(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 912 390 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
17.06.2020 Bulletin 2020/25

(21) Application number: **13840097.3**

(22) Date of filing: **15.03.2013**

(51) Int Cl.:
F25J 1/00 *(2006.01)* ***F17C 1/00*** *(2006.01)*
B63B 35/44 *(2006.01)*

(86) International application number:
PCT/AU2013/000258

(87) International publication number:
WO 2014/043736 (27.03.2014 Gazette 2014/13)

(54) **INTEGRATED STORAGE/OFFLOADING FACILITY FOR AN LNG PRODUCTION PLANT**

INTEGRIERTE SPEICHER-/ABLADEEINRICHTUNG FÜR EINE FLÜSSIGERDGASPRODUKTIONSANLAGE

INSTALLATION INTÉGRÉE DE STOCKAGE/TRANSFERT POUR UNE UNITÉ DE PRODUCTION DE GNL

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **21.09.2012 AU 2012904129**

(43) Date of publication of application:
02.09.2015 Bulletin 2015/36

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an integrated storage/offloading facility for a liquefied natural gas ("LNG") production plant.

BACKGROUND TO THE INVENTION

[0002] Large volumes of natural gas (i.e., primarily methane) are located in remote areas of the world. This gas has significant value if it can be economically transported to market. Natural gas ("NG") is routinely transported from an onshore LNG production plant to another location in its liquid state as liquefied natural gas ("LNG") by way of loading the LNG in the cryogenic storage tanks of purpose built large ocean going vessels known as "LNG Carriers". Liquefaction of the natural gas makes it more economical to transport as LNG occupies only about 1/600th of the volume than the same amount of natural gas does in its gaseous state. Prior to liquefaction, raw natural gas that has been sourced from a wellhead is subjected to a series of gas pre-treatment processes including acid gas removal and dehydration to remove contaminants. After liquefaction, LNG is typically stored in cryogenic storage tanks at the LNG production plant either at or slightly above atmospheric pressure at a temperature of around -160 degrees Celsius.

[0003] Gas pre-treatment, liquefaction and storage are typically undertaken at a fixed onshore LNG production plant associated with a jetty that is built in sufficiently deepwater to allow berthing of the LNG Carriers. To ship liquefied natural gas (LNG) by sea, a way to transfer LNG between the cryogenic storage tanks of the onshore LNG production plant and the cryogenic storage tanks of the LNG Carrier is required. Traditionally, the transfer means has taken the form of an insulated pipe that is laid on an elevated supporting trestle structure between the onshore LNG production plant and the jetty so that the insulated pipe remains at all times above the water line. These prior art transfer facilities include a vapour return line to return boil-off gas to the onshore LNG production plant. After LNG have been loaded into the cryogenic storage tanks of the LNG Carrier vessel for marine transport LNG is regasified before distribution to end users through a pipeline or other distribution network at a temperature and pressure that meets the delivery requirements of the end users.

[0004] The cost of LNG storage and offloading facilities has continued to increase through the years and is now a very significant component of the total installed cost for an LNG project. Efforts to reduce this cost have largely been focused on storage tank size optimization and seeking to leverage the economics of scale via increased LNG train capacity size and improvement in LNG berth utilization. Document FR2967484 A1 discloses an LNG production plant according to the preamble of claim 1.

[0005] There remains a need to explore alternative designs for LNG storage and offloading facilities.

SUMMARY OF THE INVENTION

[0006] According to a first aspect of the present invention there is provided an LNG production plant according to claim 1.

[0007] In one form, the selected location has a water depth of at least 14 metres, at least 15 metres, or at least 16 metres. In one form, the integrated storage/offloading facility is a breakwater for an LNG Carrier. In one form, the cryogenic pipeline is a cryogenic subsea pipeline or a cryogenic pipeline on a trestle.

[0008] The first facility is a gas processing facility for receiving raw hydrocarbons from a producing well and treating the raw hydrocarbons to remove contaminants therefrom to produce a stream of treated gas as a source of feed to a liquefaction facility for receiving the stream of treated gas from a gas processing module and liquefying the natural gas to produce LNG.

[0009] In one form, the integrated storage/offloading facility is transportable from a construction location to an assembly location by towing or on floating barges. In one form, the integrated storage/offloading facility is transportable from an assembly location to the production location by towing or on floating barges. In one form, commissioning of the integrated storage/offloading facility is done at an onshore construction location or an onshore assembly location prior to transportation of integrated storage/offloading facility to the production location. In one form, the integrated storage/offloading facility includes a ballast storage compartment, and the integrated storage/offloading facility is settled into the selected location by way of addition of a ballasting material to the ballast storage compartment. In one form, the ballast storage compartment is arranged around the periphery of the integrated storage/offloading facility or arranged toward the base of the integrated storage/offloading facility for ballasting. In one form, the ballast storage compartment is at least partially filled with one or both of a solid ballasting material or a liquid ballasting material. In one form, the solid ballasting material is iron ore or sand. In one form, the liquid ballasting material is one or more of: water, condensate, monoethylene glycol (MEG), methanol, diesel, demineralised water, diesel, or, LPG.

