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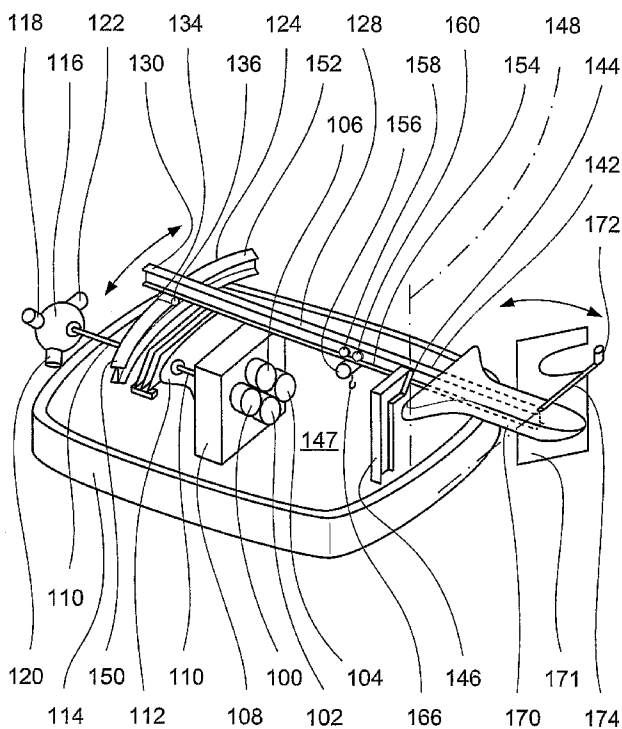
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(54) Title: WIND TURBINE NACELLE WITH INTEGRAL SERVICE CRANE FOR ACCESSING TURBINE COMPONENTS



(57) Abstract: A service crane for a wind turbine comprising a main crane beam (128) having a track (154) that accommodates a trolley (156). A hinge (144) is provided at a pivot point (148) near a proximate end of the main beam (128), such that an aft portion of the main beam (128) extends beyond the pivot point (148) to the exterior of the turbine. A distal end of the main beam (128) rests upon a forward beam. A lateral motion actuator (134) moves the main beam (128) back and forth along the forward beam. The trolley (156) runs back and forth along the main beam (128). A turbine component is attached to a hook lowered by cable from the trolley (156). The trolley (156) with the component on the hook is moved to the aft portion of the main beam (128), which extends beyond the turbine. The hook is lowered to the ground so that the component can be serviced or replaced.

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**WIND TURBINE NACELLE WITH INTEGRAL SERVICE CRANE FOR ACCESSING
TURBINE COMPONENTS**

5 Field of the Invention

This invention relates to wind turbines housed in a nacelle atop a tall tower, and more particularly to an integrated service crane for accessing turbine components atop high towers.

10

Description of the Prior Art

The cost of wind-generated electricity has been dropping due to technological innovations and economies of scale. The average turbine size is now approximately 1.5 MW with rotor diameters ranging from 70 to 85m. This class of turbines has on average a nacelle weight of 50 tons (generators, gear box and nacelle housing) and a rotor weight of approximately 35 tons. To improve the economics of wind turbines, manufacturers have been designing taller towers to take advantage of greater wind energy at higher levels above ground. Manufacturers are increasingly relying on 80 and 100 m tower designs, rather than the shorter towers used previously. The cost of lowering and lifting these weights from/to the top of tall land based towers for servicing can be prohibitive, mainly due to the reach of conventional cranes, which require much higher crane capacity than the actual weight being lifted. This is due to the bending moment resulting from the reach of conventional cranes.

US Patent 6,955,025 discloses a method of raising a wind turbine tower wherein the nacelle and turbine generators housed in the nacelle are raised together, such that once the

tower is raised the nacelle is at the top of the tower. It is possible using the method described therein to lower the tower and nacelle to replace the nacelle and turbine. However for routine maintenance or replacement of only one component, such
5 as one generator, it is not cost effective to lower the entire nacelle. Only the defective component need be lowered.

