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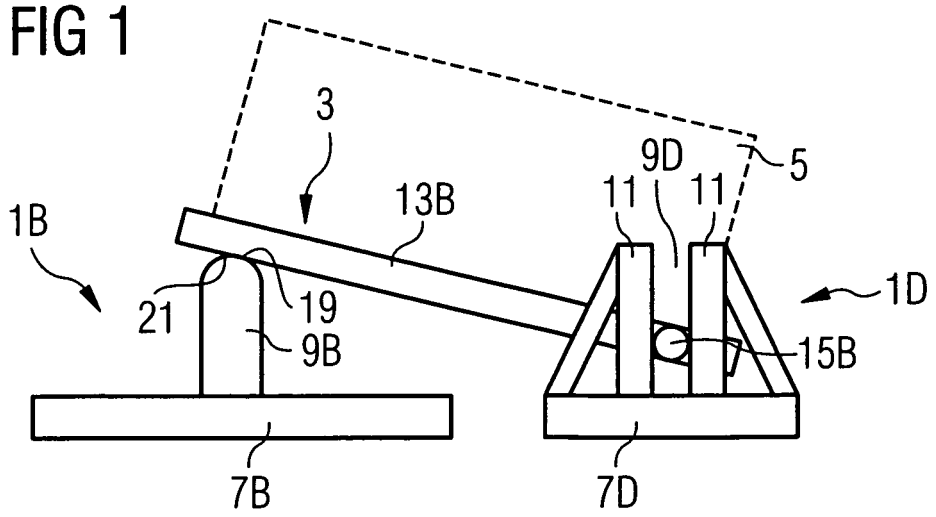
(54) **Tool and method for erecting a tower segment**

(57) A tower segment (5) erection tool is provided. The tool comprises a frame (1A - 1D, 101) which is adapted to rest on the ground and which comprises at least one upstanding stop portion (9A, 9B) and at least one guide portion including at least one guideway (9C, 9D) which has the same height as the stop portion (9A, 9B) and is adapted to restrict the movement of a guide element (15A, 15B) to a vertical movement. It further comprises a bracket (3) which is designed to be detachably fixed to the lowermost section of the tower segment (5) and which comprises an abutment face (19) being adapted to abut on the stop portion (9A, 9B) and at least one guide element (15A, 15B) which is adapted to be guided by the at least one guideway (9C, 9D) of the frame (1A, 1B, 101).

FIG 1



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Description

[0001] The present invention relates to a tower segment erection tool and to a tower segment erection method. Under the expression "tower segment" either a whole tower or a part of a tower shall be understood. In particular, the tower segment erection tool and the method can be used for erecting wind turbine towers or tower segments thereof.

[0002] For erecting a wind turbine tower usually two cranes are needed to keep the moment of tilt under control when the tower reaches the vertical position. Just before reaching the vertical position the moment acting on the tower induced by gravitational force acts on a side of the tower and tends to tilt it in a more horizontal position. When reaching the vertical position, the tower may swing over. Such a swing over would then lead to a sudden change in the direction the gravitational force tends to tilt the tower, i.e. the tower now tends to be tilt to the opposite direction than before. Usually therefore a second crane is used to keep the tower under control and to prevent it from falling over due to the tilt moment. However, it would be desirable using only one crane for erecting the tower and thereby save the direct and indirect costs for the second crane.

[0003] US 6,408,575 W1 and US 6,782,667 W2 describe methods for erecting wind turbine towers which are pivotably connected to a base foundation. These towers could, in principle, be erected with one crane only. However, the hinge at which a tower is pivotably connected to the foundation and the foundation itself would experience considerable loads during the erection of the tower. In particular, the load at the moment of swing over would lead to rather high forces on the hinge entailing the risk of damaging the hinge.

[0004] It is therefore an objective of the present invention to provide a tool and an improved method by which a tower or tower segment can be erected without the need of a second crane.

[0005] This objective is solved by a tower segment erection tool, as claimed in claim 1, and by a method of erecting a tower segment as claimed in claim 7. The depending claims define further developments of the invention.

