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(54) **METHOD AND SYSTEM FOR REMOVING COMPONENTS OF A FAN ASSEMBLY OF AN INDUCED-DRAFT HEAT EXCHANGER SYSTEM**

(57) The present disclosure relates to a method for removing components of one or more fan assemblies of an induced-draft air-cooled heat exchanger system. The method comprises: driving a mobile crane on a fan deck and/or on a fan bridge of a first fan assembly, lifting a first component of the first fan assembly using the mobile crane, transporting the first component towards an edge

area of the fan deck, lowering the first component from the fan deck down to the ground floor. The disclosure also relates to a system for removing components of one or more fan assemblies of an induced-draft air-cooled heat exchanger system, wherein the system comprises a mobile crane and driving means for driving the mobile crane.

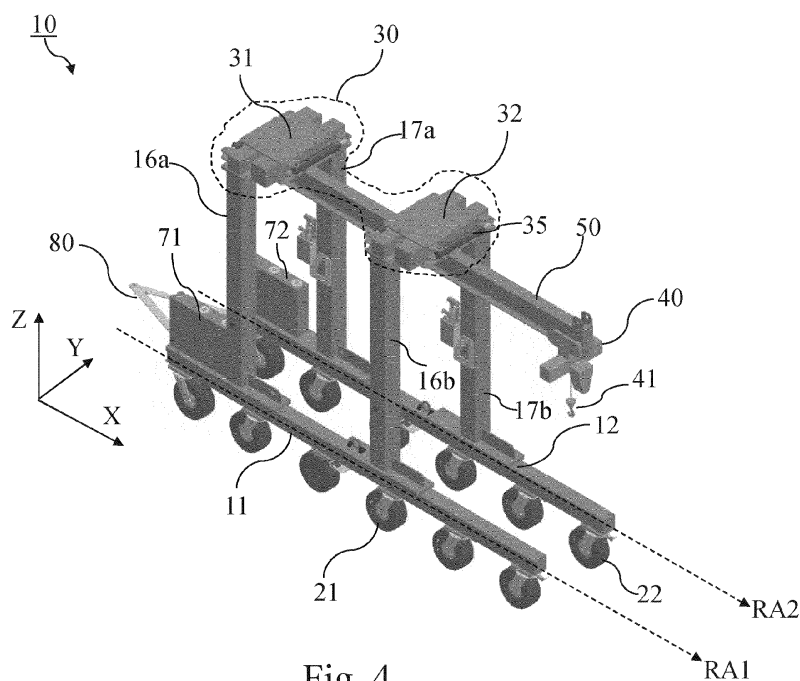


Fig. 4

**Description****Field of the disclosure**

5 [0001] The present disclosure is related to a method for removing components of one or more fan assemblies, more specifically for removing components of one or more fan assemblies of an induced-draft air-cooled heat exchanger system such as an air-cooled condenser or a wet cooling tower.

[0002] The present disclosure is also related to a system for removing components of one or more fan assemblies of an induced-draft air-cooled heat exchanger system.

**Background**

10 [0003] Induced-draft air-cooled heat exchanger systems comprise a plurality of fan assemblies located on top of the heat exchangers. In order to have a sufficient air volume to circulate, the fan assemblies and the heat exchanger are placed at a high elevation with respect to the ground level. Depending on the detailed design and type of air-cooled heat-exchanger, elevations of for example 4m to 20 m or more are required.

[0004] Examples of systems using induced-draft air-cooled heat exchangers are air-cooled condensers for condensing steam from for example a power plant, or wet cooling towers for cooling hot water.

15 [0005] The induced-draft air-cooled heat exchanger systems make use of a plurality of motorized fan assemblies to generate an air draft through the heat exchangers. Each of the fan assemblies is surrounded by a fan bell, also named fan shroud, and the area between the fan bells is covered such that induced-air crossing the heat exchangers can only escape through the fan bells. The covered area surrounding the fan bells is generally named a fan deck.

20 [0006] An example of an induced draft air-cooled condenser is described in patent EP3287732B1. These V-shaped or W-shaped heat exchangers comprise a main steam manifold for supplying exhaust steam and this main manifold is connected to lower ends of the condensing tubes. The upper ends of the condensing tubes are connected to top steam manifolds. On top of the top steam manifolds, a fan support assembly for supporting the fan assemblies is provided and the fan support assembly includes a covered fan deck with circular openings fringed by fan bells.

25 [0007] Induced-draft air-cooled heat exchanger systems comprise a plurality of fan assemblies, generally ordered in multiple adjacent rows, corresponding to multiple adjacent rows of heat exchangers, as schematically illustrated on Fig. 1a. Each of the fan assemblies typically comprise a fan hub, fan blades and one or more driving components for rotating the fan blades. The one or more driving components comprise for example a gearbox, a motor, and a drive shaft connecting the motor to the gearbox.

30 [0008] One of the problems with these induced draft air-cooled heat exchanger systems where the fan assemblies are located on top of the heat exchangers is the maintenance of the fan assemblies, including removal and replacement of the various components of the fan assembly. In view of the fact that multiple fan assemblies are located close to each other, access to each fan assembly and removal and replacement of its related components is difficult and cumbersome. Especially for the heavy components such as the motor and the gear box which may have weights of more than one ton. The fan blades, the fan hub and the drive shaft have large dimensions, which further complicates the replacement procedures.

35 [0009] Generally, for performing maintenance activities, large overhead tower cranes located on the ground floor are used to remove components of the fan assemblies, as schematically illustrated on Fig.2. This method of removing components of fan assemblies however limits the number of rows of fan assemblies that can adjacently be placed together, and hence limits the size of the heat exchanger system, due to the fact that fan assemblies located in central rows cannot or difficultly be reached with an overhead crane.

40 [0010] Hence, replacing components of fan assemblies of induced-draft air-cooled heat exchanger systems is challenging and there is room for improving methods and equipment for performing maintenance of such fan assemblies.

**Summary of the disclosure**

45 [0011] It is an object of the present disclosure to provide a faster and more cost-effective method for removing components of one or more fan assemblies of an induced-draft air-cooled heat exchanger system, especially for heat exchanger systems having multiple adjacent rows of fan assemblies. It is a further objective to provide a single system that allows to remove and replace each of the major components of a fan assembly of an induced draft air-cooled heat exchanger, wherein the removable components include for example a fan hub, fan blades and one or more driving components for rotating the fan blades. A driving component is for example a motor, a gearbox or a drive shaft coupled between the motor and the gearbox.

50 [0012] The present disclosure is defined in the appended independent claims. Preferred embodiments are defined in the dependent claims.

**[0013]** According to a first aspect of the present disclosure, a method for removing components of fan assemblies of an induced-draft air-cooled heat exchanger system is provided.

**[0014]** Each fan assembly of the heat exchanger system comprises any of the following non-limiting list of components: a fan blade, a fan hub and one or more driving components for rotating the fan blades.

**[0015]** The induced-draft heat exchanger system comprises a covered fan deck located at a given altitude from a ground floor and the fan deck comprises a plurality of openings, each opening being fringed by a fan bell that is associated to one of the fan assemblies of the heat exchanger system. Inside each fan bell, a fan bridge is extending towards a center of the fan bell. The method according to the present disclosure comprises:

- driving a mobile crane on the fan deck following a trajectory path, preferably the trajectory path is at least partly running between adjacent fan bells,
- driving the mobile crane to a neighborhood of a first fan bell associated to a first fan assembly,
- lifting a first component of the first fan assembly using the mobile crane,
- transporting the first component towards an edge area of the fan deck by either driving the mobile crane, while supporting the first component, towards the edge area, or alternatively, using the mobile crane for placing the first component on a cart and driving the cart to the edge area,
- using a permanent hoist structure located in the edge area of the fan deck for lowering the first component from the fan deck down to the ground floor, or alternatively, using a tower crane located on the ground floor for lowering the first component located in the edge area of the fan deck down to the ground floor.

**[0016]** In embodiments, the method further comprises:

- before lifting the first component, driving the mobile crane on a first fan bridge located inside the first fan bell associated to the first fan assembly.

**[0017]** Advantageously, by driving a mobile crane on the fan deck and/or the fan bridge, each of the components of the fan assemblies of any of the streets is accessible without the need of any large overhead tower crane, independently of the number of rows of fan assemblies of the heat exchanger system.

**[0018]** In embodiments, each of the fan bells is formed by a plurality of fan bell segments and the method comprises:

- before driving with the mobile crane on the first fan bridge, removing a first fan bell segment of the first fan bell, wherein the first fan bell segment is located in front of an entrance of the first fan bridge, preferably using the mobile crane for lifting the first fan bell segment.

**[0019]** According to a second aspect of the present disclosure, a system for removing components of one or more fan assemblies of an induced-draft air-cooled heat exchanger system is provided. The system comprises a) a mobile crane for driving on a covered deck of the induced-draft air-cooled heat exchanger system and/or for driving on fan bridges located inside fan bells associated to the fan assemblies, and b) driving means for driving the mobile crane, preferably the driving means are configured for driving the mobile crane in a forward and backward direction.

**[0020]** The mobile crane according to the present disclosure comprises a first siderail assembly comprising a first row of wheels extending along a first rail axis, a second siderail assembly comprising a second row of wheels extending along a second rail axis, and wherein the second siderail assembly is spaced from the first siderail assembly, and a support frame structure mounted on the first and second siderail assembly.

**[0021]** The support frame structure comprises i) a first side frame, wherein a bottom portion of the first side frame is attached to the first siderail assembly, ii) a second side frame, wherein a bottom portion of the second side frame is attached to the second siderail assembly, and iii) an overhead spacing structure coupling a top portion of the first side frame to a top portion of the second side frame.

**[0022]** The mobile crane further comprises a hoist support beam and a hoist, wherein the hoist is rigidly or moveably coupled to the hoist support beam.

**[0023]** In some embodiments, the hoist support beam comprises at least a first beam portion and a second beam portion, and wherein the first beam portion is rigidly attached to the overhead spacing structure and the second beam portion is cantilevered with respect to the support frame structure.

**[0024]** Advantageously, with the first and second side rail assembly and the coupled support frame structure as claimed, a rigid and stable mobile crane is obtained. It is important to have a stable mobile crane as heavy winds can occur on

the fan deck.

**[0025]** Advantageously, with the support frame structure as claimed, a spacing is maintained between the first and second side rail assembly such that a cart can be placed between the first and second side rail assembly and a component lifted with the mobile crane can be lowered in the cart for further transportation.

**[0026]** In some embodiments, the first and said second rail axis of the mobile crane are parallel.

**[0027]** In embodiments, the overhead spacing structure of the mobile comprises means for relatively moving the first side frame with respect to the second side frame along a lateral axis transverse to the first and second rail axes of respectively the first and second siderail assembly. In this way, a distance between the first and the second rail axis measured along the lateral axis is variable between a first distance and a second distance, wherein the second distance is smaller than the first distance.

**[0028]** In other words, the lateral width of the mobile crane is variable from a maximum lateral width to a minimum lateral width. Advantageously, with the minimum lateral width the mobile crane can follow a trajectory path between two adjacent fan bells separated by a narrow distance, of for example less than one meter. When the mobile crane is on the fan bridge for example, the mobile crane can be set to its maximum lateral size, for providing a better stability.

**[0029]** In embodiments, the system for removing components of one or more fan assemblies of an induced-draft air-cooled heat exchanger system further comprises c) a cart, and wherein a width of the cart is configured such that the cart can be driven between the first and the second siderail assemblies.

**[0030]** Advantageously, the cart can be used in combination with the mobile crane to transport smaller but heavy components such as for example the motor or the fan gearbox.

**[0031]** In embodiments wherein the lateral width of the mobile crane is variable, the lateral stroke defined as the difference between the maximum and minimum lateral width is between 30 cm and 90 cm, preferably between 40 cm and 80 cm and more preferably between 50 cm and 70 cm.

**[0032]** In some embodiments, the height of the mobile crane can be adjusted between a maximum height  $H_{\max}$  and a minimum height  $H_{\min}$ .

**[0033]** In embodiments wherein the height of the mobile crane can be adjusted, a height stroke defined as the difference between the maximum  $H_{\max}$  and the minimum  $H_{\min}$  height of the mobile crane is generally between 50 cm and 200 cm, preferably between 80 cm and 160 cm, more preferably between 90 cm and 150 cm.

**[0034]** In some embodiments, the system according to the present disclosure comprises a first siderail extension for extending the first siderail assembly and a second siderail extension for extending the second siderail assembly, and wherein at least one additional wheel is coupled to each of the first and second siderail extensions.

### Short description of the drawings

**[0035]** These and further aspects of the disclosure will be explained in greater detail by way of example and with reference to the accompanying drawings in which:

|                      |                                                                                                                                                                                         |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fig.1a               | schematically represents a top view of a prior art induced-draft heat exchanger system,                                                                                                 |
| Fig.1b               | schematically represents an isometric view of a fan bell, a fan bridge and a portion of a fan deck,                                                                                     |
| Fig.2                | schematically illustrates a tower crane located on a ground floor used for removing fan parts of                                                                                        |
| Fig.3                | a heat exchanger system,                                                                                                                                                                |
| Fig.4                | schematically illustrates a trajectory path for a mobile crane on a fan deck of a heat exchanger according to the method of the present disclosure,                                     |
| Fig.5                | represents an isometric view of an embodiment of a mobile crane according to the present disclosure,                                                                                    |
| Fig.6a to Fig.6d     | is an isometric view of a fixed hoist that is located in an edge area of the fan deck,                                                                                                  |
| Fig.7                | partly illustrates removing respectively a fan bell segment of a fan bell, a fan blade, a fan hub and a gear box according to the method of the present disclosure,                     |
| Fig.8a and Fig.8b    | is a cross-sectional view of an embodiment of a portion of a fan showing two fan blades coupled to a fan hub,                                                                           |
| Fig.9a and Fig.9b    | show a top view of two embodiments of a first and second siderail assembly,                                                                                                             |
| Fig.10a and Fig.10b, | illustrate side views of a mobile crane with variable height, and wherein the mobile crane is respectively set to a maximum height and set to a minimum height,                         |
| Fig.11a and Fig.11b, | illustrate top views of a mobile crane with variable lateral width, and wherein the lateral width is respectively set to a maximum and a minimum width,                                 |
| Fig.12a and Fig.12b  | illustrate front views of a mobile crane with variable height and variable lateral width, and wherein the height and lateral width are respectively set to a maximum and minimum value, |
|                      | shows respectively a front and side view of an exemplary electrical tractor for pushing or pulling a mobile crane according to the present disclosure,                                  |

Fig.13a and Fig.13b show respectively a sideview and a front view of a cart of the system according to the present disclosure,  
 Fig.14 shows an isometric view of a hub support structure for placing on the cart of Fig.13a/13b,  
 Fig.15 shows a system according to the present disclosure comprising a mobile crane and a cart,  
 5 wherein the cart is placed between the first and second side of the mobile crane,  
 Fig.16a and Fig.16b partly illustrate a removal of a gearbox according to the present disclosure,  
 Fig.17a and Fig.17b partly illustrate a removal of a motor according to the present disclosure.

10 **[0036]** The figures are not drawn to scale. Generally, identical components are denoted by the same reference numerals in the figures.

