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(54) Combined lifting beam arrangement for wind turbine parts

Kombinierte Hebebalkenanordnung für Windturbinenteile

Agencement combiné de poutre de levage pour pièces d'éolienne

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Description

[0001] The present invention describes a combined lifting beam arrangement for handling wind turbine parts, in particular to a combined lifting beam arrangement for handling tower wall portions and a nacelle and/or a hub and/or a generator of a wind turbine without changing the lifting beam arrangement between two lifting operations. The present invention further describes a method of handling different wind turbine parts using the same combined lifting beam arrangement. Such a device is disclosed in document EP 2364949 A1.

[0002] Many wind turbines are constructed as hollow steel towers made of prefabricated tower portions. The tower is constructed or assembled by successively lifting and placing a series of tower wall portions on top of each other, whereby the lowest tower wall portion is mounted on a foundation, usually made of concrete, and includes access means such as a doorway to later allow access for a maintenance crew. The tower wall portions become successively smaller in diameter towards the top of the tower. Neighbouring tower wall portions are connected by means of fasteners such as construction bolts inserted into connection holes in the end flanges. For example, for a pair of tower wall portions comprising a 'lower' tower wall portion and an 'upper' tower wall portion, the connection holes of the neighbouring portions are positioned such that connection holes in the top flange of the lower tower wall portion match the connection holes in the bottom flange of the upper tower wall portion.

[0003] To lift a tower wall portion, a number of lifting fittings - usually at least two - is mounted to one of the end flanges of the portion, usually the upper flange, and a cable is connected to the lifting fittings to allow a crane to hoist the portion onto the previously assembled partial tower wall portion. However, the successive tower wall portions generally differ in diameter owing to the overall conical tower shape, and the spacings between the connection holes therefore also differ. To accommodate these differences, prior art lifting techniques have required multiple lifting fittings, sometimes even a specific lifting fitting for each tower section.

[0004] Alternatively, standard universal lifting brackets for mounting in the tower wall flanges by bolts were used in the prior art. After lifting and assembling a first tower wall portion to an already installed tower wall portion, the lifting bracket has to be removed from the flange of the lifted tower wall portion and mounted again to the next tower wall portion. Thus, during the unbolting process of the lifting brackets, a technician must climb to the top of the tower. In this time, the crane with the lifting bracket is still above the tower.

[0005] In addition, the same or another technician must climb to the top of a tower wall portion for hooking it onto the lifting bracket before being handled as the tower wall portion to be installed as the next one. This procedure may be very time-consuming because of the need that technicians must hook on and hook off the tower wall

portions manually.

[0006] Several lifting techniques for the installation of a nacelle, hub and generator at the top of a wind turbine tower are also known in the art. Usually, individual lifting brackets or sling systems are used for handling these wind turbine parts. For example, a special sling system is connected to a nacelle or hub or generator to lift it into the position at the top of the tower, wherein the sling system comprises a number of slings for holding the nacelle or the hub or the generator at special coupling means.

[0007] As the working time, i.e. the man-hours of the technicians are highly expensive for wind turbine installations and, especially, in offshore wind farms, there may be a need for shortening the time and reducing the working hours for the installation of wind turbines. It is therefore an object of the present application to provide an improved lifting beam arrangement and a method for handling wind turbine parts easier and faster.

[0008] The object of the invention is achieved by the combined lifting beam arrangement according to claim 1, and by the method of handling wind turbine parts according to claim 10.

[0009] The combined lifting beam arrangement according to the invention is specifically adjusted for handling wind turbine parts, in particular wind turbine parts having different engaging structures, such as tower wall parts, nacelles, hubs, or generators of a wind turbine. In order to be connectable to a lifting device such as a crane suitable for installing a wind turbine on a foundation or for loading or unloading parts thereof in or from a transportation vehicle, the combined lifting beam arrangement comprises a beam with a connecting element. The connecting element is realized to be connected to the lifting device directly or via a coupling element such as a hook liftable by the lifting device.

[0010] The beam may be connectable to the lifting device by means of the connecting element, such as a pad eye, a loop, a grommet or the like. In particular, the beam may be connectable to the connecting element in a detachable manner, for example for facilitating the transport, maintenance work of the lifting beam arrangement or the like.

[0011] The lifting beam arrangement according to the invention further comprises a first interface for a first engaging structure and a second interface for a second engaging structure which are provided at the beam, preferably at different positions so that they cannot interfere with each other. Of course additional interfaces for a third or fourth or even more engaging structures may be present at the beam without deviating from the invention. "Interface" means in the sense of the present invention, any connecting means adapted to a specific engaging structure of a wind turbine part such as of the tower wall portions, the nacelle, the hub, the generator or the like. The term "engaging structure" means that the element to be lifted has a portion into which a holding member of the interface can be engaged by means of a structural

engagement, e.g. by engaging behind a protruding element or by a bolt-engagement, e.g. in an eye of the part to be lifted, or a frictional connection of the holding element at a friction surface of the part to be lifted. Any other engagement technique known to the skilled person in this field such as clamping techniques and so forth may be used as engaging structures.

[0012] In order to provide a connection with specific engaging structures, the first interface has a number of first holding members adapted for an engagement of the lifting beam arrangement with a tower wall portion of a wind turbine and the second interface has a number of second holding members adapted for an engagement of the lifting beam arrangement with coupling elements of a nacelle and/or a hub and/or a generator of a wind turbine. A "holding member" can be any member suitable for holding the respective wind turbine part with a specific engaging structure such as a holding tool having a corresponding structural configuration.

[0013] The first and second holding members may comprise portions for locking the first and/or second holding members at the beam. In particular, they can be locked at the beam in a releasable manner in one preferred position or may be slideable at the beam along its longitudinal direction. Thereby, an adaptation of the position of the first holding members to different diameters of the tower wall portions or of the second holding members to the geometry of the other wind turbine parts is possible. For locking the first holding member and/or the second holding member to the beam one or more bolts may be provided which may be inserted into one or more holes in the first holding member and/or in the second holding member and/or in the beam. Alternatively, the first and/or the second holding members may be integrally provided in the beam.

[0014] The above-described combined lifting beam arrangement may be used in the method according to the invention.

