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(54) Title: OFF-SHORE TRANSFORMER STATION WITH EXCHANGEABLE TRANSFORMER ASSEMBLY

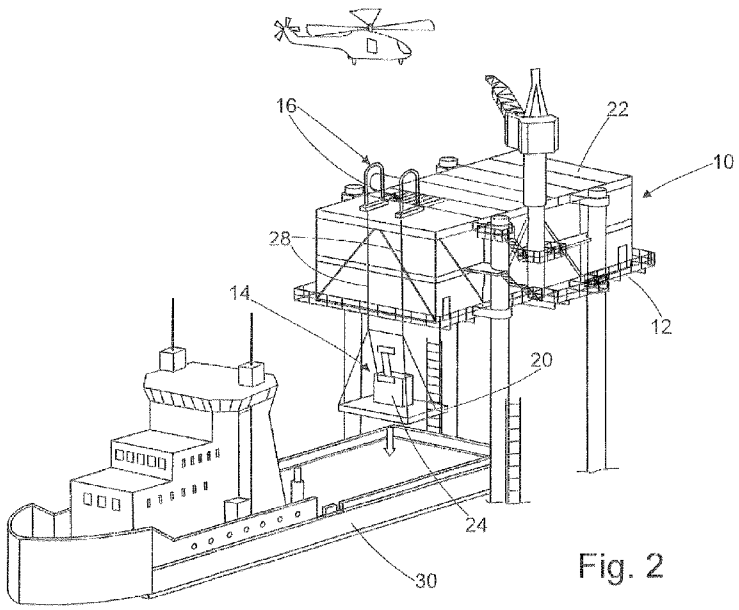

Fig. 2

(57) Abstract: A substation platform (10) for use in offshore power transmission comprises a primary floor (12) including at least one opening, at least one transformer assembly (14) including one or more transformers (24) for connection in use to one or more electrical networks, the or each transformer assembly (14) being releasably connected to the primary floor (12), and at least one strand jack (16) including one or more cables (28), the or each cable (28) being operable to releasably connect to a respective transformer assembly (14) and the or each strand jack (16) being operable to lower or lift the respective transformer (24) through the respective opening of the primary floor (12).

OFF-SHORE TRANSFORMER STATION WITH EXCHANGEABLE TRANSFORMER ASSEMBLY

This invention relates to a substation platform for use in offshore power transmission and a method of replacing a transformer on such a substation platform.

In power transmission networks electrical power typically undergoes an increase in voltage to decrease its current level before being transmitted over long distances. The transmission of electrical power using low current minimises losses associated with resistive heating in the transmission lines or cables, and thereby improves the cost-effectiveness of power transmission over such lines and/or cables. The increase in voltage is carried out using an electrical substation which includes a transformer with a voltage step-up capability.

To maximise the cost-effectiveness of long-distance power transmission, electrical substations are usually located as close as possible to power-producing facilities. When such a power-producing facility, such as an offshore wind farm, is located at sea, an electrical substation is typically located on a nearby offshore platform near the power-producing facility. Any electrical power generated by the power-producing facility can then be stepped up to a higher voltage level via a transformer of the substation before being transmitted over long distances.

In the event of damage to the transformer, a replacement transformer is transported via a transport barge to the substation platform. Conventionally the defective and replacement transformers are transferred between the transport barge and the substation platform using a barge including a jack-up crane. The jack-up crane is employed to lift the defective transformer from the offshore platform and transfer the defective transformer to the barge for subsequent transport to land. The jack-up crane is also employed to lift the replacement transformer from the barge to a designated location on the substation platform.

Such barges with a jack-up crane however are usually not available at short notice. The lack of availability of barges with jack-up cranes

results in a long lead time in replacing the defective transformer, and therefore a substantial offline period of the electrical substation. This not only leads to lost revenue for the power-producing facility operator, but also results in inconvenience for those relying on supply of electrical power from the power-producing facility.

According to a first aspect of the invention, there is provided a substation platform for use in offshore power transmission comprising a primary floor including at least one opening; at least one transformer assembly including one or more transformers for connection in use to one or more electrical networks, the or each transformer assembly being releasably connected to the primary floor, and at least one strand jack including one or more cables, the or each cable being operable to releasably connect to a respective transformer assembly and the or each strand jack being operable to lower or lift the respective transformer through the respective opening in the primary floor.

The provision of at least one strand jack in the substation platform removes the need for jack-up cranes when replacing a defective transformer. Strand jacks can be used to lift heavy equipment while occupying a relatively small footprint. It is therefore possible to install multiple strand jacks on a substation platform without significant increase in size and weight of the platform. The constant availability of strand jacks results in a relatively short lead time in replacing defective transformers on substation platforms.

