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(54) PORTABLE SUBSEA WELL SERVICE SYSTEM

(57) A technique facilitates a subsea operation such as a well intervention operation. A system (20) comprises a station (22) movably positioned at a subsea location. The station comprises a housing (26) and a lifting arrangement (28) mounted on the housing to enable lifting of the station and movement of the station from one subsea location to another to enable successive subsea operations. The station further comprises a docking station (30) which may have connectors within the housing. In some applications, the station also may comprise a power lead (34) which may be operatively connected to a subsea installation and a transceiver (44) for communicating data to a desired location, e.g. a surface location. The docking station enables docking with an underwater vehicle (32) used to facilitate the subsea servicing operation.

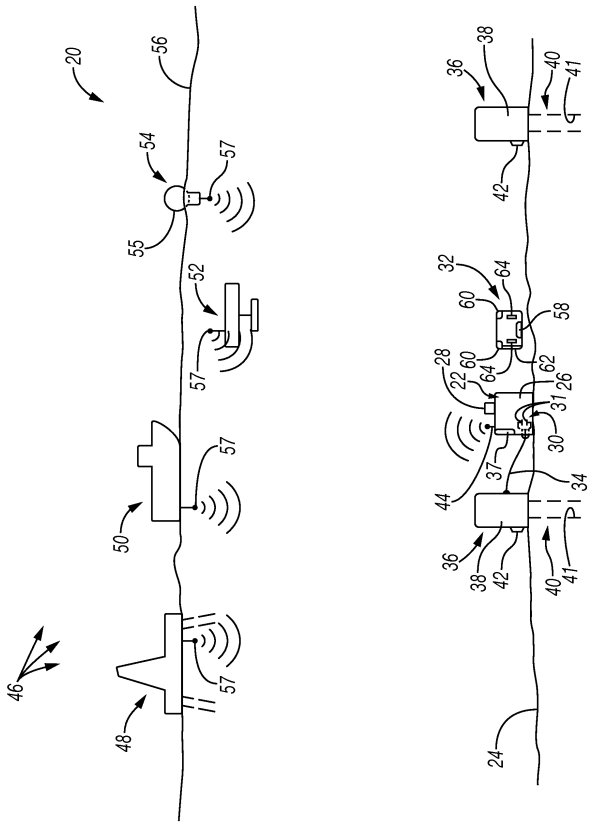

FIG. 1

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Description

BACKGROUND

[0001] Hydrocarbon fluids such as oil and natural gas are obtained from a subterranean geologic formation, referred to as a reservoir, by drilling a well that penetrates the hydrocarbon-bearing geologic formation. In subsea applications, the well is drilled at a subsea location and completed with the appropriate type of completion equipment. The well and the completion equipment may be serviced via intervention operations. However, subsea intervention operations tend to be extremely costly. For example, intervention operations often involve deployment of a rig, e.g. a semi-submersible rig using tension risers, and this deployment is time-consuming and costly. Some subsea intervention operations also may employ a surface vessel to supply equipment for use in the intervention. In some applications, the surface vessel also may be used as a platform for the intervention by being precisely positioned over the subsea well during the well servicing operation.

SUMMARY

[0002] In general, a system and methodology facilitate subsea well servicing, e.g. intervention operations. The system utilizes a station movably positioned on a sea floor. The station comprises a housing and a lifting arrangement mounted on the housing to enable lifting of the station. Consequently, the station may be lifted from one subsea location and moved to another subsea location for a subsequent well service operation. The station further comprises a docking station having connectors within the housing. The docking station may be coupled with a power lead operatively connected with a subsea installation for transfer of power to the station. In some applications, the station also may comprise a transceiver for communicating data to a desired location, e.g. a surface location. The docking station enables docking with an underwater vehicle used to facilitate the subsea intervention operation or other well servicing operation.

[0003] However, many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

Figure 1 is a schematic illustration of an example of a subsea well system utilizing a transportable station able to communicate with a variety of hosts located at the surface or at other suitable locations, according to an embodiment of the disclosure;

Figure 2 is a schematic illustration similar to that of Figure 1 but showing an example of an underwater vehicle in a different operational position relative to the station, according to an embodiment of the disclosure;

Figure 3 is a schematic illustration of an example of a transportable subsea station being moved from one subsea location to another, according to an embodiment of the disclosure; and

Figure 4 is an illustration of an example of a transportable station which may be used with a dockable underwater vehicle, according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0005] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. However, it will be understood by those of ordinary skill in the art that the system and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0006] The present disclosure generally relates to a system and methodology which facilitate subsea well intervention operations. The system utilizes a transportable station which may be movably positioned on a sea floor. The transportable station is readily coupled with a surface vessel or other transport vehicle so that it may be lifted from a subsea location and moved to another subsea location. For example, the transportable station may be positioned on the seabed proximate a well to facilitate a well intervention operation. Upon completion of the well intervention operation, the transportable station may be lifted and moved to another seabed location to facilitate an intervention operation for another well.