### Detailed description of preferred embodiments

15 **[0037]** The present disclosure will be described in terms of specific embodiments, which are illustrative of the disclosure and not to be construed as limiting. It will be appreciated by persons skilled in the art that the present disclosure is not limited by what has been particularly shown and/or described and that alternatives or modified embodiments could be developed in the light of the overall teaching of this disclosure. The drawings described are only schematic and are non-limiting.

20 **[0038]** Use of the verb "to comprise", as well as the respective conjugations, does not exclude the presence of elements other than those stated.

**[0039]** Use of the article "a", "an" or "the" preceding an element does not exclude the presence of a plurality of such elements.

25 **[0040]** Furthermore, the terms first, second and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequence, either temporally, spatially, in ranking or in any other manner. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the disclosure described herein are capable of operation in other sequences than described or illustrated herein.

### Method, general

30 **[0041]** According to a first aspect of the present disclosure a method for removing components of fan assemblies of an induced-draft air-cooled heat exchanger system is provided. Such an induced-draft heat exchanger system comprises a plurality of fan assemblies 3 ordered in rows, as schematically shown in Fig.1a where a top view of an example of an induced-draft air-cooled heat exchanger system 1 is schematically shown. A row of fan assemblies on top of heat  
 35 exchangers generally corresponds to what is named a heat exchanger street 2 and multiple streets 2 are placed adjacently to each other to form the heat exchanger system 1. In the example shown on Fig.1a, five streets 2 are shown, and wherein each street comprises a row of seven fan assemblies.

40 **[0042]** Each fan assembly 3 comprises a number of components such as fan blades coupled to a fan hub, and one or more driving components for rotating the fan blades. In Fig.7, a cross-sectional view of an embodiment of a portion of a fan assembly is shown, illustrating two fan blades 61 coupled to a fan hub 62. In embodiments, a rotation diameter of the fan assembly, indicated with reference DF on Fig.7, is in a range between 8 and 15 meters, for example 12 meter. The fan hub 62 is generally a circular frame and each fan blade 61 is rigidly coupled with one end to the fan hub 62. In embodiments, the diameter of the fan Hub DH is between 1 and 3 meters, for example 2 meter. In embodiments, the blade span LB is between 3 and 7 meters, for example 5 meter.

45 **[0043]** As known in the art and illustrated on Fig.2, an induced-draft heat exchanger system 1 comprises a covered fan deck 4 located at a given altitude H with respect to a ground floor 300. The fan deck 4 comprises a plurality of openings, generally circular openings, fringed by a fan bell 5. Each fan bell is associated to one fan assembly. Inside each fan bell 5, the fan blades coupled to the fan hub are rotatably mounted.

50 **[0044]** In embodiments, the fan bell 5 is composed of a plurality of fan bell segments attached together to form the fan bell.

55 **[0045]** As schematically illustrated on Fig.1b, inside each fan bell 5, a fan bridge 8, is provided that is extending towards a center of the fan bell, generally corresponding to a center of the opening in the fan deck being surrounded by the fan bell. No fan assembly is shown in Fig.1b, only a portion of the fan deck 4, the fan bell 5 and the fan bridge 8 are schematically shown for illustrative purposes. Such a fan bridge 8 is to be construed as a walking bridge, generally provided to allow inspection of the fan by maintenance personnel. There is generally one fan bridge for each fan bell. In embodiments, for maintenance personnel to have access to the fan bridge, a fan bell segment 5a in front of the fan bridge is provided with a hatch 5b or a small door. Generally, the fan bridge comprises additional safety railings, not shown on the fig.1b, to allow a safe access to the fan.

**[0046]** To provide major maintenance operations, components of the fan assembly need to be removed from the fan deck and be replaced by spare parts. Non-limiting examples of components of the fan assembly are: the fan blades, the fan hub and one or more driving components for rotating the blades. In embodiments, the components for rotating the blades are for example a gear box, a drive shaft and a motor.

**[0047]** The method according to the present disclosure uses a mobile crane that both can drive on the fan deck 4 and/or on the fan bridges 8. In some embodiments wherein the driving means comprise a motor coupled to a drive shaft, for removing the motor it is not necessary to drive with the mobile crane on the fan bridge. In other embodiments, for removing for example a fan blade, it is necessary to drive with the mobile crane on the fan bridge, as will be discussed below in more detail.

**[0048]** An exemplary embodiment of a mobile crane 10 for driving on the fan deck 4 and fan bridges 8 is shown on Fig.4 and will be discussed in more detail below. The hoist 40 of the mobile crane is then used to lift and remove any of the components of the fan. As illustrated on Fig.3, according to the present method, the mobile crane drives on the fan deck 4 following a trajectory path 6. Preferably, the trajectory path is, as illustrated on Fig.3, running at least partly, between adjacent fan bells 5. The trajectory path 6 of the mobile crane is indicated on Fig.3 by white arrows. In the embodiment shown on Fig.3, a heat exchanger system comprising twenty four fan assemblies is shown.

**[0049]** The white arrows on Fig.3 illustrate a direction of motion of a mobile crane, when following the trajectory 6, towards an edge area 7 of the fan deck. The mobile crane can also follow the trajectory in the opposite direction from the edge area 7 to anyone of the fan assemblies of the heat exchanger system.

**[0050]** In embodiments wherein the fan bell 5 is composed of a plurality of fan bell segments, in order to have access for example to a first fan bridge 8 inside a first fan bell associated to a first fan assembly, a first fan bell segment of the first fan bell needs to be removed. Indeed, as mentioned above, the fan bridge is basically an access for maintenance personnel, and generally only a hatch 5b or small door is provided in the first fan bell segment of the fan bell in front of the fan bridge, as illustrated on Fig.1b. In embodiments, to have access to the fan bridge with a mobile crane, the first fan bell segment that is located in front of the entrance of the fan bridge is to be removed.

**[0051]** By following the trajectory path 6, each of first fan bell segments of each of the fan bells can be reached with the mobile crane and the mobile crane can have access to each of the respective fan bridges. In embodiments, as shown on Fig.3, when the mobile crane is driving along the trajectory path 6 it will have to drive at least between two adjacent fan bells.

**[0052]** In embodiments wherein the fan bell 5 is composed of a plurality of fan bell segments, to remove the first fan bell segment 5a of the fan bell that is blocking the access to the fan bridge, the mobile crane 10 can be used to lift the first fan bell segment 5a, as illustrated on Fig.6a. In other embodiments, alternatively, the first fan bell segment 5a can be removed in a manual way by maintenance personnel. The removed first fan bell segment 5a can either be placed in a storage area on the fan deck or the first segment can be transported to the edge area of the fan deck. From the edge area, the first fan bell segment can be lowered to the ground floor by either using a permanent hoist structure located in the edge area of the fan deck, or alternatively using a tower crane located on the ground floor.

**[0053]** In embodiments, for removing a first component of a first fan assembly, the method according to the present disclosure comprises a step of driving the mobile crane on a first fan bridge located inside a first fan bell associated to a first fan assembly. For some embodiments, for example for removing a motor, it is not necessary to drive with the mobile crane on the fan bridge to remove the motor. Indeed, in embodiments wherein the motor is coupled to a drive shaft, the motor is located outside the fan bell, i.e. in the neighbourhood of the fan bell. For removing a motor located outside the fan bell, it is then sufficient to drive with the mobile crane to the neighbourhood of the fan bell.

**[0054]** In a further step according to the present method, the mobile crane 10 is used for lifting the first component of the first fan assembly. The first component can be any of the non-limiting list of components of the fan assembly as mentioned above.

**[0055]** Following the method of the present disclosure, the first component is further transported towards the edge area 7 of the fan deck by either driving the mobile crane, while supporting the first component, or alternatively, using the mobile crane for placing the first component on a cart and driving the cart to the edge area. In Fig.16b and Fig.17b, transportation with a cart is schematically illustrated for respectively a gearbox and a motor.

**[0056]** Finally, the permanent hoist structure located in the edge area of the fan deck is used for lowering the first component from the fan deck down to the ground floor. In other embodiments, alternatively, a tower crane located on the ground floor is used for lowering the first component located in the edge area of the fan deck down to the ground floor. In Fig.5, an example of a fixed hoist structure 200 located in an edge area 7 of the fan deck 4 is shown. In Fig.5 a safety railing 4a is shown surrounding the fan deck 4.

**[0057]** When a first component of the first fan assembly is removed according to the method described above, a further component of the first fan assembly can be removed following the same method and/or one or more components of a second fan assembly can be removed.

**[0058]** One of the problems of using a mobile crane on the fan deck is that the distance between fan bells 5 can be very narrow, for example less than one meter, e.g. 80 cm or 90 cm. Therefore, a dedicated mobile crane 10 with a small

lateral dimension is to be used that at the same time is configured for lifting on the one hand the various fan drive components having a weight of more than one ton and on the other hand lifting fan components such as fan blades having a span length LB of several meter long, for example more than 5 meter long. The mobile crane has also to be stable as strong winds can occur on the fan deck.

**[0059]** Further, the mobile crane 10 needs also to be adapted to spread the load on the fan deck 4. Indeed the fan deck is basically a cover, as discussed in the introduction part, to make sure that the induced-draft air is only escaping through the fan bells. To reduce cost, the amount of steel for building the fan deck is limited to the minimum necessary and the fan deck is generally not designed to support heavy loads such as a mobile crane for lifting components of more than one ton and wherein the mobile crane has a weight of a few ton. Typically, the fan deck plating and structure are designed for a maximum concentration load, and hence the mobile crane needs to be designed accordingly.

**[0060]** Also the fan bridge, which is generally a grating frame, is in the first place designed to provide access to workers for inspection or small maintenance work of the fans. The loads on the fan bridge are also limited and the mobile crane needs to be designed accordingly.

**[0061]** Examples of mobile cranes that can be used for the method according to the present disclosure are further discussed below. The specific procedural steps according to the method of the present disclosure for removing specific components such as fan blades, the fan hub, the gearbox, motor or drive shaft are discussed below.

#### Installing new or repaired components

**[0062]** The method disclosed above for removing components from the fan assembly can also be applied in a reverse order for installing new or repaired components.

**[0063]** Hence, according to the present disclosure a method is also provided for installing a new component of a second fan assembly of the one or more fan assemblies 3 of an induced-draft air-cooled heat exchanger system 1, wherein the new component is any of the following non-limiting list of components: a fan blade, a fan hub or one or more driving components for rotating the fan blades. The method for installing a new component comprises:

- using a permanent hoist structure located in the edge area 7 of the fan deck 4 for lifting the new component from the ground floor to the edge area of the fan deck, or alternatively, using a tower crane located on the ground floor for lifting the new component from the ground floor to the edge area of the fan deck,
- transporting the new component from the edge area of the fan deck to the fan bell of the second fan, by either using a mobile crane for transporting the new component, or alternatively, placing the new component on a cart and transporting the new component with the cart,
- when driving the mobile crane 10 or driving the cart on the fan deck 4, following a trajectory path 6, preferably the trajectory path is at least partly running between adjacent fan bells 5,
- driving the mobile crane on the fan bridge associated to the second fan assembly,
- lifting the new component with the mobile crane for installing the new component of the second fan assembly.

**[0064]** In some embodiments, before driving with the mobile crane on the fan bridge associated to the second fan assembly, the method comprises removing a fan bell segment of the fan bell associated to the second fan assembly. In this way, access is provided to the mobile crane for driving on the fan bridge associated to the second fan assembly.

**[0065]** In embodiments, for replacing some components such as a motor coupled to a drive shaft, it is not necessary to drive with the mobile crane on the fan bridge to position a new motor.

#### Removing fan blades

**[0066]** The method according to the present disclosure provides for removing a first fan blade 61 of a first fan assembly of the plurality of fan assemblies of the air-cooled heat exchanger by performing steps of:

- a) before driving the mobile crane on the first fan bridge associated to the first fan assembly, rotating the fan blades of the first fan assembly until the first fan blade is aligned with the fan bridge of the first fan,
- b) coupling the first fan blade to a hoist of the mobile crane,
- c) unbolting the first fan blade from a fan hub of the first fan assembly,
- d) using the hoist of the mobile crane for lifting the first fan blade,
- e) transporting the first fan blade towards the edge area of the fan deck by either driving the mobile crane, while supporting the first fan blade, towards the edge area, or alternatively, using the mobile crane for placing the first fan blade on the cart and driving the cart to the edge area,
- f) using the permanent hoist structure located in the edge area of the fan deck for lowering the first fan blade from

the fan deck down to the ground floor, or alternatively, using the tower crane located on the ground floor for lowering the first fan blade from the fan deck down to the ground floor.

**[0067]** In Fig.6b, a mobile crane positioned on the fan bridge of the first fan assembly is shown, and wherein the mobile crane is lifting the first fan blade for removal.

**[0068]** In embodiments, the method comprises a step of tilting the first fan blade in an upward position. This upward tilting facilitates the lifting of the first fan blade with the hoist of the mobile crane and the further transportation of the first fan blade with the mobile crane.

#### Removing a fan hub

**[0069]** The method according to the present disclosure provides for removing a first fan hub of the first fan assembly by performing steps of:

- a) removing each remaining fan blade of the first fan assembly by repeating for each remaining fan blade the steps used for removing the first fan blade,
- b) driving the mobile crane on the fan bridge of the first fan assembly until the hoist of the mobile crane is located on top of the first fan hub of the first fan assembly,
- c) coupling the first fan hub to the hoist of the mobile crane, preferably using a hub spreader bar 42 comprising a lifting drawbar for attaching the hub spreader bar to the hoist of the mobile crane and at least two support drawbars for attaching the first fan hub to the hub spreader bar,
- d) removing bolts between the first fan hub and a first driving component of the one or more driving components of the first fan assembly,
- e) using the mobile crane for lifting the first fan hub, preferably rotating the fan hub by 90°,
- f) transporting the first fan hub towards the edge area of the fan deck by either driving the mobile crane, while supporting the first fan hub, towards the edge area, or alternatively using the mobile crane for placing the first fan hub on the cart and driving the cart to the edge area, preferably, when using the cart, positioning a hub support frame on the cart and securing the first fan hub to the hub support frame before driving the cart to the edge area,
- g) using the permanent hoist structure located in the edge area of the fan deck for lowering the first fan hub from the fan deck down to the ground floor, or alternatively, using the tower crane located on the ground floor for lowering the first fan hub from the fan deck down to the ground floor.

**[0070]** The hub spreader bar 42 is a tool that facilitates the lifting of the fan hub and is illustrated on Fig.6c and Fig. 15. In Fig.15, the fan hub has been rotated by 90° when compared to the position of the fan hub shown in Fig.6c. This position of the fan hub after the 90° rotation facilitates the further transport of the fan hub by for example attaching the rotated fan hub 62 to the fan hub support structure 110 of the cart 100, as illustrated on Fig.15.

#### Removing a fan gearbox, drive shaft and motor

**[0071]** In some embodiments the one or more driving components of each of the fan assemblies comprises a gearbox, a drive shaft and a motor. The drive shaft is coupled with a first end to the gearbox and coupled with an opposite second end to the motor. For these embodiments, the method further comprises steps for removing the motor, the gearbox and the drive shaft.