[0006] An inventive tower segment erection tool includes a frame which is adapted to rest on the ground. The frame comprises at least one upstanding stop portion and at least one guide portion including a guideway, which, when the frame rests on the ground, extends vertically and has the same height as a stop portion. It further includes a bracket which is designed to be detachably fixed to the lower most section of the tower segment which is to be erected. The brackets comprise an abutment face being adapted to abut on the stop portion and at least one guided element, e.g. a projection like a stud or bolt, which is adapted to be guided by the guideway of the frame.

[0007] The inventive tool can be advantageously used for erecting tower segments or whole towers, such as wind turbine towers. For erecting a tower segment the at least one guided element is inserted into the guideway of a frame resting on the ground. The bracket is fixed to the tower segment which is to be erected when the tower segment is in a horizontal or near horizontal position. In general, the fixing of the bracket to the tower segment may take place before or after inserting the guide element into the guideway of the frame. However, when the bracket is first fixed to the tower segment then the whole tower segment needs to be moved in order to insert the guide element into the guideway. Therefore, it is advantageous first to insert the guide element into the guideway and then to fix the bracket to the tower segment. When the bracket is fixed to the tower segment and the guided element is inserted into the guideway of the frame, then the tower is tilted into a tilted position, in which the abutment face of the bracket abuts on the at least one stop portion of the frame. From then on a further tilting of the tower segment into a vertical position takes place with the abutment face resting on the stop portion and the guide elements being guided upwards by a guideway.

[0008] As the guideway prevents the guided element (s) of the bracket from moving horizontally and due to the same dimension of the stop portion and the guideway in vertical direction the tower segment is prevented from swinging over during the erection process, i.e. until it is in a precise vertical position, where the gravitational force is acting only along the longitudinal axis of the power segments. Thus, no moment trying to tilt the tower segment out of its vertical position is present any more, when the guided elements leave the guideway. After the tower segment is in its upright position, the bracket is dismounted.

[0009] The frame of the tower segment erection tool may comprise at least two independent frame parts one of which carries the stop portion(s) while the other carries the guideway(s). By varying the distance between the two frame parts the point at which the abutment face of the bracket abuts on the stop portion, i.e. the tilt angle of the tower segment at the moment of abutting on the stop portion, can be set to the actual need. Further, the frame can be adapted to brackets of different size, i.e. brackets designed for tower segments having different profile width. However, the frame could as well be implemented as a one part structure, which would be particularly useful, where very high stability of the frame is needed.

[0010] The guide portion(s) of the frame may be implemented by first and second beams which are fixed to the frame such as to leave a slit between them. The slit then forms the guideway.

[0011] In such a case, the guided element(s) could be implemented e.g. as a stud extending from the bracket.

[0012] In an advantageous development of the inventive tool each stop portion comprises or is implemented as a sliding surface. Additionally or alternatively, each abutment face comprises or is implemented as a sliding surface. By this development, horizontal movement of

the abutment face relative to the stop portion is less obstructed by friction. Such a horizontal movement arises when the tower fixed to the bracket is tilted as the movement of the guided element is restricted to a strictly linear movement by a linear guideway. This restriction is compensated by a horizontal movement of the bracket relative to the stop portion.

[0013] Further features, properties and advantages of the present invention will become clear by the following description of embodiments of the invention with reference to the accompanying drawings.

[0014] Figure 1 schematically shows a first embodiment of the inventive tower segment erection tool.

[0015] Figure 2 shows the frame of the first embodiment in a top view.

[0016] Figure 3 shows the bracket of the first embodiments in a top view.

[0017] Figure 4 shows a first step in erecting a tower segment with the top segment erection tool.

[0018] Figure 5 shows a second step of erecting a tower segment with the tower segment erection tool.

[0019] Figure 6 shows a third step of erecting a tower segment with the tower segment erection tool according to a third step.

[0020] Figure 7 shows the frame of the tower segment erection tool according to a second embodiment of the invention in a side view.

[0021] Figure 8 shows the frame according to the second embodiment in a top view.

[0022] Throughout the figures, like reference numerals designate like or similar elements.

[0023] A first embodiment of the inventive tower segment erection tool will now be described with reference to figures 1, 2 and 3. The tower segment erection tool according to the first embodiment of the invention comprises a frame 1A to 1E and bracket 3 which can be fixed to the bottom side of a tower segment. The tower segment is indicated in Figure 1 and Figure 3 by dashed lines. It may in particular be a wind turbine tower.