[0015] In contrast to prior art handling procedures, the method according to the invention is particularly straightforward and fast. Since no individual slings and lifting brackets are used for handling of wind turbine parts having different engaging structures and the same combined lifting beam arrangement is used for handling the tower wall portions and the nacelle and/or the hub and/or the generator, the main lifting device, e.g. a crane, can go directly from the tower top to the nacelle after transferring or installing the top tower wall portion. "Transferring" in the sense of the invention means any handling procedure used during installation, transportation or loading of wind turbine parts. Therefore, the method according to the invention reduces not only crane time and human resources needed for handling operations of wind turbine parts, but also reduces the overall costs.

[0016] Particularly advantageous embodiments and features of the invention are given by the dependent claims, as revealed in the following description. Further embodiments may be derived by combining the features

of the various embodiments described below, and features of the various claim categories can be combined in any appropriate manner.

[0017] The combined lifting beam arrangement according to the invention may preferably be constructed to handle wind turbine parts having different engaging structures, such as tower wall portions with different diameters or a nacelle or hub or generator of a wind turbine. In order to be suitably adapted to handle different wind turbine parts, the beam of the combined lifting beam arrangement may have an elongated shape being extendable in its longitudinal direction. The beam may for example be manufactured from a rigid material such as a metal, in particular iron or steel. The beam may also be represented by a bar, a rod, a pole or the like. The length of the beam (along its longitudinal direction) may range between about 2 m and 20 m, in particular between about 4 m and 10 m, more preferably between about 5 and 8 m. The length of the beam may depend on the diameter or the length of the parts of a wind turbine to be lifted with the same lifting beam arrangement such as a tower wall portion, a nacelle or the like. In particular, the length of the beam may be larger than the diameter of the largest tower wall portion and/or the length of the other parts to be lifted.

[0018] The beam may have a specific cross-sectional shape for providing a sufficient stiffness to withstand forces acting on the holding members and being transferred to the beam, when the tower wall portion and/or the other parts of a wind turbine such as the nacelle, the hub, or the generator are engaged by the interfaces. In particular, the beam may have a cross-sectional shape such as a T-shape, H-shape, I-shape, U-shape, O-shape or any other shape providing a sufficient stiffness for holding and lifting a wind turbine part such as a tower wall portion or a nacelle or the like.

[0019] In a preferred embodiment of the combined lifting beam arrangement, the first interface comprises an automatic hook system. An automatic hook system may have a number of (in particular 2, 3, 4 or even more) locking elements for locking the tower wall portions at different positions. An example of such a locking element is a grabbing element or a claw which can grab the top flange of a tower portion at different positions, in particular at two opposite positions at the inner perimeter of the tower top flange.

[0020] The first interface, in particular the automatic hook system of the first interface, may further comprise a manually or automatically driven actuator moving at least one of the holding members. Examples of actuators are hydraulic or pneumatic or electrical actuators like a piston, a motor, a magnetic valve, or the like. Those actuators may be driven by a battery or a fuel-driven generator. Preferably, the actuator is a remote controlled (for example by means of radio frequency) actuator which can be controlled from a site different from the place of the actuator. In particular, the remote control may be handled from any position suitable to control the installation

of a wind turbine, for example from the ground, a ship, a crane or the like. Thus, an automatic engagement and disengagement of the tower wall portions during the installation or handling process is possible. This reduces working hours and is safer because a manual interaction of a technician is not demanded.

[0021] Such an actuator may for example bring locking elements of an automatic hook system in engagement with the tower wall portion at a specific engagement position. Thus, in one embodiment of the invention, at least one of the first holding members comprises a locking element adapted for engaging with an engaging structure of a tower wall portion. Thereby, it is for example possible to bring a first locking element in engagement with the tower wall portion at a first position and to bring a second locking element in engagement with the tower wall portion at a second engagement position. Further locking elements, such as three or four locking elements may be used to stabilize the locking position during the transferring procedure.

[0022] The locking elements are adapted for engaging with a flange arranged at an end, e.g. the top, of a tower wall portion during the handling operation. The locking elements may be mechanically displaced from one inner position to one outer position, e.g. by activating two or more joined rods by an actuating means. In the outer position, the locking elements are positioned behind at least a part of a bracket of an end part of a tower wall portion or a rim or a flange protruding from the tower wall portion inwards. In particular, by increasing the distance between the locking elements the locking elements and thereby the combined lifting beam arrangement may be locked or secured to the tower wall portion from falling down. More particularly, the locking of the tower wall portion to the first holding member may be stably achieved by increasing the distance between the locking elements, involving clamping radial outer portions of the locking elements between inner surfaces of the tower wall portion.

[0023] In another embodiment of the combined lifting beam arrangement according to the invention, the second holding member comprises a number of, preferably essentially vertical, wires which can be used for handling and lifting a nacelle or a hub or a generator. Instead of wires, other flexible lifting means such as, e.g., slings, ropes, chains, or more stiff lifting means such as, e.g. plates, beams or frames, can be used. Especially the more stiff lifting means may be useful to withstand the weight or the structure of the turbine part. In case frames or plates are used, they can be combined with more flexible lifting means to provide a second holding member adjusted to a specific part of a wind turbine. For example, a frame for a nacelle, hub or generator made of a rigid material can be connected by means of a chain or a sling to the beam.

[0024] If the holding members such as slings or wires are positioned such that they are in a nearly vertical position during operation, that means that the coupling means of the wind turbine part and the holding member

connection with the combined lifting beam arrangement are vertically aligned, the forces in the lifting points, i.e. the coupling means, may be reduced significantly in contrast to a diagonal or tilted connection between both points.

Thus, if slings are used it is preferred that the both ends of the slings are positioned at the beam in a position that each of the ends will be essentially vertical, i.e. up to an angle of about 1 to 15 degree, preferably between about 2 to 10 degree, more preferably between about 4 to 8 degree, especially about 6 degree. The distance between both connection points with the beam depends thus on the width of or the distance of the coupling means at the nacelle or other wind turbine parts to be lifted. Therefore, it is preferable that the second holding members may be movably connected to the beam so that the distance between two or three connection points at the beam can be manually or automatically varied.

[0025] A further advantage of vertical second holding members, e.g. vertical slings, is that less force is applied to the lifting points and thus smaller slings can be used, for example slings made of wires with a smaller diameter than conventional wires. Hence, this would reduce the amount of material and thus lowers the costs and the weight of the second holding members and the whole combined lifting beam arrangement. Moreover, smaller and vertical slings may be easier to handle for the technicians.

