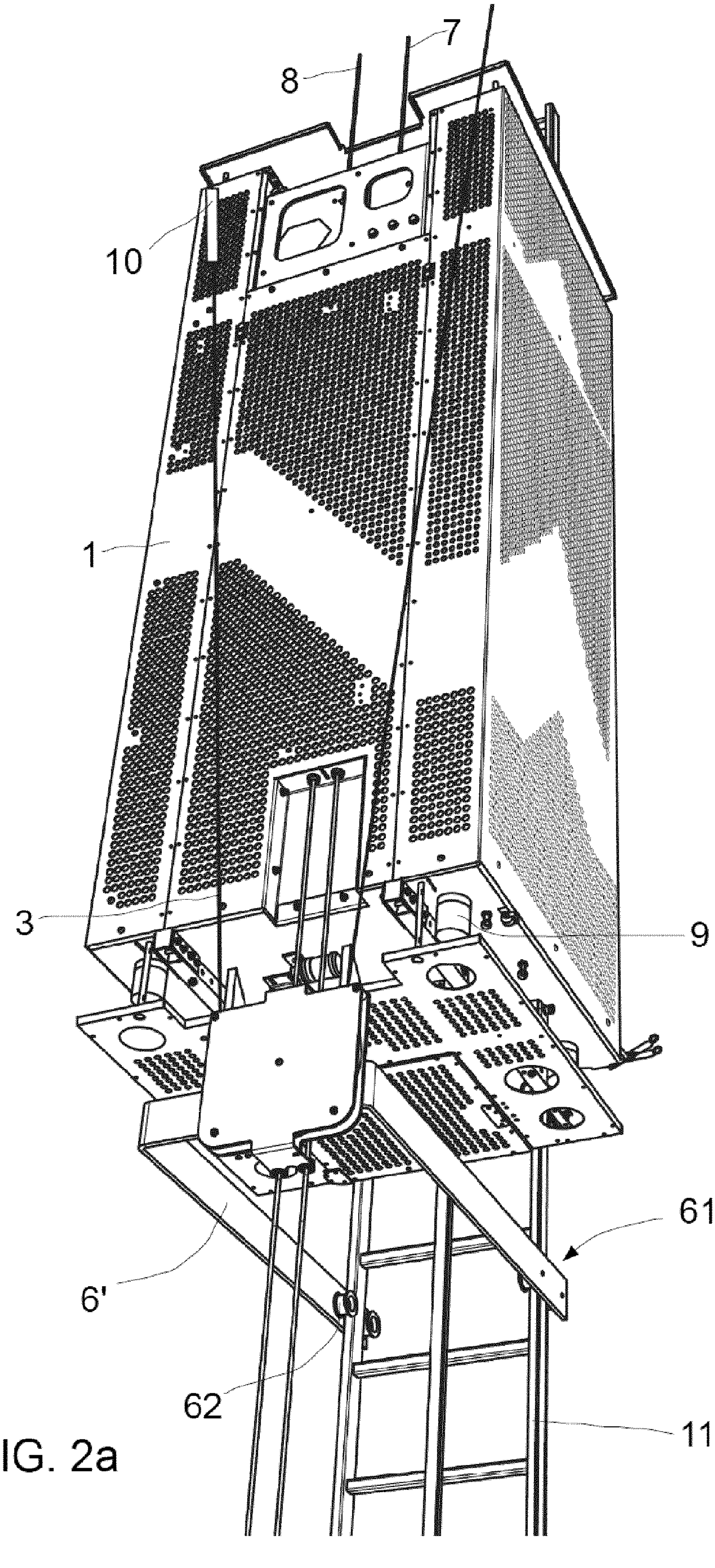

FIG. 2a

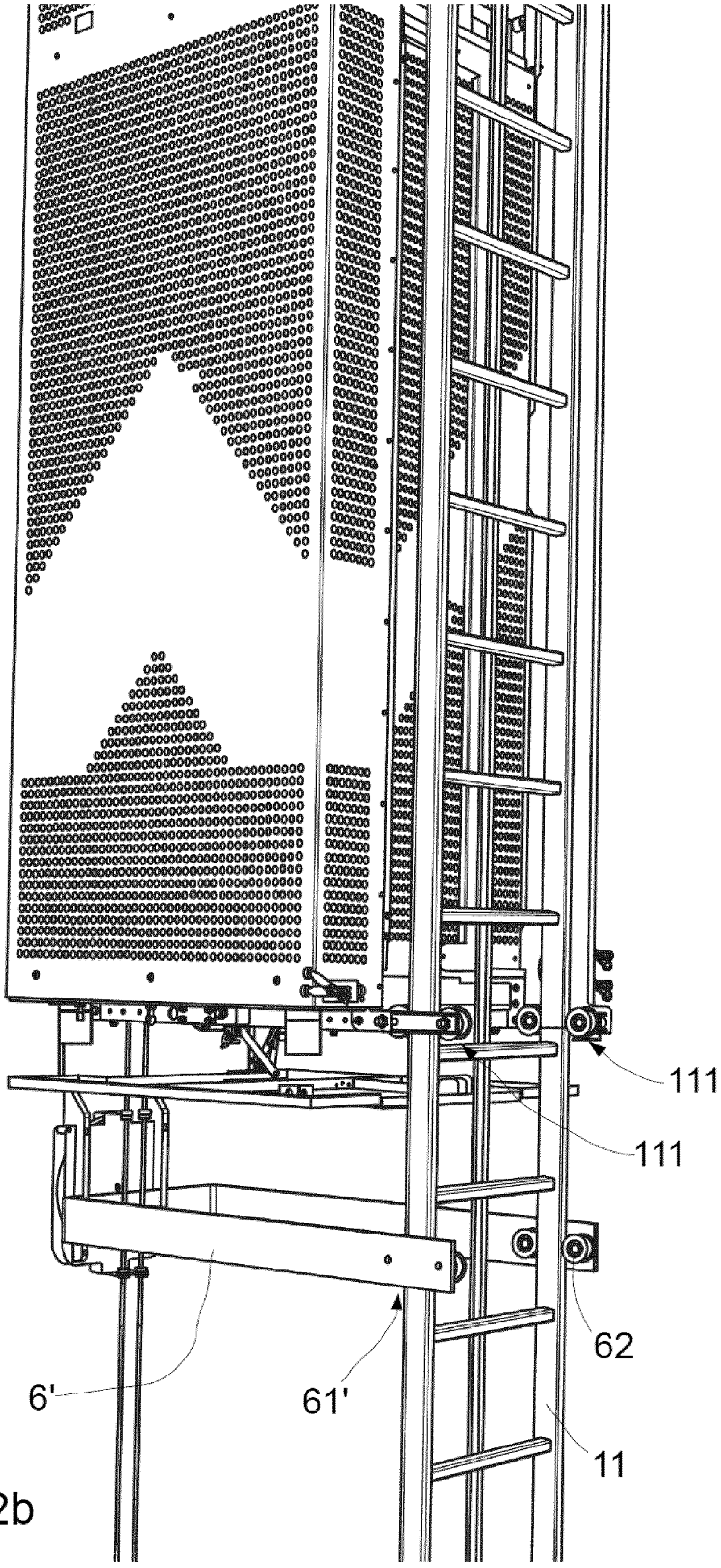

FIG. 2b

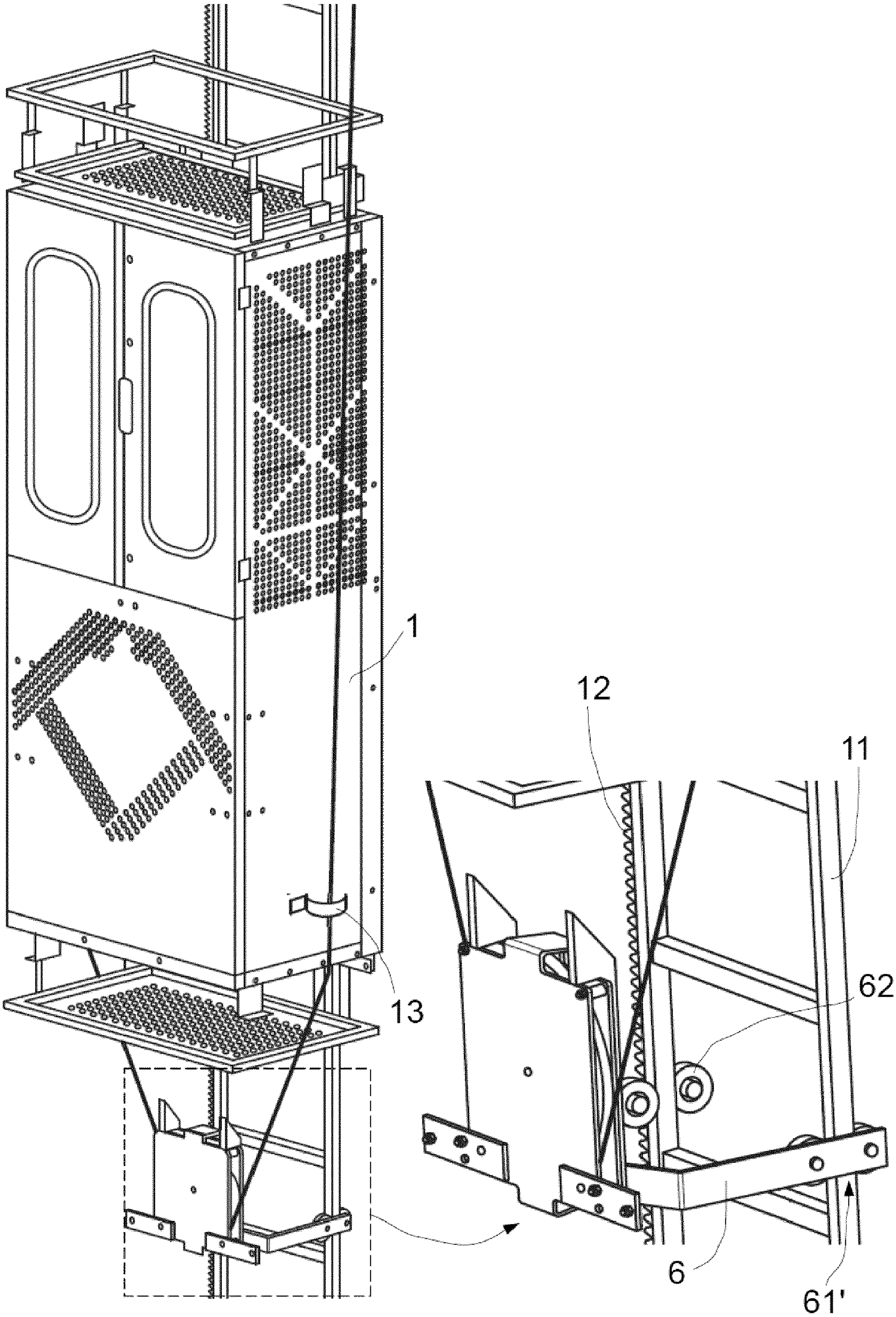

FIG. 3

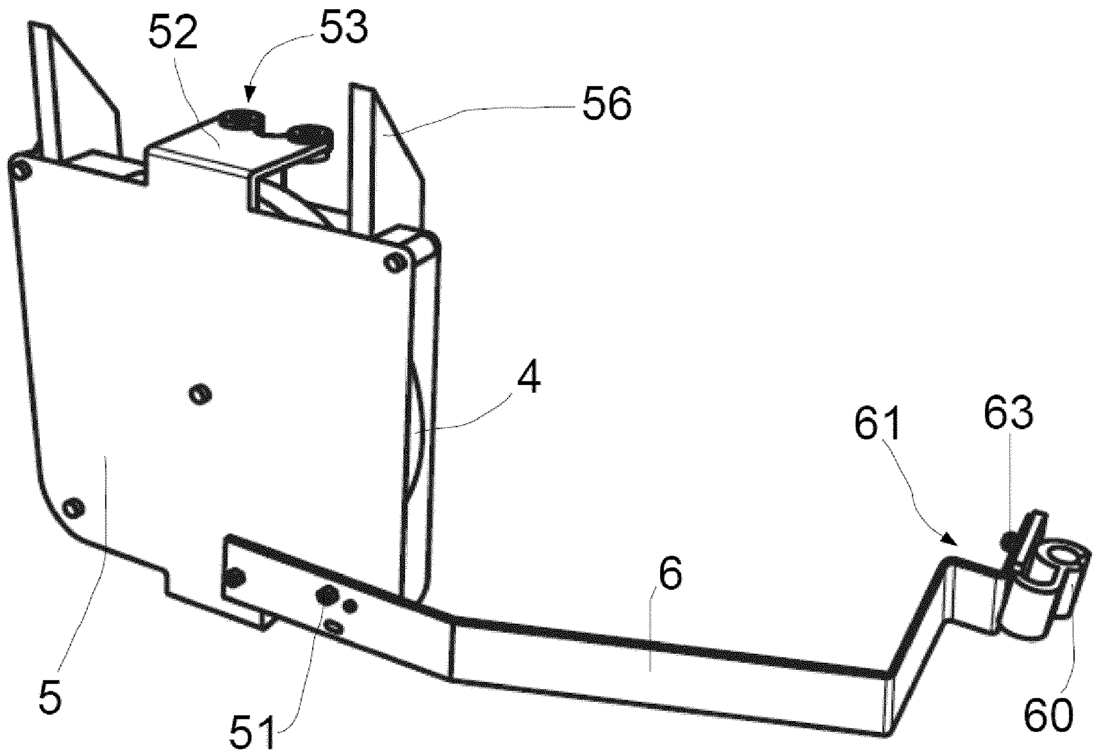

FIG. 4a

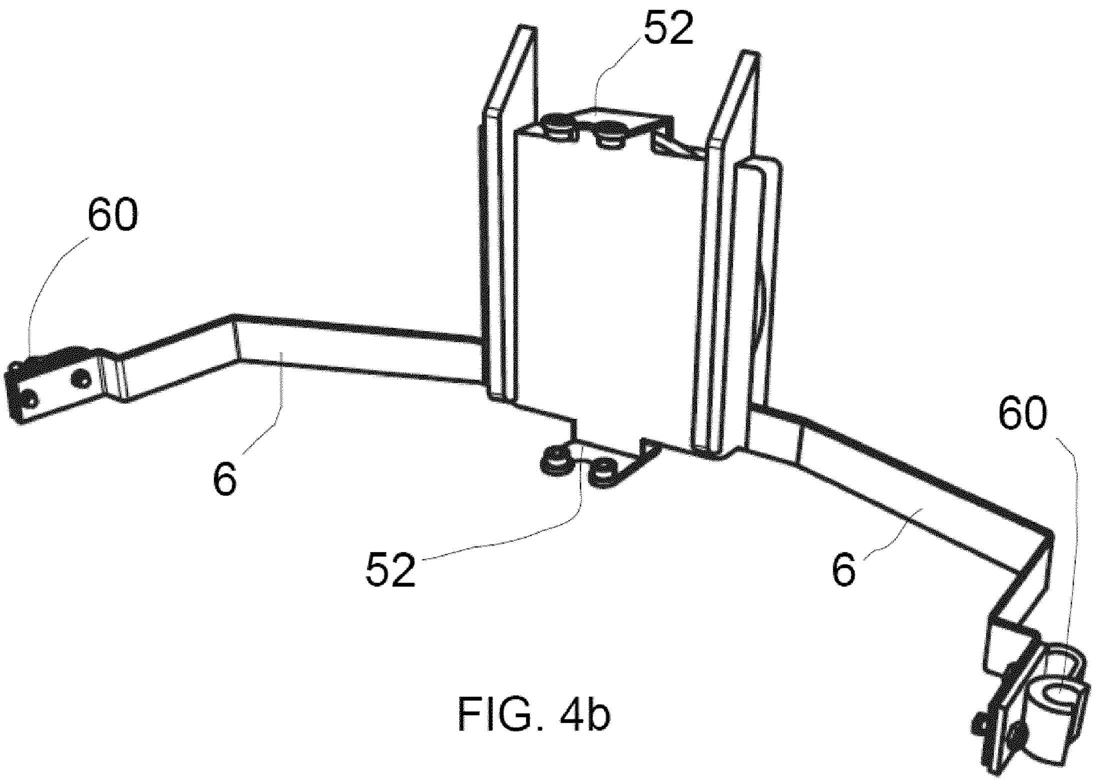