[0024] While figure 1 shows the frame 1A to 1D and the bracket 3 with the wind turbine tower 5 attached thereto in a side view, figures 2 and 3 show the frame 1A to 1D and the bracket 3, respectively, in a top view. In the first embodiment, the frame comprises four independent frame parts, 1A to 1D. Each frame part 1A - 1D comprises a base steel beam 7A to 7D to which either a stop portion 9A, 9B or a guideway 9C, 9D is fixed. The guideways 9C, 9D are formed by upstanding parallel steel beams 11 fixed to the base steel beams 7C and 7D, respectively, in a right angle. Each base steel beam 7A to 7D forms a base portion one side of which is adapted to rest on the ground. When the base portions 7A to 7D rest on the ground the respective stop portions 9A, 9D and guideways 9C, 9D extend vertically.

[0025] The arrangement of the frame portions 1A - 1D on the ground for erecting, e.g., a wind turbine tower is shown in figure 2. The frame parts 1A, 1B comprising the stop portions 9A, 9B are set on the ground with their beams 7A, 7B oriented in parallel and with their stop portions lying on the line L which extends perpendicular to the orientation of the beams 7A, 7B. The frame parts 1C, 1D comprising the guideways 9C, 9D are set on the ground with a distance to the frame parts 1A, 1B in the direction,parallel to the base steel beams 7A, 7B. The distance between the frame parts 1C, 1D, the base steel beams 7C, 7D of which are oriented the same way as the base steel beams 7A, 7B, is slightly larger than the distance between the frame parts 1A, 1B.

[0026] Although the base portions 7B to 7D of the frame parts 1A to 1D are formed by single base steel beams 7A to 7D in the first embodiment they could as well be formed differently, e.g. by steel plates, crossing steel beams, etc. Further, other materials than steel could, in principle, also be used as long as they provide sufficient strength to bare the loads which are imparted to the frame when the tower segment 5 is erected.

[0027] A top view onto the bracket 3 of the tower segment erection tool according to the first embodiment is shown in figure 3. Like in figure 1, a wind turbine tower 5 fixed with its bottom side to the bracket 3 is indicated by a dashed circle.

[0028] The bracket 3 is formed by four steel beams 13A to 13B. Two parallel first beams 13A, 13B are connected to each other by cross beams 13C, 13D such that a more or less quadratic face is enclosed by the four beams 13A - 13D. At one end of each first steel beam 13A, 13B studs 15A, 15B extend perpendicularly outwards from the respective beam. The width of the stud's 15A, 15B cross sections are chosen such that they fit into the guideways 9C, 9D formed by the upstanding steel beams 11 of the frame parts 1C, 1D. The studs 15A, 15B form guided elements which are guided by the guideways 9C, 9D when the tower 5 is erected.

[0029] Each beam 17A to 17B may comprise a number of hols or openings (not shown) through which screws, bolts or other fixing means could be inserted in order to fix the bracket 3 to the bottom side of the tower 5.

[0030] Erecting a tower segment by use of the inventive tool will now be explained with respect to figures 4 to 6. The figures show three stages of erecting a wind turbine tower, as an example for the inventive tower segment erection method.

[0031] Figure 4 shows the method after the bracket 3 has been fixed to the bottom side of a wind turbine tower 5. The fixing of the bracket 3 to the bottom side 17 usually takes place when the tower 5 is in a horizontal position. However before fixing the brackets to the bottom side 17 at least the frame parts 1C, 1D are suitably set on the ground and bracket 3 is inserted with its studs 15a, 15b into the guideways 9C, 9D. Then the bracket 3 is brought into an upright position and the bottom side 17 of the wind turbine tower 5 which is, at that moment, in a horizontal position is fixed thereto.

[0032] After the bracket 3 has been fixed to the bottom side 17, the erection of the wind turbine tower 5 begins. For erecting the wind turbine tower 5, a single crane (not

shown) is used. Although only a single crane is used, more than one crane could be used, as well. However, with the inventive tower segment erection tool, a single crane is enough for safely erecting the tower.