[0026] In a further embodiment, the inventive combined lifting beam arrangement according to the invention may have one or two control line coupling means for connecting control lines for rotating the lifting beam arrangement and the wind turbine part hanging thereon. As the control lines are attached to the lifting beam arrangement and not to the tower wall portion, nacelle, hub or generator, the wind turbine parts can be freely rotated during the handling operation. In addition, there is no need of attaching or removing the control lines when the nacelle, the hub or the generator is placed at their respective position, for example in 90 meters or more. This also reduces the crane time and resources needed and, thus, the overall costs for the handling procedures.

[0027] The combined lifting beam arrangement further may be designed to have a pitch system for adjusting a pitch of the beam from a horizontal position into a position angular to the horizontal position, preferably during operation of the lifting beam arrangement. The pitch is the deviation of the main horizontal axis of the beam from the horizontal position. If the beam and the main horizontal axis of the lifted wind turbine part are nearly in a parallel position, the pitch may also be the deviation of the main axis of the wind turbine part from the horizontal position. The pitch system preferably comprises at least two pitch system connecting members connecting the pitch system with the beam at two or more different coupling positions in a longitudinal direction of the beam. For example, the pitch system connecting members comprise two or more wires connecting the lifting device (e.g. a hook of a crane) with two or more different coupling positions

at the beam for holding the beam in a working position. [0028] In an exemplary preferred embodiment, the working position is generally horizontal in its basic modus, while the beam may be in a pitch modus by changing the length of at least one of the wires. For changing the length of the wires (i.e. of the pitch system connecting members) individually, one, two or more of the wires may be provided with a winch to adjust the pitch (that means the angle between the beam and the horizontal position) of the lifting beam arrangement. Optionally, the winches are provided movable in longitudinal direction at the beam. Thereby, the pitch of the lifting beam arrangement may be adjusted by moving the position of one or more of at least two coupling positions at which at least two pitch system connecting wires are provided for connecting the pitch system with the beam in a longitudinal direction of the beam. If, for example, moving the position of one of the coupling positions to a different position nearer to the end of the beam the leverage force on the beam is changed.

[0029] Alternatively, the pitch of the wind turbine parts lifted can be changed by individually changing the length of the first and second holding members connecting the beam with the wind turbine part lifted. This change of the length can also be made by means of winches provided in the first or second holding members.

[0030] In another embodiment of the combined lifting beam arrangement according to the invention, the first interface comprises parts of the second interface and/or the second interface comprises parts of the first interface. For example, the holding members of the first interface can be used together with or instead of some of the holding members of the second interface. For example, the slings for nacelle or generator lifting can be used as additional holding members during the handling or installation of the tower wall portions. Preferably, the tower wall portion can be supported by the second holding members. That means, e.g., the wires can be locked into separate coupling elements at the outside of the tower wall portion in order to stabilize the position of the tower wall portion during installation. It may also be possible that the wires constituting the second holding members may be used as control lines during the tower installation instead of separate control lines or together with separate control lines provided at the combined lifting beam arrangement.

[0031] In another embodiment, the combined lifting beam arrangement comprises a remote control system realized to control parts of the first and/or the second interface. Thereby, controlling the locking or the releasing of the wind turbine parts without any need of manual interaction is possible, especially if the lifted wind turbine part has been placed at the respective place in the wind turbine system or the transportation system. This is in particular possible, if at least the first or the second interfaces, preferably the first and the second interfaces, have automatic holding members. The advantage is that no technician is needed for removing slings at the top of

the tower or at the nacelle position of a wind turbine. In addition, the remote controlled locking and releasing of the interfaces, in particular the holding members, reduces installation time because the technician does not need to change the position and, in particular, the right surveillance eliminates the demand for having technicians in the tower when hooking on and off the tower. This will also allow the lifting apparatus such as the main crane, to be released faster to grab the nacelle, the hub or the generator.

[0032] The above described combined lifting beam arrangement may advantageously be used in the method of handling wind turbine parts according to the invention because it is specifically adapted for tower wall portion lifting and nacelle lifting and, optionally, hub or generator lifting. Thus a change of the lifting beams during the installation of a wind turbine is not necessary and the main crane can start nacelle installation subsequently after having installed the top of the wind turbine tower portions. Hence, the time for installation can be significantly reduced with this combined lifting beam arrangement.

[0033] In addition, it is preferable that at least one of the engaging and/or transferring steps is controlled by remote control. Preferably, an automatic hook system is used for hooking on and off the tower wall portions. Then, the crane may go directly to hook on the nacelle without any change in the lifting beam arrangement after installation of the tower wall portions. The second holding members are then engaged into the respective engaging structures to lift the nacelle. It is further preferred that an automatic system is used with the second holding members. Then, the first and the second interfaces can be remote controlled from a position outside the tower, for example on the ground or in a crane. If, for example, the first and/or the second interface is controlled by remote control mechanisms, installation time can be significantly decreased and the installation procedure can be made safer because it is not demanded that a technician need to climb up and down the tower to disengage the wind turbine parts.

[0034] In a preferred embodiment of the inventive method a pitch control step for adjusting a pitch of a beam of the lifting beam arrangement from a horizontal position into a position angular to the horizontal position is comprised. For example, the pitch control step comprises changing the length of one of at least two pitch system connecting members connecting the pitch system with the beam at two or more different coupling positions in a longitudinal direction of the beam. Usually, the working position of the lifting beam arrangement is generally horizontal in a basic modus. The beam may be in a pitch modus by changing the length of at least one of the pitch system connecting members such as wires connecting the beam with the connecting element provided for connecting the lifting beam arrangement with a lifting device. For changing the length of the wires (i.e. of the pitch system connecting members) individually, one, two or more of the wires may be provided with a winch to adjust the

pitch (that means the angle between the beam and the horizontal position) of the lifting beam arrangement.

[0035] Alternatively or in addition to the first exemplary embodiment, the control step comprises moving the position of one or more of at least two coupling positions at which at least two pitch system connecting wires are provided for connecting the pitch system with the beam in a longitudinal direction of the beam. In this embodiment, the winches are provided movable in longitudinal direction at the beam. Thereby, the pitch of the lifting beam arrangement may be adjusted by moving the position of one or more of at least two coupling positions at which at least two pitch system connecting wires are provided for connecting the pitch system with the beam in a longitudinal direction of the beam. If, for example, moving the position of one of the coupling positions to a different position nearer to the end of the beam the leverage force on the beam is changed and a desired pitch can be foreseen.

[0036] Other objects and features of the present invention will become apparent from the following detailed descriptions considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for the purposes of illustration and not as a definition of the limits of the invention.