**[0072]** According to the present method, a first motor of the first fan, coupled to a first drive shaft, is removed by performing steps of:

- a) removing the coupling between the first motor and the first drive shaft,
- b) driving the mobile crane towards the first motor,
- c) coupling the first motor to the hoist of the mobile crane,
- d) using the mobile crane for lifting the first motor,
- e) transporting the first motor towards the edge area of the fan deck by either driving the mobile crane supporting the first motor towards the edge area, or alternatively positioning the cart below the first motor and using the mobile crane for lowering the first motor until the first motor rests on the cart and then driving the cart to the edge area,
- f) using the permanent hoist structure located in the edge area of the fan deck assembly for lowering the first motor from the fan deck down to the ground floor, or alternatively, using the tower crane located on the ground floor for lowering the first motor from the fan deck down to the ground floor.

**[0073]** In Fig.17a and Fig.17b, a removal of a motor is partly illustrated. In this embodiment, the motor 63 is located

on the fan deck 4 in front of the fan bridge 8. The mobile crane 10 is partly positioned on the fan bridge and partly on the fan deck. After lifting the motor 63 with the mobile crane, a cart 100 is placed between the first and second side rail assemblies of the mobile crane. The mobile crane 10 is then used for placing the motor in the cart by lowering the motor. Thereafter, the cart 100 is pulled by an electrical tractor 150 for transporting the motor to the edge area of the fan deck.

**[0074]** According to the present method, removing the first drive shaft of the first fan assembly is performed by steps of:

- a) unbolting the first drive shaft from the gearbox of the first fan assembly,
- b) driving the mobile crane on the fan bridge,
- c) coupling the first drive shaft to the hoist of the mobile crane,
- d) lifting the first drive shaft using the mobile crane,
- e) transporting the first drive shaft towards the edge area of the fan deck by either driving the mobile crane supporting the first drive shaft towards the edge area, or alternatively positioning the drive shaft on the cart using the mobile crane and driving the cart to the edge area,
- f) using the permanent hoist structure located in the edge area of the fan deck for lowering the first drive shaft from the fan deck down to the ground floor, or alternatively, using the tower crane located on the ground floor for lowering the first drive shaft from the fan deck down to the ground floor.

**[0075]** Finally, for removing the gearbox, the present method provides for removing a first gearbox of the first fan assembly by performing steps of:

- a) driving the mobile crane on the fan bridge of the first fan assembly,
- b) unbolting the first gearbox from a gear box support structure,
- c) coupling the first gearbox to the hoist of the mobile crane,
- d) lifting the first gearbox with the mobile crane,
- e) transporting the first gearbox towards the edge area of the fan deck by either driving the mobile crane supporting the first gearbox towards the edge area, or alternatively positioning the cart below the first gearbox and using the mobile crane for lowering the first gearbox until the first gearbox rests on the cart and then driving the cart to the edge area,
- f) using the permanent hoist structure located in the edge area of the fan deck for lowering the first gearbox from the fan deck assembly down to the ground floor, or alternatively, using the tower crane located on the ground floor for lowering the first gearbox from the fan deck down to the ground floor.

**[0076]** In Fig.6d, a mobile crane 10 driven on the fan bridge 8 for lifting a gear box 64 is illustrated. In Fig.16a and Fig.16b, the removal of the gearbox 64 is further illustrated. After lifting of the gearbox with the mobile crane, a cart 100 is placed between the first and second side rail assembly of the mobile crane 10. The mobile crane 10 is then used for placing the gearbox in the cart by lowering the gearbox with the mobile crane. Thereafter, the cart 100 is pulled with an electrical tractor 150 for transporting the gearbox 64 to the edge area of the fan deck.

#### Removing a segment of a fan bell

**[0077]** As mentioned above, to have access to the fan bridge 8 with the mobile crane, a first segment 5a of the fan bell 5 that is blocking the access to the fan bridge 8, is to be removed. In embodiments, for removing the first segment 5a of the fan bell, the method comprises performing steps of:

- a) driving the mobile crane towards the first segment 5a to be removed,
- b) coupling the first segment 5a to the hoist of the mobile crane,
- c) lifting the first segment with the mobile crane,
- d) transporting the first segment towards the edge area of the fan deck assembly or towards a storage area located on the fan deck assembly by either driving the mobile crane supporting the first segment towards the edge area or the storage area, or alternatively by positioning the first segment on the cart and then driving the cart to the edge area or to the storage area,
- e) optionally, if the first segment is moved to the edge area, then using the permanent hoist structure located in the edge area of the fan deck assembly for lowering the first segment from the fan deck down to the ground floor 300, or alternatively, using the tower crane 90 located on the ground floor for lowering the first segment from the fan deck down to the ground floor.

**[0078]** In Fig.6a, a mobile crane 10 lifting the first segment 5a of the first fan is illustrated.

System for removing components, general

**[0079]** According to a second aspect of the present disclosure a system for removing components of one or more fan assemblies of an induced-draft air-cooled heat exchanger system is provided. Such a system comprises a) a mobile crane for driving on the covered deck of the induced-draft air-cooled heat exchanger system and for driving on the fan bridges associated to the fan assemblies, and b) driving means for driving the mobile crane.

**[0080]** In embodiments the driving means are removably connectable to the mobile crane and the mobile crane has no proper motorization directly coupled to the wheels of the mobile crane. In these embodiments, the driving means for driving the mobile crane comprises for example an electric tractor for pushing or pulling the mobile crane. Thereto the mobile crane comprises a drawbar 80 for coupling the electric tractor to the mobile crane, preferably, as illustrated on Fig.4, the drawbar 80 is connected to the first and second siderail assembly of the mobile crane. In this way, the electrical tractor can be removed from the crane when the crane does not need to be moved and/or the electrical tractor can be used for other purposes, such as pushing or pulling a cart, as will be further discussed below.

**[0081]** In other embodiments, the driving means are not removably attached to the mobile crane but are fixed to the mobile crane. In these embodiments, the driving means comprise a motorization, such as for example an electrical motor coupled to at least two wheels of the mobile crane for driving the mobile crane.

**[0082]** Preferably, the driving means for driving the mobile crane are configured for driving the mobile crane in a forward and in a backward direction.

**[0083]** In embodiments, the system for removing components further comprises a cart having a drawbar for coupling with an electrical tractor. In embodiments, the electrical tractor for driving the cart is the same as the electrical tractor for driving the mobile crane, in other embodiments a second electrical tractor can be used to drive the cart on the fan deck, in addition to a first electrical tractor for driving the mobile crane.

Mobile crane

**[0084]** An isometric view of an example of an embodiment of a mobile crane 10 of the system for removing components of one or more fan assemblies according to the present disclosure is shown in Fig.4. A top view and a front view of the mobile crane shown on Fig.4 is shown respectively on Fig.10a and Fig.11a. The mobile crane 10 comprises a first siderail assembly 11 comprising a first row of wheels 21 extending along a first rail axis RA1 and a second siderail assembly 12 comprising a second row of wheels 22 extending along a second rail axis RA2. As illustrated on Fig.4 and Fig.11a, the second siderail assembly 12 is spaced from the first siderail assembly 11.

**[0085]** The first and second siderail assemblies of the mobile crane, each at least comprise two wheels. In the embodiment shown on Fig.4, six wheels are coupled to each of the first and second siderail. Generally, the number of wheels on each of the first and second siderail assembly is between two and ten, depending on the load characteristics of the fan deck.

**[0086]** In embodiments, each of the siderail assemblies comprises a rail and a row of casters attached to the rail, wherein the caster comprises a bracket and a wheel. Preferably, the casters are swivel casters configured such that the wheels in the casters can rotate 360°. In these embodiments, illustrated on Fig.10a, the rail of the first and second siderail assembly is respectively parallel with the first RA1 and second RA2 rail axis.

**[0087]** The first and second siderail assemblies can be construed as a base of the mobile crane, also named chassis.

**[0088]** The mobile crane 10 further comprises a support frame structure mounted on top of the first and second siderail assembly. As for example illustrated on Fig.11a, the support frame structure comprises i) a first side frame 16, wherein a bottom portion of the first side frame is attached to the first siderail assembly 11, ii) a second side frame 17, wherein a bottom portion of the second side frame is attached to the second siderail assembly 12, and iii) an overhead spacing structure 30 coupling a top portion of the first side frame 16 to a top portion of the second side frame 17.

**[0089]** In other words, the support frame structure, comprising the first and second side frame and the overhead spacing structure, can be construed as a frame that couples the first and second siderail while maintaining a free space between the first 16 and second 17 side frame.

**[0090]** When looking in front of the mobile crane, as illustrated in Fig.11a, the first 16 and second 17 side frames can be construed as a left-side and a right-side frame of the mobile crane.

**[0091]** The mobile crane further comprises, as for example illustrated on Fig.4 and Fig.9a, a hoist support beam 50 and a hoist 40 for lifting a load. The hoist support beam 50 comprises a first beam portion 50a that is rigidly attached to the overhead spacing structure 30, and preferably a second beam portion 50b that is cantilevered with respect to the support frame structure. The hoist 40 is either rigidly or moveably coupled to the hoist support beam. If the hoist is located in the first position at the end of the second beam portion, components of the fan such as for example the fan hub, as illustrated on Fig.6c, can be lifted as a result of the cantilevered hoist. Depending on the detailed design of the fan, the fan hub can have a diameter of one to a few meters. Therefore, the second beam portion 50b of the hoist support beam is at least one meter long. In Fig.4, the hoist 40 is illustrated to be located at the first hoist position, i.e. at the end

of the hoist support beam.

[0092] In the embodiment of the mobile crane shown on Fig.4, Fig.10a, Fig.10b, Fig.11a and Fig.11b, the first 11 and second 12 side rail assemblies are running parallel with a longitudinal axis X, i.e. the first RA1 and the second RA2 rail axis of the first and second side rail assemblies are parallel. This is further schematically illustrated on Fig.8a where a top view of the first 11 and second 12 side rail assemblies are shown and wherein the first RA1 and the second RA2 rail axes are running parallel with the longitudinal axis X. In other embodiments, the first and second side rail assemblies are not running parallel, and the corresponding first and second axis are not parallel. This is for example illustrated in Fig.8b where the first RA1 and second RA2 axis of respectively the first and second side rail assemblies are rotated with an angle  $\delta$  with respect to the longitudinal axis X.

[0093] In the embodiments illustrated on Fig.4, Fig.10a and Fig.11a, the hoist support beam 50 is extending in a direction parallel with the longitudinal axis X. In embodiments, the hoist support beam is for example an I-profile beam.

[0094] In embodiments the hoist support beam comprises one hoist position, i.e. the hoist position located at the end of the second portion of the overhead beam. In other embodiments, multiple hoist positions are provided along the first and/or second portion of the hoist support beam. With hoist positions available on the first portion of the hoist support beam, the hoist is no longer in a cantilever position and heavier loads can be lifted. For example, in Fig.17a, the hoist 40 is positioned in the first portion of the overhead beam 50, in non-cantilevered position for lifting a motor 63, while in Fig.15, the hoist 40 is positioned at the end of the second portion of the overhead beam 50 in a cantilevered position for lifting for example a fan hub 62.

[0095] In embodiments having multiple hoist positions, the hoist 40 is moveably attached to the hoist support beam 50 for moving along the hoist support beam between a first hoist position and a second hoist position.

[0096] In embodiments, as illustrated on Fig.4, the hoist 40 of the mobile crane 10 comprises a trolley with a hook 41 to attach an object to be lifted.

[0097] In embodiments, the mobile crane comprises a first siderail extension for extending the first siderail assembly along the first rail axis RA1 and a second siderail extension for extending the second siderail assembly along the second rail axis RA2. In these embodiments, at least one additional wheel is coupled to each of the first and second siderail extensions. For example, when the mobile crane is operational in the cantilever mode, the siderail extension can be removed to better access the component to be reached when the hoist is in a cantilevered position. On the other hand, if the hoist is not located in the cantilevered position, the siderail extensions can be added to facilitate the movement and stability of the crane while driving.

#### Mobile crane, overhead spacing structure

[0098] In embodiments, the overhead spacing structure 30 is a metal frame comprising cross beam members for connecting the first and the second side frames.

[0099] In some embodiments, the spacing structure is a fixed structure to maintain a fixed width between the first side and the second side frame.

[0100] In other embodiments, the overhead spacing structure 30 comprises means for relatively moving the first side frame with respect to the second side frame along a lateral axis Y transverse to the first R1 and second R2 axis of respectively the first and second siderail assembly such that a distance between the first R1 and second R2 rail axis measured along the lateral axis Y is variable between a first distance D1 and a second distance D2, wherein the second distance D2 is smaller than the first distance D1. In this way, a lateral width of the mobile crane measured along the lateral axis Y is variable between a maximum lateral width  $LW_{max}$  and a minimum lateral width  $LW_{min}$ . The first D1 and second D2 distance are illustrated for example on respectively Fig.10a and Fig.10b.

[0101] The minimum lateral width  $LW_{min}$  and maximum lateral width  $LW_{max}$  correspond to a folded and an unfolded position of the mobile crane. In Fig.10a and Fig.10b, showing top views of an embodiment of a mobile crane with variable width, the lateral width is respectively set to the maximum  $LW_{max}$  and to the minimum  $LW_{min}$  lateral width. When in the folded position a minimum space between the first and the second side is maintained and when in the unfolded position a maximum space between the first and second side is maintained.

[0102] For example when the mobile crane has to move between two fan bells of two fan assemblies, the mobile crane is generally in a folded position. The difference between the lateral width when in respectively the unfolded and folded position, i.e. the difference between the maximum and minimum lateral width is further named lateral stroke.

[0103] Generally, the lateral stroke is between 30 cm and 90 cm, preferably between 40 cm and 80 cm and more preferably between 50 cm and 70 cm. In embodiments, as illustrated on Fig.10a and Fig.10b, the lateral stroke is for example 60 cm and the minimum and maximum lateral width correspond for example to respectively, 84 cm and 144 cm.

[0104] In embodiments, the means of the overhead spacing structure for relatively moving the first side frame 16 with respect to the second side frame 17 comprises cross beams configured for varying the distance between the first and second side from the first to the second distance and vice versa.

[0105] The cross beams having a variable length are for example telescopic cross beams. Generally, such a telescopic

cross beam comprises a first and a second beam member wherein a first beam member glides inside or glides alongside a second member so as to vary the overall length of the cross-beam member.

**[0106]** In embodiments, as illustrated on Fig.4, Fig.10a and Fig.10b, the overhead spacing structure 30 of the mobile crane comprises a first spacing member 31 having a first pair of cross beams 31a,31b and a second spacing member 32, separated from the first spacing member, having a second pair of cross beams 32a,32b. A top view of a mobile crane having a spacing structure 30 comprising a first 31 and a second 32 spacing member is illustrated on Fig.10a.

**[0107]** The first pair 31a,31b and second pair 32a,32b of cross beams of respectively the first 31 and second 32 spacing member are configured for varying the distance between the first 16 and second 17 side frame. In the example shown on Fig.4 and Fig.10a, each cross beam of the pair of cross beams is configured for traveling half of the maximum stroke defined above. Hence, by combining two cross beam members, the entire maximum stroke can be covered for moving between the folded and unfolded position.

**[0108]** In the embodiment shown on Fig.10a, the first 31 and second 32 spacing member comprises respectively a first 31c and a second 32c coupling member. The first coupling member 31c is configured such that the cross beams 31a,31b of the first pair of cross beams can move with respect to the first coupling member in the lateral direction Y. Similarly, the second coupling member 32c is configured such that the cross beams 32a,32b of the second pair of cross beams can move with respect to the second coupling member.