[0033] While being erected, the tower 5 is initially tilted around a tilt axis which extends through the studs 15A, 15B of the frame 3. The tilt axis is horizontally held in position by the guideway 9C, 9D. However, this axis is allowed to move vertically guided by the guideways 9C and 9D.

[0034] When the tilt angle depicted in figure 5 is reached the abutment face of the bracket abuts on the top of the stop portions 9A and 9B. From this moment on, the axis about which the tower 5 will be tilted while being further erected moves out of the axis extending through the studs 15A, 15B to point 20 where the abutment face 19 of the bracket 3 abuts on the top 21 of the stop portions 9A, 9B. Thus, when the tower 5 is further erected from the stage shown in figure 5, the tilting of the tower takes place about the axis defined by the points 20. As a consequence the studs 15A, 15B move upwards guided by the guideways 9C, 9D during the further erection of the tower. A horizontal movement of the studs 15A, 15B is prevented by the upstanding steel beams 11. To increase the resistance of the upstanding beams 11 to forces acting in horizontal direction during the erection of the tower 5 the upstanding beams 11 can be stabilised by traverses 23 as it can be best seen in figure 1.

[0035] When the tower 5 is erected to a nearly vertical position, as it is depicted in figure 6, the studs 15A, 15B have reached the uppermost part of the guideway 9C, 9D. In this position, the tower 5 is still secured against overshooting, i.e. against a horizontal movement of the bottom part of the tower 5, by the guideways 9C, 9D. The studs 15A, 15B only move fully out of the guideway when the tower is oriented fully vertical. Thus, overshooting of the tower is prevented until it is exactly vertical. A second crane for preventing overshooting is therefore not necessary.

[0036] After the tower 5 has been fully erected, the bracket 3 will be dismounted from the bottom of the tower 5.

[0037] A second embodiment of the inventive tower segment erection tool is shown in figures 7 and 8. These figures only show the frame 101 of the tool as the bracket of the second embodiment does not differ from the bracket 3 of the first embodiment.

[0038] In contrast to the first embodiment, where the frame comprises four parts 1A - 1D, the frame 101 of the second embodiment is implemented as a single part. It is built up from two beams 103A, 103B and two cross beams 105 and 107. All beams 103A, 103B, 105, 107 are made from steel. The beams 103A, 103B extend substantially parallel to each other, and the cross beams 105, 107 extend perpendicular to these beams 103A, 103B. The cross beams 105, 107 connect the beams 103A, 103B in their outermost sections. In the middle section of the beams 103A, 103B, chamfered sections 104A, 104B are present, so that the distance between the beams 103A, 103B is slightly larger in the section 109, which will be referred to as the wide section hereinafter, than in the section 111, which will be referred to as the narrow section hereinafter. Correspondingly, the cross beam 107 in the wide section 109 is slightly longer than the cross beam 105 in the narrow section 111.

[0039] In the wide section 109, the guideways 9C, 9D are located, and in the narrow section 111 of the frame 101, the stop portions 9A, 9B are located. The stop portions 9A, 9B and the guideways 9C, 9D do not differ from the stop portions and guideways described with respect to the first embodiment and will therefore not be described again.

[0040] Although the frame has been a four-part-frame in the first embodiment and a one-part-frame in the second embodiment, it could as well be a three-part-frame formed by connecting either the beams 7A and 7B or the beams 7C and 7D by a traverse. A two-part-frame could be realized if beams 7A and 7B and beams 7C and 7D, are respectively connected to each other by traverses. Alternatively, a two-part-frame could also be realized by omitting the beams 105, 107 in figure 8.

[0041] In order to reduce friction between the abutment faces 19, and the top 21 of the stop portions 9A, 9B either of each could be provided with a friction reducing coating so as to form sliding surfaces. By such a coating, the movement of the abutment face around the arcuate top 21 of the stop portions 19A, 19B could be assisted. Such a movement takes place as the studs 15A, 15B are prevented from moving on a circle through the guideways 9C, 9D after the step of the erection method depicted in figure 5 has been reached, in which the tilt axis extends through or near to the points 20.