Transferring transformers between platform and barge through an opening in the primary floor leads to improved safety for workers on the substation platform because it eliminates the risk of a transformer falling onto the platform while being lifted in the air.

Preferably the or each opening in the primary floor is located underneath the transformer assembly.

The provision of an opening underneath the transformer assembly results in time savings and convenience for the platform workers because there is no need to move the heavy transformer to another location on the platform

before being lowered onto an incoming barge. In addition, the risk of accidents arising from the transport of heavy transformers around the platform is eliminated.

The or each transformer assembly preferably closes the respective opening of the primary floor when the or each transformer assembly is attached to the primary floor.

Using the transformer assembly to close the opening in the primary floor decreases the risk of workers falling through uncovered openings in the platform.

In embodiments of the invention the or each strand jack may be located above the respective transformer assembly.

Such an arrangement allows for fast attachment of the or each strand jack to the transformer assembly and thereby reduces lead time associated with replacing the transformer. Otherwise it would be necessary to move the or each strand jack from elsewhere on the substation platform to the desired position to enable replacement of the transformer.

Additionally the or each strand jack positioned above the transformer assembly may be attached to the transformer assembly at all times during normal operation of the substation platform to provide the transformer assembly with additional support and prevent the possibility of the transformer assembly falling through the opening in the primary floor into the sea. In addition, constant attachment of the or each strand jack to the transformer assembly reduces lead time in replacing defective transformers by removing the step of attaching the or each strand jack to the transformer assembly.

In other embodiments the or each transformer assembly may include a secondary floor attached to the base of the respective transformer and releasably connected to the primary floor.

The secondary floor provides additional support to the transformer assembly. In addition, the inclusion of a secondary floor results in a modular arrangement in which the secondary floor having a standard size is used to support a range of transformers having different footprint sizes.

In further embodiments the or each secondary floor closes the respective opening in the primary floor when the or each secondary floor is connected to the primary floor.

Closing the opening in the primary floor with the secondary floor of the transformer assembly reduces the risk of people or equipment falling through the primary floor into the sea. In addition, it is more straightforward to fasten the secondary floor to the primary floor when the footprints of the secondary floor and the opening are closely matched.

In embodiments of the invention the primary floor and/or the or each secondary floor may include a grill structure.

The use of a grill structure reduces the weight of the or each floor, which renders the or each floor easier to transport. It also leads to a reduction in material, which leads to increased cost savings without affecting the strength of the floor.

In other embodiments the or each secondary floor may be releasably connected to the primary floor via one or more bolted connections.

The inclusion of one or more bolt connections allows for quick attachment and/or detachment of the secondary floor during the transfer of the transformer assembly between platform and barge.

In further embodiments, the or each transformer assembly may include a spreader beam for connection in use to the or each cable of the respective strand jack. In such embodiments employing the use of a spreader beam, the or each spreader beam may be operable to releasably connect to a respective secondary floor using a plurality of chains or slings.

The use of a spreader beam to interconnect strand jacks and the transformer assembly helps to maintain the positions of lifting equipment, such as chains and slings, relative to the transformer assembly during lifting or lowering of the transformer assembly. This prevents contact between such lifting equipment and the transformer, and thereby prevents accidental damage to the transformer.

Preferably at least one floor may include a bunded tank. The bunded tank acts to secure against transformer leaks and/or as a catchment for fire suppression fluids.

According to a second aspect of the invention, there is provided a method of replacing a transformer on a substation platform of any of the preceding claims comprising the steps of detaching a first transformer assembly from a primary floor; operating the or each strand jack to lower the first transformer assembly through an opening in the primary floor; placing the first transformer assembly onto a boat; and detaching the or each cable of the respective strand jack from the first transformer assembly.

In such embodiments the method may further include the step of the connecting one or more cables of at least one strand jack to the first transformer assembly before the step of detaching the first transformer assembly from the primary floor.

In embodiments of the invention the method may further include positioning a boat carrying a second transformer assembly so that the second transformer assembly is beneath the opening in the primary floor; connecting one or more cables of at least one strand jack to the second transformer assembly; operating the or each strand jack to lift the second transformer assembly through the opening in the primary floor; and attaching the second transformer assembly to the primary floor.

In such embodiments the method may further include the step of detaching the or each cable of the respective strand jack from the second transformer assembly after the step of attaching the second transformer assembly to the primary floor.

The first transformer assembly may be detached from the first primary floor by detaching a secondary floor of the first transformer assembly from the primary floor. Preferably this is performed by releasing the one or more bolted connections.