[0010] In one form, integrated storage/offloading facility includes a boil-off gas reliquefaction facility. In one form, the integrated storage/offloading facility has at least one lateral side which has a length of a sufficient size to allow an LNG Carrier to be moored along alongside the gravity-based structure without overhang of the LNG Carrier beyond an end of the gravity-based structure. In one form, the integrated storage/offloading facility has a lee side, whereby, in use, the LNG Carrier approaches the integrated storage/offloading facility from the lee side of integrated storage/offloading facility. In one form, the integrated storage/offloading facility has a longitudinal axis aligned substantially parallel to the direction of a predominant current for bi-directional berthing of an LNG Carrier.

[0011] In one form, the integrated storage/offloading facility comprises a plurality of similarly-sized sub-facilities, which are integrated at a construction location, the production location, or at an independent assembly location. In one form, the sub-facilities are constructed at a plurality of construction locations and towed to a common assembly location for integration. In one form, the sub-facilities are assembled to form the integrated storage/offloading facility at the assembly location and testing or commissioning of the sub-facilities is conducted a construction or assembly location before transportation of the integrated storage/offloading facility to the production location.

[0012] In one form, the integrated storage/offloading facility is movable from a first production location to a second production location. In one form, the integrated storage/offloading facility includes a boil-off gas reliquefaction facility for liquefying at least a portion of the boil off gas that is generated either during the transfer of the LNG through the pipeline to the first cryogenic storage tank of the integrated storage/offloading facility or during the transfer of the LNG from the first cryogenic storage tank to the second cryogenic storage tank of the LNG Carrier. In one form, a portion of boil off gas is a source of fuel for a first power generation system which forms part of the integrated storage/offloading facility or a second power generation facility onboard the LNG Carrier. In one form, a first portion of the LNG produced by the liquefaction facility is transferred directly into a second cryogenic storage tank onboard an LNG Carrier and a second portion of the LNG produced by the liquefaction facility is stored in the first cryogenic storage tank of the integrated storage/offloading facility. In one form, the integrated storage/offloading facility has a multilateral footprint when viewed in plan view. In one form, the footprint is triangular, rectangular, square, pentagonal or hexagonal whereby, in use, a first LNG Carrier berths at a first lateral side of the integrated storage/offloading facility while a second LNG Carrier berths at a second lateral side of the integrated storage/offloading facility.

[0013] In one form, the LNG production plant further comprises a breakwater facility positioned adjacent to the integrated storage/offloading facility at the selected location. In one form, a first breakwater facility is located towards a first end of the integrated storage/offloading facility and a second breakwater facility is located towards a second end of the integrated storage/offloading facility.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] In order to facilitate a more detailed understanding of the nature of the invention several embodiments of the present invention will now be described in detail, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic plan view of a first embodiment of the present invention;

FIG. 2 is a schematic side view of the first embodiment of the present invention;

FIG. 3 is a process diagram illustrating the use of a plurality of independent construction locations, an assembly location and relocatability of the LNG production facility from a first location to a second location;

FIG. 4 is a schematic plan view of a second embodiment of the present invention;

FIG. 5 is a schematic plan view of an embodiment of the present invention;

FIG. 6 is a schematic plan view of an embodiment of the present invention showing the use of a breakwater facility; and,

FIG. 7 is a schematic plan view of an embodiment of the present invention showing the use of a first breakwater facility and a second breakwater facility.

[0015] It is to be noted that the drawings illustrate only preferred embodiments of the invention and are therefore not to be considered limiting of the invention's scope as it may admit to other equally effective embodiments. Like reference numerals refer to like parts. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. Moreover, all drawings are intended to convey concepts, where relative sizes, shapes and other detailed attributes may be illustrated schematically rather than literally or precisely.

DETAILED DESCRIPTION OF PARTICULAR EMBODIMENTS

[0016] Particular embodiments of the present invention are now described. The terminology used herein is for the purpose of describing particular embodiments only, and is not intended to limit the scope of the present invention. Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which this invention belongs.

[0017] Throughout this specification, the term "integrated storage/offloading facility" refers to a storage facility that is located together with an offloading facility, for example on top of or inside of a gravity based structure.

[0018] Using the process and system of the present invention, an LNG production plant is positioned at a production location adjacent to a body of water, the LNG production plant comprising a plurality of spaced-apart facilities including a first facility and a second facility, each facility provided with plant equipment related to a predetermined function associated with the production of LNG, wherein the first facility is an onshore facility and the second facility is arranged on a gravity-based structure having a base that rests on the seabed at a selected location within the body of water. More specifically, embodiments of the present invention relate to an LNG production plant including at least the following facilities:

a) a gas processing facility for receiving raw hydrocarbons from a producing well and treating the raw hydrocarbons to remove contaminants therefrom to produce a stream of treated gas;
b) a liquefaction facility for receiving the stream of treated gas from a gas processing facility and liquefying the natural gas to produce a product stream of LNG;
c) a storage facility operatively associated with a transfer means for receiving the product stream of LNG from the liquefaction facility for receiving and storing LNG in a first cryogenic storage tank; and,
d) an offloading facility including LNG transfer facilities to transfer the LNG from the first cryogenic storage tank of the storage facility to a second cryogenic storage tank onboard an LNG Carrier on an as-needs basis.