**[0109]** The relative movement of the first side frame with respect to the second side frame is generally automated. In embodiments, as shown in Fig.4, the means for relatively moving the first side frame with respect to the second side frame comprise one or more hydraulic cylinders 35 for actuating the telescopic cross beam members.

**[0110]** In other embodiments telescopic beams are used wherein a first member is forming a rail and a second member is forming a beam configured for gliding over the rail formed by the first member. In such embodiments the gliding of the second member over the first rail member can be automated by for example an electrical motor.

**[0111]** In embodiments, the drawbar 80 is adaptable to the lateral width of the mobile crane, as illustrated on Fig.10a and Fig.10b.

**[0112]** In some embodiments, the hoist support beam 50 is centrally located between the first 16 and the second 17 side frame. Preferably, the means for relatively moving are configured such that the hoist support beam remains centrally located when the mobile crane is in the folded and unfolded position.

**[0113]** In embodiments, the movement of each cross beam member of a pair of cross beams of the overhead spacing structure, is synchronized such that when varying the lateral width of the mobile crane, the hoist support beam 50 maintains in its central location between the first and second side frame, independent of the distance between the first and the second side frame.

#### Mobile crane, side frames

**[0114]** In embodiments, each of the first 16 and second 17 side frames are formed by connecting, e.g. by welding and/or bolting, a plurality of metal beams.

**[0115]** In the exemplary embodiment shown on Fig.4 and Fig.9a, the first side frame 16 comprises a first support beam 16a and a second support beam 16b spaced from the first support beam. In this example, the first and second support beams are extending in a direction parallel with a Z-axis perpendicular to the longitudinal axis X and the lateral axis Y. The first support beam 16a is attached with a lower end to the first siderail assembly 11 and with an upper end to the first spacing member 31, and the second support beam 16b is attached with a lower end to the first siderail assembly 11 and with an upper end to the second spacing member 32.

**[0116]** Similarly, the second side frame 17 comprises a third support beam 17a and a fourth support beam 17b spaced from the third support beam and wherein the third and fourth support beams are extending in a direction parallel with the Z-axis, and wherein the third support beam 17a is attached with a lower end to the second siderail assembly 12 and with an upper end to the first spacing member 31, and the fourth support beam 17b is attached with a lower end to the second siderail assembly 12 and with an upper end to the second spacing member 32.

**[0117]** The attachments of the support beams to the siderail assemblies and spacing member can be realized by welding or bolting.

**[0118]** In embodiments, as shown on Fig.9a and Fig.9b, the first 16a and second 16b support beams are perpendicular to the first rail axis R1, and the third 17a and fourth 17b support beams are perpendicular to the second rail axis R2.

**[0119]** The wheels that are attached to the siderail assemblies are for example wheels having rubber tyres for facilitating movement on a deck of an air-cooled condenser.

**[0120]** As mentioned above, the mobile crane can be used in a cantilever mode. Therefore, in embodiments, a counterweight is provided to compensate the weight of the component being lifted when the hoist is in a cantilevered hoist position. In embodiments, as illustrated on Fig.4, Fig.9a and Fig.9b, a first counterweight 71 is supported by an end portion of the first siderail assembly and a second counterweight 72 is supported by an end portion of the second siderail assembly. A counterweight can be composed of a plurality of plates.

**[0121]** In some embodiments, the height of the mobile crane can be adjusted between a maximum height  $H_{\max}$  and a minimum height  $H_{\min}$ . In Fig.9a and Fig.9b, side views of a mobile crane with variable height are shown, and wherein the mobile crane is respectively set to a maximum height  $H_{\max}$  and set to a minimum height  $H_{\min}$ .

**[0122]** As the hoist support beam is attached to the overhead spacing structure, varying a height of the mobile crane has to be construed as varying a height of the hoist support beam 50 between a maximum and minimum height with respect to the first and the second siderail assemblies. The minimum height  $H_{\min}$  is smaller than the maximum height  $H_{\max}$ . The height is measured along a vertical axis Z perpendicular to the lateral axis Y. The maximum  $H_{\max}$  and minimum  $H_{\min}$  height can for example be measured between a side of the hoist support beam and a side of the siderail assemblies, as illustrated on Fig.9a, Fig.9b, Fig.11a and Fig.11b. In other embodiments, a measurement between any other reference points of the hoist support beam and the siderail assemblies, can be selected to define a height of the mobile crane.

**[0123]** In the embodiments shown on Fig.11a and Fig.11b, the first side frame and the second side frame each comprise one or more support beams variable in length and configured for varying a height of the hoist support beam 50 with respect to first and second siderail assemblies. Preferably the one or more support beams variable in length are telescopic beams.

**[0124]** A height stroke defined as the difference between the maximum  $H_{\max}$  and the minimum  $H_{\min}$  height of the mobile crane is generally between 50 cm and 200 cm, preferably between 80 cm and 160 cm, more preferably between 90 cm and 150 cm.

#### Electrical tractor for driving the mobile crane/cart

**[0125]** As discussed above, in embodiments the system for removing components one or more fan assemblies comprises an electrical tractor for pulling or pushing the mobile crane and/or for pushing or pulling the cart.

**[0126]** The electrical tractor typically comprises a plurality of wheels and a driving means.

**[0127]** The electric tractor is for example operational with rechargeable batteries. Hence, to charge the batteries, the electric tractor must for example be plugged in a 3 phase 480V 60Hz plug. For charging the electrical tractor while located on the fan deck, an electrical plug located on the fan deck can be used.

**[0128]** These electrical tractors 150 are commercially available and a front and side view of an example of an electrical tractor is shown in Fig.12a and Fig.12b, respectively. A lateral width TW-T of the electrical tractor has to be sufficiently narrow in order to be able to easily drive with the electrical tractor on the trajectory path between the adjacent fan bells, and, in some embodiments, to drive with electrical tractor between the first and second siderail assemblies of the mobile crane. The lateral width TW-T of the tractor has to be construed as the maximum lateral dimension of the cart measured in a lateral direction.

**[0129]** In the embodiment of an electrical tractor shown on Fig.12a and Fig.12b, the lateral size of the electrical tractor is determined by the track width TW-T of two of the wheels of the tractor. In these embodiments, the track width is defined such that the electrical tractor can drive between the first and the second siderail assembly of the mobile crane. The maximum track width TW-T of the electrical tractor, illustrated on Fig.12a, is preferably between 50 cm and 100 cm, more preferably between 60 cm and 90 cm.

#### Cart and cart support for supporting fan components

**[0130]** A side and front view of an example of a cart 100 of the system for removing components of one or more fan assemblies is respectively shown in Fig.13a and Fig.13b. When components of the fan have been lifted with the mobile crane 10, they can be positioned on the cart 100 and the cart can then be used to transport the components of the fan towards the edge area of the fan bridge.

**[0131]** The cart 100 comprises a support deck or support beams to support a component of the fan to be transported and the cart comprises at least three wheels, preferably at least four wheels, and more preferably at least six wheels. The wheels are for example caster wheels of the swivel and/or fixed type.

**[0132]** Preferably, the cart has a lateral width LW-C, illustrated on Fig.13b, between 60 cm and 120 cm, more preferably between 70 cm and 90 cm. The lateral width LW-C of the cart must be construed as the maximum lateral dimension of the cart measured in a lateral direction.

**[0133]** In embodiments, the lateral width of the cart is configured such that the cart can be driven and placed between the first and the second siderail assemblies of the mobile crane, as illustrated on Fig.15. In this way, a component of a fan, such as for example fan hub 62, as shown on Fig.15, can in first step be removed with the mobile crane and in a second step be placed on the cart 100 for further transportation to for example the permanent hoist located on the fan deck.

**[0134]** In embodiments, the cart comprises support elements for carrying specific components of the fan. For example, in Fig.14, a hub support structure 110 is shown that can be placed on the cart for supporting a fan hub 62. For transporting the fan hub 62, the fan hub is attached to the hub support structure 110. In Fig.15, a fan hub 62 is supported by the hub support structure 110 and the hub support structure 110 is attached to the cart 100.

**[0135]** Further, as illustrated on Fig.6c and Fig.15, a hub spread bar 42 is forming an interface between the hoist 40 of the mobile crane and the fan hub. The hub spread bar 42 facilitates the lifting and lowering of the fan hub with the mobile crane.

## Claims

1. A method for removing components of fan assemblies (3) of an induced-draft air-cooled heat exchanger system (1) such as an air-cooled condenser or a wet cooling tower, wherein each fan assembly (3) of the heat exchanger system (1) comprises any of the following non-limiting list of components: a fan blade, a fan hub and one or more driving components for rotating the fan blades, and wherein the heat exchanger system (1) comprises a covered fan deck (4) located at a given altitude (H) from a ground floor (300) and wherein the fan deck (4) comprises a plurality of openings, each opening being fringed by a fan bell (5) associated to one of the fan assemblies, and wherein inside each fan bell a fan bridge (8) is extending towards a center of the fan bell (5), the method comprising:

- driving a mobile crane (10) on the fan deck (4) following a trajectory path (6), preferably the trajectory path (6) is at least partly running between adjacent fan bells (5),
- driving said mobile crane (10) to a neighborhood of a first fan bell associated to a first fan assembly,
- lifting a first component of the first fan assembly using the mobile crane,
- transporting the first component towards an edge area of the fan deck by either driving the mobile crane, while supporting the first component, towards the edge area, or alternatively, using the mobile crane for placing the first component on a cart and driving the cart to the edge area,
- using a permanent hoist structure (200) located in the edge area (7) of the fan deck (4) for lowering the first component from the fan deck down to the ground floor, or alternatively, using a tower crane located on the ground floor for lowering the first component located in the edge area of the fan deck down to the ground floor.

2. A method according to claim 1 further comprising

- before lifting the first component, driving said mobile crane (10) on a first fan bridge located inside the first fan bell associated to the first fan assembly.

3. A method according to claim 2 wherein each of the fan bells (5) is formed by a plurality of fan bell segments (5a) and wherein the method comprises:

- before driving the mobile crane on the first fan bridge, removing a first fan bell segment (5a) of the first fan bell, wherein the first fan bell segment (5a) is located in front of an entrance of the first fan bridge (8), preferably using the mobile crane for lifting the first fan bell segment.

4. A method according to claim 2 or claim 3 comprising:

- removing a first fan blade of the first fan assembly by performing steps of:
  - a) before driving the mobile crane on the first fan bridge, rotating the fan blades of the first fan assembly until the first fan blade is aligned with the first fan bridge,
  - b) coupling the first fan blade to a hoist of the mobile crane,
  - c) unbolting the first fan blade from a fan hub of the first fan assembly,
  - d) using the hoist of the mobile crane for lifting the first fan blade,
  - e) transporting the first fan blade towards the edge area of the fan deck by either driving the mobile crane, while supporting the first fan blade, towards the edge area, or alternatively, using the mobile crane for placing the first fan blade on the cart and driving the cart to the edge area,
  - f) using the permanent hoist structure located in the edge area of the fan deck for lowering the first fan blade from the fan deck down to the ground floor, or alternatively, using the tower crane located on the ground floor for lowering the first fan blade from the fan deck down to the ground floor,

and/or wherein the method further comprises:

- removing a first fan hub of the first fan assembly by performing steps of:

- a) removing each remaining fan blade of the first fan assembly by repeating for each remaining fan blade the steps used for removing the first fan blade,
- b) driving the mobile crane on the fan bridge of the first fan assembly until the hoist of the mobile crane is located on top of the first fan hub,
- c) coupling the first fan hub to the hoist of the mobile crane, preferably using a hub spreader bar comprising a lifting drawbar for attaching the hub spreader bar to the hoist of the mobile crane and at least two support drawbars for attaching the first fan hub to the hub spreader bar,
- d) removing bolts between the first fan hub and a first driving component of one of the one or more driving components of the first fan assembly,
- e) using the mobile crane for lifting the first fan hub, preferably rotating the first fan hub by 90°,
- f) transporting the first fan hub towards the edge area of the fan deck by either driving the mobile crane, while supporting the first fan hub, towards the edge area, or alternatively using the mobile crane for placing the first fan hub on the cart and driving the cart to the edge area, preferably, when using the cart, positioning a hub support frame on the cart and securing the first fan hub to the hub support frame before driving the cart to the edge area,
- g) using the permanent hoist structure located in the edge area of the fan deck for lowering the first fan hub from the fan deck down to the ground floor, or alternatively, using the tower crane (90) located on the ground floor for lowering the first fan hub from the fan deck down to the ground floor.

5. A method according to anyone of previous claims wherein the one or more driving components of each of the fan assemblies comprise a gearbox and a drive shaft coupled with a first end to the gearbox and coupled with an opposite second end to a motor, the method comprising:

- removing a first motor of the first fan assembly, wherein the first motor is coupled to a first drive shaft, by performing steps of:

- a) removing the coupling between the first motor and the first drive shaft,
- b) driving the mobile crane towards the first motor,
- c) coupling the first motor to the hoist of the mobile crane,
- d) using the mobile crane for lifting the first motor,
- e) transporting the first motor towards the edge area of the fan deck by either driving the mobile crane supporting the first motor towards the edge area, or alternatively positioning the cart below the first motor and using the mobile crane for lowering the first motor until the first motor rests on the cart and then driving the cart to the edge area,
- f) using the permanent hoist structure located in the edge area of the fan deck assembly for lowering the first motor from the fan deck down to the ground floor, or alternatively, using the tower crane located on the ground floor for lowering the first motor from the fan deck down to the ground floor.

6. A method according to anyone of claims 2 to 4, wherein the one or more driving components of each of the fan assemblies comprise a gearbox and a drive shaft coupled with a first end to the gearbox and coupled with an opposite second end to a motor, the method comprising:

- removing the first drive shaft of the first fan assembly by performing steps of:

- a) unbolting the first drive shaft from the gearbox of the first fan assembly,
- b) driving the mobile crane on the first fan bridge,
- c) coupling the first draft shaft to the hoist of the mobile crane,
- d) lifting the first drive shaft using the mobile crane,
- e) transporting the first drive shaft towards the edge area of the fan deck by either driving the mobile crane supporting the first drive shaft towards the edge area, or alternatively positioning the drive shaft on the cart using the mobile crane and driving the cart to the edge area,
- f) using the permanent hoist structure located in the edge area of the fan deck for lowering the first drive shaft from the fan deck down to the ground floor, or alternatively, using the ground crane located on the ground floor for lowering the first drive shaft from the fan deck down to the ground floor,

and/or wherein the method further comprises:

- removing a first gearbox of said first fan assembly by performing steps of:

- a) driving the mobile crane on the first fan bridge of the first fan assembly,
- b) unbolting the first gearbox from a gear box support structure,
- c) coupling the first gearbox to the hoist of the mobile crane,
- d) lifting the first gearbox with the mobile crane,
- e) transporting the first gearbox towards the edge area of the fan deck by either driving the mobile crane supporting the first gearbox towards the edge area, or alternatively positioning the cart below the first gearbox and using the mobile crane for lowering the first gearbox until the first gearbox rests on the cart and then driving the cart to the edge area,
- f) using the permanent hoist structure located in the edge area of the fan deck for lowering the first gearbox from the fan deck assembly down to the ground floor, or alternatively, using the tower crane located on the ground floor for lowering the first gearbox from the fan deck down to the ground floor.

