



(51) International Patent Classification:

E21B 41/00 (2006.01) *B63C 11/34* (2006.01)
B63G 8/00 (2006.01)

(21) International Application Number:

PCT/US2018/017996

(22) International Filing Date:

13 February 2018 (13.02.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/459,819 16 February 2017 (16.02.2017) US

(71) Applicant (for US only): **SHELL OIL COMPANY**
[US/US]; P.O. Box 576, Houston, Texas 77001-0576 (US).

(71) Applicant (for all designated States except US): **SHELL
INTERNATIONALE RESEARCH MAATSCHAPPIJ
B.V.** [NL/NL]; Carel van Bylandtlaan 30, NL-2596 The
Hague (NL).

(72) Inventors: **BLIESKE, Matthew**; Shell TechWorks,
1 Broadway, Cambridge, Massachusetts 02142 (US).
MAUNUS, Jeremy; Shell TechWorks, 1 Broadway Cam-
bridge, Cambridge, Massachusetts 02142 (US). **FITZPA-**

TRICK, Garret; 41 Danny Rd., Readville, Massachusetts
02137 (US).

(74) Agent: **VANDENHOFF, Deborah**; Shell Oil Company,
P.O. Box 576, Houston, Texas 77001-0576 (US).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP,
KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: SUBMERSIBLE AUTONOMOUS BARGE

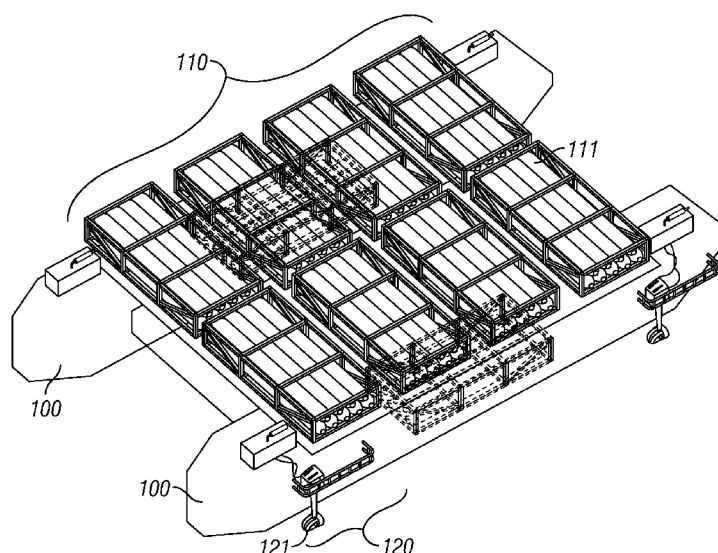


FIG. 1

(57) Abstract: A submersible barge (100) comprising a variable buoyancy system (110), one or more thrusters (121), and a subsea navigation system and associated methods and systems.



TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments (Rule 48.2(h))*

SUBMERSIBLE AUTONOMOUS BARGE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/459,819, filed February 16, 2017, which is incorporated herein by reference.

BACKGROUND

5 [0002] The present disclosure relates generally to submersible barges. More specifically, in certain embodiments, the present disclosure relates to submersible barges useful in low cost subsea installations or recoveries and associated methods and systems.

10 [0003] Currently, subsea equipment may be deployed and/or retrieved using a semi-submersible drilling rig. Typically, drilling rigs are configured to lower the subsea equipment to the ocean floor or to hoist the subsea equipment from the ocean floor to the surface through the use of cables and lines. The subsea equipment may pass through an opening in the center of the rig as it is lowered or lifted from the seafloor. The piece of subsea equipment being retrieved or deployed may be susceptible to being damaged during the installation process or while transporting the subsea equipment. Further, drilling rigs are extremely expensive to
15 operate, costing around \$600,000-\$800,000/day to lease. Furthermore, drilling rigs are transported at a slow rate when compared to other floating vessels (e.g., ships, tug boats), which may increase the amount of time it takes to retrieve and/or deploy sub-sea equipment.