In the conventional method of the prior art, using a typical crane at ground level, a drivetrain or a component thereof is lifted up and over the top of a nacelle located on
10 the top of a tall tower. The drivetrain or component is then lowered through a hatch door in the top of the nacelle. The reverse procedure is used to remove and lower components for servicing. A 50-ton drivetrain lift would require a 400-600 ton crane. This higher capacity is required due to the high
15 bending moment associated with the crane reach.

Currently wind turbines require that a crane or special apparatus to be brought to the wind turbine site for accessing the components through removal of the nacelle top, in order to remove components out of the nacelle top and lower them down
20 to the ground for repair or replacement. This adds a substantial cost for repair and component replacement activity leading to an increase in the cost of energy.

It is desirable to provide an apparatus which facilitates the repair and replacement of wind turbine components and lowers
25 the costs of such repair and replacement.

SUMMARY OF THE INVENTION

Briefly, the invention is concerned with a wind turbine
30 service crane for lifting heavy turbine components onto the top of a very tall tower (80-100m).

The service crane for a wind turbine comprises a movable main crane beam having a track for guidance of a trolley, a

first frame comprising a hinge at a pivot point, wherein the crane beam is connected to the hinge such that a portion of the crane beam extends beyond the pivot point, a stationary beam which is connected with a distal end of the crane beam
5 such that the crane beam can laterlly move along the station-ary beam.

According to one embodiment of the present invention, the service crane comprises a main crane beam having a track upon which a trolley can run. A hinge is provided at a pivot point
10 near a proximate end of the main beam, such that an aft portion of the beam extends beyond the pivot point to the exterior of the turbine, the hinge being supported by an aft frame attached to a floor of the nacelle and connected to the main beam.

15 A distal end of the main beam rests upon a forward beam, which is supported by a forward frame attached to the floor of the nacelle. A lateral motion actuator operatively connected to the main beam moves the main beam back and forth along the forward beam. The trolley includes a longitudinal motion ac-
20 tuator such that the trolley runs back and forth along the main beam.

In operation the trolley is moved to the interior of the turbine where a turbine component is attached to a hook that is lowered by cable from the trolley. The trolley with the
25 component on the hook is moved to the aft portion of the main beam, which extends beyond the turbine. The hook is then lowered to ground so that the component can be serviced or replaced.

The on-board service crane comprises a service crane
30 structure supporting the housing and provides housing access to the nacelle exterior, from the service level through a housing door.

The service crane enables servicing the upper end of a wind turbine tower without the need to mobilize a large crane.

The capacity of the service crane is comparable to the weights lifted. The invention has the advantage that because
5 the crane is an integral part of the nacelle it avoids the need to bring a ground level crane or special apparatus to the wind turbine site for accessing the components through removal of the nacelle top, in order to remove components and lower them down the ground for repair or replacement.

10 The invention has the advantage of lowering the cost of clean energy by reducing the maintenance and repair costs of wind turbines.

BRIEF DESCRIPTION OF THE DRAWINGS

15 The invention will be described in detail with reference to the drawings in which:

FIGURE 1 is a perspective view of a crane within a nacelle for lifting turbine components to the nacelle located on the top of a tower;

20 **FIGURE 2** is a front elevation view of the nacelle shown in **FIGURE 1**;

FIGURE 3 is a port side view of the nacelle shown in **FIGURE 1**; and,

FIGURE 4 is a perspective drawing showing the nacelle bed
25 with the crane in the nacelle.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Refer to **FIGURE 1**, which is a perspective view of a crane within a nacelle for lifting turbine components to the nacelle
30 located on the top of a tower. An on-board 2-ton capacity service crane is installed at the rear of the nacelle. A hinged or roll down door at the rear of the nacelle allows for components to be lowered and service tools and other materials to

be raised from the ground. This crane allows for service of brakes, yaw motors, generators, gearbox pinion cartridges and other components. By avoiding the need to call out even a small service crane, the use of this on-board service crane is expected to produce a positive benefit to both scheduled and unscheduled maintenance costs.