7. A system for removing components of one or more fan assemblies of an induced-draft air-cooled heat exchanger system, the system for removing components comprising:

a) a mobile crane for driving on a covered deck of the induced-draft air-cooled heat exchanger system and/or for driving on fan bridges located inside fan bells associated to the fan assemblies, said mobile crane comprising:

- a first siderail assembly (11) comprising a first row of wheels (21) extending along a first rail axis (RA1),
- a second siderail assembly (12) comprising a second row of wheels (22) extending along a second rail axis (RA2), and wherein the second siderail assembly is spaced from the first siderail assembly, preferably said first (RA1) and said second rail axis (RA2) are parallel,
- a support frame structure mounted on said first and second siderail assembly and wherein said support frame structure comprises

i) a first side frame (16), wherein a bottom portion of the first side frame is attached to the first siderail assembly (11),

ii) a second side frame (17), wherein a bottom portion of the second side frame is attached to the second siderail assembly (21), and

iii) an overhead spacing structure (30) coupling a top portion of the first side frame to a top portion of the second side frame,

- a hoist support beam (50), preferably the hoist support beam comprises at least a first beam portion and a second beam portion wherein the first beam portion is rigidly attached to the overhead spacing structure (30) and the second beam portion is cantilevered with respect to the support frame structure,
- a hoist (40) rigidly or moveably coupled to the hoist support beam,

b) driving means for driving the mobile crane, preferably the driving means are configured for driving the mobile crane in a forward and backward direction.

8. A system according to claim 7, wherein said overhead spacing structure (30) comprises means for relatively moving the first side frame (16) with respect to the second side frame (17) along a lateral axis (Y) transverse to said first (RA1) and second (RA2) rail axes of respectively the first and second siderail assembly, such that a distance between the first (RA1) and the second (RA2) rail axis measured along said lateral axis (Y) is variable between a first distance (D1) and a second distance (D2), wherein the second distance is smaller than the first distance.

9. A system according to claim 8, wherein said means for relatively moving the first side frame (16) with respect to the second side frame (17) comprises cross beams (31a, 31b, 32a, 32b) configured for varying the distance between the first and second side from the first (D1) to the second (D2) distance and vice versa.

10. A mobile crane according to claim 9, wherein said means for relatively moving comprise one or more hydraulic cylinders coupled to said cross beams so as to actuate a movement of the cross beams along the lateral axis (Y), or alternatively, said means for relatively moving comprises one or more electrical motors configured for moving the cross beams along the lateral axis (Y).

11. A mobile crane according to anyone of claims 7 to 10, wherein the first side frame (16) and the second side frame (17) each comprise one or more support beams (16a, 16b, 17a, 17b) variable in length and configured for varying a height of the hoist support beam (50) with respect to first (11) and second (21) siderail assemblies between a

maximum ( $H_{\max}$ ) and a minimum height ( $H_{\min}$ ), preferably said one or more support beams variable in length (16a, 16b, 17a, 17b) are telescopic beams.

- 5 12. A mobile crane according to anyone of claims 7 to 11, comprising a first (71) and a second (72) counterweight, preferably said first (71) and second counterweight (72) are supported by a portion of respectively the first (11) and second (12) siderail assembly.
- 10 13. A mobile crane according to anyone of claims 7 to 12, wherein said overhead spacing structure (30) comprises a first spacing member (31) and a second spacing member (32) separated from the first spacing member, and wherein said first side frame (16) comprises a first support beam (16a) and a second support beam (16b) spaced from the first support beam, and wherein the first support beam (16a) is attached with a lower end to the first first siderail assembly (11) and with an upper end to the first spacing member (31), and the second support beam (16b) is attached with a lower end to the first siderail assembly (11) and with an upper end to the second spacing member (32), and wherein said second side frame (17) comprises a third support beam (17a) and fourth support beam (17b) spaced from the third support beam, and wherein the third support beam (17a) is attached with a lower end to the second siderail assembly (12) and with an upper end to the first spacing member (31), and the fourth support beam (17b) is attached with a lower end to the second siderail assembly (12) and with an upper end to the second spacing member (32).
- 20 14. A system according to anyone of claims 7 to 13, wherein said driving means for driving the mobile crane comprises an electric tractor (150) for pushing or pulling the mobile crane, and wherein the mobile crane comprises an drawbar (80) for coupling the electric tractor (150) to the mobile crane for pushing or pulling the mobile crane.
- 25 15. A system according to anyone of claims 7 to 14, further comprising c) a cart (100), and wherein a lateral width of said cart is configured such that the cart can be driven between the first (11) and the second (12) siderail assemblies.

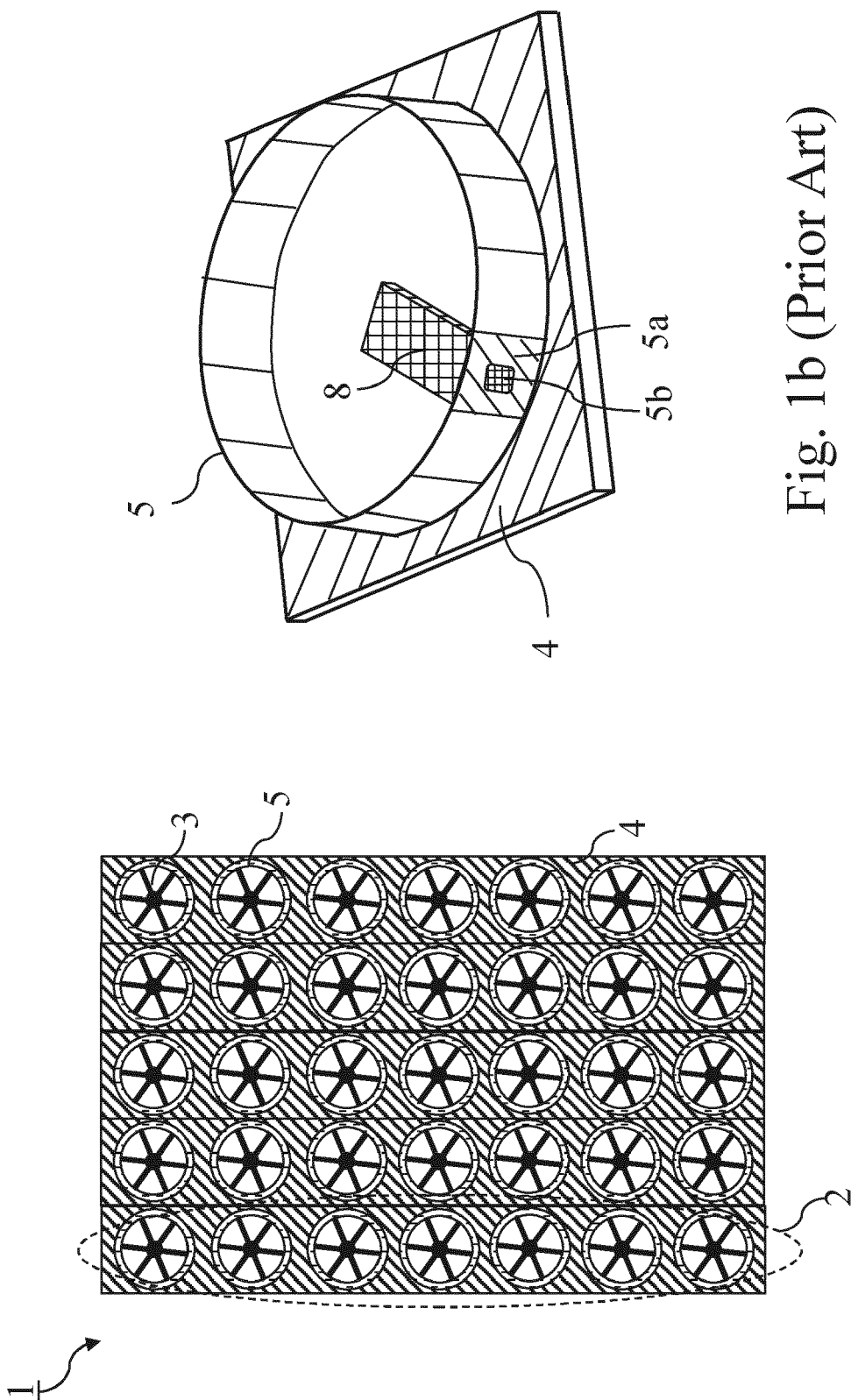


Fig. 1b (Prior Art)

Fig. 1a (Prior Art)

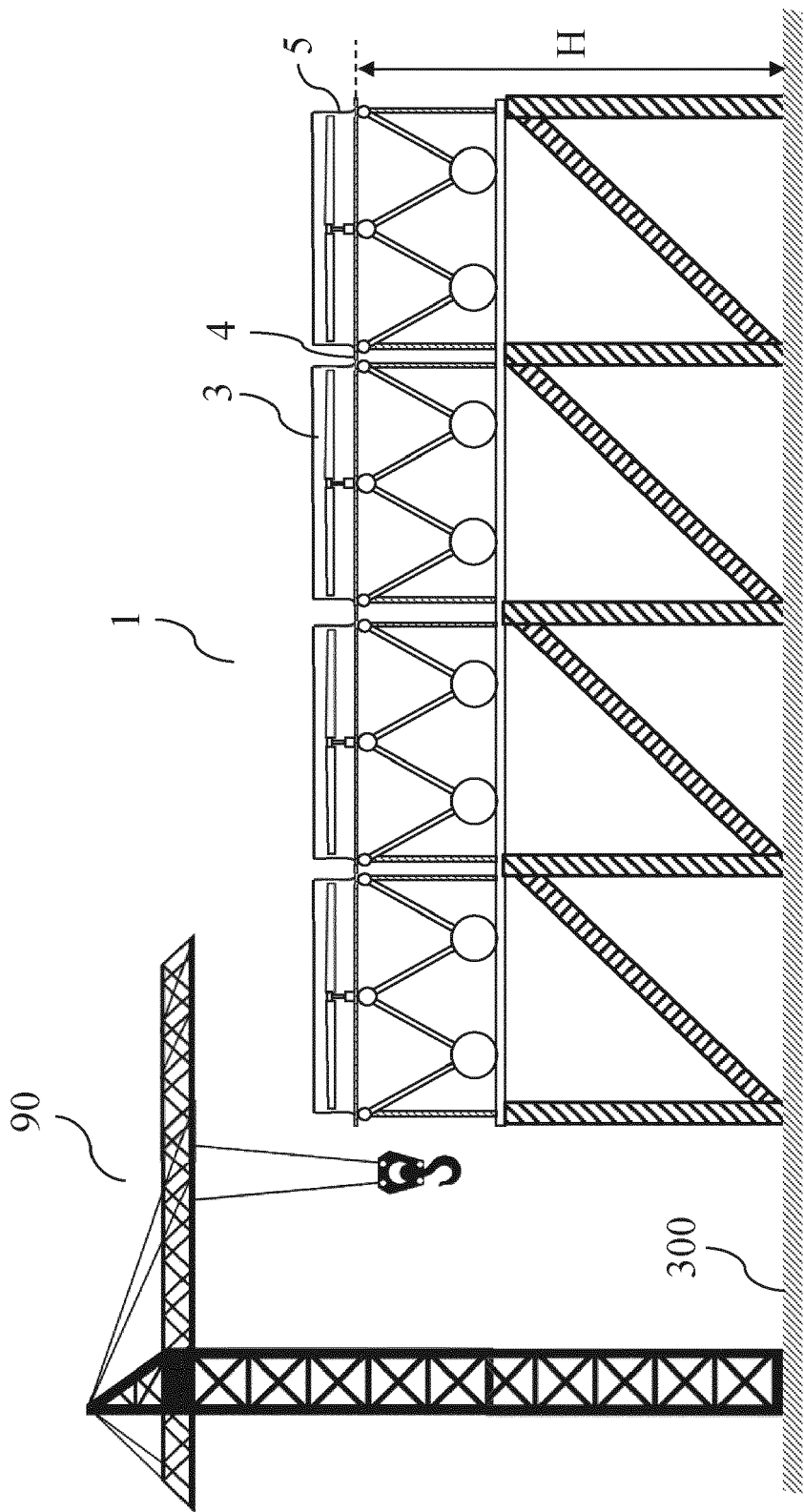


Fig. 2 (Prior Art)