Fig. 1 shows a side view of an embodiment of a combined lifting beam arrangement according to the invention during tower lifting;

Fig. 2 shows a sectional view of the same embodiment;

Fig. 3 shows a side view of the same embodiment during nacelle lifting; and

Fig. 4 shows a front view of the same embodiment as shown in Fig. 3; and

Fig. 5 shows a block diagram of an embodiment of the method according to the invention.

[0037] In the drawings, like reference numbers refer to like objects throughout. Objects in the diagrams are not necessarily drawn to scale.

[0038] Fig. 1 shows a side view of an embodiment of a combined lifting beam arrangement 1 and Fig. 2 shows a sectional view of the combined lifting beam arrangement of Fig. 1. The combined lifting beam arrangement comprises a beam 2, a connecting element 3, and a first interface 4 with first holding members 5, locking members 8, and an actuator 13. The Figures further show a second interface 6 with second holding members 7. Moreover, control line coupling means 9, control lines 10, pitch system connecting members 23, and coupling positions 24 as well as a tower 11 with an inner flange 12 are shown as well.

[0039] The combined lifting beam arrangement 1 con-

sists of the beam 2 which extends in its longitudinal direction such that the two interfaces do not interfere with each other, but provides enough space for providing both thereon. The total length depends on the parts to be lifted and is longer than the biggest distance of the lifting points (coupling points at the wind turbine parts to be lifted) at the biggest tower wall portion or the biggest other wind turbine part such as the nacelle, the hub or the generator. Generally, the distance of the lifting points of a nacelle

5 are bigger than the inner diameter of a tower wall portion so that the first interface 4 is provided in the middle of the longitudinal direction of the beam 2 and the second interface 6 is provided around the first interface 4 or closer to the ends of the beam 2 as shown in Figures 1 and 2.

10 **[0040]** The connecting element 3 is provided at the top of the beam 2 and consists of a pitch system consisting of two wires 23 each of which is fixed to the upper side of the beam 2 in a middle position close to the gravity centre of the beam 2. The wires 23 extend vertically to a point at which a hook can be locked and then each of them goes to one of the outer ends of the beam 2. At this end, the wires 23 are connected to winches (not shown) provided at coupling positions 24. The winches are useful to change the length of the wires 23 for adjusting the pitch 15 of the beam, if necessary. If, for example, the right wire as the right pitch system connecting member 23 is shortened the right-hand side of the beam will be raised up and the beam 2 will be in a pitched position. The same can be made by prolonging the left-hand wire as the left 20 pitch system connecting member 23. In a similar manner, the left-hand side of the beam 2 can be varied by changing the length of the right or the left wire 23 of the coupling 25 means 3.

[0041] In Fig. 2, the first interface 4 holding the tower 30 wall portion 11 is shown. The first interface 4 is mounted in the middle of the beam at its side opposite to the coupling means 3. Thus, the tower wall portion 11 can be balanced more easily.

[0042] The interface 4 consists of an actuator 13 and 35 holding members 5. At the end of the holding members 5, locking portions 8 protruding behind a flange 12 of the tower wall portion 11 in a locked position are shown. This is only an exemplary embodiment of an automatic hook system and the skilled person knows how such automatic 40 hook systems can be varied or adjusted to fulfil the same function.

[0043] The combined lifting beam arrangement 1 is engaged into the engaging structure, the flange 12, of the tower wall portion 11 by means of the first interface 4. In 45 the engaged position, the tower wall portion 11 can be handled, for example, be installed on a foundation or placed in a transportation vessel. It is of course possible to lift and transport any such parts at the same time from one place to another place.

[0044] At both ends of the beam 2, control line coupling means 9 are provided. In the Fig. 1 and 2, both control line coupling means 9 are provided at a separate part of the beam 2, a so called beam-extending portion 20. This

beam-extending portion 20 may be a fixed element or can be detachable or movable provided so that the position of the control line coupling means 9 can be varied manually and/or automatically before or during the handling operation. The beam-extending portion 20 may be provided as a pivoting element if the lifted wind turbine parts may hinder the control lines 10 in the straight line position. The control lines 10 are connected to the lifting device (not shown) such as a crane (not shown) to rotate the tower wall portion 11 into the correct position.

[0045] The second interface 6 with the second holding members 7 is not engaged in this embodiment where the tower wall portion is lifted.

[0046] In Fig. 3, the same combined lifting beam arrangement 1 as in Fig. 1 and 2 is shown. However instead of handling and lifting a tower wall portion 11, a nacelle 15 is lifted by means of the second interface 6. The combined lifting beam arrangement 1 has the same parts as in Fig. 1 and 2, while the first interface 4 is not engaged at this time.

[0047] A nacelle 15 is held by means of two slings 7 of the second interface 6. The slings 7 are connected to coupling means at the nacelle which are located at the front side 16 (preferably near to the gravity centre) and in the middle of the nacelle housing 17. The sling 7 at the nacelle housing 17 goes through holes in the housing into the nacelle housing 17 and is connected to the inner wall of the nacelle housing 17. The length of the slings 7 is such that the nacelle 15 is lifted in a slightly pitched manner. The angle to the horizontal position is less than about 15 degree, preferably between 2 and 10 degrees, in particular about 6 degrees, while the combined lifting beam arrangement 1 is nearly in a horizontal position. If the desired pitch needs to be varied, this can be done by using the pitch system (not shown) as described before.

[0048] In Fig. 4, a same combined lifting beam arrangement 1 as in the Fig. 1 to 3 is shown. The lifted nacelle 15 is a nacelle 15 with a cooler 18 at its rear side. The sling 7 at the front side 17 of the nacelle 15 comprises one wire 7 which is connected to a coupling means (not shown) at the middle of the front side 17 of the nacelle. The other wire 7 is constituted of two separate wires which go to coupling means inside the nacelle housing 17 wherein one is provided at the left and the other at the right side of the nacelle housing 17 to achieve a stable lifting condition. It is a three point connection between the beam 2 and the nacelle 15 so that the nacelle 15 can easily be rotated and placed into the installation position on the top of a tower (not shown). For rotation, the control lines 10 (shown in Fig. 3) provided at the end of the beam 2 can be used as has been described above for the tower rotation.

[0049] Thus, the combined lifting beam arrangement 1 is advantageous because any wind turbine parts, even though they have different engaging structures, such as a tower wall portion or a nacelle can be lifted without changing the lifting beam arrangement between two lifting procedures. Thereby the overall time of installation

of a wind turbine, especially in an off-shore wind farm, can be reduced.