[0019] A first embodiment is now described with reference to FIGS. 1 to 3 in which an LNG production plant 10 is positioned at a production location 12 adjacent to a body of water 14. The production plant includes a first facility in the form of an onshore liquefaction facility 16 for receiving a stream of pre-treated gas 18 from a gas processing facility 20 and liquefying the pre-treated gas stream to produce a product stream of LNG 22. The gas processing facility includes an acid gas removal facility 24 and a dehydration and mercury removal facility 26 of the kind that is known in the art. Liquefaction is achieved onshore each liquefaction facility using any liquefaction process well established in the art which typically involve compression, expansion and cooling. Such prior art liquefaction processes include processes based on a nitrogen cycle, the APCI C3/MR™ or Split MR™ or AP-X™ processes, the Phillips Optimized Cascade Process, the Linde Mixed Fluid Cascade process or the Shell Double Mixed Refrigerant or Parallel Mixed Refrigerant process.

[0020] In the embodiment illustrated in FIG. 1, the storage facility and the offloading facility have been combined to provide a second facility in the form of an integrated storage/offloading facility 28 arranged at a selected location 30 in the body of water 14. The integrated storage/offloading facility 28 has a first cryogenic storage tank 32 operatively associated with the liquefaction facility 16 for receiving LNG from the onshore liquefaction facility via a cryogenic pipeline 34 and storing LNG in the first cryogenic storage tank. The first storage tank 32 may be one of a plurality of first storage tanks with two such first storage tanks illustrated in FIG. 1 by way of example only. The integrated storage/offloading offloading 28 further includes an LNG transfer facility 36 for transferring LNG from the first cryogenic storage tank 32 to a second cryogenic storage 38 tank onboard an LNG Carrier 40. The first cryogenic storage tank may be a double containment, full containment, prismatic or membrane systems with a primary tank constructed from, by way of example, stainless steel, aluminum, and/or 9%-nickel steel. The first cryogenic storage tank may include pre-tensioned concrete to provide structural resistance to the stored LNG, boil off gas pressure loads and to external hazards.

[0021] In the embodiment illustrated in FIG. 2, the integrated storage/offloading facility 28 is a gravity based structure with a base 42 of the integrated storage/offloading facility 28 resting on the seabed 44 at the selected location 30 within the body of water 14 to maximise the stability of the integrated storage/offloading offloading 28. By way of example, the gravity based structure is constructed using lightweight or semi-lightweight concrete (having a density of less than about 2000kg/m^3). Alternatively or additionally, the gravity based structure may be constructed of steel or a hybrid comprising a combination of steel and concrete or a composite material. Advantageously, the integrated storage/offloading facility is able to be constructed and commissioned at a construction location such as a shipyard or another location where trained and efficient labour force is available and floated in before being positioned at the selected location 30 to act as a breakwater for the LNG Carrier to reduce environmental loads (illustrated by way of an arrow in FIG.2) on the LNG Carrier 40.

[0022] Referring to FIG. 3, the integrated storage/offloading offloading 28 is transportable from a construction location 46 to the production location 12 or from the assembly location 48 to the production location 12 by towing or on floating barges. The construction location may be one of a plurality of constructions locations with three shown in FIG. 3 by way of example only. Advantageously, testing or pre-commissioning of the integrated storage/offloading offloading 28 can be conducted before transportation of the integrated storage/offloading offloading 28 to the production location 14. This feature not only allows the facility to be deployed where required but is also advantageous when maintenance or upgrading is required. The integrated storage/offloading facility may be re-deployed at a different location at a later time to suit LNG supply and demand, for example, due to changes in the capacity of the production plant or towards the end of a gas field life. Thus with reference to FIG. 3, the integrated storage/offloading facility can be moved from a first production location 50 to a second production location 52.

[0023] To allow sufficient water depth for an LNG Carrier 40 to berth alongside the integrated storage/offloading facility 28, the selected location 30 has a water depth as measured from the waterline 54 to the seabed 44 of at least 14 metres, at least 15 metres, or at least 16 metres. The integrated storage/offloading facility 28 includes a ballast storage compartment 56, preferably arranged around the periphery of the integrated storage/offloading facility or arranged toward the base of the facility, for ballasting. For flexibility to adjust the level of ballasting to suit the seabed conditions at a given selected location 30, the ballast storage compartment may be one of a plurality of ballast storage compartments with three ballast storage compartments shown in FIG.2 by way of example only. The integrated storage/offloading facility 28 is towed from the construction or assembly location (46 or 48, respectively) to the production location 12 and then arranged at the selected location 30 where settling is achieved by the addition of a ballasting material to the ballast storage compartment 56 until the base 42 of the integrated storage/offloading facility 28 rests on the seabed 44 to secure the position of the integrated storage/offloading facility 28. This provides the integrated storage/offloading facility with greater stability. The amount of ballasting material required to secure the the integrated storage/offloading facility to the seabed at the selected location depends on a number of relevant factors including but not limited to the shear strength of the underlying clay or silt material found at the bottom of the body of water at the selected location. If required, the the integrated storage/offloading facility 28 may include a piling system 58 to anchor the integrated storage/offloading facility 28 into the seabed 44. The ballasting material may be a solid ballasting material or a liquid ballasting material. By way of example, one or both of iron ore and sand may be used as the solid ballast material. In one embodiment of the present invention, the liquid ballasting material is water, condensate, monoethylene glycol (MEG), methanol, diesel, demineralised water, LPG or combinations thereof. The liquid ballasting material may be stored in a non-cryogenic storage tank.