20 [0004] U.S. Patent No. 8,992,127, the entirety of which is hereby incorporated by reference, describes a method of subsea installation which uses a fully submersible deployment vehicle transported to the installation site by submerged tow. The deployment vehicle uses solid buoyancy modules in the form of syntactic foam to remain neutrally buoyant during the towing phase and achieves its final positioning and set down by means of chains lowered into the deployment vehicle that behave as soft springs to control buoyancy and minimize dynamic loading. While this deployment vehicle may not necessarily require
25 the use of large vessels, this concept still requires the chartering of a vessel with a small crane to control positioning and set down.

 [0005] Other methods of utilizing submersible deployment vehicles to install subsea structures is described in U.S. Patent Nos. 9,156,609, the entirety of which is hereby incorporated by reference

30 [0006] It is desirable to develop a subsea installation system that uses a submersible deployment vehicle that does not require the use of a crane.

SUMMARY

[0007] The present disclosure relates generally to submersible barges. More specifically, in certain embodiments, the present disclosure relates to submersible barges useful in low cost subsea installations or recoveries and associated methods and systems.

5 [0008] In one embodiment, the present disclosure provides a submersible barge comprising: one or more buoyancy modules; one or more thrusters, and a subsea navigation system.

[0009] In another embodiment, the present disclosure provides a subsea installation system comprising: a submersible barge; subsea equipment; and a vessel.

10 [0010] In another embodiment, the present disclosure provides a method of installing subsea equipment comprising: providing a submersible barge, transporting the submersible barge to a location above a subsea well site, and maneuvering the barge to the seafloor.

BRIEF DESCRIPTION OF THE DRAWINGS

15 [0011] A more complete and thorough understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings.

[0012] Figure 1 is an illustration of a submersible barge in accordance with certain embodiments of the present disclosure.

20 [0013] Figure 2 is an illustration of a submersible barge in accordance with certain embodiments of the present disclosure.

[0014] The features and advantages of the present disclosure will be readily apparent to those skilled in the art. While numerous changes may be made by those skilled in the art, such changes are within the spirit of the disclosure.

25 DETAILED DESCRIPTION

[0015] The description that follows includes exemplary apparatuses, methods, techniques, and/or instruction sequences that embody techniques of the inventive subject matter. However, it is understood that the described embodiments may be practiced without these specific details.

30 [0016] The present disclosure relates generally to submersible barges. More specifically, in certain embodiments, the present disclosure relates to submersible barges useful in low cost subsea installations or recoveries and associated methods and systems.

[0017] In certain embodiments, the present disclosure describes methods and systems that enable a piece of subsea equipment to be installed on the seafloor without the use of a crane or a heavy lifting vessel. In certain embodiments, the present disclosure provides an alternative to methods that require expensive, multi-purpose, installation vessels to install subsea equipment by instead using a semi-autonomous, submersible barge that can be towed to an installation site by a small vessel.

[0018] In certain embodiments, the present disclosure describes a submersible barge. Referring now to Figure 1, Figure 1 illustrates submersible barge 100. In certain embodiments, submersible barge 100 may comprise a variable buoyancy system 110, thruster assembly 120, and subsea navigation system (not illustrated in Figure 1).

[0019] In certain embodiments, the variable buoyancy system 110 may comprise one or more pressure vessels 111. In certain embodiments, variable buoyancy system 110 may comprise from 10 to 200 pressure vessels 111. In certain embodiments, variable buoyancy system 110 may comprise from 50 to 100 pressure vessels 111.

[0020] In certain embodiments, the one or more pressure vessels 111 may be pressure vessels converted from Compressed Natural Gas (CNG) cylinders. In other embodiments, the one or more pressure vessels 111 may comprise rigid pressure vessels, flexible pressure bladders, and/or other buoyancy devices known in the art.

[0021] In certain embodiments, the one or more pressure vessels 111 may be pressurized with air. In certain embodiments, the one or more pressure vessels 111 may be pressure controlled from the surface to alter the buoyancy as the barge descends through the water column. In certain embodiments, a surface vessel may be used to control the pressure level in each of the one or more pressure vessels. In certain embodiments, the surface vessel may control the pressure level in each of the one or more pressure vessels 111. In certain embodiments, not illustrated in Figure 1, the surface vessel may be attached to submersible barge 100 through tether. In certain embodiments, the tether may be used to provide power and communications to submersible barge 100.