[0042] The inventive tool and the inventive method allow for erecting a tower segment, like e.g. a wind turbine tower, with the aid of only one crane. As no second crane is necessary the costs related with the erection of a tower segment can be reduced.

Claims

1. A tower segment (5) erection tool with

- a frame (1A - 1D, 101) which is adapted to rest on the ground and which comprises at least one upstanding stop portion (9A, 9B) and at least one guide portion including at least one guideway (9C, 9D) which has the same height as the stop portion (9A, 9B) and is adapted to restrict the movement of a guided element (15A, 15B) to a vertical movement; and
- a bracket (3) which is designed to be detachably fixed to the lowermost section of the tower segment (5) and which comprises an abutment face (19) being adapted to abut on the stop portion (9A, 9B) and at least one guided element

(15A, 15B) which is adapted to be guided by the at least one guideway (9C, 9D) of the frame (1A, 1B, 101).

2. The tower segment (5) erection tool as claimed in claim 1, in which the frame comprises at least two independent frame parts (1A - 1D) carrying the stop portion(s) (9A, 9B) and the guideway(s) (9C, 9D).

3. The tower segment (5) erection tool as claimed in claim 1, in which the frame (101) is implemented as a one part structure.

4. The tower segment (5) erection tool as claimed in any of the preceding claims, in which each guide portion comprises first and second beams (11) which are fixed to a base portion (7C, 7D) of the frame (1C, 1D) with a slit between them, the slit forming the guideway (9C, 9D).

5. The tower segment (5) erection tool as claimed in claim 4, in which each guided element (15A, 15B) is a stud extending from the bracket (3).

6. The tower segment (5) erection tool as claimed in any of the preceding claims, in which each stop portion (9A, 9B) and/or each abutment face (19) comprises a or is implemented as a sliding surface.

7. A method of erecting a tower segment (5) using a tower segment (5) erection tool as claimed in any of the preceding claims, comprising the steps of:

- inserting the at least one guided element (15A, 15B) into the guideway (9C, 9D) of a frame (1A, 1D) resting on the ground;
- fixing the bracket (3) to the tower segment (5) which is to be erected when it is in a horizontal or near horizontal position;
- tilting the tower segment (5) into a tilted position in which the abutment face (19) of the bracket (3) abuts on the at least one stop portion (9A, 9B) of the frame (1A, 1D);
- further tilting the tower (5) into a vertical position with the abutment face (19) resting on the stop portion (9A, 9B) and the guided element (15A, 15B) being guided upwards by the guideway (9c, 9D).

8. The method as claimed in claim 7 in which the bracket (3) is dismounted from the tower segment (5) after it is in the upright position.