[0007] According to an embodiment, the transportable station comprises a housing and a lifting arrangement mounted on the housing to enable lifting of the station. The lifting arrangement may be coupled with a lift line or other suitable mechanism so the transportable station may be lifted from one subsea location and moved to another subsea location for a subsequent intervention operation or other well servicing operation. Depending on the location of the subsequent well, the station may be lifted to the surface and transported via sea, air, and/or land to the subsequent subsea location. The transportable station may further comprise a docking station having connectors within the housing. The docking station may be coupled with a power lead which, in turn, may be

operatively connected with a subsea installation for transfer of power to the station. In some applications, the power lead also may be used to communicate data. However, the transportable station may comprise a transceiver for communicating data to a desired location, e.g. a surface location.

[0008] The docking station further enables docking with an underwater vehicle used to perform the subsea intervention operation. The underwater vehicle may comprise a variety of controllable underwater vehicles having a rechargeable battery or other power supply to power thrusters or other motive devices for moving the underwater vehicle between the station and the desired subsea installation, e.g. wellhead assembly. The underwater vehicle is able to move into the transportable station and dock with the docking station to receive power and/or data. In some applications, the underwater vehicle may remain docked in the transportable station while the station is moved from one subsea location to another.

[0009] The system may be used with subsea wells which extend beneath the sea floor. In such an embodiment, the subsea station may be located on the sea floor. An underwater vehicle is housed in the station and is adapted to service at least one subsea well. The station and underwater vehicle are transportable and may be moved from one subsea well to another subsea well not serviceable from the original position of the station. In some applications, the station and underwater vehicle are used to service wells in a first grouping of subsea wells and then the station and underwater vehicle are transported together to a second location for servicing wells in a second grouping of subsea wells.

[0010] In a specific example, the underwater vehicle comprises a battery which may be recharged when the underwater vehicle docks with a docking station within the underwater station. While docked, the battery may be recharged for further operation of the underwater vehicle in performing well service operations and/or other subsea operations. The battery of the underwater vehicle may be charged, for example, by power supplied via the power lead and/or batteries located on the transportable station. Various data also may be communicated between the surface and the station/underwater vehicle while, for example, the underwater vehicle is docked with the station. In some applications, data also may be communicated when the underwater vehicle is undocked. As described in greater detail below, the underwater vehicle may comprise various other components, such as sensors used to locate wells, the station, and/or other underwater installations.

[0011] In an operational example, the underwater vehicle may be used in a well intervention operation. According to commands provided from the surface, the underwater vehicle gathers appropriate tools from the station. The underwater vehicle is then directed to a desired wellhead corresponding with the well to be serviced. While at the desired well, the underwater vehicle performs a desired intervention operation before returning to and again docking with the underwater station.

[0012] Referring generally to Figure 1, an example of a subsea well system 20 is illustrated. The subsea well system 20 may be used in a variety of subsea applications, e.g. subsea well applications, and comprises a station 22 which is movably positioned on a sea floor 24 or at another subsea location, e.g. on a subsea installation. In other words, the station 22 is transportable from one subsea location to another, e.g. from one sea floor position to another sea floor position, for performance of subsequent subsea operations.

[0013] In the illustrated example, the subsea station 22 comprises a housing 26 and a lifting arrangement 28 mounted on the housing 26 to enable lifting and transport of the station 22 between subsea locations. The underwater station 22 further comprises a docking station 30 located at least partially within the housing 26 and having interfaces 31 to enable docking and undocking with an underwater vehicle 32. The docking station 30 also may be coupled with a power lead 34 which may be selectively coupled with various types of subsea infrastructure 36, e.g. a subsea installation. In some embodiments, the transportable station 22 also may comprise a power source 37, e.g. batteries, for use by the station 22 to recharge the underwater vehicle 32 and/or for other uses.

[0014] By way of example, at least one of the subsea installations 36 may comprise a wellhead assembly 38 (and associated equipment, e.g. blowout preventer and other subsea equipment) positioned generally over a well 40 having a wellbore 41 extending into the subsea geologic formation. The subsea installations 36 may be positioned at desired locations along the sea floor 24 and may each comprise a subsea installation docking station 42 for engagement with underwater vehicle 32. Depending on the application, the underwater vehicle 32 may be used for carrying tools, operating equipment, and performing various subsea operations, e.g. intervention operations, with respect to a given well 40. In some applications, the underwater vehicle 32 may be used for coupling and uncoupling the power lead 34 with the appropriate subsea installation 36.