[0024] In use, an LNG Carrier 40 comes in to berth at the integrated storage/offloading facility 28 to receive a cargo of LNG. The integrated storage/offloading facility 28 is designed so that the LNG Carrier 40 may approach the integrated storage/offloading facility from either direction depending on the prevailing weather conditions. A side of the integrated storage/offloading facility that is facing away from the prevailing weather conditions is referred to as the "lee side". Preferably, the integrated storage/offloading facility 28 has a lee side 60, whereby, in use, the LNG Carrier 40 approaches the integrated storage/offloading facility 28 from the lee side 60 of the integrated storage/offloading facility 28. Depending on the size of the LNG Carrier, the bow 62 or the stern 64 of the LNG Carrier 40 may extend beyond an end 66 of the integrated storage/offloading facility 28 when the LNG Carrier 40 is berthed alongside the integrated storage/offloading facility 28. This overhang of the bow or stern of the LNG Carrier beyond an end of the integrated storage/offloading facility may expose the LNG Carrier to adverse environmental conditions. To minimize this effect, the integrated storage/offloading facility 28 preferably has at least one lateral side 68 which has a length of a sufficient size to allow an LNG carrier to be moored along alongside the integrated storage/offloading facility 28 without overhang of the LNG Carrier 40 beyond an end of the integrated storage/offloading facility. The integrated storage/offloading facility 28 can be fitted with fendering equipment (not shown) to absorb a substantial portion of a load generated by impact of the LNG Carrier with the integrated storage/offloading facility during transfer of LNG from the first cryogenic tank 32 to the second cryogenic tank 38.

[0025] The integrated storage/offloading facility 28 may comprise a plurality of similarly-sized sub-modules 82, which can be integrated at the production location 12, at a construction location 46, or at an independent assembly location 48. The sub-modules may be constructed at separate construction locations and towed to a common assembly location. This option is particularly attractive if there is a restriction on the space available at the dry dock or "graving dock" or restrictions on the towable or installable size of a given facility or sub-facility. Advantageously, once the sub-modules have been assembled to form the integrated storage/offloading facility at the assembly location, testing or pre-commissioning of the integrated storage/offloading facility can be conducted before transportation of the integrated storage/offloading facility to the production location. It is particularly advantageous when such pre-commissioning can be done at an assembly location onshore prior to transportation of the facility to a production location offshore or near shore.

[0026] As set out above, the first cryogenic storage tank 32 which forms a part of the integrated storage/offloading facility 28 is operatively associated with the liquefaction facility 16 and receives a product stream of LNG 22 from the liquefaction facility 16 via a cryogenic pipeline 34. In the embodiment illustrated in FIG. 2, the cryogenic pipeline is a subsea cryogenic pipeline which is a preferred option when the selected location 30 is located more than 500 metres from the shoreline 29. However, a cryogenic pipeline arranged on a trestle may be used as an alternative, particularly when the selected location 30 is less than 500 metres from the shoreline 29. When the cryogenic pipeline is a subsea cryogenic pipeline, it may take the form of a dual-wall pipe-in-pipe or triple-wall pipe-in-pipe-in-pipe system. Using a dual-wall pipe-in-pipe system, the cryogenic subsea pipeline includes an inner pipe for carrying LNG and an outer jacket around the inner pipe defining an annular space there between with a layer of insulation in the annular space. Using a triple-wall pipe-in-pipe-in-pipe system, an intermediate pipe is located between an inner pipe and an outer pipe to protect the inner pipe from damage and to insulate the inner pipe to reduce heat leak and minimise LNG vaporization. Using either system, the inner pipe is preferably constructed from a pipeline material having sufficient ductility and toughness to be usable at cryogenic temperatures, for example, aluminium, high nickel content steels or austenitic stainless steels. One example of a suitable pipeline material is 36% nickel steel (known in the art commercially as INVAR) which allows the cryogenic subsea pipelie it to be restrained at both ends and used for LNG service without the use of an expansion joint. Alternatively, the cryogenic subsea pipeline may include at least one expansion joint 84 to compensate for thermal expansion and contraction. One example of an expansion joint is a bellows type expansion joint in which contraction is taken up by a longitudinal bellows or corrugations in the inner pipe. The bellows is constructed out of a material that is relatively thinner than the material of the LNG pipeline so the bellows is free to expand and contract axially with respect to the LNG pipeline.