FIG 1

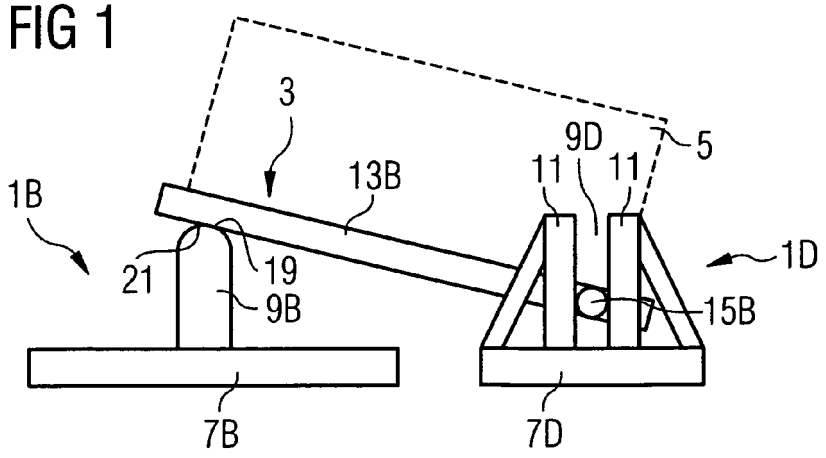


FIG 2

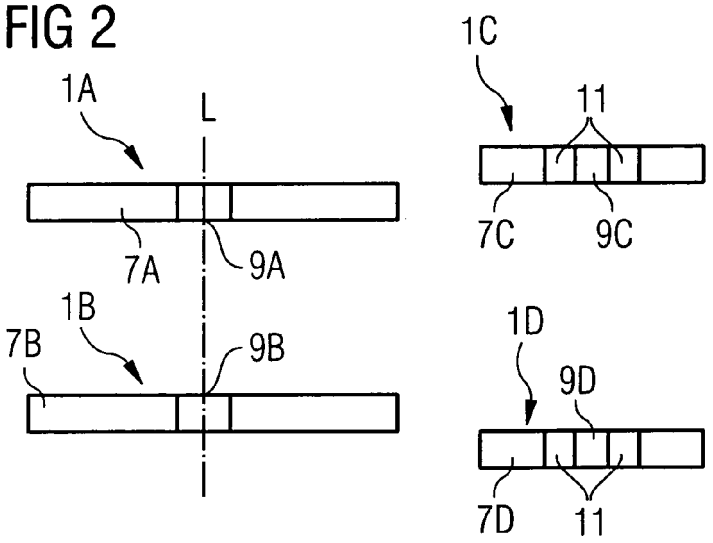


FIG 3

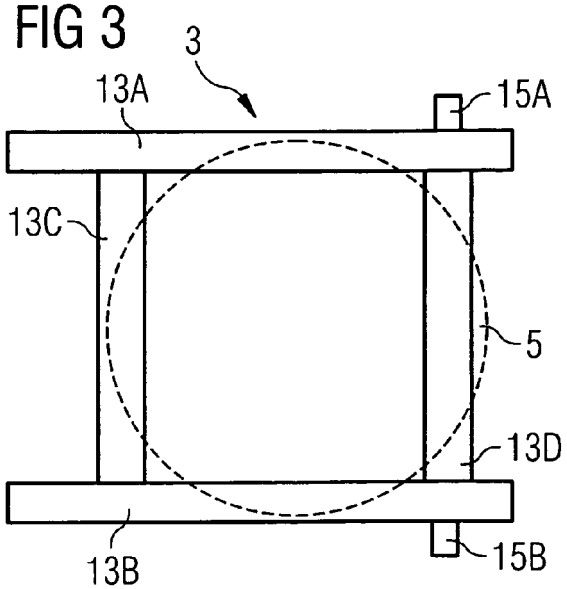


FIG 4

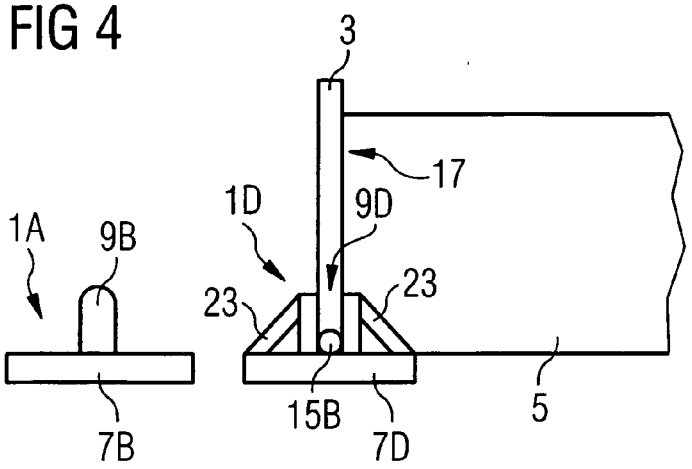


FIG 5

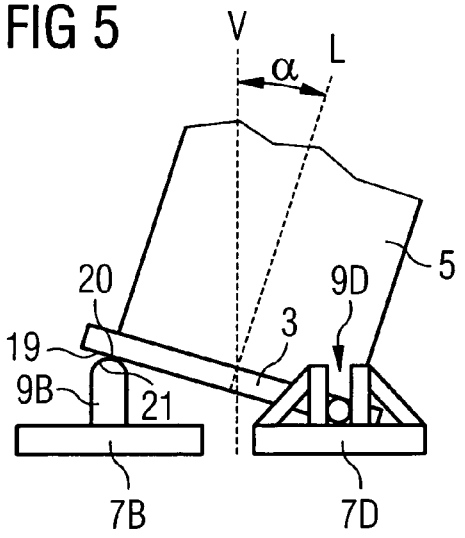


FIG 6

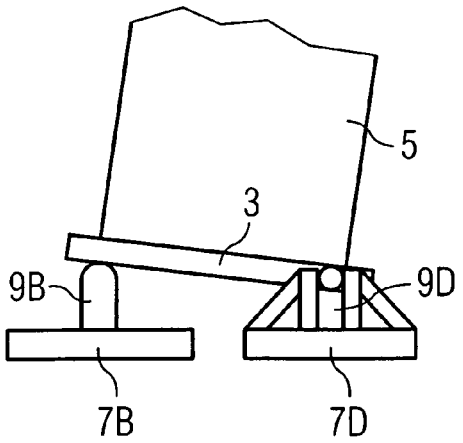


FIG 7

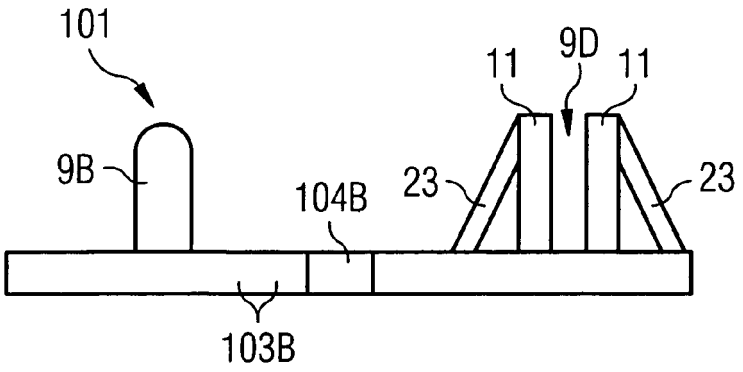
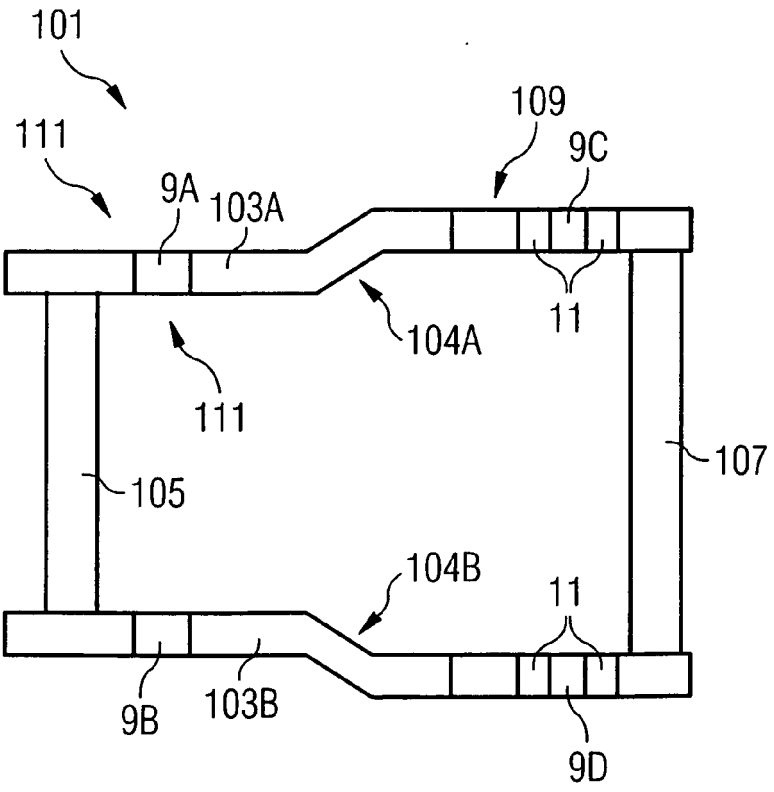

101
11
9D
11
9B
104B
23
23
103B

FIG 8


101
109
111
9C
9A
103A
11
104A
111
107
105
104B
11
9B
103B
9D

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EUROPEAN SEARCH REPORT

Application Number
EP 06 01 3265

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TECHNICAL FIELDS SEARCHED (IPC)

E04H
F03D
F21V
B66F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 November 2006	Stefanescu, Radu

CATEGORY OF CITED DOCUMENTS

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