[0015] During various operations, command signals and/or other data may be communicated from the surface to station 22 or from station 22 to the surface. Accordingly, the station 22 may comprise a transceiver 44 used, for example, to communicate data between the subsea station 22 and a host 46. By way of example, the transceiver 44 may comprise an acoustic or optical transmitter and receiver for sending and/or receiving data wirelessly with respect to the host 46.

[0016] The host 46 may comprise various types of hosts and may comprise one or more of a platform 48, a surface vessel (e.g. a floating production storage and offloading vessel) 50, a wave glider 52, an unmanned surface vehicle 54, e.g. a buoy 55 or other unmanned surface vehicle, or another suitable host located at a sea surface 56 or at a suitable submerged location. Each host 46 comprises a suitable host transceiver 57 for commu-

nicating with station transceiver 44. It should be noted that communication data, e.g. commands, may be communicated via transceiver 44 and/or over power lead 34. For example, low bandwidth data communication may be provided along with power through the power lead 34. The power lead 34 also may incorporate other types of communication lines, e.g. fiber optic communication lines, so that power and data, e.g. underwater vehicle command signals, may be relayed from the subsea installation 36 to the station 22. Other communication systems also may be used for communication of data or to supplement communication of data.

[0017] The underwater vehicle 32 may be constructed in various sizes, configurations, and with several types of components. By way of example, the underwater vehicle 32 may comprise a battery 58, e.g. a rechargeable battery pack, a sensor 60 (or several sensors 60), and a vehicle docking assembly 62. The vehicle docking assembly 62 is configured for docking and undocking with respect to docking station 30 of subsea station 22.

[0018] The sensor or sensors 60 may be used to guide the underwater vehicle 32 to the desired well 40, e.g. to the desired wellhead assembly 38, or to other subsea infrastructure 36 under the power of battery 58. By way of example, the sensor(s) 60 may comprise a laser sensor or other type of light sensor which tracks light from a given light source on the desired subsea infrastructure, e.g. the subsea wellhead assembly 38, so that control signals may be provided to suitable thrusters 64 or other motive units. In this type of example, the battery 58 may be used to power thrusters 64 or other types of motive units which may be selectively oriented or which may work in cooperation with controllable guide vanes to direct the underwater vehicle 32 along a desired path.

[0019] Based on data from the sensor/sensors 60, an internal controller may be used to control thrusters 64, e.g. side thrusters and end thrusters, to guide the underwater vehicle 32 to a desired location. Examples of suitable underwater vehicles 32 may be based on remotely operated vehicles (ROVs) or other controllable underwater vehicles such as the underwater vehicle described in US Patent 6,808,021. Additionally, the underwater vehicle 32 may comprise a variety of tool grasping devices, tool storage devices, torque arms, grappling devices, robotic arms, and/or other features selected to enable a desired intervention operation or other subsea operation.

[0020] With additional reference to Figure 2, the underwater vehicle 32 is illustrated as having undocked from station 22 and moved via thrusters 64 to a well 40. By way of example, the underwater vehicle 32 may be guided via at least one of the sensors 60 into docking engagement with the desired subsea installation 36. However, the underwater vehicle 32 may be operated in cooperation with the subsea installation 36 in a variety of other ways to facilitate a given well servicing operation, e.g. intervention operation.

[0021] In some embodiments, at least one of the sensors 60 may be in the form of a light sensor used to track a light source on the desired subsea installation 36. The light sensor 60 provides sensor data to a suitable vehicle controller, e.g. microprocessor, to enable control over thrusters 64. Thrusters 64 may be controlled so as to direct the underwater vehicle 32 into engagement with installation docking assembly 42 or to another suitable position for interaction with well 40 or other subsea infrastructure 36. In some operations, the underwater vehicle may be used to provide a desired tool or other equipment for use in an intervention operation with respect to the well 40.

[0022] When a given operation is completed with respect to well 40 or a group of wells 40, the underwater station 22 may be moved to another underwater location for servicing of other wells. By way of example, a lift line 66 or other suitable mechanism may be coupled with lifting arrangement 28 of station 22. The station 22 is then lifted from a subsea location, e.g. from a location on sea floor 24, and moved to another desired location, e.g. another location along see floor 24. It should be noted the station 22 also may be transported from and/or to subsea locations on subsea infrastructure 36, e.g. on subsea installations.

[0023] In the embodiment illustrated, lift line 66 also is connected with a surface vessel 68 via, for example, a winch 70 or other suitable lifting device. The lifting device/winch 70 may be operated to lift the station 22 from its position on sea floor 24. This enables the surface vessel 68 to move the station 22 to a subsequent subsea location. Depending on the distance station 22 is to be moved, the station 22 potentially can be moved through water or lifted to the surface vessel 68 for transport. In some operations, the station 22 may be placed on another vessel for transport by sea or by air to another subsea well site. Here, the station 22 may be deployed to the subsequent subsea location for servicing additional wells 40.