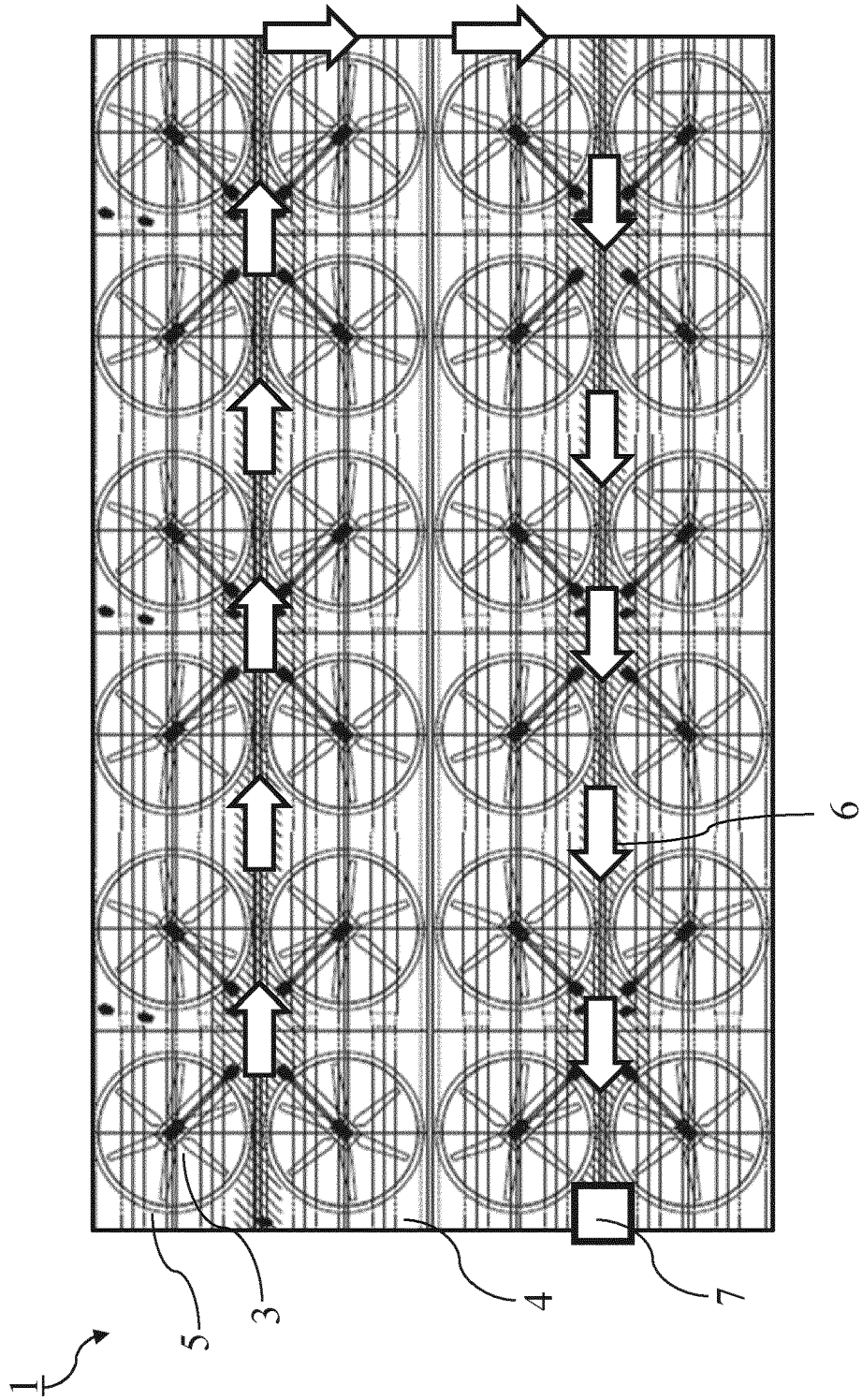
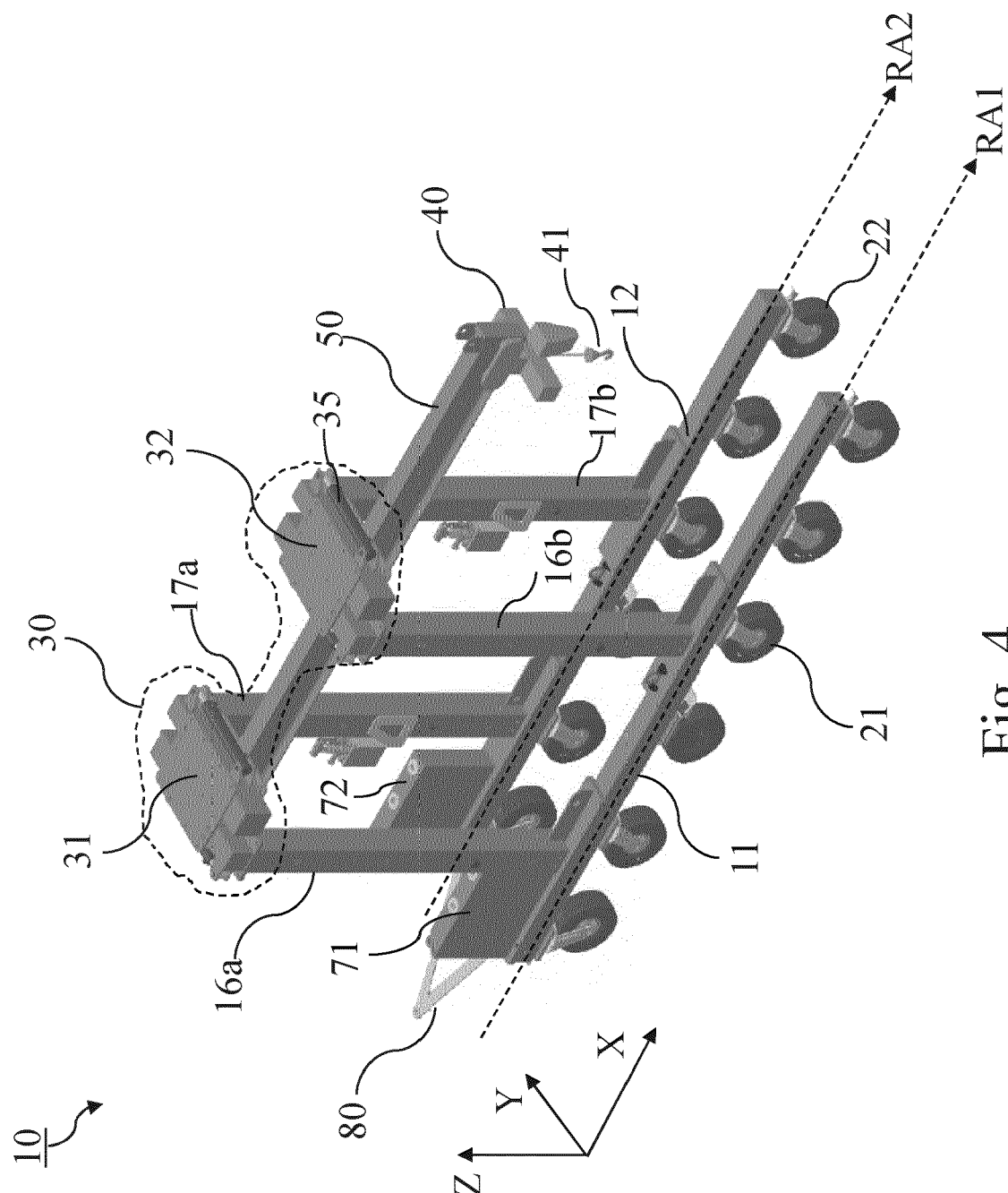


Fig. 3

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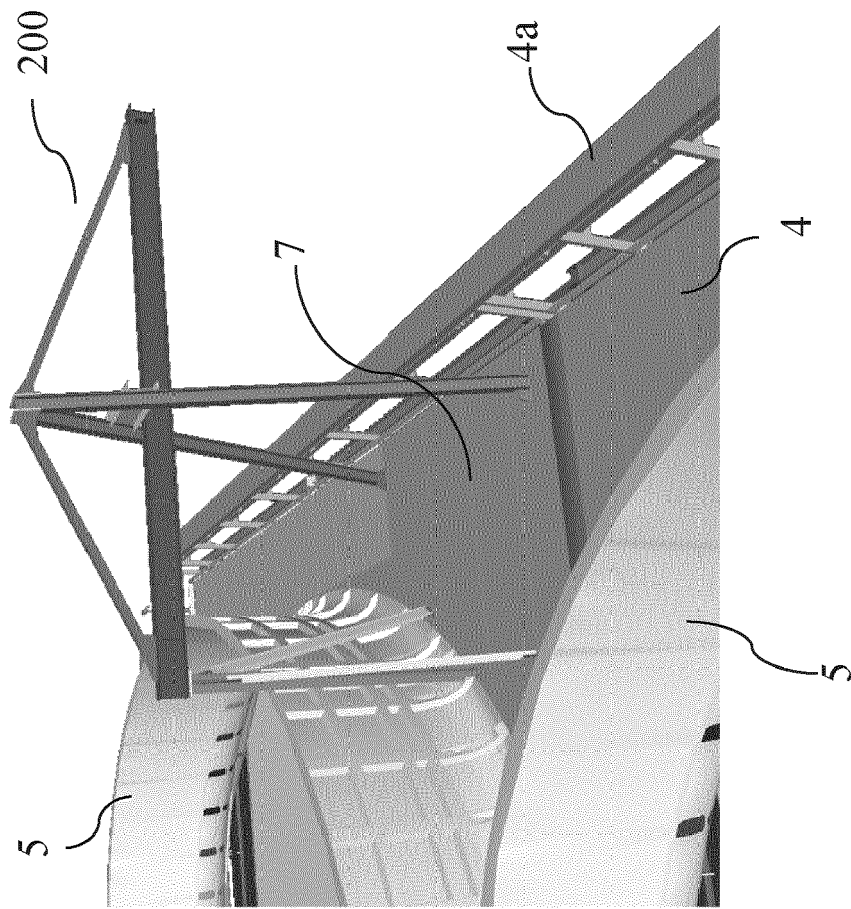