[0022] In certain embodiments, thruster assembly 120 may comprise one or more thrusters 121. In certain embodiments, thrusters 121 may comprise electric or hydraulic thrusters. In certain embodiments, thruster assembly 120 may comprise from 4 to 20 thrusters 121. In certain embodiments, thruster assembly 120 may comprise 4 to 10 thrusters 121.

[0023] In certain embodiments, thrusters 121 may be arranged on submersible

10 barge 100 such that each of the thrusters are oriented along a horizontal plane. In other
embodiments, one or more of the thrusters 121 may be orientated not along the horizontal
plane. In certain embodiments, one or two thrusters 121 may be oriented at each corner of
submersible barge 100. In certain embodiments, thruster assembly 120 may be capable of
5 providing horizontal positioning while submersible barge 100 ascends or descends through
a water column. In certain embodiments, the integrated control system may communicate
with a surface vessel via the winch.

[0024] In certain embodiments, subsea navigation system may comprise an
integrated control system (not illustrated in Figure 1) and an acoustic communication
10 system (not illustrated in Figure 1). In certain embodiments, each thruster 121 may be
connected through the integrated control system. In certain embodiments, the integrated
control system may be capable of distributing power and commands to thrusters 121.

[0025] In certain embodiments, the subsea navigation system may be powered from
the surface through a tether. In other embodiments, the subsea navigation system may be
15 powered from a battery located on the submersible barge 100.

[0026] In certain embodiments, the acoustic communication system may be
capable of communicating with one or more transponders located on a seafloor. In certain
embodiments, the subsea navigation system may be capable of orienting submersible barge
100 relative to one or more transponders on the seafloor to achieve accurate positioning
20 and set down of a subsea equipment module (not illustrated in Figure 1).

[0027] Referring now to Figure 2, Figure 2 illustrates submersible barge 100
connected to a subsea equipment module 150. For clarity sake in Figure 2, the variable
buoyancy system is not illustrated. In certain embodiments, subsea equipment module 150
may comprise a subsea manifold, towhead, or other conventional subsea structure,
25 component, or module. In certain embodiments, subsea equipment module 150 may be
connected to an equipment attachment assembly (not illustrated in Figure 2) on
submersible barge 100.

[0028] In certain embodiments, the present disclosure provides a method
comprising: providing a submersible barge, transporting the submersible barge to a subsea
30 well site, and maneuvering the barge to the seafloor.

[0029] In certain embodiments, the submersible barge may comprise any
combination of features discussed above with respect to submersible barge 100 or 200. In
certain embodiments, the submersible barge may be connected to a subsea equipment

module. In certain embodiments, the subsea equipment module may comprise any combination of features discussed above with respect to subsea equipment modules 150 or 250. In certain embodiments, the subsea module may be connected to the submersible barge in a dry dock before it is transported to a subsea well site. In certain embodiments, the subsea module may be connected to the submersible barge after it is transported to a location above a subsea well site or while it is transported to a location above a subsea well site.

[0030] In certain embodiments, the submersible barge may be transported to the subsea well site by towing it with a vessel. In certain embodiments, the submersible barge may be towed by a tug boat. In certain embodiments, the submersible barge may be floating on a sea surface as it is towed. In other embodiments, the submersible barge may be submerged or partially submerged as it is towed. In certain embodiments, the submersible barge may be neutrally buoyant or near neutrally buoyant state and towed at a specified depth.

[0031] In certain embodiments, the submersible barge may be transported to a location above the subsea well site. In certain embodiments, three or more transponders may be located on the seafloor at or near the subsea well site. In certain embodiments, the three or more transponders may comprise acoustic transponding systems and arrangements similar to those typically used for subsea structure installations. In certain embodiments, three or more transponders may be placed on the seafloor before the submersible barge is transported to a location above the subsea well site. In other embodiments, the one or more transponders may be placed on the seafloor after the submersible barge is transported to a location above the subsea well site or while the submersible barge is transported to a location above the subsea well site.