FIG. 4b

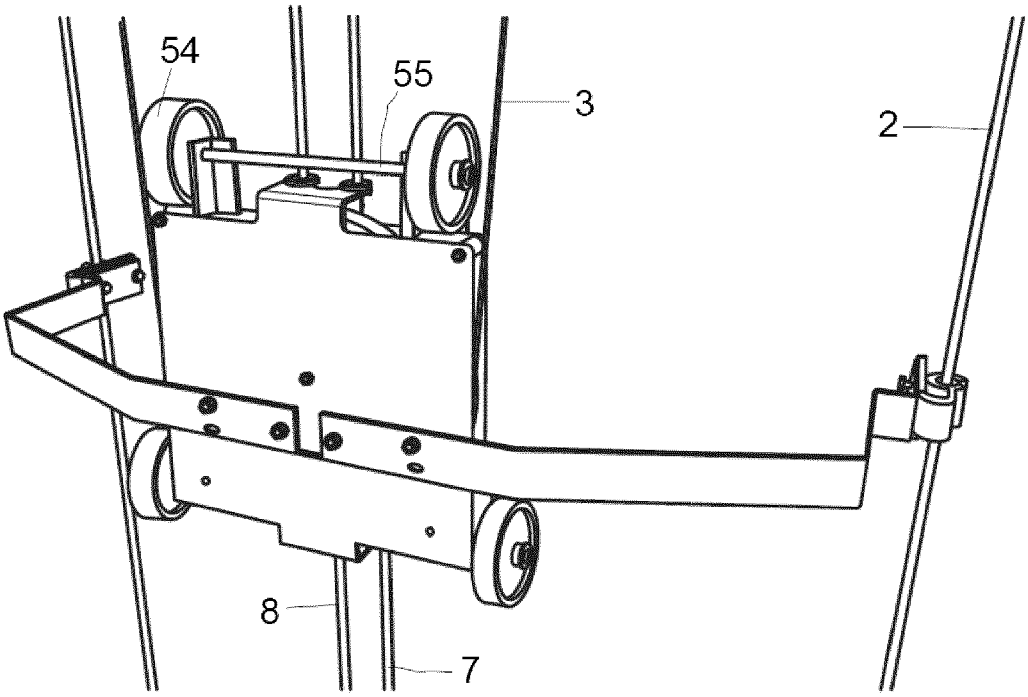

FIG. 4c

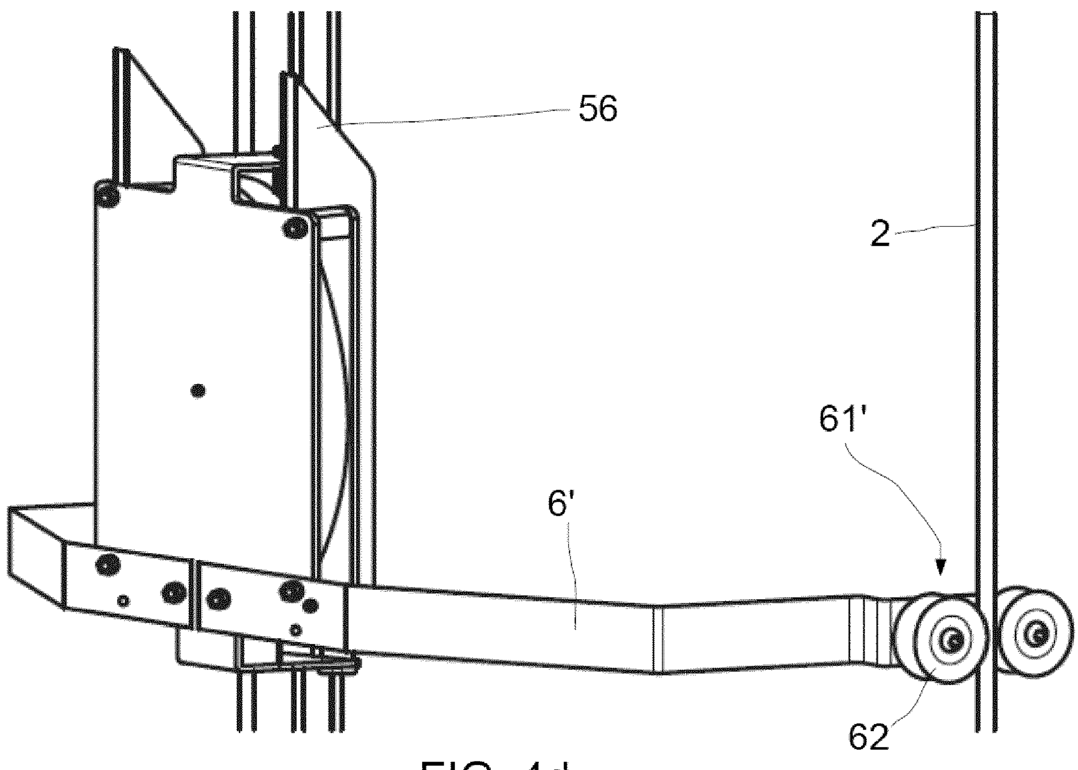

FIG. 4d

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EUROPEAN SEARCH REPORT

Application Number
EP 19 16 9642

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	CN 201 261 671 Y (ZHONGJI LIANHE IND TECHNOLOGY [CN]) 24 June 2009 (2009-06-24) * abstract; figures 1,5,11-14,17 * -----	1-9	INV. B66B7/06 B66B9/187
A	EP 2 522 616 A1 (SIEMENS AG [DE]) 14 November 2012 (2012-11-14) * paragraphs [0005] - [0023]; figures 1-5 * -----	1-9	
A	CA 2 823 982 A1 (WOBBEN PROPERTIES GMBH [DE]) 2 August 2012 (2012-08-02) * pages 19,20; figures 7-9 * -----	1-9	

TECHNICAL FIELDS SEARCHED (IPC)

B66B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 September 2019	Iuliano, Emanuela

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CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 16 9642

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