Fig. 5

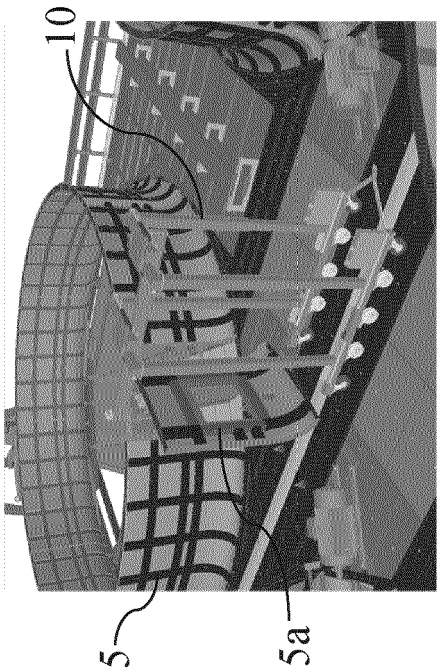


Fig. 6a

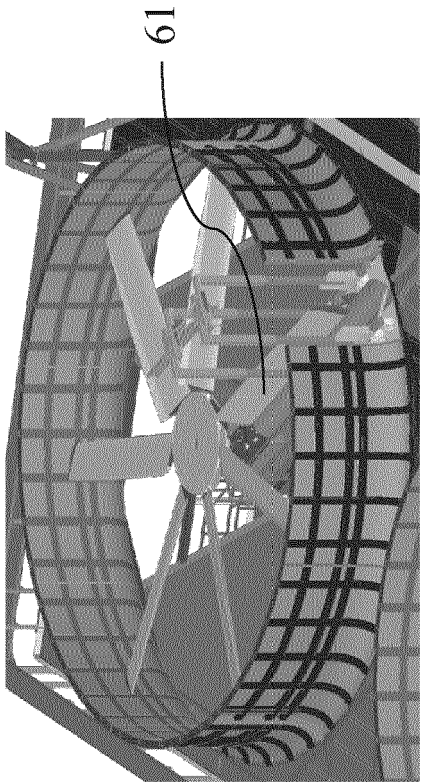


Fig. 6b

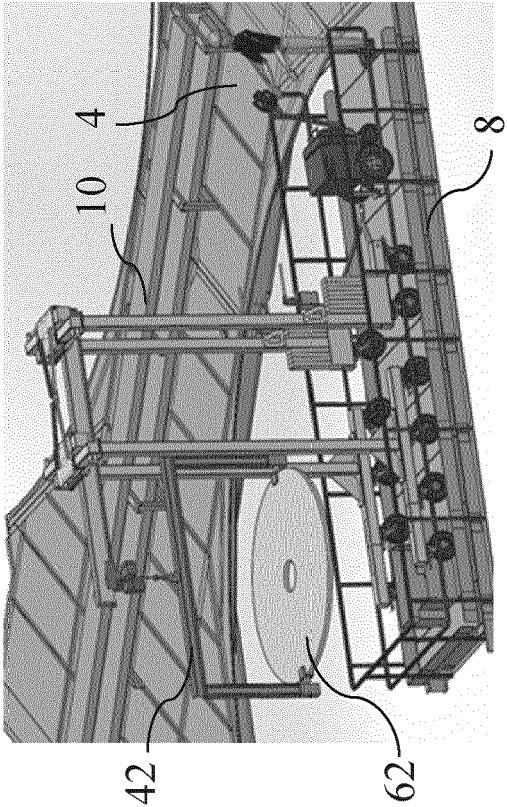


Fig. 6c

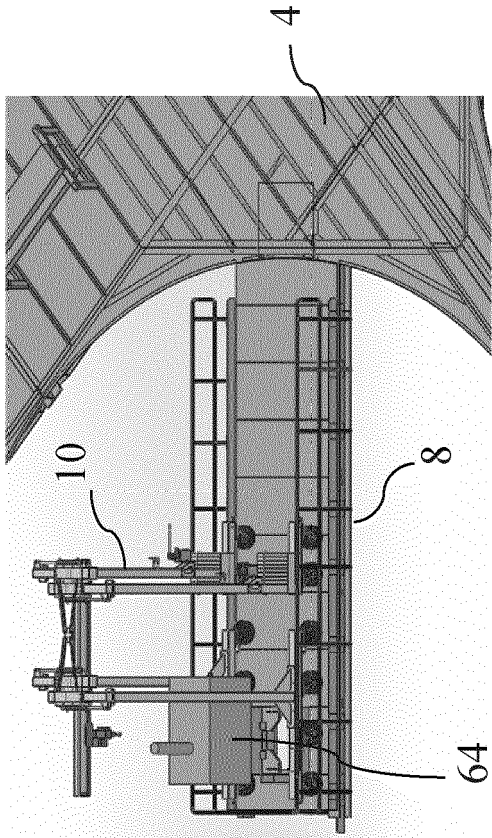


Fig. 6d

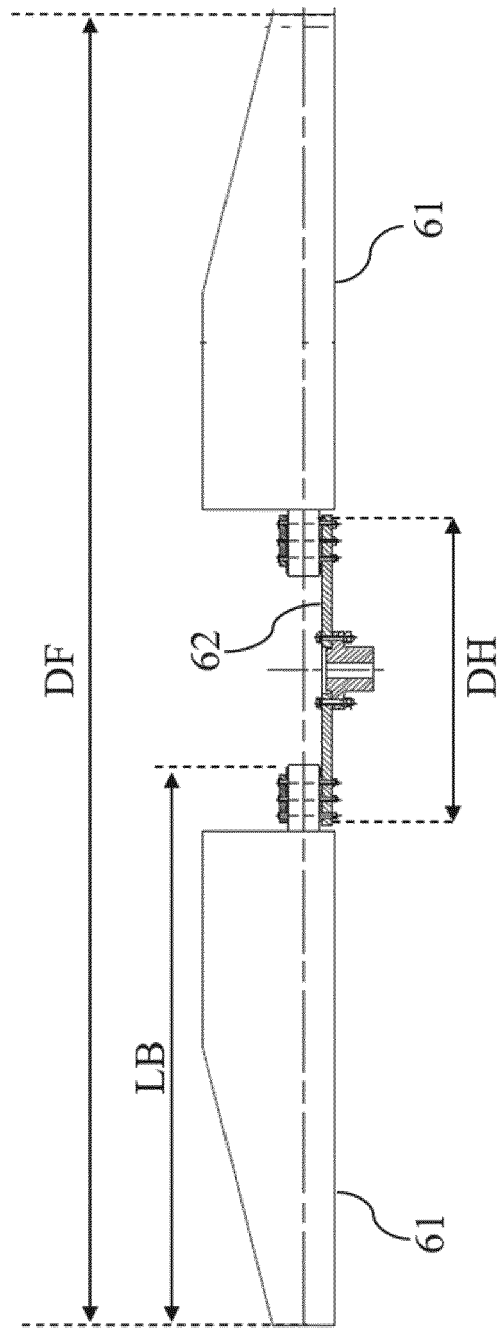


Fig. 7

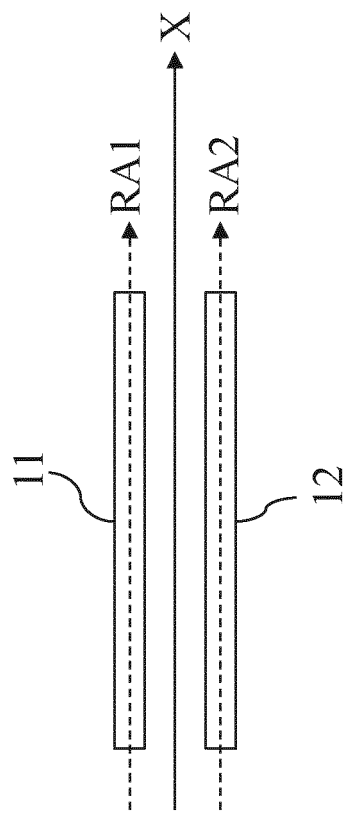


Fig. 8a

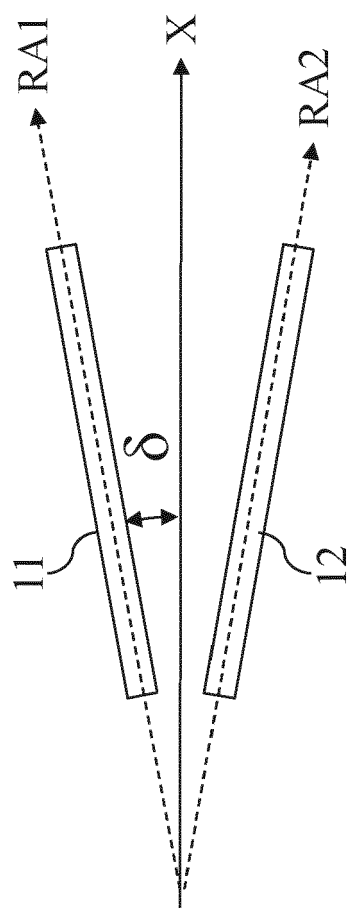


Fig. 8b

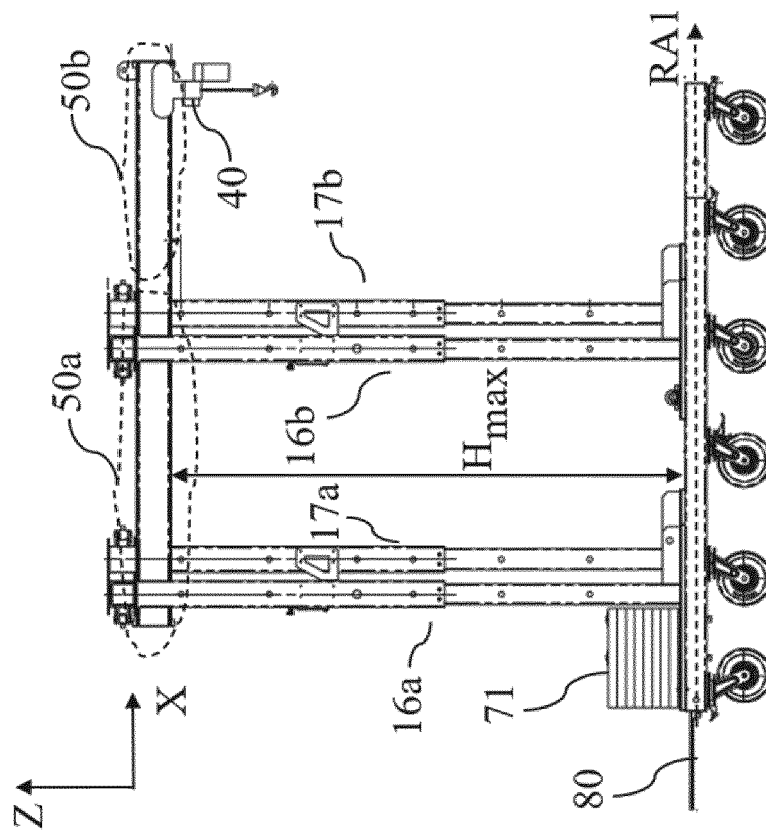


Fig. 9a

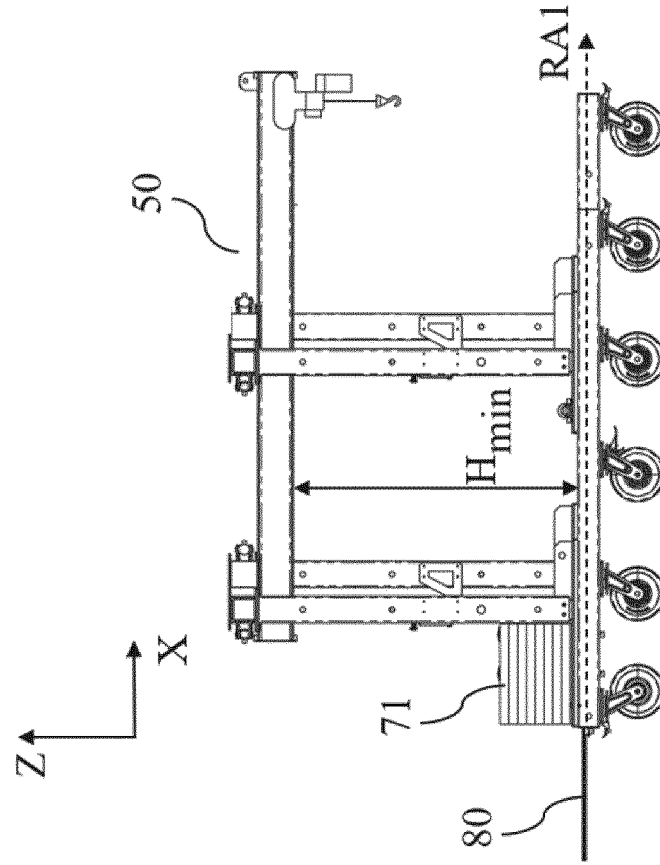


Fig. 9b

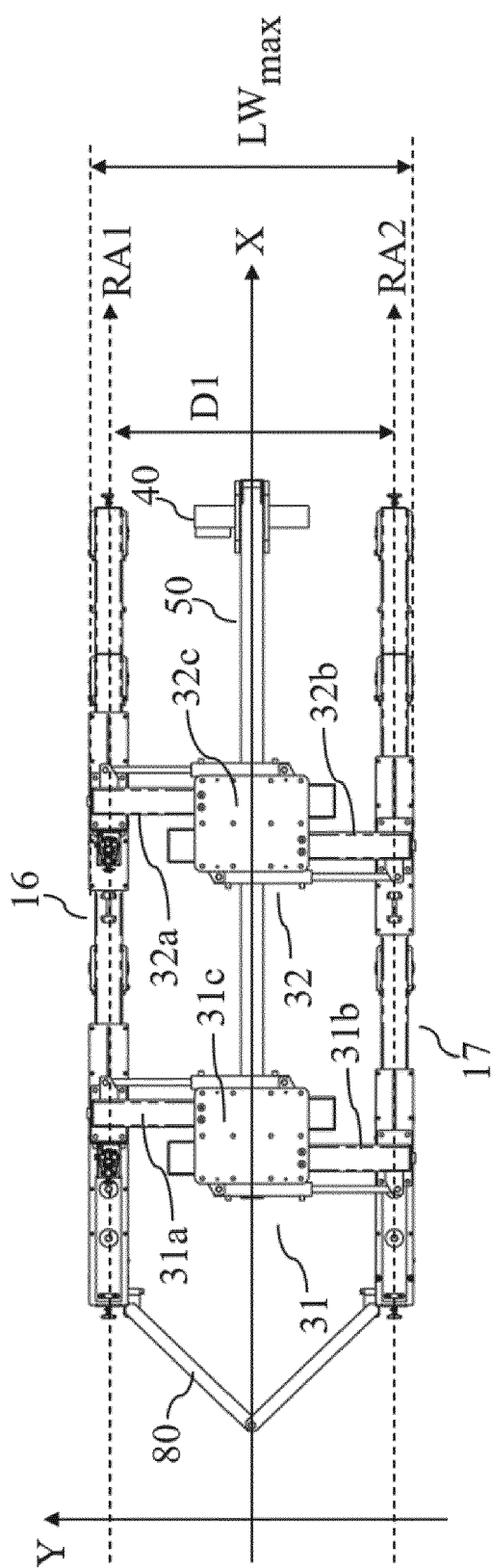


Fig. 10a

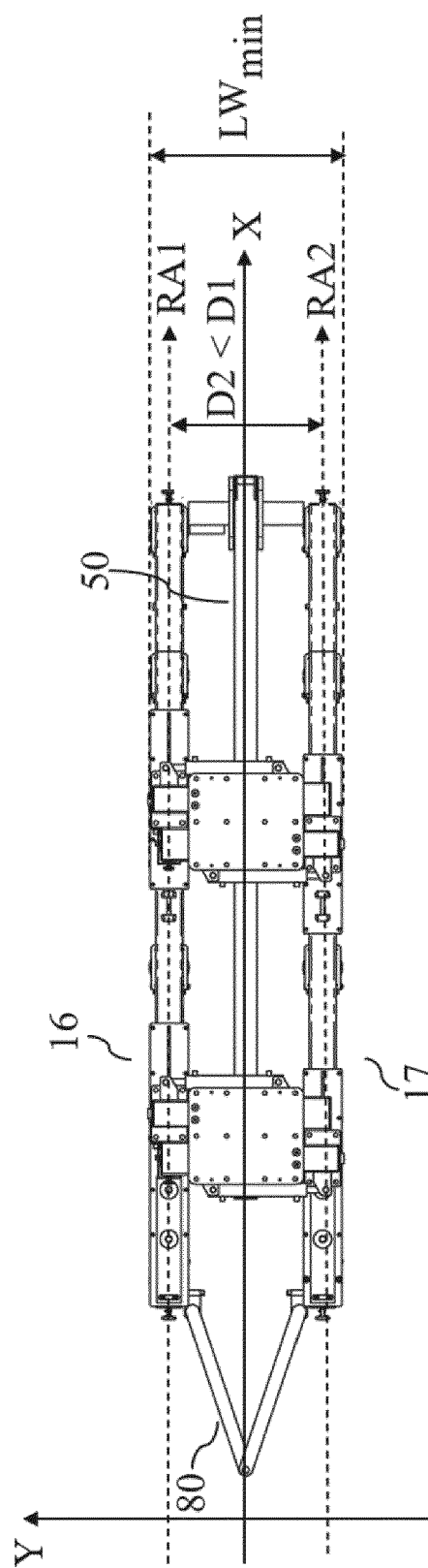


Fig. 10b

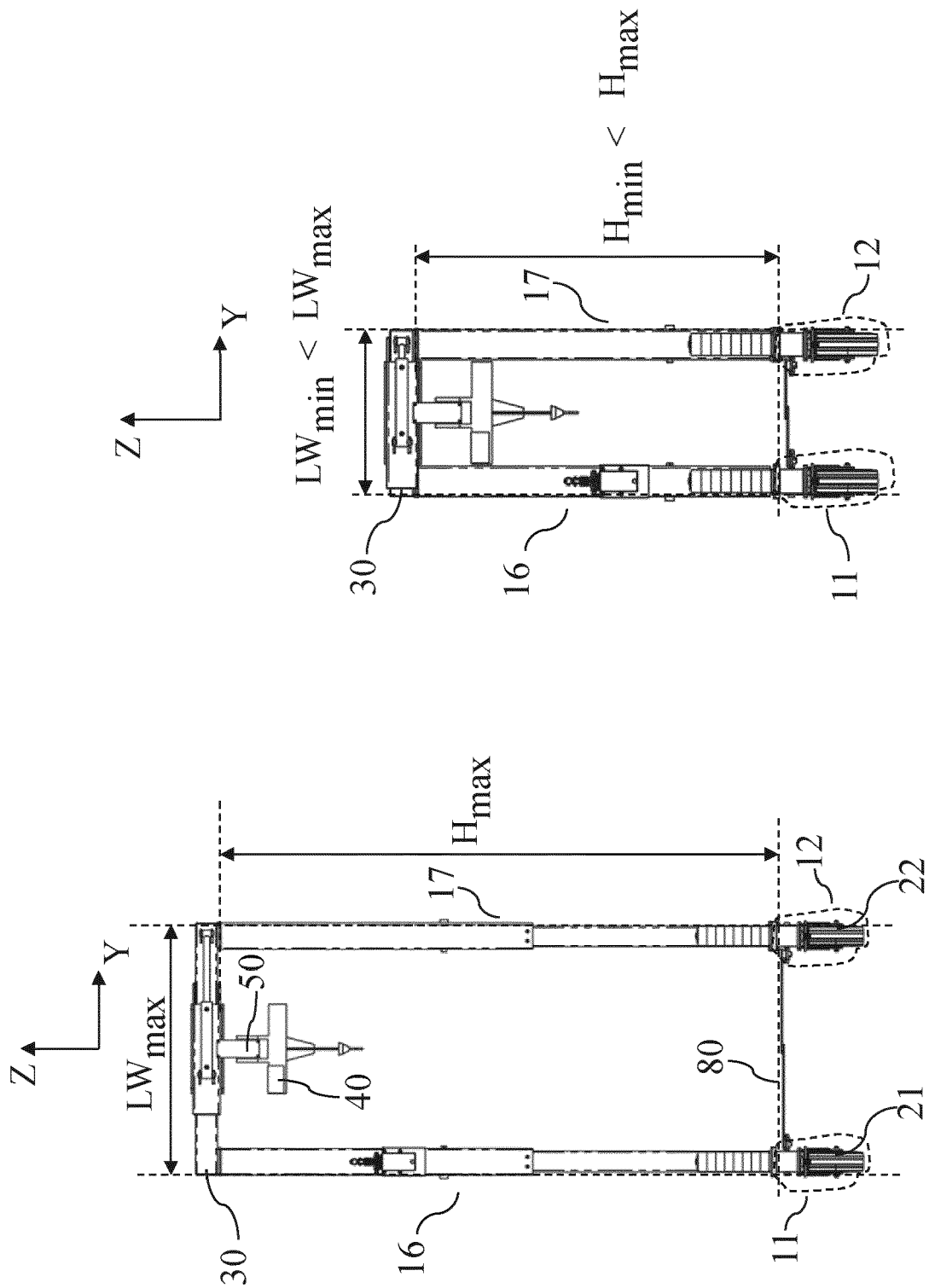


Fig. 11b

Fig. 11a

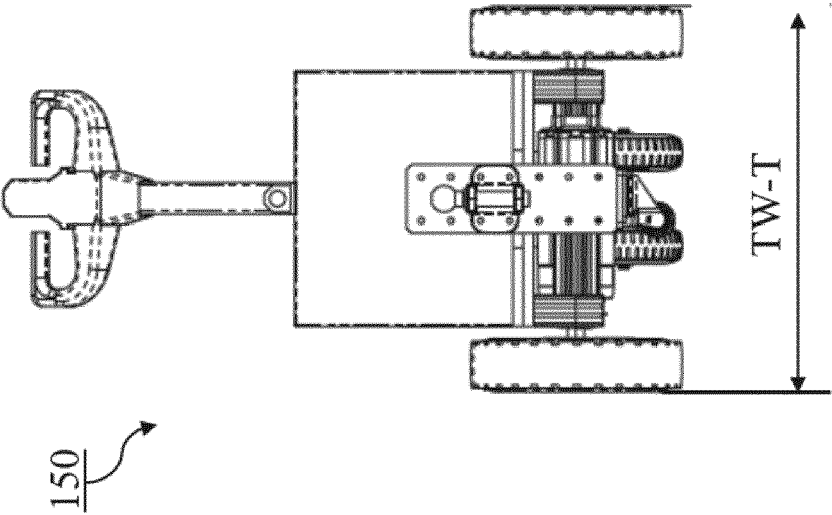


Fig. 12a

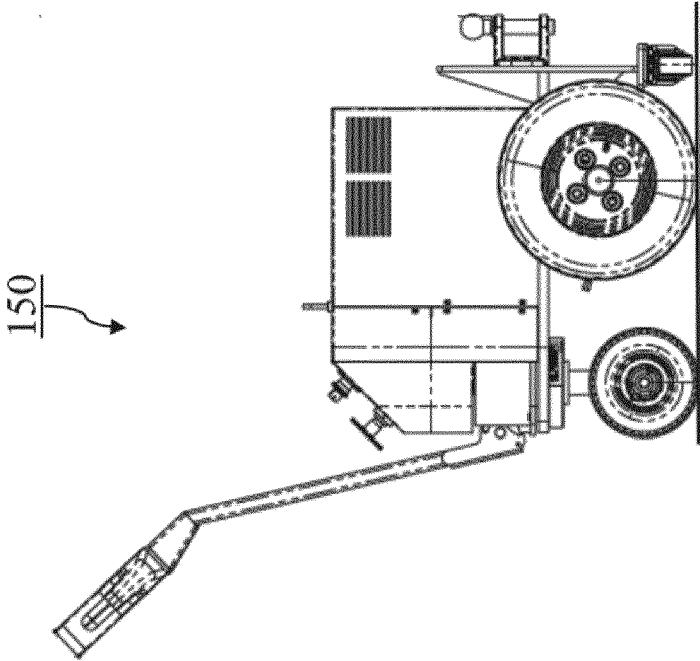


Fig. 12b

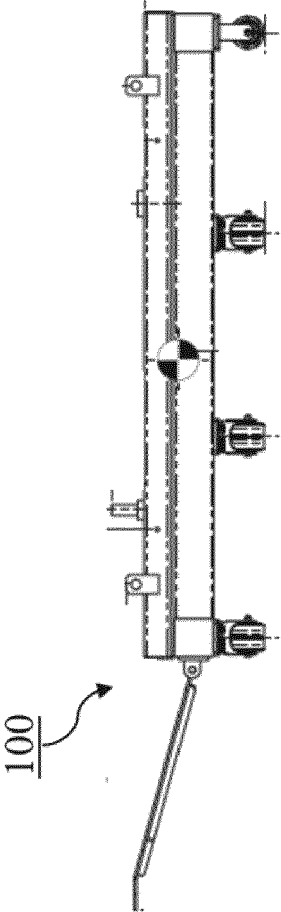


Fig. 13a

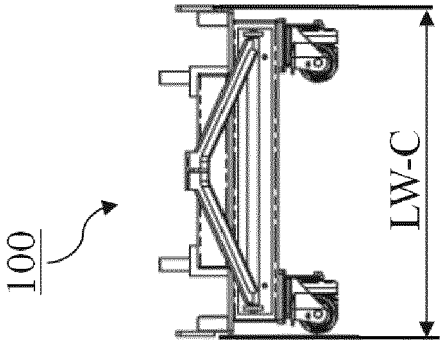


Fig. 13b

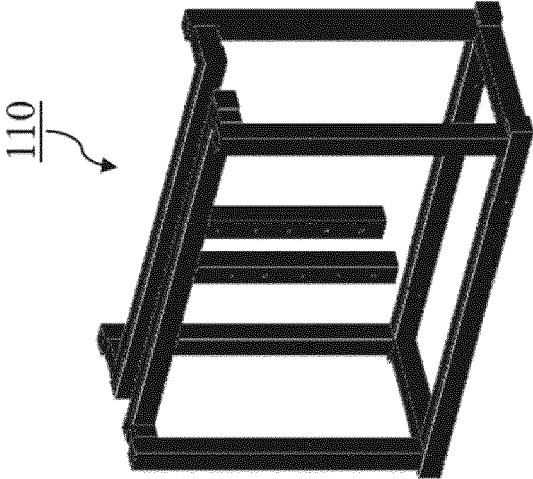


Fig. 14

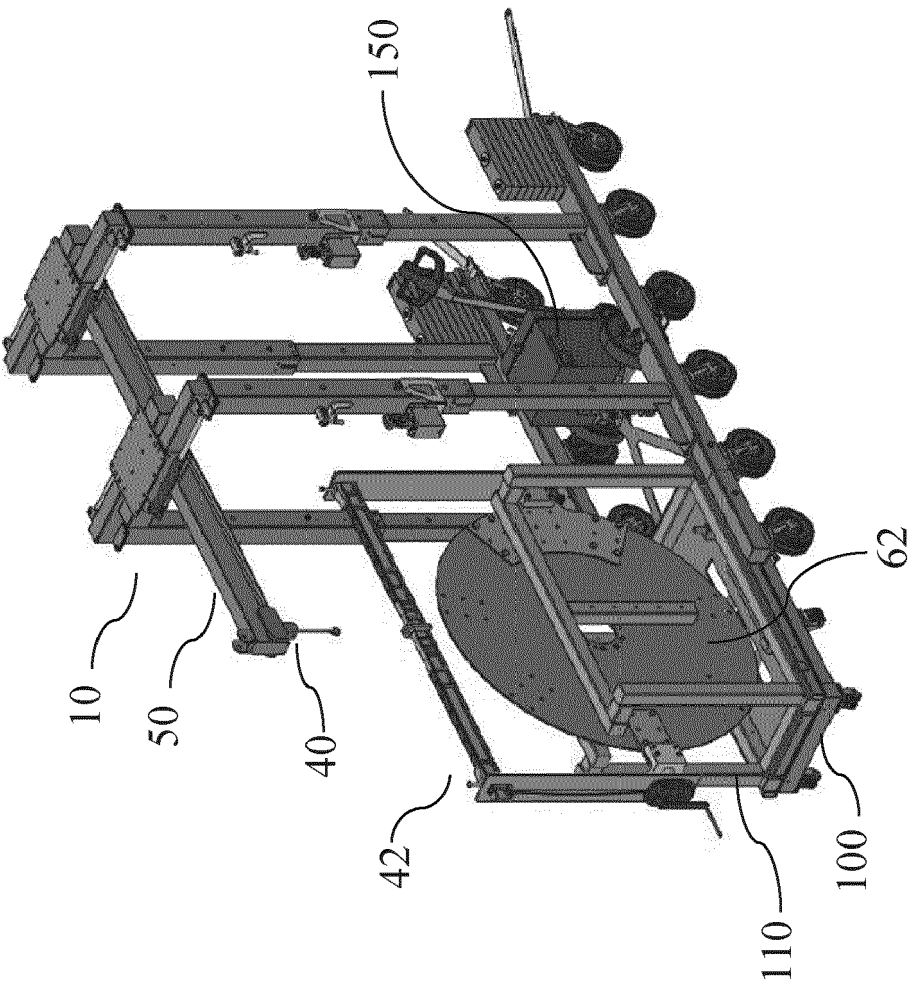
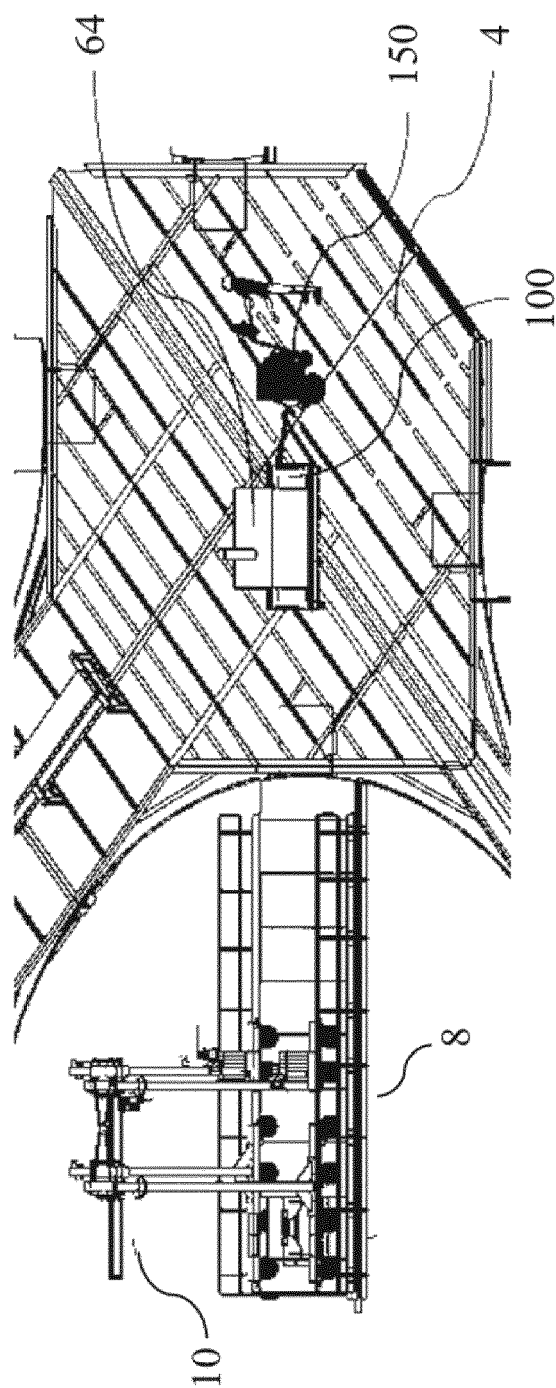
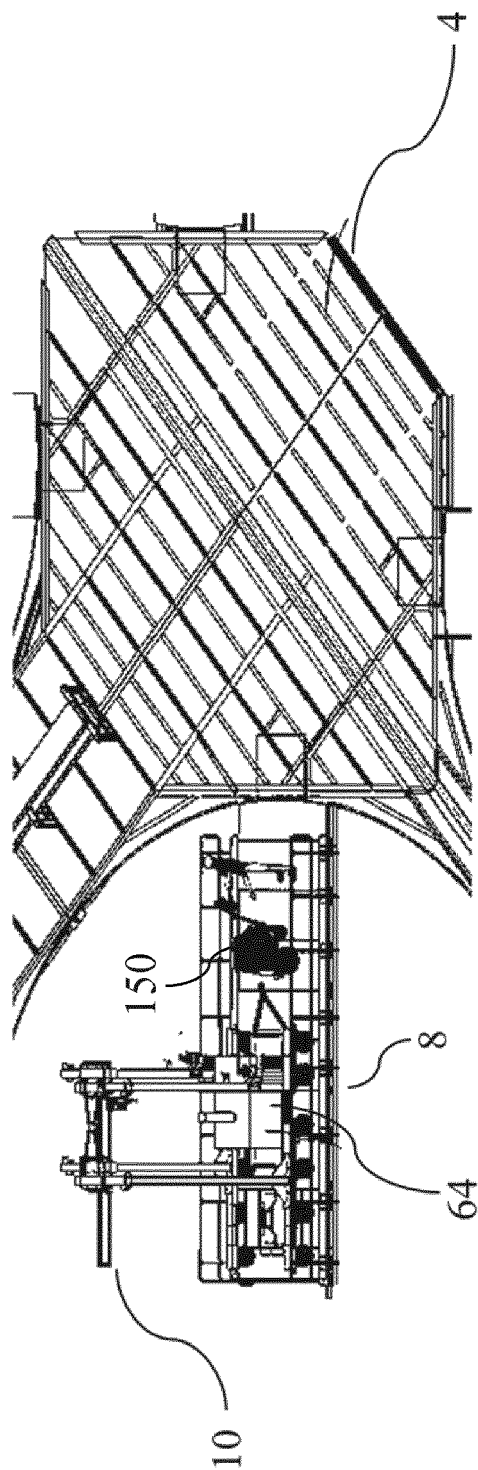


Fig. 15



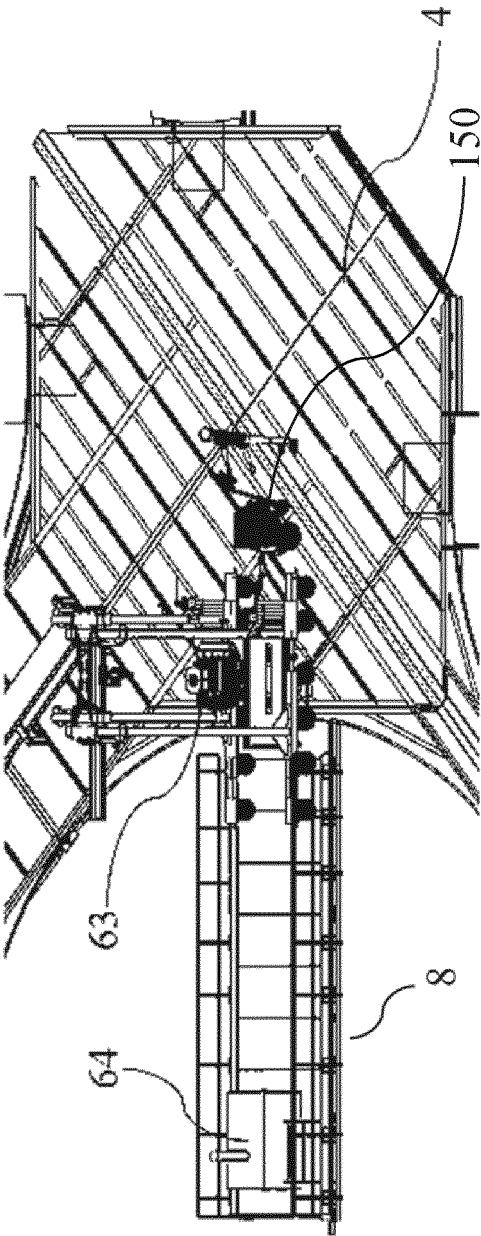


Fig. 17a

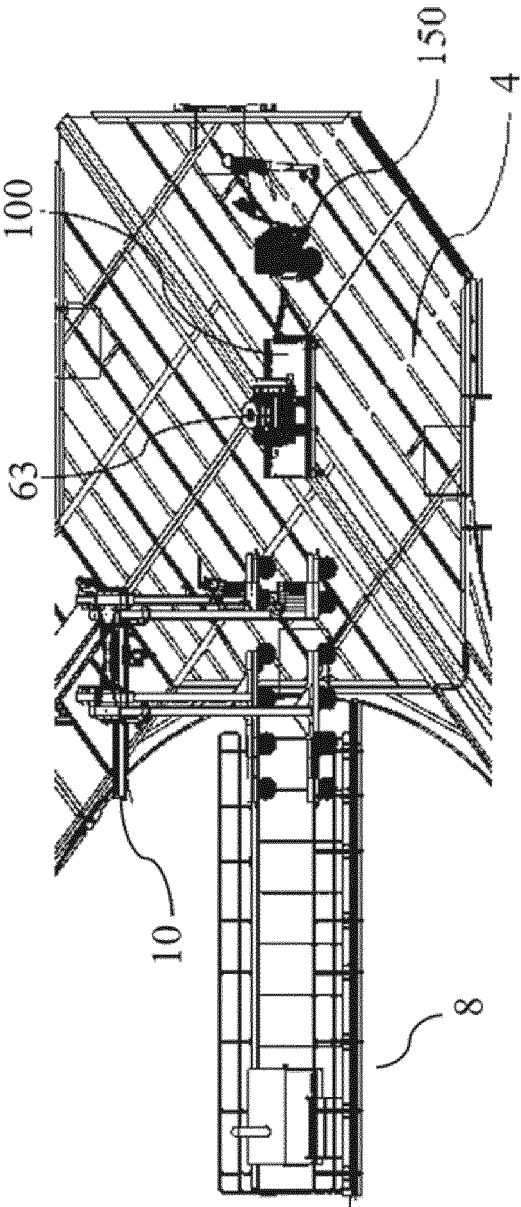


Fig. 17b



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| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                              |                                                                                                                                                                                                                                                                              |                                              |
| Place of search<br><b>Munich</b>                                                                                                                                                                                                                       |                                                                                                              | Date of completion of the search<br><b>10 December 2020</b>                                                                                                                                                                                                                  | Examiner<br><b>Mellado Ramirez, J</b>        |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                              | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                              |

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