Refer to **FIGURE 2**, which is a front elevation view of the nacelle shown in **FIGURE 1** and to **FIGURE 3**, which is a port side view of the nacelle shown in **FIGURE 1**. The service crane structure supports the sides and top surfaces of the nacelle. There is access to the wind turbine components from the service level of the nacelle to the exterior through a rear door, shown in **FIGURE 1**, and on the right-hand side of the drawing of **FIGURE 3**.

The nacelle is partially illustrated in **FIGURE 4** and is of a conventional "bathtub" shaped design. The nacelle houses a turbine having four generators, 100, 102, 104, 106, connected through a gearbox 108 to a main shaft 110 held in place by a main bearing 112 attached to the floor of the nacelle bathtub 114. The main shaft is connected to a rotor hub 116, which conventionally has three rotor blades, 118, 120, and 122, which are turned by wind. The rotor blades turn the main shaft 110, which moves gears in the gearbox 108. The gears turn the generators, which produce electricity from wind power.

The nacelle service crane includes a curved, stationary forward I-beam frame 124 attached to the main bearing 112 and a linear, moveable I-beam crane rail 128 resting at a distal end 130 on the forward frame 124 by means of four rollers 134, 136, 138, 140. One or more of the rollers are connected to a lateral motion main beam actuator, such as a servomotor, which when actuated causes the main beam to move in a lateral direction. Alternatively, a cable and pulley lateral motion actua-

tor may achieve lateral motion. The proximate end 142 of the crane rail 128 is attached via a hinge 144 to a stationary aft frame 146 mounted on the floor of the nacelle bathtub 114. The crane rail can rotate about the hinge axis 148 within the outer limits 150, 152 set by the length of the forward frame upon which the distal end of the crane rail rests. A lower portion 154 of the crane-rail I-beam acts as an overhead mono-rail upon which a trolley 156 runs. The trolley is suspended from the overhead crane rail by means of four wheels 158, 160, 162, and 164, that straddle the crane rail I-beam. One or more of the rollers are connected to a longitudinal motion trolley actuator, such as a servomotor, which when actuated causes the trolley to move in a longitudinal direction along the crane rail. Alternatively, a cable and pulley longitudinal motion actuator may achieve longitudinal motion.

The trolley has a hook 166 that can be raised and lowered by a cable 168 and winch (not shown). The hook can be attached to a component, such as one of the generators, for the purpose of transporting it to the proximate end of the crane rail, which is outside of the nacelle. Because the crane rail is moveable about the pivot point 148, any one of the generators is accessible to the hook by moving the crane rail laterally. A fairing 170 is mounted at the proximate end 142 of the crane rail. The fairing is shaped so as to reduce drag, which may induce yaw. The winch mechanism is housed within the fairing, with the additional ability to operate the crane rail actuator to move the crane rail back and forth on the forward frame 124 and to operate the trolley actuator to move the trolley back-and-forth along the crane rail 128. The trolley is free to move past the aft frame 146 to the outside of the nacelle and into the fairing 170, which is also outside of the nacelle. Once outside the nacelle the hook 166 with component attached

can be lowered by the cable to ground level for servicing the component.

The nacelle is fitted with a hinged or roll-up door 171, which is operated by a mechanism within the fairing to move
5 the door out of the way to permit the trolley to exit the rear of the nacelle. The FAA pod 172 pivots forward on a moveable arm 174 to permit access. The crane support structural frame, the curved, stationary forward I-beam frame 124, stationary aft frame 146 mounted to the nacelle bathtub 114, also serve
10 as structural support for the sides and top of the nacelle turbine housing. The sides and top of the nacelle are not shown in **FIGURE 4**. The crane structure allows for horizontal delivery of components to the exterior of the nacelle through the rear door 171 from which they are lowered to ground level.
15 Conventional designs require removal of the nacelle top and component extraction is performed vertically. Lateral movement of the crane's main beam 128 and the crane trolley 156 movement along the beam permit a full range of turbine component access. Since the service crane is an integral part of the
20 wind turbine structure it is always available for maintenance or component replacement work. The use of existing structure allows the lifting crane to be cost effective, reliable and rated to required workload. This helps reduce the cost of clean energy by reducing the maintenance and repair costs of
25 wind turbines

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and detail may be made therein
30 without departing from the scope of the invention.