[0050] Fig. 5 shows a block diagram of the method of the invention. In step A a number of first holding members 5 of a first interface portion 4 of a combined lifting beam arrangement 1 are engaged into a tower wall portion 11 of a wind turbine. In step B the tower wall portion 11 is transferred from a first location to a second location, for example from a loading vessel on a ship to a foundation of an off-shore wind power plant. In step C the first interface 4 is disengaged from the tower wall portion 11, for example by using a remote controlled automatic hook system as described before. After the tower wall portion installation step, a nacelle 15 of a wind turbine is engaged by means of a number of second holding members 7 of a second interface 6 of the lifting beam arrangement 1 as described beforehand (step D). Then, the nacelle 15 is transferred from a third location to a fourth location in step E. In the last step, step F, the second interface 6 is disengaged from the nacelle 15 by using a remote controlled automatic second interface. Of course, the method can be used for hub or generator installation after the nacelle has been installed (not shown).

[0051] Although the present invention has been disclosed in the form of preferred embodiments and variations thereon, it will be understood that numerous additional modifications and variations could be made thereto without departing from the scope of the invention. While the assembly of wind turbines made of tower wall portions and a nacelle portion was used as a basis for the description, the combined lifting beam arrangement according to the invention may be used to good effect in assembling constructions other than wind turbines installed from separate tower portions. For example, prefabricated concrete towers could also be assembled using a combined lifting beam arrangement according to the invention. Those could assemble with a nacelle or a hub or a generator or any of those additional components in an easy and fast manner. For the sake of clarity, it is to be understood that the use of "a" or "an" throughout this application does not exclude a plurality, and "comprising" does not exclude other steps or elements. A "means", "member", "device" or "element" can comprise a number of separate means, members, devices or elements, unless otherwise stated.

Claims

50. 1. Combined lifting beam arrangement (1) for handling wind turbine parts, comprising:
 - a beam (2) with a connecting element (3) realized to be connected to a lifting device,
 - a first interface (4) having a number of first holding members (5) adapted for an engagement of the lifting beam arrangement with a tower wall portion (11) of a wind turbine, wherein at least

one of the first holding members. (5) comprises a locking element (8) adapted for engaging with a flange (12) arranged at an end of the tower wall portion (11), and

- a second interface (6) having a number of second holding members (7) adapted for an engagement of the lifting beam arrangement with coupling elements of a nacelle (15) and/or a hub and/or a generator of a wind turbine.

2. Combined lifting beam arrangement according to claim 1, wherein the first interface (4) comprises an automatic hook system.

3. Combined lifting beam arrangement according to claims 1 or 2, wherein the first interface comprises an actuator (13), preferably an RF controlled actuator, moving at least one of the holding members (5).

4. Combined lifting beam arrangement according to any of the preceding claims, wherein the second holding member comprises a number of wires (7).

5. Combined lifting beam arrangement according to any of the preceding claims having one or two control line coupling means (9).

6. Combined lifting beam arrangement according to any of the preceding claims having a pitch system for adjusting a pitch of the beam (2) from a horizontal position into a position angular to the horizontal position.

7. Combined lifting beam arrangement according to claim 6, wherein the pitch system (3) comprises at least two pitch system connecting members (23) connecting the pitch system (3) with the beam (2) at two or more different coupling positions (24) in a longitudinal direction of the beam.

8. Combined lifting beam arrangement according to any of the preceding claims, wherein the first interface (4) comprises parts of the second interface (6) and/or the second interface (6) comprises parts of the first interface (4).

9. Combined lifting beam arrangement according to any of the preceding claims, comprising a remote control system realized to control parts of the first and/or the second interface (4,6).

10. A method of handling wind turbine parts, comprising the steps of:

- engaging (A) a tower wall portion (11) of a wind turbine with a number of first holding members (5) of a first interface portion (4) of a combined lifting beam arrangement (1) according to any

of claims 1 to 9, wherein at least one of the first holding members (5) comprises a locking element (8) adapted for engaging with a flange (12) arranged at an end of the tower wall portion (11) ;

- transferring (B) the tower wall portion (11) from a first-location to a second location,
- disengaging (C) the first interface (4) from the tower wall portion (11),
- engaging (D) a nacelle (15) or a hub or a generator of a wind turbine with a number of second holding members (7) of a second interface (6) of the lifting beam arrangement (1),
- transferring (E) the nacelle (15) or the hub or the generator from a third location to a fourth location, and
- disengaging (F) the second interface (6) from the nacelle (15) or hub or generator.

11. The method according to claim 10, wherein at least one of the engaging and/or transferring steps is controlled by remote control.

12. The method according to claim 10 or 11, further comprising a pitch control step for adjusting a pitch of a beam (2) of the lifting beam arrangement (1) from a horizontal position into a position angular to the horizontal position.

13. The method according to claim 12, wherein the pitch control step comprises changing the length of one of at least two pitch system connecting members (23) connecting the pitch system (3) with the beam (2) at two or more different coupling positions (24) in a longitudinal direction of the beam.

14. The method according to claim 12 or 13, wherein the control step comprises moving the position of one or more of at least two coupling positions (24) at which at least two pitch system connecting wires (23) are provided for connecting the pitch system (3) with the beam (2) in a longitudinal direction of the beam.

Patentansprüche

1. Kombinierte Hebebalkenanordnung (1) zur Handhabung von Windkraftanlagenteilen, welche umfasst:
 - einen Balken (2) mit einem Verbindungselement (3), das dafür ausgebildet ist, mit einem Hebezeug verbunden zu werden,
 - eine erste Schnittstelle (4) mit einer Anzahl von ersten Halteelementen (5), die für einen Eingriff der Hebebalkenanordnung mit einem Turmwandabschnitt (11) einer Windkraftanlage eingerichtet sind, wobei mindestens eines der ersten Halteelemente (5) ein Verriegelungselement (8) umfasst, das für einen Eingriff mit ei-

nem Flansch (12) ausgelegt ist, der an einem Ende des Turmwandabschnitts (11) angeordnet ist, und

- eine zweite Schnittstelle (6) mit einer Anzahl von zweiten Halteelementen (7), die für einen Eingriff der Hebebalkenanordnung mit Kopp lungselementen einer Gondel (15) und/oder einer Nabe und/oder eines Generators einer Windkraftanlage eingerichtet sind.

2. Kombinierte Hebebalkenanordnung nach Anspruch 1, wobei die erste Schnittstelle (4) ein automatisches Hakensystem umfasst.