[0027] In the embodiment illustrated in FIG. 2, the cryogenic subsea pipeline 34 includes an elongate open frame 86 adapted to be laid underwater is used for supporting the pipeline and resisting subsea forces on the pipeline. At least one pipe anchor 88 is attached to the pipeline 34 and to the frame 86 to transfer axial forces in pipeline 34 to the frame 86. At least one steel or concrete ground anchor 90 is attached to the frame 86 for transmitting axial forces in the frame 86 to the sea bed 44.

[0028] The LNG transfer facility 36 located on the integrated storage/offloading facility 28 includes a fixed or swivel joint loading arm above the water surface, preferably fitted with an emergency release system at one end of the loading arm. Between transfer operations, the LNG transfer facility may be kept cold by re- circulation of a small quantity of LNG. The LNG transfer facility may include an emergency safety system to allow loading to be stopped if required in a quick, safe, and controlled manner by closing an isolation valve on the LNG transfer lines or shutting down the cargo pumps associated with the cryogenic storage tank 38 onboard the LNG carrier 40. The emergency safety system is designed to allow LNG transfer to be restarted with minimum delay after corrective action has been taken.

[0029] In a preferred embodiment, the integrated storage/offloading facility 28 includes a boil-off gas reliquefaction facility 92 for liquefying at least a portion of the boil off gas that is generated either during the transfer of the LNG through the cryogenic subsea pipeline to the first cryogenic storage tank 32 of the integrated storage/offloading facility 28 or during the transfer of the LNG from the first cryogenic storage tank 32 to the second cryogenic storage tank 38 of the LNG Carrier. The reliquefied boil-off gas may be returned for storage in the first cryogenic storage tank. Boil off gas is generated due to one or more of the following: a) cooling down of the interior surfaces of the second cryogenic storage tank onboard the LNG Carrier; b) heat leaking in from the environment through the exterior surfaces of the second cryogenic storage tank onboard the LNG Carrier; c) heat from the cryogenic pumps used to transfer the LNG from the first cryogenic storage tank to the second cryogenic storage tank; and d) heat ingress from the LNG transfer facility transfer hoses or loading arms; e) flashing off due to a temperature increase during the transfer operation, and, f) flashing due to pressure drop during LNG transfer from liquefaction to storage. The inclusion of a boil-off gas reliquefaction facility as an integral part of the integrated storage/offloading facility overcomes the need for the cryogenic subsea pipeline to include a vapour return line. Alternatively or additionally, a portion of the boil off gas may be used as a source of fuel for a first power generation system which forms part of the integrated storage/offloading facility or a second power generation facility onboard the LNG Carrier. In addition to this, the first cryogenic storage tank of the integrated storage/offloading facility can be operated at a higher pressure compared with the second cryogenic storage tank of the LNG carrier by way of using reinforced membrane tank technology to minimize boil-off gas generation. Alternatively, the boil-off gas may be recycled back to the integrated storage/offloading facility 28.

[0030] A second embodiment of the present invention is now described with reference to FIG.4 which allows continuous or semi-continuous loading of LNG without the need to use a cryogenic pipeline 34. In this embodiment, the LNG production plant 10, positioned at a production location 12 adjacent to a body of water 14, includes an onshore gas processing plant 20 with the liquefaction facility being integrated into the integrated storage/offloading facility 28 arranged at a selected location 30 in the body of water 14. In this embodiment, a gas pipeline 94 replaces the cryogenic pipeline 34, the gas pipeline being cheaper to construct, lay, and maintain. Advantageously, a portion of the LNG produced by the liquefaction facility 16 can be transferred directly into the second cryogenic storage 38 tank onboard an LNG Carrier 40, whenever an LNG Carrier is berthing at the offloading facility 28, reducing the need to store the LNG in the first cryogenic storage tank 32 of the offloading facility 28. In the embodiment illustrated in FIG. 4, the integrated storage/offloading facility 28 has a multilateral footprint when viewed in plan view. This footprint provides for continuous or semicontinuous production whereby a first LNG Carrier 70 berths at a first lateral side 72 of the integrated storage/offloading facility 28 while a second LNG Carrier 74 berths at a second lateral side 76 of the integrated storage/offloading facility 28. In the embodiment shown in FIG.4, the integrated storage/offloading facility 28 has a triangular footprint with the first and second lateral sides (72 and 76, respectively) each representing a lee side 60 based on the prevailing weather conditions indicated by the arrow in FIG.4. However, the multilateral footprint could equally be rectangular, square, pentagonal or hexagonal. In the embodiment illustrated in FIG. 5, the footprint of the integrated storage/offloading facility 28 is rectangular such that the integrated storage/offloading facility 28 has a longitudinal axis 80 aligned substantially parallel to the direction of a predominant current for bi-directional berthing of an LNG Carrier 40. Preferably each of the first and second lateral sides (72 and 76, respectively) has a length of a sufficient size to allow an LNG carrier to be moored along alongside the integrated storage/offloading facility 28 without overhang of the LNG Carrier 40 beyond an end of the integrated storage/offloading facility.