[0024] The station 22 may be transported alone or with the underwater vehicle 32 disposed within housing 26 of station 22, as illustrated. For example, the underwater vehicle 32 may be powered via thrusters 64 through an opening 72 in housing 26 and guided into docking engagement with docking station 30 for transport. In some operations, the underwater vehicle 32 may first be used to disconnect power lead 34 from the corresponding subsea installation 36. However, other methods of disconnecting power lead 34 also may be employed to enable transport of station 22.

[0025] Referring generally to Figure 4, an embodiment of station 22 is illustrated in greater detail. It should be noted the station 22 may have a variety of other and/or additional components and features to accommodate parameters of a given operation and/or environment. In the illustrated example, the subsea station 22 comprises housing 26 with generally rectangular sides and having opening 72 located at one end. However, the housing 26 may be constructed with various other shapes, e.g. semi-cylindrical shapes, to accommodate different types of un-

derwater vehicles 32.

[0026] In the example illustrated, lifting arrangement 28 comprises a plurality of lugs 74 having attachment features 76, e.g. openings, to which the lift line 66 or other lifting mechanism may be attached. The plurality of lugs 74 may comprise four lugs 74 positioned in corners of the housing 26, as illustrated. However, different numbers and arrangements of lugs 74 may be used to enable lifting and transport of station 22. In some applications, the lugs 74 may be replaced or supplemented with various other features of lifting arrangement 28.

[0027] As illustrated, the docking station 30 is positioned at least partially within housing 26. By way of example, the docking station 30 may be located within housing 26 and the power lead 34 may be routed from the internal docking station 30, through a wall of housing 26, and to an exterior of housing 26 for coupling with a suitable subsea installation 36 or other subsea equipment. The docking station 30 may comprise a connector 78 or a plurality of connectors 78 to which the power lead 34 is coupled for supplying power and/or data communication.

[0028] By way of example, connectors 78 may comprise power connectors to which electrical conductors of power lead 34 are coupled so as to supply electrical power to docking station 30. The power may be used to recharge battery 58 and/or to provide electrical power for other uses with respect to the underwater vehicle 32 and station 22. In some embodiments, at least one of the connectors 78 may be used for communication of data to or from the underwater vehicle 32 when, for example, transceiver 44 is not used or as a supplement to transceiver 44.

[0029] Depending on the type of application, the power lead 34 may comprise an electrical flying lead adapted to connect to the desired subsea infrastructure, such as the desired subsea installation 36. The power lead 34 may be used for coupling with subsea trees, subsea manifolds, electrical termination units, existing field control systems, or other subsea installations. The power lead 34 receives power from the existing subsea architecture, e.g. the subsea installation 36 to which it is attached. In some embodiments, the power lead 34 also may be configured to receive communication data from the existing subsea system by incorporating fiber optics or other data transmission media. The underwater vehicle 32 or another suitable underwater device may be used to engage the power lead 34 with the subsea installation 36 and to disengage the power lead 34 when the station 22 is moved to another location.

[0030] The docking station 30 also may comprise a guide structure 80 which works in cooperation with connectors 78 so as to facilitate easy docking and undocking of underwater vehicle 32. In this example, the connectors 78 and guide structure 80 serve as interfaces 31 to facilitate the docking and undocking. By way of example, the underwater vehicle 32 may be guided through opening 72 and towards docking station 30 via one or more emitters 82, e.g. light sources, cooperating with a corresponding sensor or sensors 60 of the underwater vehicle 32. The underwater vehicle 32 is moved into station 22 via, for example, thrusters 64 until engaging guide structure 80. The guide structure 80 ensures proper coupling of the vehicle docking assembly 62 with connectors 78. It should be noted the station 22 also may comprise an additional emitter or emitters 83, e.g. a light source, positioned along the exterior ofhousing 26 so as to initially guide underwater vehicle 32 to the general vicinity of station 22 for docking.

[0031] Depending on the parameters of a given operation, e.g. well intervention operation, the subsea station 22 may comprise various other features. For example, the station 22 may comprise internal tool storage areas 84 located along a floor of housing 26. Additionally, the station 22 may comprise storage bins 86, vertical racks 88, horizontal racks 90, and/or other features to accommodate storage of tools 92 and/or other devices. By way of example, the tools 92 may be well intervention tools which may be selected and utilized by underwater vehicle 32 during a well intervention operation on a desired well 40.

[0032] In a well intervention operation, for example, the underwater vehicle 32 may be sent suitable commands via transceiver 44 and/or power lead 34. Based on this command data, the underwater vehicle 32 gathers appropriate tools 92 from station 22 and then undocks from docking station 30. The underwater vehicle 32 then moves via thrusters 64 to the appropriate wellhead assembly 38 corresponding with the well 40 in which the intervention operation is to be performed. In some operations, the underwater vehicle 32 may dock with the corresponding installation docking assembly 42 to perform the intervention operation. Once the intervention operation is completed, the underwater vehicle 32 returns to station 22 and docks with docking station 30 to, for example, recharge battery 58.