The second transformer assembly may be attached to the first primary floor by attaching a secondary floor of the second transformer assembly to

the primary floor. Preferably this is performed by bolting the secondary floor of the secondary transformer assembly to the primary floor.

Preferred embodiments of the invention will now be described, by way of non-limiting examples, with reference to the accompanying drawings in which:

Figures 1 and 2 show a substation platform according to an embodiment of the invention; and

Figure 3 shows the transfer of a transformer assembly between the substation platform and a barge.

A substation platform for use in offshore power transmission according to an embodiment of the invention is shown in Figure 1.

The substation platform 10 comprises a primary floor 12, which is in the form of a floor of the substation platform 10. In other embodiments it is envisaged that the primary floor 12 may be in the form of a floor of a sub-frame attached to the substation platform 10.

The substation platform 10 is supported by a plurality of jack up legs 18, as shown in Figures 1 and 2, the jack up legs being operable to raise the substation platform 10 such that the primary floor 12 is raised at a height above sea level to allow barges to pass through underneath the primary floor 12.

In Figure 2, the transformer assembly 14 includes a secondary floor 20 attached to the base of the transformer 24 and releasably connected to the primary floor 12 to ensure that the transformer assembly 14 retains its position during normal operation of the substation platform 10, regardless of weather conditions. For example, the secondary floor 20 may be fastened to the primary floor 12 using one or more bolted connections. The transformer assembly 14 may be located inside a topsides structure 22 to protect the transformer assembly 14 from adverse weather conditions.

The transformer assembly 14 includes a transformer 24 for connection in use to one or more electrical networks which are capable of stepping up or stepping down the voltage of electrical power transmitted between electrical networks via the transformer 24. The transformer 24 sits on the secondary floor 20 and may be either attached or unattached to the secondary floor 20. It is envisaged

that in embodiments of the invention each transformer assembly 14 may include more than one transformer 24.

The primary floor 12 includes an opening which is formed underneath the transformer assembly 14 by detaching the secondary floor 20 of the transformer assembly 14 from the primary floor 12. Preferably the or each secondary floor 20 closes the respective opening in the primary floor 12 when the or each secondary floor 20 is connected to the primary floor 12. Closing the opening in the primary floor 12 with the secondary floor 20 of the transformer assembly 14 reduces the risk of people or equipment falling through the primary floor 12 into the sea. In addition, it is more straightforward to fasten the secondary floor 20 to the primary floor 12 when the footprint of the secondary floor 20 closely matches the footprint of the opening in the primary floor 12.

The primary floor 12 and/or the secondary floor 20 include a grill structure. The use of a grill structure reduces the weight of the or each floor, which renders the or each floor easier to transport. It also leads to a reduction in material, which leads to increased cost savings without affecting the mechanical strength of the or each floor 12,20.

The primary floor 12 and/or the secondary floor 20 may include a bunded tank to secure against transformer leaks and/or act as a catchment for fire suppression fluids.

The footprint of the secondary floor 20 may be different in size to that of the transformer 24. This allows the development of a modular arrangement in which a secondary floor 20 of standard size is used with an opening 26 of standard size while accommodating transformers 24 with different footprint sizes.

It is envisaged that in other embodiments a substation platform 10 may include a plurality of transformer assemblies 14, each being releasably connected to the primary floor 12 of the substation platform 10.

Each strand jack 16 includes a hydraulic cylinder, one or more cables 28 guided through the hydraulic cylinder, and first and second anchors.

Preferably the plurality of strand jacks 16 is located above the respective transformer assembly. For example, in Figures 1 and 2, the strand jacks 16 are mounted onto the roof of the topsides structure 22 so as to be located above the transformer assembly. The roof beams of the topsides structure 22 are designed to accommodate the weight of the transformer at the strand jack positions. The strand jacks 16 pass through a sealed penetration in a roof deck plate of the topsides structure 22 to permit attachment of each strand jack 16 to the transformer assembly.

It is envisaged that in other embodiments of the invention, the or each strand jack 16 may be temporarily positioned above the transformer assembly during replacement of the transformer and stored elsewhere on the substation platform during normal operation of the substation platform.

The transformer assembly 14 includes a spreader beam for connection in use to the or each cable 28 of the respective strand jack 16. The or each cable 28 is releasably connected to the spreader beam at a first end and anchored at a second end. The spreader beam is releasably connected to the secondary floor 20 using a plurality of chains or slings.

The first and second anchors are positioned at opposite ends of the hydraulic cylinder to allow the or each cable 28 to pass through the first and second anchors. These first and second anchors are operable to alternate between gripping and releasing the or each cable 28.