[0031] A third embodiment is now described with reference to FIG. 6 and FIG. 7 which illustrate continuous production. In the embodiment illustrated in FIG.6, the lee side 60 has a length that is less than the length of the LNG Carrier 40. When the LNG carrier 40 is moored along alongside the integrated storage/offloading facility 28, one or both of the stern 62 or the bow 64 of the LNG Carrier 40 extends beyond the length of the lee side 60 of the integrated storage/offloading facility 28. In order to provide breakwater protection for the LNG Carrier 40, a breakwater facility 100 is floated in and positioned adjacent to the integrated storage/offloading facility 28 at the selected location 30. In FIG. 6, the breakwater facility 100 is arranged to provide a breakwater to the integrated storage/offloading facility 28 and the LNG Carrier 40 with only one breakwater facility 100 being shown. In embodiment illustrated in FIG. 7, two such breakwater facilities are shown. In FIG. 6, the liquefaction facility 16 is the breakwater facility 100. In FIG. 7, the liquefaction facility 16 is onshore. A first breakwater facility 102 is located towards a first end 104 of the integrated storage/offloading facility 28 with a second breakwater facility 106 being located towards a second end 108 of the integrated storage/offloading facility 28. In this embodiment, the first cryogenic storage tank 32 operatively associated with the liquefaction facility 16 is integrated with the breakwater facility 100 with the boil-off gas reliquefaction facility 92 being integrated with the second breakwater facility.

[0032] Now that several embodiments of the invention have been described in detail, it will be apparent to persons skilled in the relevant art that numerous variations and modifications can be made without departing from the basic inventive concepts. For example, an LNG Carrier may be used as the offloading facility. By way of further example, the liquefaction facility may be integrated with the offloading facility. All such modifications and variations are considered to be within the scope of the present invention, the nature of which is to be determined from the foregoing description and the appended claims.

[0033] It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents forms part of the common general knowledge in the art, in Australia or in any other country. In the summary of the invention, the description and claims which follow, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

Claims

1. An LNG production plant (10) positioned at a production location (12) adjacent to a body of water (14), the LNG production plant (10) comprising:

   a plurality of spaced-apart facilities including a first facility (16) that includes a gas processing facility (20) and a second facility (28) that includes a compressor, each facility provided with further plant equipment related to a pre-determined function associated with the production of LNG;
   wherein the first facility (16) is an onshore facility and the second facility (28) is an integrated storage/offloading facility arranged on a gravity-based structure having a base (42) that rests on the seabed (44) at a selected location (30) within the body of water (14);
   wherein the first facility (16) is a liquefaction facility for receiving a stream of pre-treated gas (18) from the gas processing facility (20) and liquefying the pre-treated gas to produce a product stream of LNG (22);
   a cryogenic pipeline (34) from the onshore facility (16) to the integrated storage/offloading facility (28); and;
   wherein the integrated storage/offloading facility (28) includes: a first cryogenic storage tank (32) operatively associated with the liquefaction facility (16) for receiving and storing the product stream of LNG from the liquefaction facility via the cryogenic pipeline (34); a boil-off gas re-liquefaction facility (92); and, an LNG transfer facility (36) for transferring LNG from the first cryogenic storage tank (32) to a second cryogenic storage tank (38) onboard an LNG Carrier (40) on an as-needs basis; wherein boil-off gas is generated during transfer of the LNG through the cryogenic pipeline (34) to the first cryogenic tank (32) of the integrated storage/offloading facility (28);
   characterised in that
   a subsea pipeline is provided from the integrated storage/offloading facility (28) to the onshore gas processing plant (16); and the boil-off gas is compressed by the compressor and transferred through the subsea pipeline to the onshore facility (16).

2. The LNG production plant (10) according to claim 1 wherein at least a portion of the boil off gas generated during the transfer of the LNG through the cryogenic pipeline (34) is recycled back to the integrated storage/offloading facility (28) or liquefied at the reliquefaction facility (92) at the offshore location.

3. The LNG production plant (10) of claim 1 or 2 wherein the first cryogenic storage tank (32) of the integrated storage/offloading facility (28) stores the LNG at a higher pressure compared with the second cryogenic storage tank (38) of the LNG carrier (40).

4. The LNG production plant (10) of any one of claims 1 to 3 wherein the integrated storage/offloading facility (28) is a breakwater (100) for an LNG Carrier (40).

5. The LNG production plant (10) of any one of claims 1 to 4 wherein the cryogenic pipeline (34) is a cryogenic subsea pipeline or a cryogenic pipeline on a trestle and connects to the gravity-based structure at a subsea location.

6. The LNG production plant (10) of any one of claims 1 to 4wherein the first facility (16) is a gas processing facility (20) for receiving raw hydrocarbons from a producing well and treating the raw hydrocarbons to remove contaminants therefrom to produce a stream of treated gas (18) as a source of feed to a liquefaction facility (16) for receiving the stream of treated gas from a gas processing module and liquefying the natural gas to produce LNG.

7. The LNG production plant (10) of any one of the preceding claims wherein commissioning of the integrated storage/offloading facility (28) is done at an onshore construction location or an onshore assembly location prior to transportation of integrated storage/offloading facility to the production location (12).