[0033] If the overall intervention operations are finished, the lift line 66 may be coupled with lugs 74 via underwater vehicle 32 or via another suitable underwater device. Subsequently, the station 22 (or the station 22 with internal underwater vehicle 32) may be lifted and moved to a subsequent location for additional well servicing operations. Once at the subsequent location, the station 22 is positioned on the sea floor 24 (or at another suitable subsea location) to enable operation of underwater vehicle 32 with respect to a corresponding well or wells 40.

[0034] Depending on the specifics of a given use, the shape, size, and features of station 22 may be adjusted. For example, station housing 26 may have various shapes to accommodate different types of underwater vehicles 32. Similarly, the station 22 may use a variety of lifting assemblies, docking stations, guiding lights or other emitters, transceivers, and tool storage features. The station 22 also may incorporate additional devices or features to accommodate aspects of different types of

well servicing operations. The base of housing 26 may be constructed for resting on various types of sea floor materials and/or engaging various types of subsea installations.

[0035] Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

Claims

1. A system for use in a subsea operation, comprising:

a station movably positioned at a subsea location, the station comprising:

a housing;
a lifting arrangement coupled to the housing to enable repeated coupling of the lifting arrangement with a lift line as the station is sequentially transported from one subsea location to another for a plurality of well servicing operations; and
a docking station having interfaces for an underwater vehicle receivable within the housing.

2. The system as recited in claim 1, further comprising the underwater vehicle dockable with the docking station within the housing.

3. The system as recited in claim 2, wherein the station further comprises a power lead coupled to the docking station and a transceiver for communicating data wirelessly.

4. The system as recited in claim 3, further comprising a host, the transceiver communicating data between the station and the host.

5. The system as recited in claim 1, wherein the station further comprises batteries for supplying electrical power.

6. The system as recited in claim 2, wherein the underwater vehicle comprises a sensor to detect subsurface equipment.

7. The system as recited in claim 2, wherein the underwater vehicle comprises a sensor to detect a subsea infrastructure.

8. The system as recited in claim 2, wherein the underwater vehicle comprises a battery to power the underwater vehicle when it leaves the docking station.

9. The system as recited in claim 2, wherein the transceiver comprises a transmitter for transmitting data wirelessly to a host located on the surface.

10. A system as recited in claim 4, wherein the host comprises a surface vessel.

11. A method, comprising:

placing a transportable station on a sea floor;
docking an underwater vehicle to a docking station within a housing of the transportable station;
coupling a lift line to the transportable station;
lifting the transportable station from the sea floor; and
moving the transportable station to another location on the sea floor.

12. The method as recited in claim 11, further comprising powering the transportable station from a subsea installation.

13. The method as recited in claim 11, further comprising undocking the underwater vehicle from the docking station and directing the underwater vehicle to a subsea infrastructure.

14. The method as recited in claim 11, further comprising using a power lead coupled to the docking station and a transceiver for communicating data wirelessly.

15. The method as recited in claim 11, further comprising providing the station with batteries for supplying electrical power.