3. Kombinierte Hebebalkenanordnung nach Anspruch 1 oder 2, wobei die erste Schnittstelle einen Aktuator (13), vorzugsweise einen HF-gesteuerten Aktuator, umfasst, der mindestens eines der Halteelemente (5) bewegt.

4. Kombinierte Hebebalkenanordnung nach einem der vorhergehenden Ansprüche, wobei das zweite Haltelement eine Anzahl von Drähten (7) umfasst.

5. Kombinierte Hebebalkenanordnung nach einem der vorhergehenden Ansprüche, welche ein oder zwei Steuerungsleitungs-Kopplungsmittel (9) aufweist.

6. Kombinierte Hebebalkenanordnung nach einem der vorhergehenden Ansprüche, welche ein Neigungssystem zum Verstellen einer Neigung des Balkens (2) aus einer horizontalen Position in eine schräg zu der horizontalen Position verlaufende Position aufweist.

7. Kombinierte Hebebalkenanordnung nach Anspruch 6, wobei das Neigungssystem (3) mindestens zwei Neigungssystem-Verbindungselemente (23) umfasst, welche das Neigungssystem (3) mit dem Balken (2) an zwei oder mehr verschiedenen Kopplungspositionen (24) in einer Längsrichtung des Balkens verbinden.

8. Kombinierte Hebebalkenanordnung nach einem der vorhergehenden Ansprüche, wobei die erste Schnittstelle (4) Teile der zweiten Schnittstelle (6) umfasst und/oder die zweite Schnittstelle (6) Teile der ersten Schnittstelle (4) umfasst.

9. Kombinierte Hebebalkenanordnung nach einem der vorhergehenden Ansprüche, welche ein Fernsteuerungssystem umfasst, das dafür ausgebildet ist, Teile der ersten und/oder der zweiten Schnittstelle (4, 6) zu steuern.

10. Verfahren zur Handhabung von Windkraftanlagen- teilen, welches die folgenden Schritte umfasst:

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- Ineingriffbringen (A) eines Turmwandabschnitts (11) einer Windkraftanlage mit einer Anzahl von ersten Halteelementen (5) eines ersten Schnittstellenabschnitts (4) einer kombinierten Hebebalkenanordnung (1) nach einem der Ansprüche 1 bis 9, wobei mindestens eines der ersten Halteelemente (5) ein Verriegelungselement (8) umfasst, das für einen Eingriff mit einem Flansch (12) ausgelegt ist, der an einem Ende des Turmwandabschnitts (11) angeordnet ist;

- Transportieren (B) des Turmwandabschnitts (11) von einem ersten Ort zu einem zweiten Ort,
- Lösen (C) der ersten Schnittstelle (4) von dem Turmwandabschnitt (11),
- Ineingriffbringen (D) einer Gondel (15) oder einer Nabe oder eines Generators einer Windkraftanlage mit einer Anzahl von zweiten Halteelementen (7) einer zweiten Schnittstelle (6) der Hebebalkenanordnung (1),
- Transportieren (E) der Gondel (15) oder der Nabe oder des Generators von einem dritten Ort zu einem vierten Ort, und
- Lösen (F) der zweiten Schnittstelle (6) von der Gondel (15) oder der Nabe oder dem Generator.

11. Verfahren nach Anspruch 10, wobei mindestens einer der Schritte des Ineingriffbringens und/oder Transportierens mittels Fernsteuerung gesteuert wird.

12. Verfahren nach Anspruch 10 oder 11, welches ferner einen Neigungssteuerungsschritt zum Verstellen einer Neigung eines Balkens (2) der Hebebalkenanordnung (1) aus einer horizontalen Position in eine schräg zu der horizontalen Position verlaufende Position umfasst.

13. Verfahren nach Anspruch 12, wobei der Neigungssteuerungsschritt das Ändern der Länge eines von mindestens zwei Neigungssystem-Verbindungselementen (23) umfasst, welche das Neigungssystem (3) mit dem Balken (2) an zwei oder mehr verschiedenen Kopplungspositionen (24) in einer Längsrichtung des Balkens verbinden.

14. Verfahren nach Anspruch 12 oder 13, wobei der Steuerungsschritt das Bewegen der Position einer oder mehrerer von mindestens zwei Kopplungspositionen (24), an denen mindestens zwei Neigungssystem-Verbindungsdrähte (23) zum Verbinden des Neigungssystems (3) mit dem Balken (2) vorgesehen sind, in einer Längsrichtung des Balkens umfasst.

Revendications

1. Agencement de poutre de levage combiné (1) destiné à manipuler des pièces d'éoliennes, comprenant :

- une poutre (2) avec un élément de liaison (3) réalisé pour être relié à un dispositif de levage,
- une première interface (4) comportant un certain nombre de premiers éléments de maintien (5) adaptés pour une mise en prise de l'agencement de poutre de levage avec une partie de paroi de tour (11) d'une éolienne, dans lequel au moins l'un des premiers éléments de maintien (5) comprend un élément de verrouillage (8) adapté pour venir en prise avec une bride (12) agencée au niveau d'une extrémité d'une partie de paroi de tour (11), et
- une seconde interface (6) comportant un certain nombre de seconds éléments de maintien (7) adaptés pour une mise en prise de l'agencement de poutre de levage avec des éléments d'accouplement d'une nacelle (15) et/ou d'un moyeu et/ou d'un générateur d'une éolienne.

2. Agencement de poutre de levage combiné selon la revendication 1, dans lequel la première interface (4) comprend un système de crochet automatique.

3. Agencement de poutre de levage combiné selon la revendication 1 ou 2, dans lequel la première interface comprend un actionneur (13), de préférence un actionneur à commande RF, déplaçant au moins l'un des éléments de maintien (5).

4. Agencement de poutre de levage combiné selon l'une quelconque des revendications précédentes, dans lequel le second élément de retenue comprend un certain nombre de fils métalliques (7).

5. Agencement de poutre de levage combiné selon l'une quelconque des revendications précédentes, ayant un ou deux moyens de couplage de filins de manœuvre (9).

6. Agencement de poutre de levage combiné selon l'une quelconque des revendications précédentes, possédant un système de réglage d'inclinaison pour régler l'inclinaison de la poutre (2) à partir d'une position horizontale jusqu'à une position angulaire par rapport à la position horizontale.

7. Agencement de poutre de levage combiné selon la revendication 6, dans lequel le système d'inclinaison (3) comprend au moins deux éléments de liaison de système d'inclinaison (23) reliant le système d'inclinaison (3) à la poutre (2) au niveau de deux positions d'accouplement différentes (24) ou plus dans une direction longitudinale de la poutre.