8. The LNG production plant (10) of any one of the preceding claims wherein the integrated storage/offloading facility (28) includes a ballast storage compartment (56), and the integrated storage/offloading facility (28) is settled into the selected location by way of addition of a ballasting material to the ballast storage compartment (56).

9. The LNG production plant (10) of claim 8 wherein the ballast storage compartment (56) is arranged around the periphery of the integrated storage/offloading facility (28) or arranged toward the base of the integrated storage/offloading facility (28) for ballasting.

10. The LNG production plant (10) of any one of the preceding claims wherein the integrated storage/offloading facility (28) has at least one lateral side (68) which has a length of a sufficient size to allow an LNG Carrier (40) to be moored along alongside the gravity-based structure without overhang of the LNG Carrier (40) beyond an end of the gravity-based structure.

11. The LNG production plant (10) of any one of the preceding claims wherein the integrated storage/offloading facility (28) is movable from a first production location (50) to a second production location (52).

12. The LNG production plant (10) of any one of the preceding claims wherein a portion of boil off gas is a source of fuel for a first power generation system which forms part of the integrated storage/offloading facility (28) or a second power generation facility onboard the LNG Carrier (40).

13. The LNG production plant (10) of any one of the preceding claims wherein a first portion of the LNG produced by the liquefaction facility is transferred directly into a second cryogenic storage tank (38) onboard an LNG Carrier (40) and a second portion of the LNG produced by the liquefaction facility is stored in the first cryogenic storage tank (32) of the integrated storage/offloading facility (28).

14. The LNG production plant (10) of any one of the preceding claims wherein the integrated storage/offloading facility (28) has a multilateral footprint in plan view.

15. The LNG production plant (10) of any one of the preceding claims wherein the footprint is triangular, rectangular, square, pentagonal or hexagonal whereby, in use, a first LNG Carrier (70) berths at a first lateral side (72) of the integrated storage/offloading facility (28) while a second LNG Carrier (74) berths at a second lateral side (76) of the integrated storage/offloading facility (28).

16. The LNG production plant (10) of any one of the preceding claims further comprising a breakwater facility (100) positioned adjacent to the integrated storage/offloading facility (28) at the selected location.

17. The LNG production plant (10) of claims 1-15 wherein a first breakwater facility (102) is located towards a first end (104) of the integrated storage/offloading facility (28) and a second breakwater facility (106) is located towards a second end (108) of the integrated storage/offloading facility (28).

Patentansprüche

1. LNG-Produktionsanlage (10), die an einem Produktionsort (12) benachbart zu einem Wasserkörper (14) positioniert ist, wobei die LNG-Produktionsanlage (10) umfasst:

eine Vielzahl von beabstandeten Einrichtungen, die eine erste Einrichtung (16), die eine Gasverarbeitungseinrichtung (20) einschließt, und eine zweite Einrichtung (28) einschließen, die einen Kompressor einschließt,
wobei jede Einrichtung mit weiteren Anlagengerätschaften ausgestattet ist, die mit einer vorbestimmten Funktion in Zusammenhang stehen, die zu der Produktion von LNG gehört;

wobei die erste Einrichtung (16) eine Onshore-Einrichtung ist, und die zweite Einrichtung (28) eine integrierte Speicher/Abladeeinrichtung ist, die auf einer schwerkraftbasierten Struktur mit einer Basis (42) angeordnet ist, die auf dem Meeresgrund (44) an einem ausgewählten Ort (30) innerhalb des Wasserkörpers (14) ruht;
wobei die erste Einrichtung (16) eine Verflüssigungseinrichtung zur Annahme eines Stroms von vorbehandeltem Gas (18) aus der Gasverarbeitungseinrichtung (20) und zur Verflüssigung des vorbehandelten Gases ist, um einen Produktstrom aus LNG (22) zu produzieren;
eine kryogene Pipeline (34) von der Onshore-Einrichtung (16) zu der integrierten Speicher/Abladeeinrichtung (28); und
wobei die integrierte Speicher/Abladeeinrichtung (28) einschließt: einen ersten kryogenen Speichertank (32), der funktional zu der Verflüssigungseinrichtung (16) gehört, um den Produktstrom aus LNG von der Verflüssigungseinrichtung über die kryogene Pipeline (34) anzunehmen und zu speichern; eine Einrichtung (92) zur erneuten Verflüssigung von Abdampfgas (BOG); und eine LNG-Transfereinrichtung (36) zum Transferieren von LNG aus dem ersten kryogenen Speichertank (32) zu einem zweiten kryogenen Speichertank (38) an Bord eines LNG-Tankers (40) auf Bedarfsbasis; wobei Abdampfgas während des Transfers von LNG durch die kryogene Pipeline (34) hindurch zu dem ersten kryogenen Tank (32) der integrierten Speicher/Abladeeinrichtung (28) generiert wird;
dadurch gekennzeichnet, dass
eine Unterwasserpipeline von der integrierten Speicher/Abladeeinrichtung (28) zu der Onshore-Gasverarbeitungsanlage (16) bereitgestellt wird;
und das Abdampfgas durch den Kompressor komprimiert wird und durch die Unterwasserpipeline hindurch zu der Onshore-Einrichtung (16) transferiert wird.