The purpose of the strand jacks 16 is to lower or lift the transformer assembly 14 through the opening 26 in the primary floor 12. Each strand jack 16 may be operated as follows:

The first anchor is controlled to grip a portion of the or each cable 28 and therefore supports the weight of the transformer assembly 14. The hydraulic cylinder applies a force onto the first anchor to drive the first anchor away from the hydraulic cylinder from a first position to a second position. This causes the gripped cable 28 to be guided through the hydraulic cylinder by the movement of the first anchor. When the first anchor reaches the second position, the second anchor is controlled to grip a portion of the or each cable 28 followed

by the first anchor releasing its grip on the cable 28. The second anchor now supports the weight of the transformer assembly 14.

The first anchor is controlled to return to the first position and to grip a different portion of the cable 28 at the first position. This is followed by the second anchor releasing its grip on the cable 28 to allow the hydraulic cylinder to once more drive the first anchor from the first position to the second position.

The above operation is repeated to incrementally pull the cable 28 through the cylinder and therefore the load in the intended direction. The linear movement of the cable 28 together with the hydraulic strength of the strand jack 16 can be applied to the lifting or lowering of the respective transformer assembly 14.

The or each strand jack 16 is therefore operable to lower or lift the respective transformer assembly 14 through an opening 26 in the primary floor 12.

The required number of strand jacks 16 and cables 28 per strand jack 16 may vary depending on the weight of the transformer assembly 14. It is straightforward to install a large number of strand jacks 16 due to the small footprint of each strand jack 16.

It is envisaged that in other embodiments the strand jacks 16 may either be constantly connected to the transformer assembly 14 or only connected to the transformer assembly 14 when the transformer 24 needs replacing.

The replacement of a transformer 24 on a substation platform 10 is carried out as follows:

When a transformer 24 on a substation platform 10 is found to be defective, a transport barge 30 is requested. The transport barge 30 is positioned underneath the opening 26 of the primary floor 12 corresponding to the location of a first transformer assembly 14 including the defective transformer 24.

If the strand jacks 16 are not already connected to the first transformer assembly, it is necessary to first connect one or more cables 28 of at least one strand jack 16 to a first transformer assembly 14 before detaching the first transformer assembly 14 from the primary floor 12. In embodiments

employing the use of a spreader beam, it may be necessary to connect the or each cable 28 to the spreader beam.

The first transformer assembly 14 is detached from the primary floor 12 by unbolting a secondary floor 20 of the first transformer assembly 14 from the primary floor 12. This is followed by the strand jacks 16 being operated to lower the first transformer assembly 14 through an opening in the primary floor 12 and the placement of the first transformer assembly 14 onto a barge 30, as shown in Figure 2.

Once the first transformer assembly is safely placed on the barge 30, the or each cable 28 of the respective strand jack 16 are detached from the first transformer assembly 14 to allow the barge 30 to transport the first transformer assembly 14 away from the substation platform 10 to another location.

A barge 30 carrying a second transformer assembly is then positioned underneath the substation platform 10 so that the second transformer assembly is located underneath the opening 26 in the primary floor 12, as shown in Figure 3. The or each cable of at least one strand jack is releasably connected to the second transformer assembly so that the or each strand jack can be operated to lift the second transformer assembly through the opening 26 in the primary floor 12. Once the transformer is lifted to platform level, the secondary floor of the second transformer assembly is bolted to the primary floor 12.

After securing the second transformer assembly to the primary floor 12, the or each cable 28 of the respective strand jack 16 may be detached from the second transformer assembly.

Preferably the same barge 30 is used to transport both first and second transformer assemblies to minimise the number of trips and therefore reduce the offline period of the substation platform 10.

The method of replacing a transformer 24 on a substation platform 10 may also be used to replace a non-defective transformer with another transformer having different operating parameters.

CLAIMS

1. A substation platform for use in offshore power transmission comprising a primary floor including at least one opening; at least one transformer assembly including one or more transformers for connection in use to one or more electrical networks, the or each transformer assembly being releasably connected to the primary floor, and at least one strand jack including one or more cables, the or each cable being operable to releasably connect to a respective transformer assembly and the or each strand jack being operable to lower or lift the respective transformer through the respective opening of the primary floor.

2. A substation platform according to Claim 1 wherein the or each opening in the primary floor is located underneath the respective transformer assembly.

3. A substation platform according to Claim 1 wherein the or each transformer assembly closes the respective opening of the primary floor when the or each transformer assembly is connected to the primary floor.

4. A substation platform according to any of the preceding claims wherein the or each strand jack is located above the respective transformer assembly.

5. A substation platform according to any of the preceding claims wherein the or each transformer assembly includes a secondary floor attached to the base of the respective transformer and releasably connected to the primary floor.

6. A substation platform according to Claim 5 wherein the or each secondary floor closes the respective opening in the primary floor when the or each secondary floor is connected to the primary floor.