8. Agencement de poutre de levage combiné selon l'une quelconque des revendications précédentes, dans lequel la première interface (4) comprend des parties de la seconde interface (6) et/ou la seconde interface (6) comprend des parties de la première interface (4).

9. Agencement de poutre de levage combiné selon l'une quelconque des revendications précédentes, comprenant un système de télécommande réalisé afin de commander des parties de la première et/ou de la seconde interface (4,6).

10. Procédé de manipulation de pièces d'éoliennes, comprenant les étapes consistant à :

- mettre en prise (A) une partie de paroi de tour (11) d'une éolienne avec un certain nombre de premiers éléments de maintien (5) d'une première partie d'interface (4) d'un agencement de poutre de levage combiné (1) selon l'une quelconque des revendications 1 à 9, dans lequel au moins l'un des premiers éléments de maintien (5) comprend un élément de verrouillage (8) adapté pour venir en prise avec une bride (12) agencée au niveau d'une extrémité d'une partie de paroi de tour (11) ;
- transférer (B) la partie de paroi de tour (11) à partir d'un premier emplacement vers un second emplacement,
- désolidariser (C) la première interface (4) de la partie de paroi de tour (11),
- mettre en prise (D) une nacelle (15) ou un moyeu ou un générateur d'une éolienne avec un certain nombre de seconds éléments de maintien (7) d'une seconde interface (6) de l'agencement de poutre de levage (1),
- transférer (E) la nacelle (15) ou le moyeu ou le générateur à partir d'un troisième emplacement vers un quatrième emplacement, et
- désolidariser (F) la seconde interface (6) de la nacelle (15), du moyeu ou du générateur.

11. Procédé selon la revendication 10, dans lequel au moins l'une des étapes de mise en prise et/ou de transfert est commandée par une télécommande.

12. Procédé selon la revendication 10 ou 11, comprenant en outre une étape de commande d'inclinaison pour régler une inclinaison d'une poutre (2) de l'agencement de poutre de levage (1) à partir d'une position horizontale jusqu'à une position angulaire par rapport à la position horizontale.

13. Procédé selon la revendication 12, dans lequel l'étape de commande d'inclinaison comprend la modifi-

cation de la longueur de l'un d'au moins deux éléments de liaison de système d'inclinaison (23) reliant le système d'inclinaison (3) à la poutre (2) au niveau de deux positions d'accouplement différentes (24) ou plus dans une direction longitudinale de la poutre. 5

14. Procédé selon la revendication 12 ou 13, dans lequel l'étape de commande comprend le déplacement de la position d'une ou plusieurs d'au moins deux positions d'accouplement (24) au niveau desquelles au moins deux fils métalliques de liaison de système d'inclinaison (23) sont situés pour relier le système d'inclinaison (3) à la poutre (2) dans une direction longitudinale de la poutre. 10