Claims:

1. A service crane for a wind turbine, comprising:
5 a movable main crane beam (128) having a track (154) for guidance of a trolley (156);
a first frame (146) comprising a hinge (144) at a pivot point (148), wherein the crane beam (128) is connected to the hinge (144) such that a portion of the crane beam (128)
10 extends beyond the pivot point (148);
a stationary beam (124) which is connected with a distal end of the crane beam (128) such that the crane beam (128) can laterally move along the stationary beam (124).
- 15 2. The service crane of claim 1, wherein the track (154) is designed as an overhead monorail upon which the trolley (156) can run.
3. The service crane of claim 1 or 2, wherein the first
20 frame (146) supports a side structure of the nacelle and is attached to a floor of the nacelle.
4. The service crane of any of the claims 1 - 3, wherein
the crane beam (128) rests on the stationary beam (124).
25
5. The service crane of any of the claims 1 - 4, wherein
the stationary beam (124) is supported by a second frame
(112).
- 30 6. The service crane of claim 5, wherein the second frame (112) comprises the main bearing of the nacelle.
7. The service crane of any of the claims 1 - 6, wherein a
lateral motion actuator (134) is operatively connected to the
35 crane beam (128) to move the crane beam (128) laterally along the stationary beam (124).

8. The service crane of any of the claims 1 - 7, wherein the stationary beam (124) is curved.

5 9. The service crane of any of the claims 1 - 8, wherein a fairing (170) is mounted to a proximate end (142) of the crane beam (128), said fairing (170) is shaped so as to reduce drag.

10 10. The service crane of any of the claims 1 - 9, wherein a longitudinal motion actuator is operatively connected to the trolley (156).