7. A substation platform according to Claim 5 or Claim 6 wherein the primary floor and/or the or each secondary floor includes a grill structure.

8. A substation platform according to any of Claims 5 to 7 wherein the or each secondary floor is releasably connected to the primary floor via one or more bolted connections.

9. A substation platform according to any of the preceding claims wherein the or each transformer assembly includes a spreader beam for connection in use to the or each cable of the respective strand jack.

10. A substation platform according to Claim 9, when dependent from any of Claims 5 to 8, wherein the or each spreader beam is operable to releasably connect to the respective secondary floor using a plurality of chains or slings.

11. A substation platform according to any preceding claim wherein at least one floor includes a bunded tank.

12. A method of replacing a transformer on a substation platform of any of the preceding claims comprising of the steps of

detaching a first transformer assembly from the primary floor;

operating the or each strand jack to lower the first transformer assembly through the respective opening in the primary floor;

placing the first transformer assembly onto a boat; and

detaching the or each cable of the respective strand jack from the first transformer assembly.

13. A method according to Claim 12 further including the step of connecting one or more cables of at least one strand jack to the first transformer assembly before detaching the first transformer assembly from the primary floor.

14. A method according to Claim 12 or Claim 13 further including the steps of:

positioning a boat carrying a second transformer assembly so that the second transformer assembly is located underneath the opening in the primary floor;

connecting one or more cables of at least one strand jack to the second transformer assembly;

operating the or each strand jack to lift the second transformer assembly through the opening in the primary floor; and

attaching the second transformer assembly to the primary floor.

15. A method according to Claim 14 further including the step of detaching the or each cable of the respective strand jack from the second transformer assembly after attaching the second transformer assembly to the primary floor.

16. A method according to any of Claims 12 to 15 when dependent from any of Claims 5 to 8 wherein the first transformer assembly is detached from the first primary floor by detaching a secondary floor of the first transformer assembly from the primary floor.

17. A method according to Claim 16 when dependent from Claim 8 wherein the secondary floor of the first transformer assembly is detached from the primary floor by releasing the one or more bolted connections.

18. A method according to any of Claims 12 to 15 when dependent from any of Claims 5 to 8 wherein the second transformer assembly is attached to the first primary floor by attaching a secondary floor of the second transformer assembly to the primary floor.

19. A method according to Claim 18 when dependent from Claim 8 wherein the secondary floor of the second transformer assembly is bolted to the primary floor.

AMENDED CLAIMS
received by the International Bureau on 02 August 2011 (02.08.2011)

AMENDED CLAIMS - ARTICLE 19 PCT

1. A substation platform for use in offshore power transmission comprising a primary floor including at least one opening; at least one transformer assembly including one or more transformers for connection in use to one or more electrical networks, the or each transformer assembly being releasably connected to the primary floor, and at least one strand jack including one or more cables, the or each cable being operable to releasably connect to a respective transformer assembly and the or each strand jack being operable to lower or lift the respective transformer through the respective opening of the primary floor, wherein the or each transformer assembly includes a secondary floor attached to the base of the respective transformer and releasably connected to the primary floor.

2. A substation platform according to Claim 1 wherein the or each opening in the primary floor is located underneath the respective transformer assembly.

3. A substation platform according to Claim 1 wherein the or each transformer assembly closes the respective opening of the primary floor when the or each transformer assembly is connected to the primary floor.

4. A substation platform according to any of the preceding claims wherein the or each strand jack is located above the respective transformer assembly.

5. A substation platform according to any of the preceding claims wherein the or each secondary floor closes the respective opening in the primary floor when the or each secondary floor is connected to the primary floor.

6. A substation platform according to any of the preceding claims wherein the primary floor and/or the or each secondary floor includes a grill structure.

7. A substation platform according to any of the preceding claims wherein the or each secondary floor is releasably connected to the primary floor via one or more bolted connections.

8. A substation platform according to any of the preceding claims wherein the or each transformer assembly includes a spreader beam for connection in use to the or each cable of the respective strand jack.

9. A substation platform according to Claim 8, wherein the or each spreader beam is operable to releasably connect to the respective secondary floor using a plurality of chains or slings.

10. A substation platform according to any preceding claim wherein at least one floor includes a bunded tank.

11. A method of replacing a transformer on a substation platform of any of the preceding claims comprising of the steps of

detaching a first transformer assembly from the primary floor by detaching a secondary floor of the first transformer assembly from the primary floor;

operating the or each strand jack to lower the first transformer assembly through the respective opening in the primary floor;

placing the first transformer assembly onto a boat; and

detaching the or each cable of the respective strand jack from the first transformer assembly.