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FIG 1

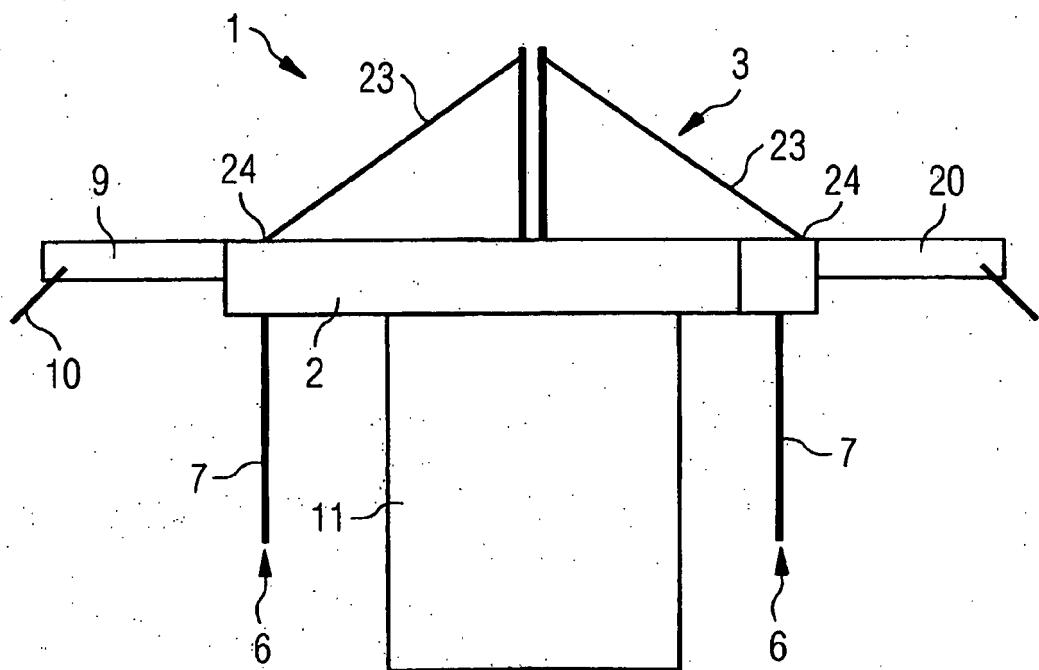


FIG 2

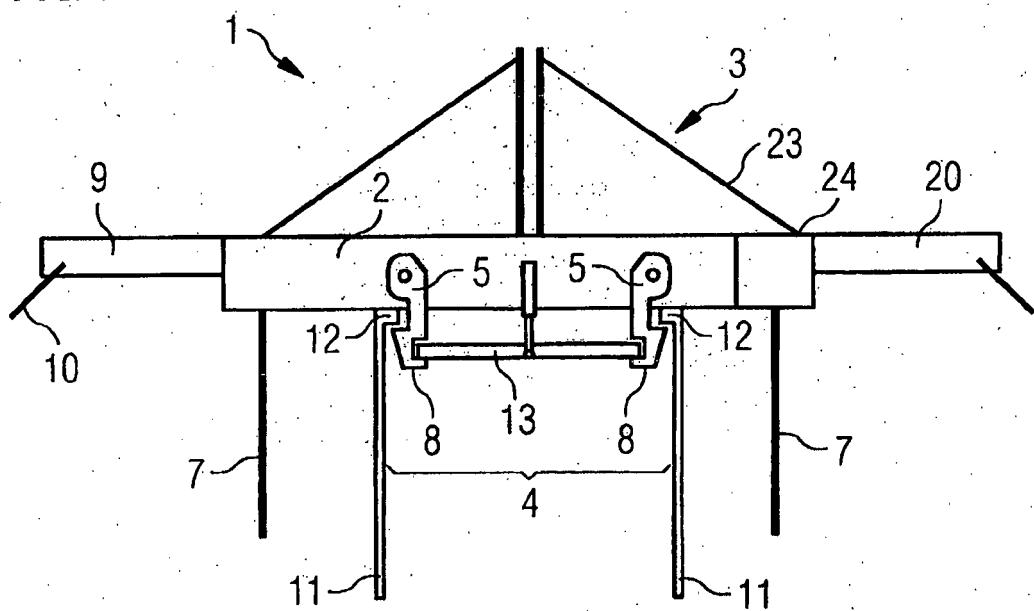


FIG 3

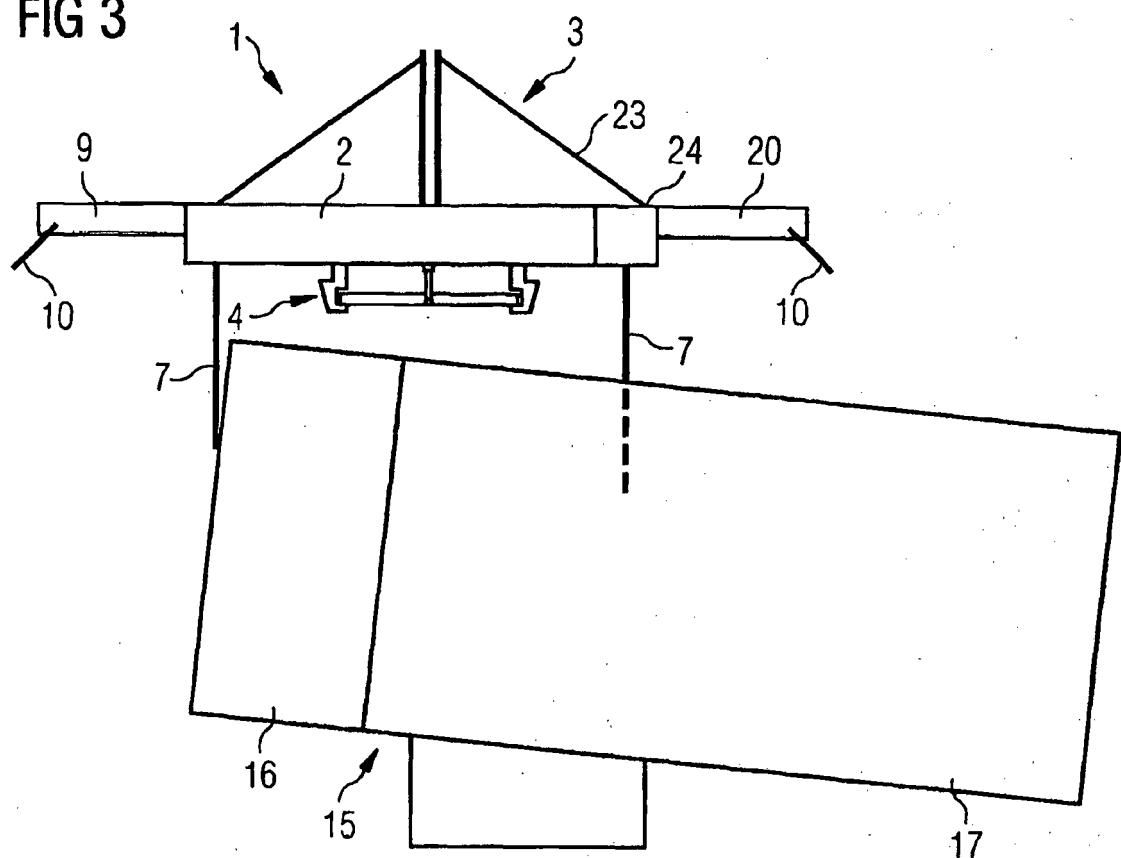


FIG 4

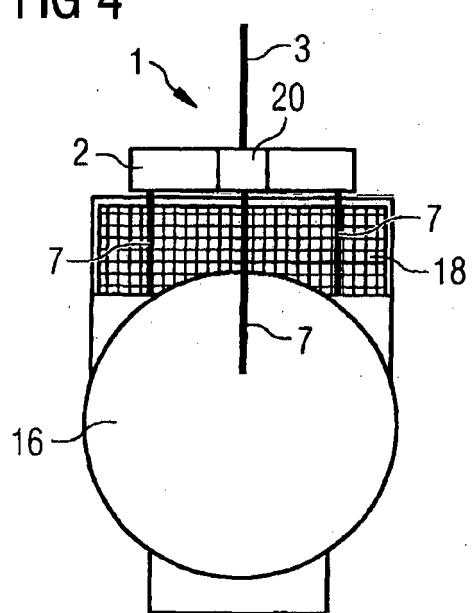
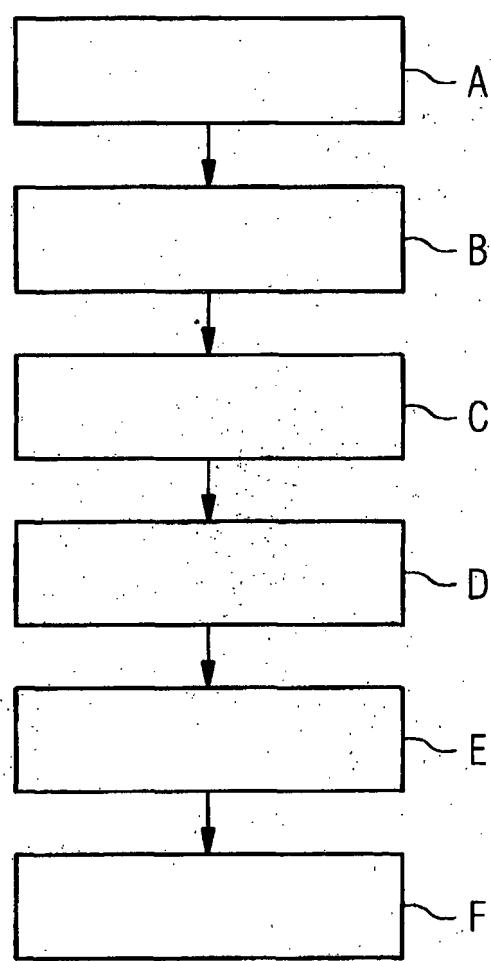


FIG 5



REFERENCES CITED IN THE DESCRIPTION

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