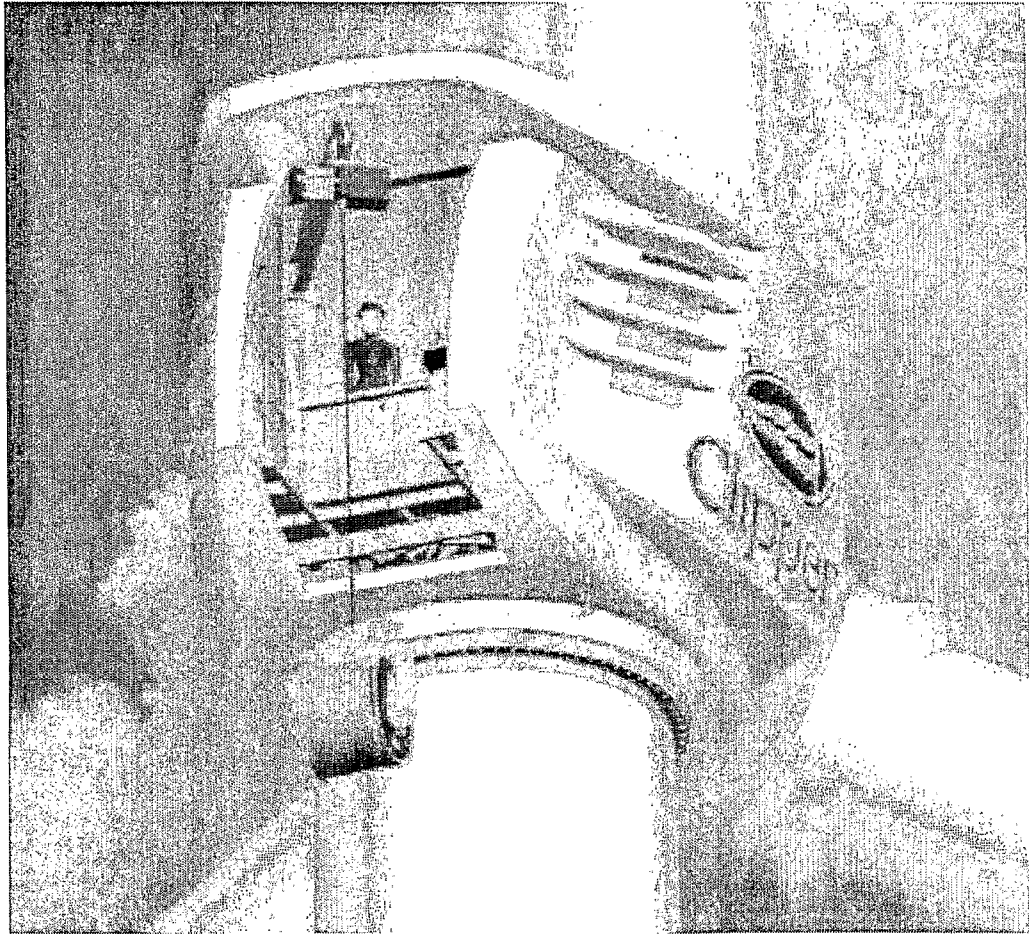


Fig. 1

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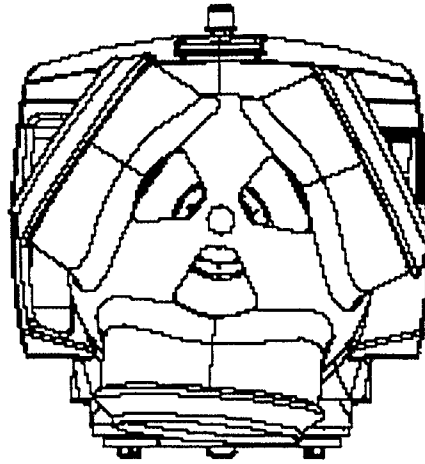