12. A method according to Claim 11 further including the step of connecting one or more cables of at least one strand jack to the first transformer assembly before detaching the first transformer assembly from the primary floor.

13. A method according to Claim 11 or Claim 12 further including the steps of:

positioning a boat carrying a second transformer assembly so that the second transformer assembly is located underneath the opening in the primary floor;

connecting one or more cables of at least one strand jack to the second transformer assembly;

operating the or each strand jack to lift the second transformer assembly through the opening in the primary floor; and

attaching the second transformer assembly to the primary floor.

14. A method according to Claim 13 further including the step of detaching the or each cable of the respective strand jack from the second transformer assembly after attaching the second transformer assembly to the primary floor.

15. A method according to any of Claims 11 to 14 when dependent from Claim 7 wherein the secondary floor of the first transformer assembly is detached from the primary floor by releasing the one or more bolted connections.

16. A method according to any of Claims 11 to 15 wherein the second transformer assembly is attached to the primary floor by attaching a secondary floor of the second transformer assembly to the primary floor.

17. A method according to Claim 16 when dependent from Claim 7 wherein the secondary floor of the second transformer assembly is bolted to the primary floor.

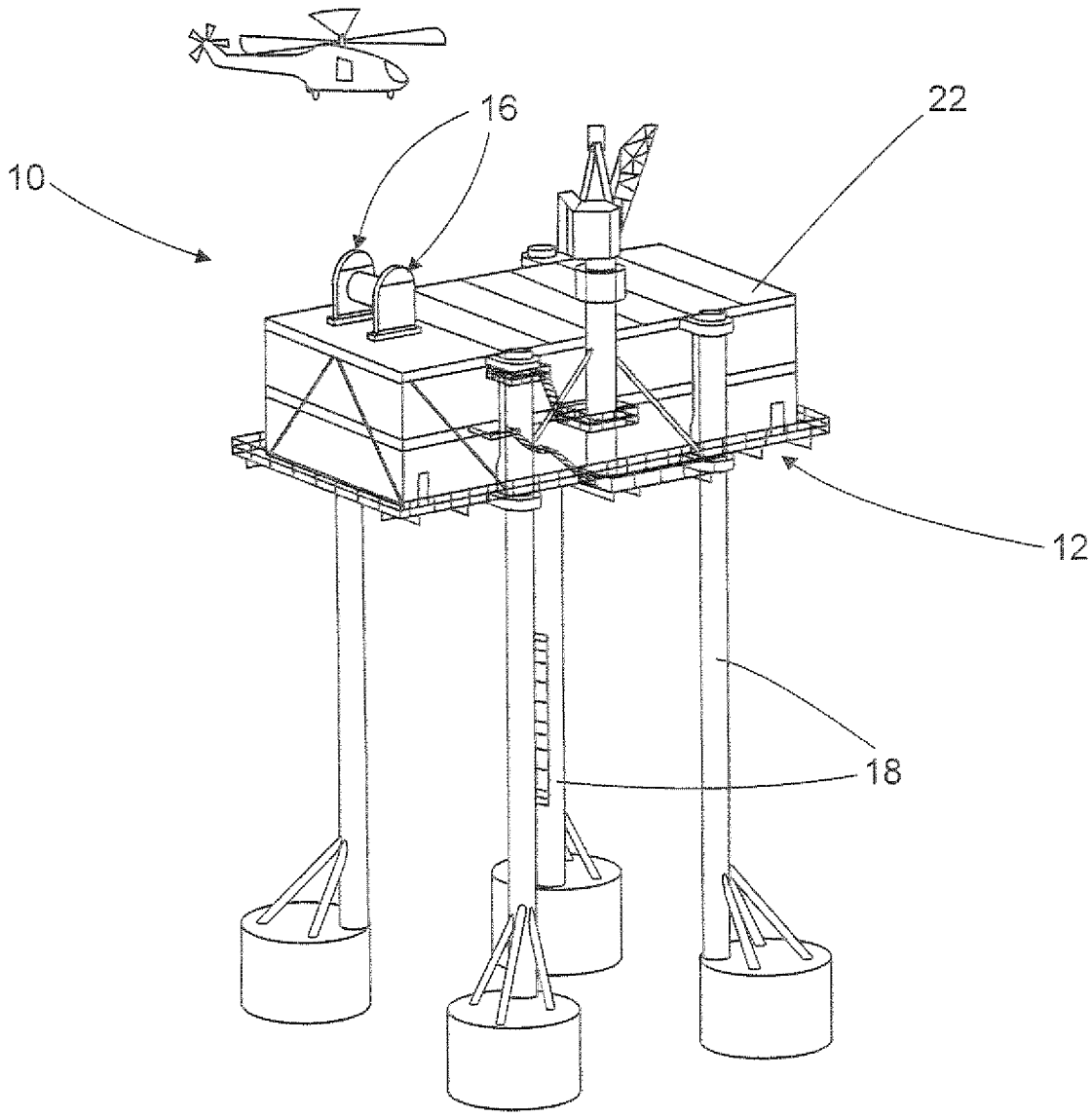

Fig. 1

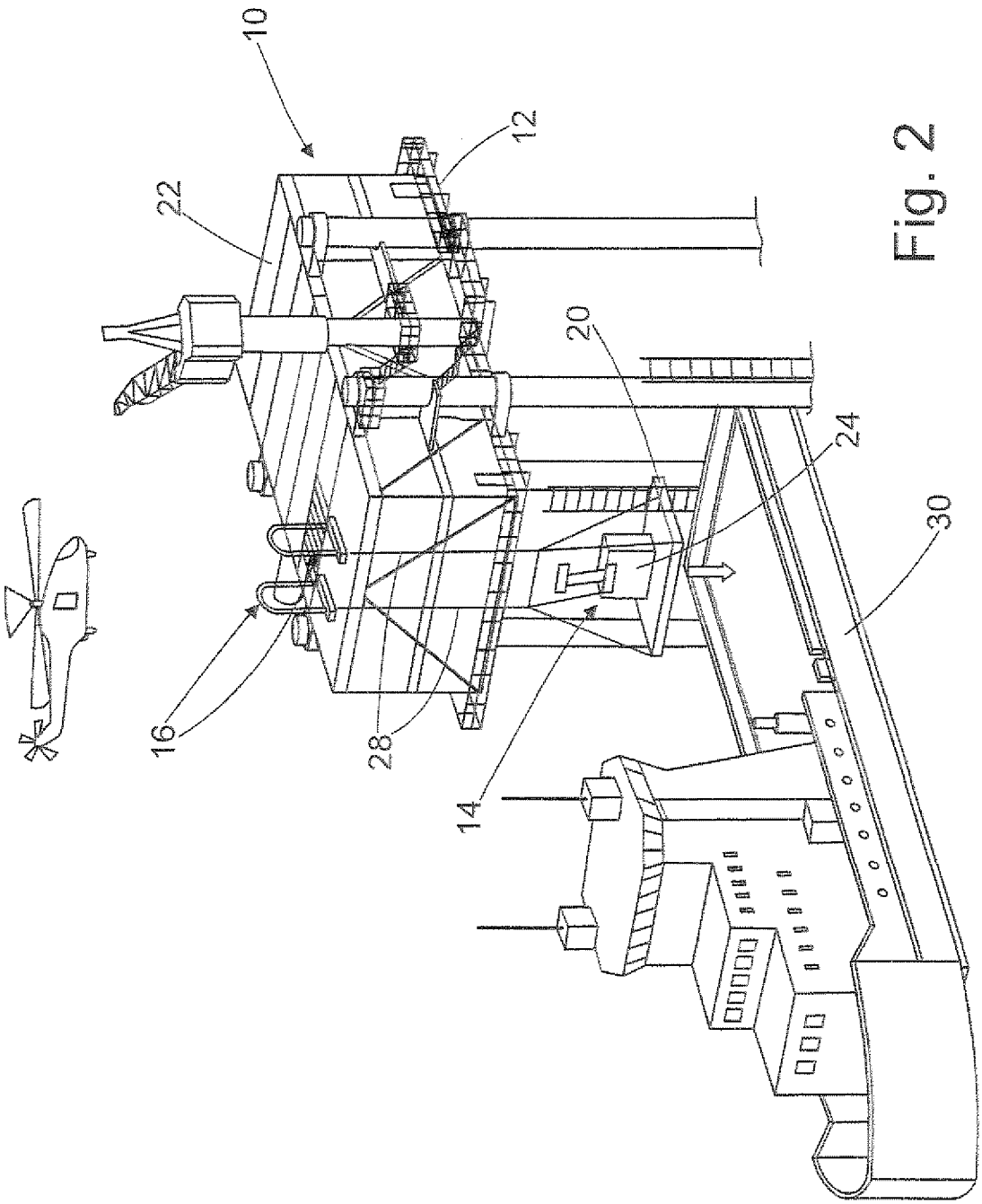

Fig. 2

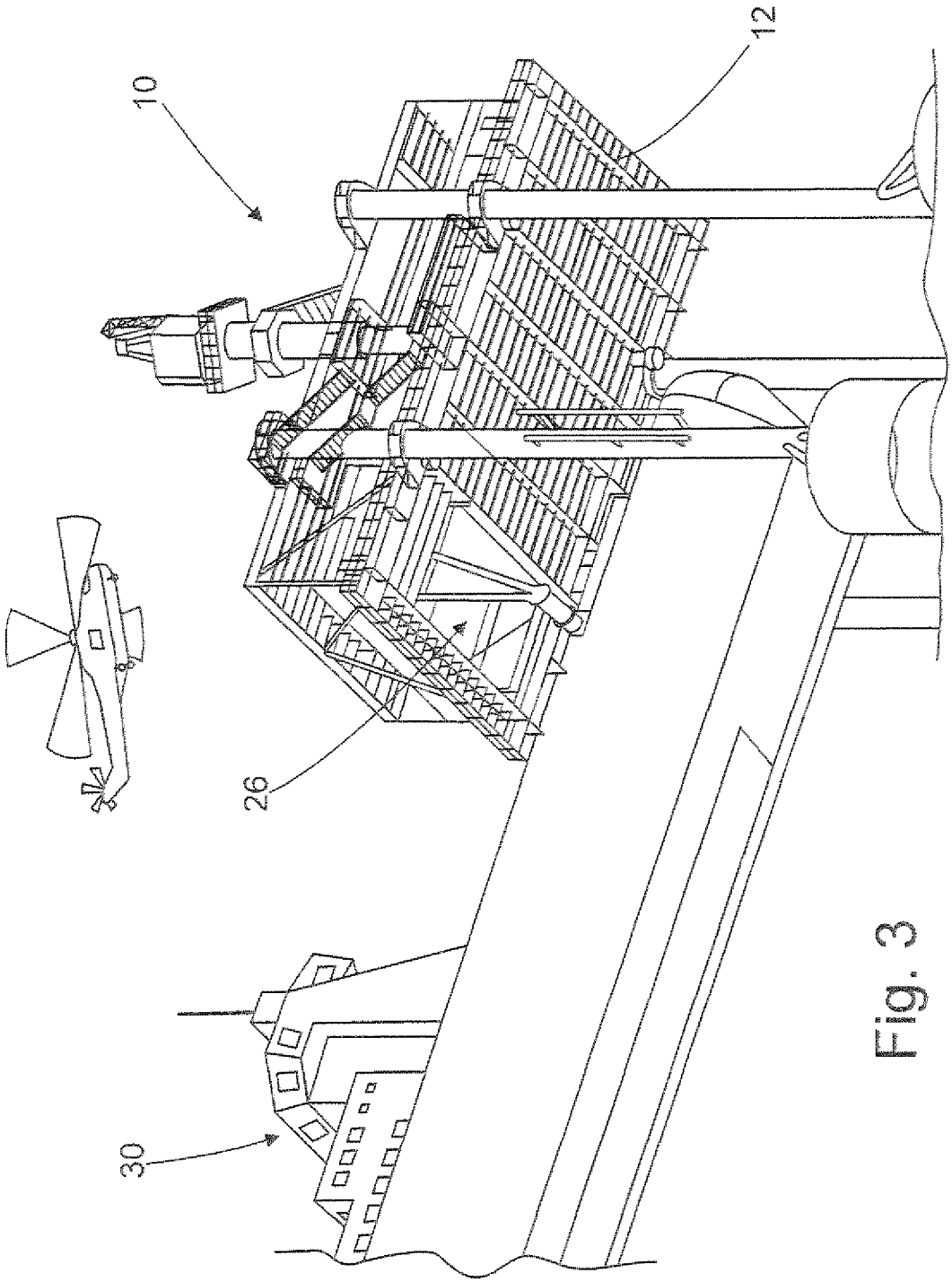

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/054465

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02B17/00 F03D1/00 H02B5/00
ADD.

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)
E02B F03D H02B

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.
X Y A	EP 2 159 420 A1 (MITSUBISHI HEAVY IND LTD [JP]) 3 March 2010 (2010-03-03) paragraph [0031]; figure 14	1-4,9,11 12-15 5-8,10, 16-19
Y	WO 01/46583 A2 (AERODYN ENG GMBH [DE]; SIEGFRIEDSEN SOENKE [DE]) 28 June 2001 (2001-06-28) page 4, paragraph 5; figure 4	12-15
A	EP 1 101 934 A2 (ENRON WIND GMBH [DE] GEN ELECTRIC [US]) 23 May 2001 (2001-05-23) the whole document	5,16
A	WO 2007/096008 A1 (ECOTECNIA S COOP C L [ES]; VILADOMIU I GUARRO PERE [ES]; VALERO SEBAST) 30 August 2007 (2007-08-30) figure 9	5,16

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 December 2010	03/01/2011

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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