[0032] In certain embodiments, the submersible barge may be disconnected from the vessel after it is transported to the location above the subsea well site. In such embodiments, a tug line may be disconnected from submersible barge and a tether may remain connected. In certain embodiments, a variable buoyancy system located on the submersible barge may be depressurized allowing for the submersible barge to sink below and/or further below the sea surface. In such embodiments, thrusters may be capable of guiding the submersible barge towards a location on the seafloor. In such embodiments, a subsea navigation system may be capable of controlling the thrusters such that the submersible barge is transported to the seafloor location where one or more transponders

are located.

[0033] In certain embodiments, the submersible barge may be maneuvered to the seafloor after it has been transported to a location above the subsea well site. In certain embodiments, a subsea navigation system on the submersible barge will orient the barge through acoustic signaling with transponders located on the seafloor.

[0034] In certain embodiments, the submersible barge may remain on the seafloor while the subsea equipment is put into operation. In certain embodiments, the submersible barge may be disconnected from the subsea equipment and return to the surface by repressurizing the variable buoyancy system from the surface after the subsea equipment is placed on the seafloor.

[0035] In certain embodiments, the submersible barge may return to the seafloor and retrieve the subsea equipment. In such embodiments, the submersible barge may then be capable of transporting the subsea equipment back to the sea surface.

[0036] While the embodiments are described with reference to various implementations and exploitations, it will be understood that these embodiments are illustrative and that the scope of the inventive subject matter is not limited to them. Many variations, modifications, additions and improvements are possible.

[0037] Plural instances may be provided for components, operations and/or structures described herein as a single instance. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements may fall within the scope of the inventive subject matter.

25

CLAIMS

1. A submersible barge comprising: a variable buoyancy system, a thruster assembly, and a subsea navigation system.
2. The submersible barge of claim 1, wherein the variable buoyancy system
5 comprises one or more pressure vessels.
3. The submersible barge of claim 1, wherein the thruster assembly comprise one or more thrusters.
4. The submersible barge of claim 3, wherein the one or more thrusters are arranged on the submersible barge such that each of the thrusters is oriented along a
10 horizontal plane.
5. The submersible barge of claim 1, wherein the subsea navigation system comprises an integrated control system and an acoustic communication system.
6. The submersible barge of claim 5, wherein the integrated control system may be capable of distributing power and commands to the one or more thrusters.
- 15 7. The submersible barge of claim 5, wherein the acoustic communication system may be capable of communicating to one or more transponders.
8. The submersible barge of claim 1, wherein the submersible barge is connected to a subsea equipment module.
9. The submersible barge of claim 8, wherein the subsea equipment module
20 comprises a subsea manifold, a tow head, or a conventional subsea structure, component, or module.
10. A method of installing subsea equipment comprising: providing a submersible barge, transporting the submersible barge to a location above a subsea well site, and maneuvering the barge to the seafloor.