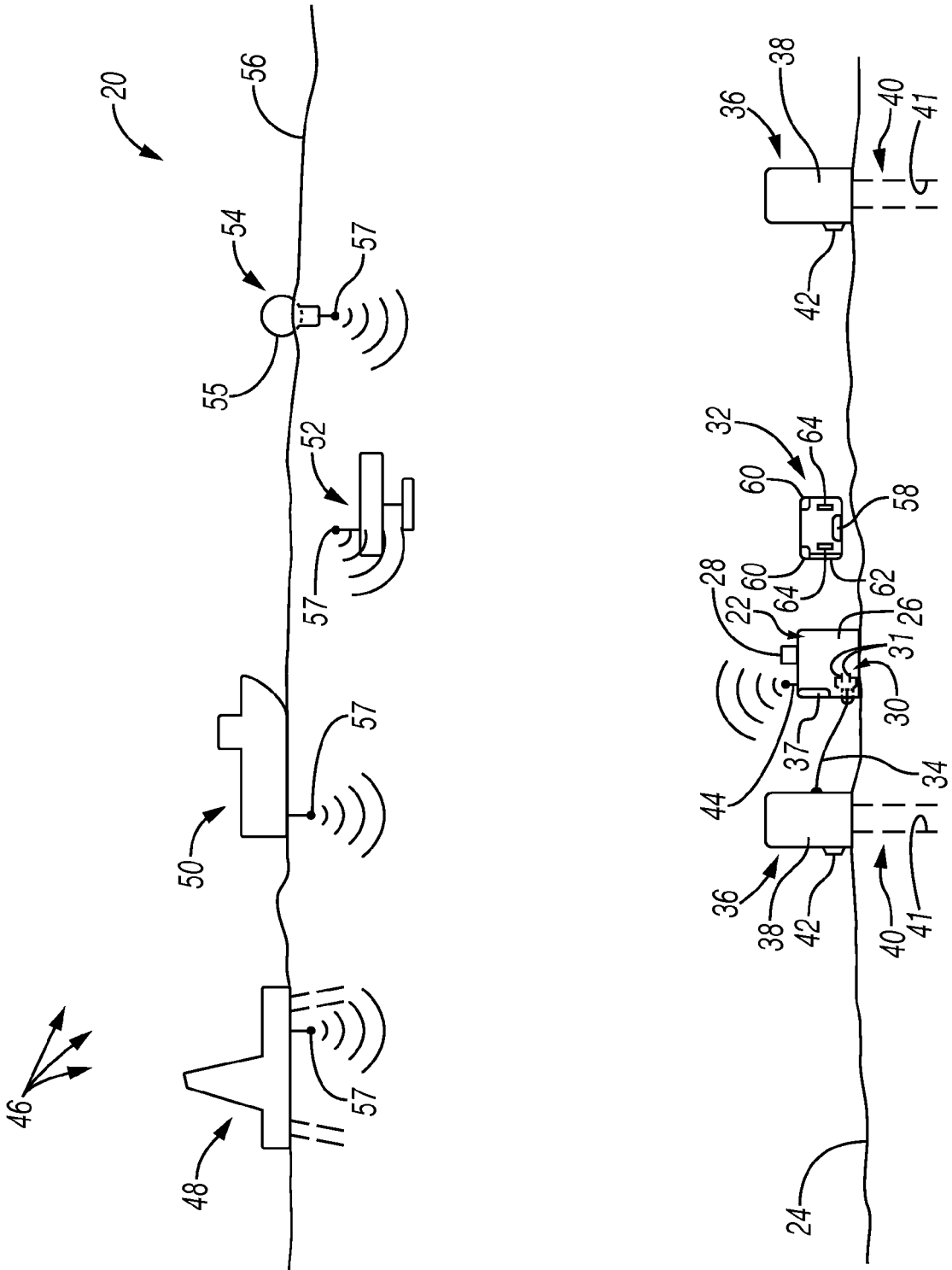
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FIG. 1

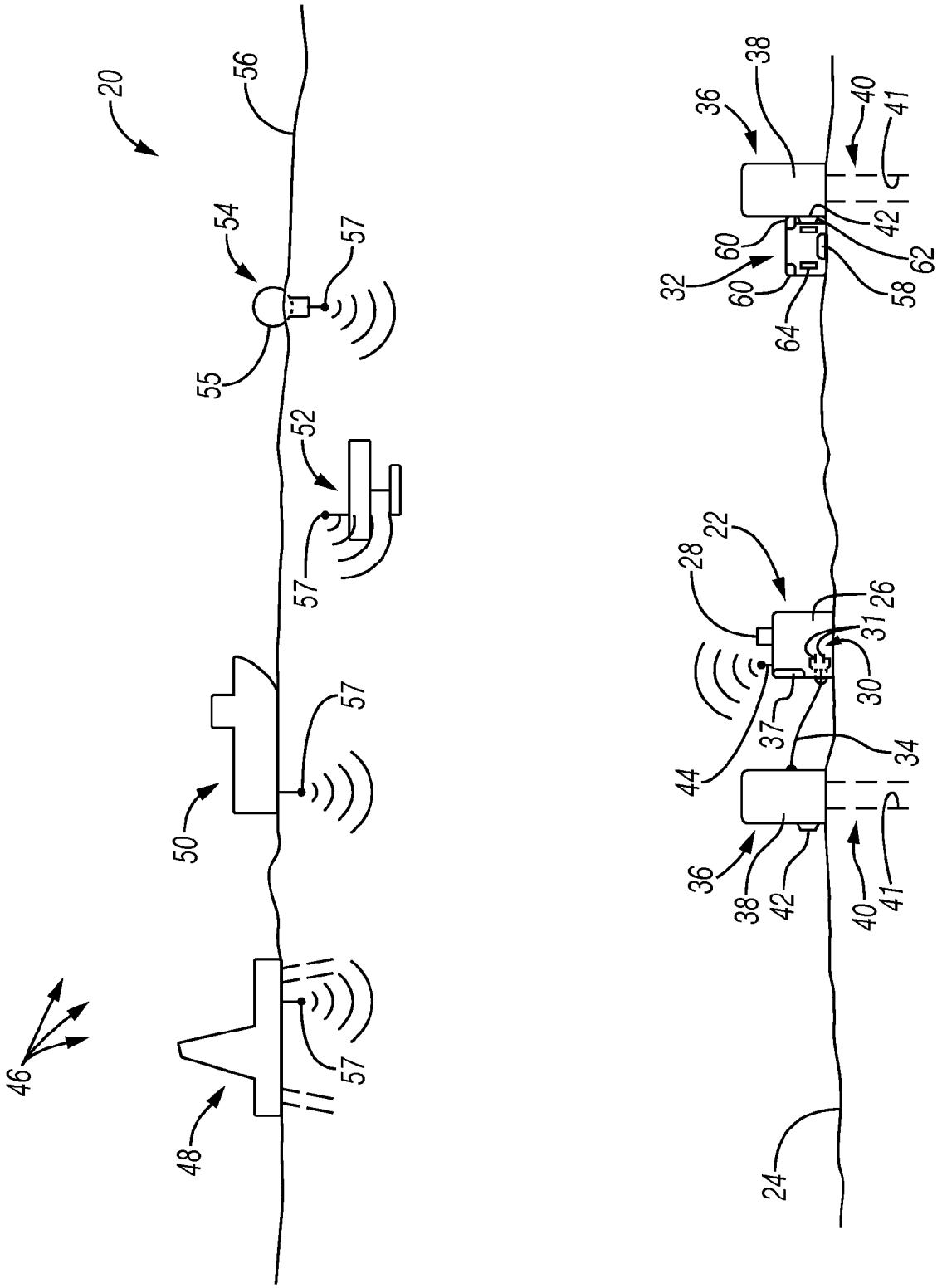
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FIG. 2