Fig. 2

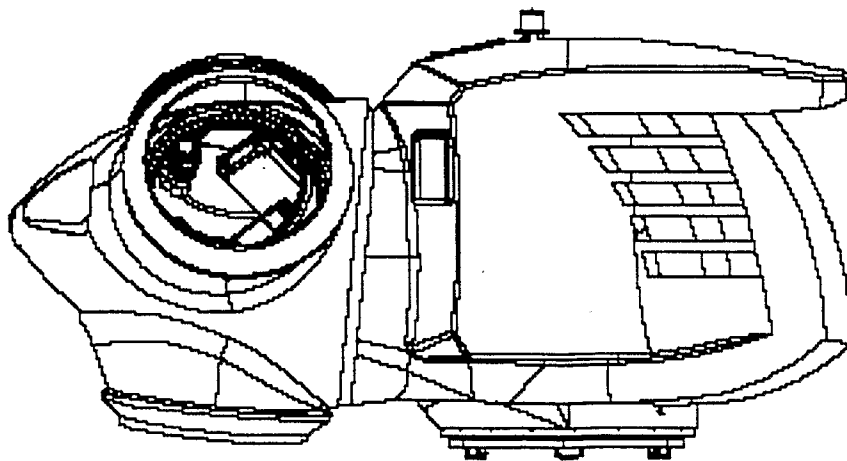


Fig. 3

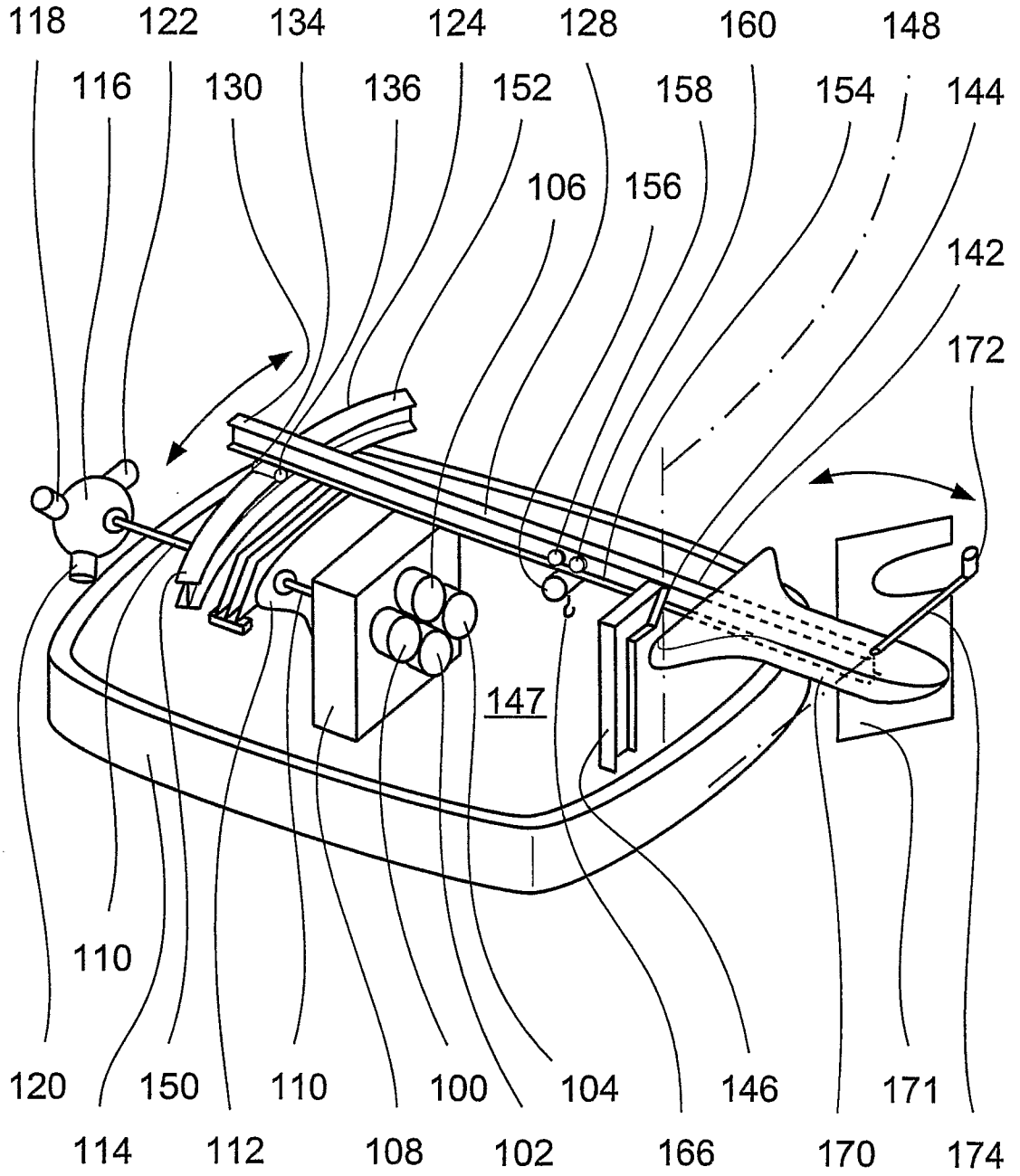


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2007/000420

A. CLASSIFICATION OF SUBJECT MATTER

INV. F03D11/04 B66C23/02 B66C23/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F03D B66C E04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2005 201128 A (TOMOE GIKEN KK) 28 July 2005 (2005-07-28) abstract; figures	1, 2, 10
A	EP 1 291 521 A (TURBOWINDS N V S A [BE]) 12 March 2003 (2003-03-12) abstract; figure 11 paragraph [0028]	1-3, 9
A	WO 2005/031159 A (NEG MICON AS [DK]; PEDERSEN BJARNE [DK]) 7 April 2005 (2005-04-07) page 7, paragraph 3 abstract; figures	1-3
A	EP 1 284 365 A (LIEBHERR WERK BIBERACH [DE]) 19 February 2003 (2003-02-19) abstract; figures	1, 3

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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