25

1/2

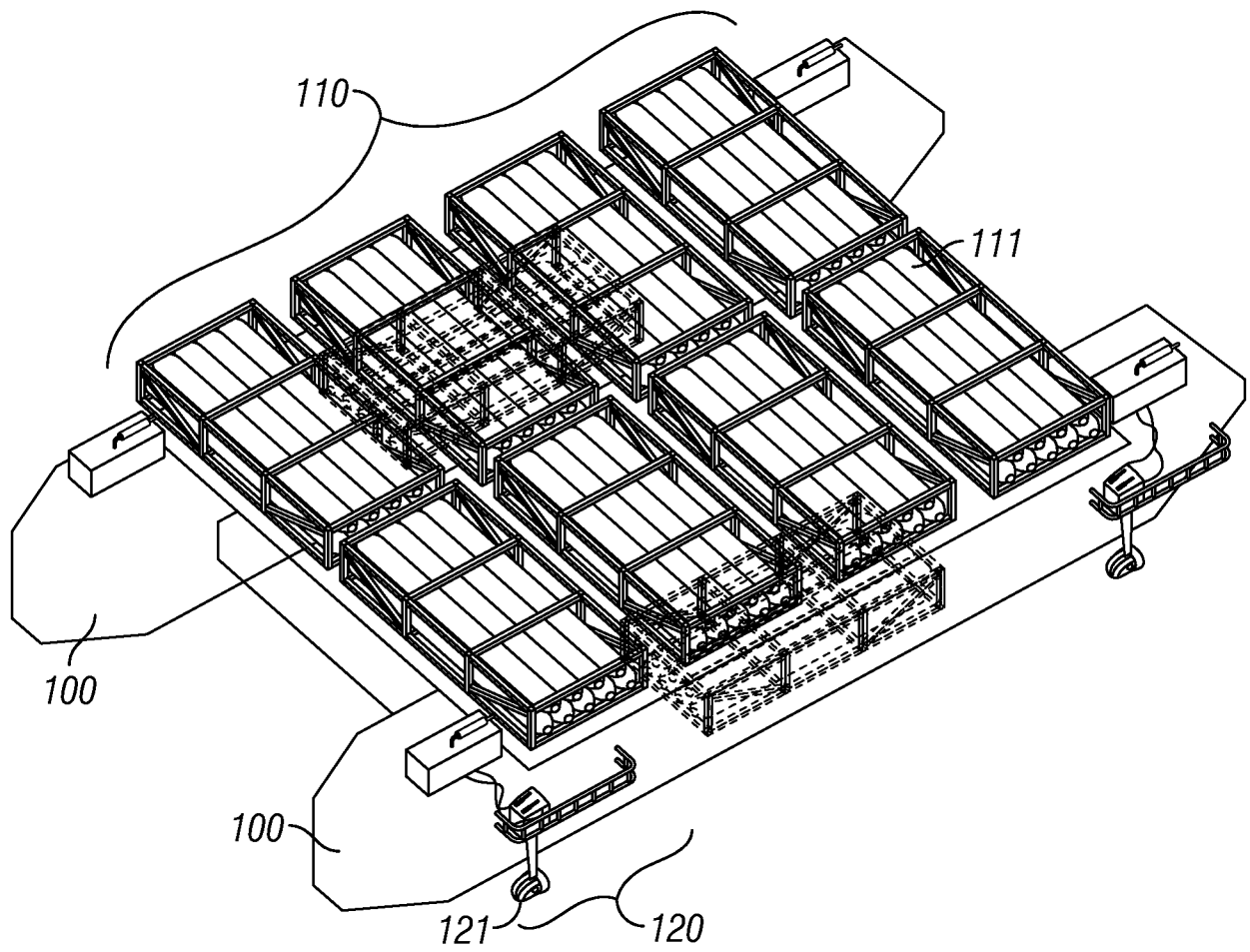


FIG. 1

2/2

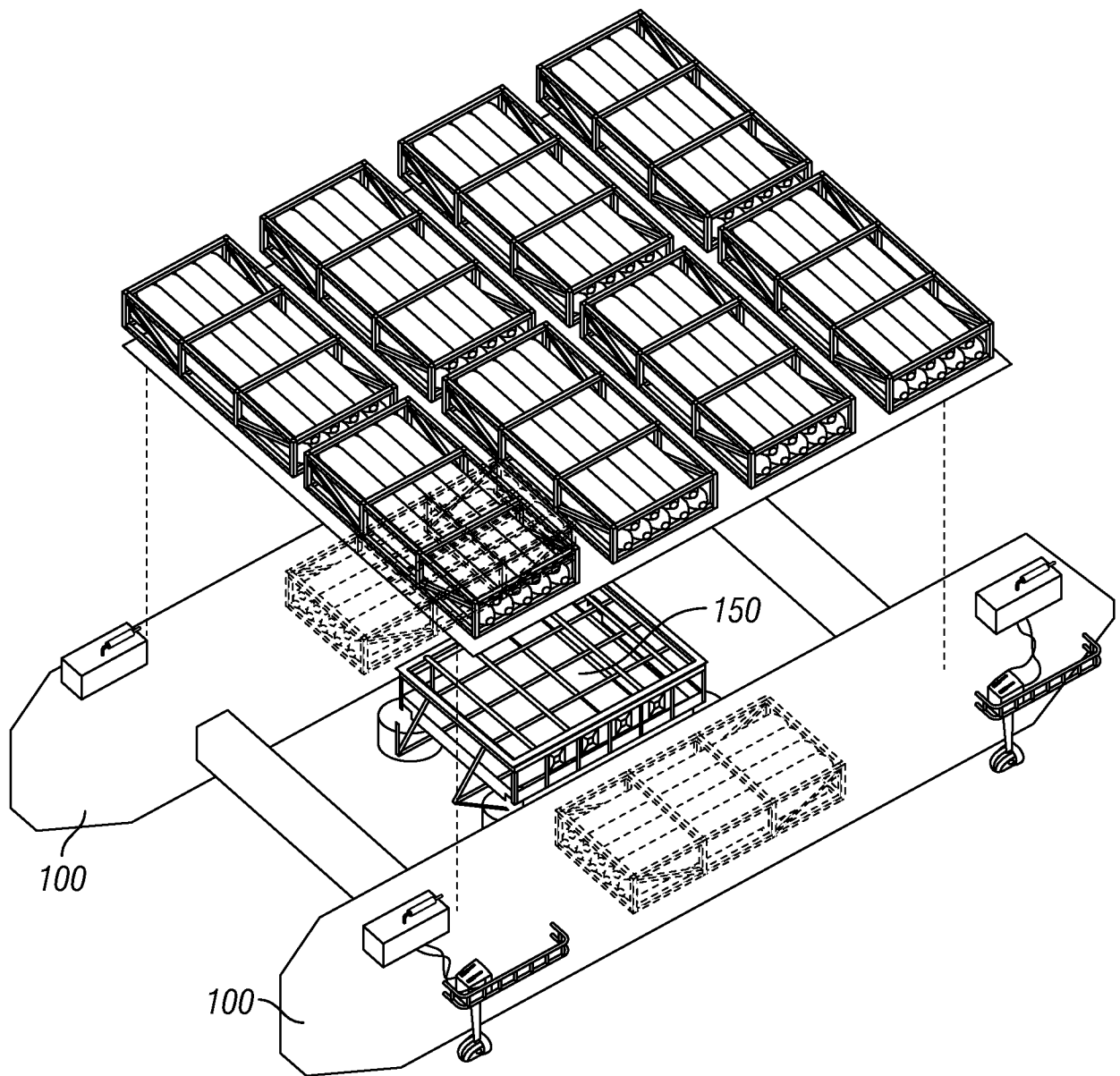


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/017996

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B41/00 B63G8/00 B63C11/34
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)
E21B B63G B63C B63B

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 272 240 A (SUBSEA OFFSHORE LTD [GB]) 11 May 1994 (1994-05-11) page 1, line 16 - page 2, line 15 page 4, line 8 - line 32 page 7, line 3 - page 10, line 1 figures 4-8	1-10
X	----- EP 1 031 506 A2 (MCDERMOTT SA J RAY [US]) 30 August 2000 (2000-08-30) the whole document	1-6,8,9
X	----- US 2011/067618 A1 (DEMPSTER HARRY EDWARD [US]) 24 March 2011 (2011-03-24) the whole document	1-7
X	----- US 7 814 856 B1 (SMITH DAVE [US] ET AL) 19 October 2010 (2010-10-19) the whole document ----- -/-	1-4,8,9



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

4 June 2018

Date of mailing of the international search report

18/06/2018

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Hennion, Dmitri

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/017996

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/108631 A1 (TECHNIP FRANCE [FR])	10
A	17 July 2014 (2014-07-17) page 1, line 3 - page 3, line 2 page 11, line 22 - page 14, line 9 figure 9 -----	1-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2018/017996

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2272240	A	11-05-1994	NONE
EP 1031506	A2	30-08-2000	AT 276919 T 15-10-2004 BR 0000653 A 19-12-2000 DE 60013930 D1 28-10-2004 DE 60013930 T2 16-02-2006 EP 1031506 A2 30-08-2000 ID 24796 A 24-08-2000 MY 120182 A 30-09-2005 NO 20000820 A 25-08-2000 OA 11359 A 17-12-2003 US 6148759 A 21-11-2000
US 2011067618	A1	24-03-2011	NONE
US 7814856	B1	19-10-2010	NONE
WO 2014108631	A1	17-07-2014	FR 3000720 A1 11-07-2014 WO 2014108631 A1 17-07-2014