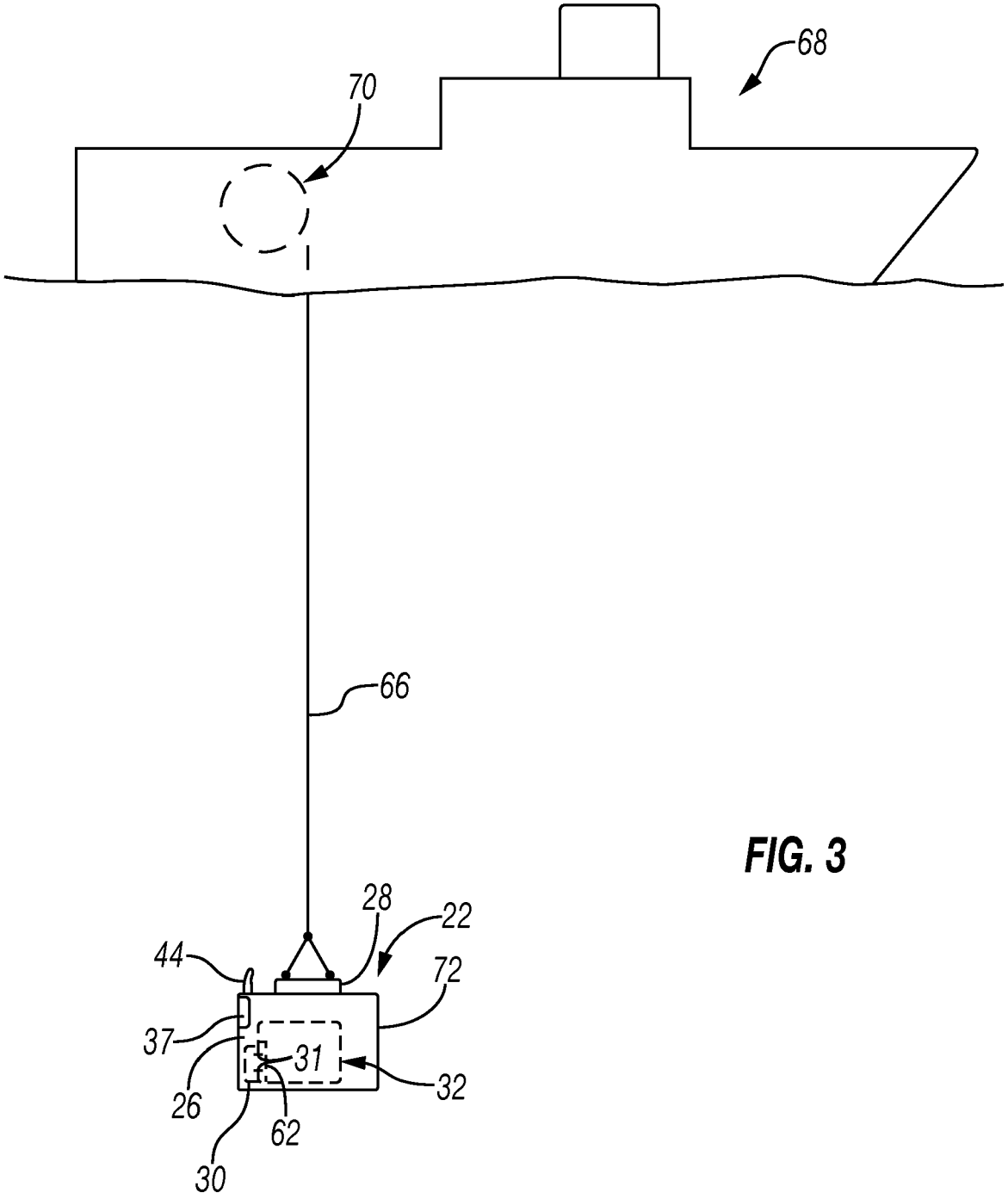

FIG. 3

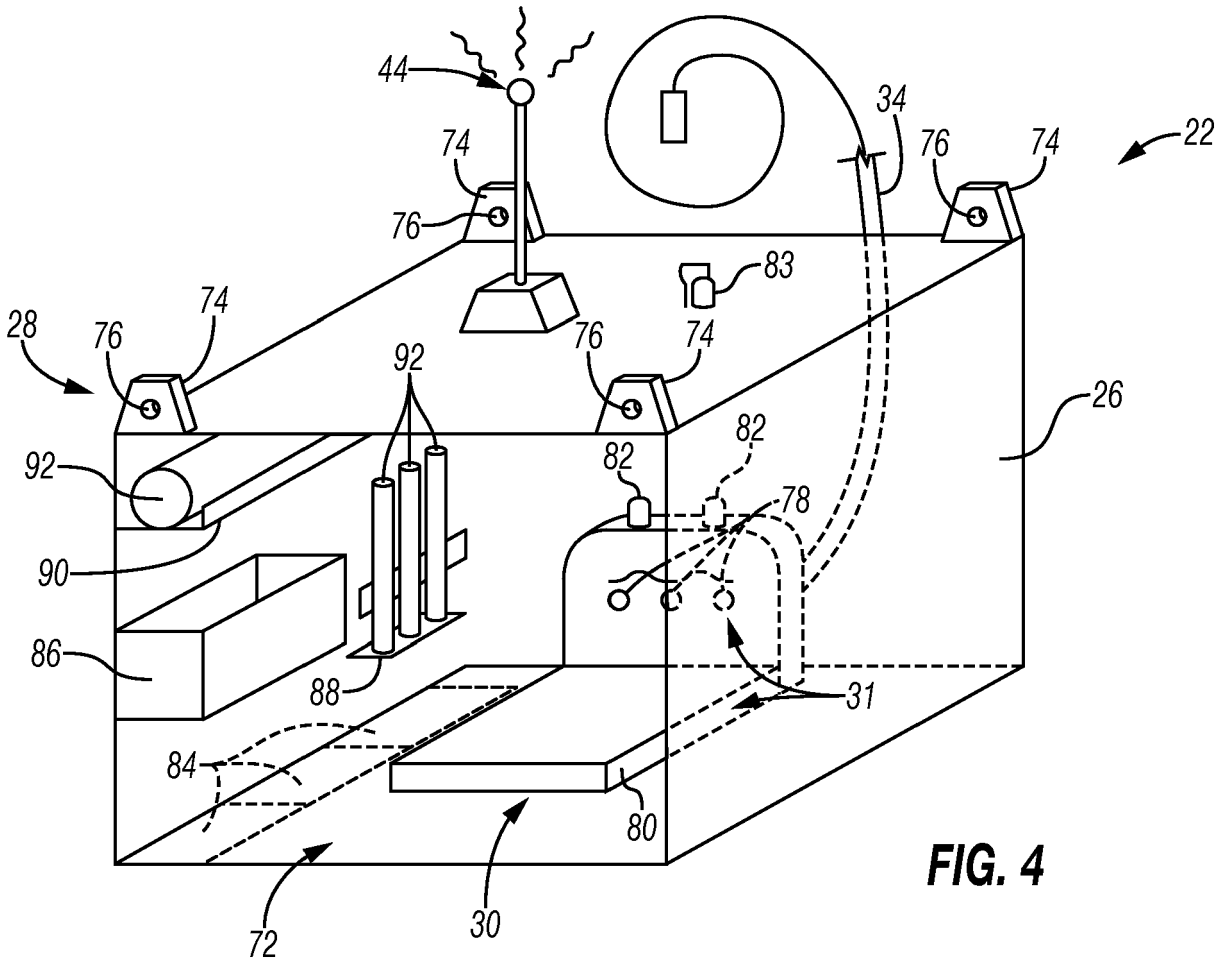
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FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 18 18 5881

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	13 September 2018	Dekker, Derk

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
EP 18 18 5881

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	13 September 2018	Dekker, Derk

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Patent documents cited in the description

- US 6808021 B **[0019]**