2. LNG-Produktionsanlage (10) nach Anspruch 1, wobei mindestens ein Anteil des Abdampfgases, das während des Transfers von LNG durch die kryogene Pipeline (34) hindurch generiert wird, zu der integrierten Speicher/Abladeeinrichtung (28) zurück recycelt oder an der Einrichtung (92) zur erneuten Verflüssigung an dem Offshore-Ort verflüssigt wird.

3. LNG-Produktionsanlage (10) nach Anspruch 1 oder 2, wobei der erste kryogene Speichertank (32) der integrierten Speicher/Abladeeinrichtung (28) das LNG mit einem höheren Druck speichert, verglichen mit dem zweiten kryogenen Speichertank (38) des LNG-Tankers (40).

4. LNG-Produktionsanlage (10) nach einem der Ansprüche 1 bis 3, wobei die integrierte Speicher/Abladeeinrichtung (28) ein Wellenbrecher (100) für einen LNG-Tanker (40) ist.

5. LNG-Produktionsanlage (10) nach einem der Ansprüche 1 bis 4, wobei die kryogene Pipeline (34) eine kryogene Unterwasserpipeline oder eine kryogene Pipeline auf einem Stützbock ist und mit der schwerkraftbasierten Struktur an einem Unterwasserort verbunden ist.

6. LNG-Produktionsanlage (10) nach einem der Ansprüche 1 bis 4, wobei die erste Einrichtung (16) eine Gasverarbeitungseinrichtung (20) zum Annehmen von Rohkohlenwasserstoffen aus einer Produktionsbohrung und Behandeln der Rohkohlenwasserstoffe zum Entfernen von Verunreinigungen daraus ist, um einen Strom von behandeltem Gas (18) als Einsatzmaterialquelle für eine Verflüssigungseinrichtung (16) zu produzieren, um den Strom des behandelten Gases aus einem Gasverarbeitungsmodul anzunehmen und das Erdgas zu verflüssigen, um LNG zu produzieren.

7. LNG-Produktionsanlage (10) nach einem der vorhergehenden Ansprüche, wobei Inbetriebnahme der integrierten Speicher/Abladeeinrichtung (28) an einem Onshore-Konstruktionsort oder einem Onshore-Montageort erfolgt, bevor der Transport der integrierten Speicher/Abladeeinrichtung zu dem Produktionsort (12) erfolgt.

8. LNG-Produktionsanlage (10) nach einem der vorhergehenden Ansprüche, wobei die integrierte Speicher/Abladeeinrichtung (28) einen Ballastspeichertank (56) einschließt, und die integrierte Speicher/Abladeeinrichtung (28) mittels Zugabe eines Ballastmaterials in den Ballastspeichertank (56) in den ausgewählten Ort hinein gesetzt wird.

9. LNG-Produktionsanlage (10) nach Anspruch 8, wobei der Ballastspeichertank (56) um die Peripherie der integrierten Speicher/Abladeeinrichtung (28) herum angeordnet ist oder zur Ballastwirkung in Richtung der Basis der integrierten Speicher/Abladeeinrichtung (28) angeordnet ist.

10. LNG-Produktionsanlage (10) nach einem der vorhergehenden Ansprüche, wobei die integrierte Speicher/Abladeeinrichtung (28) mindestens eine laterale Seite (68) aufweist, die eine ausreichend bemessene Länge aufweist, damit ein LNG-Tanker (40) entlang der schwerkraftbasierten Struktur vertäut werden kann, ohne dass der LNG-Tanker (40) über ein Ende der schwerkraftbasierten Struktur hinaus reicht.

11. LNG-Produktionsanlage (10) nach einem der vorhergehenden Ansprüche, wobei die integrierte Speicher/Abladeeinrichtung (28) von einem ersten Produktionsort (50) zu einem zweiten Produktionsort (52) bewegbar ist.

12. LNG-Produktionsanlage (10) nach einem der vorhergehenden Ansprüche, wobei ein Anteil des Abdampfgases eine Brennstoffquelle für ein erstes Energieerzeugungssystem, welches Teil der integrierten Speicher/Abladeeinrichtung (28) ist, oder eine zweite Energieerzeugungseinrichtung an Bord des LNG-Tankers (40) ist.

13. LNG-Produktionsanlage (10) nach einem der vorhergehenden Ansprüche, wobei ein erster Anteil des durch die Verflüssigungseinrichtung produzierten LNGs direkt in einen zweiten kryogenen Speichertank (38) an Bord eines LNG-Tankers (40) transferiert wird und ein zweiter Anteil des durch die Verflüssigungseinrichtung produzierten LNGs in dem ersten kryogenen Speichertank (32) der integrierten Speicher/Abladeeinrichtung (28) gespeichert wird.

14. LNG-Produktionsanlage (10) nach einem der vorhergehenden Ansprüche, wobei die integrierte Speicher/Abladeeinrichtung (28) in der Draufsicht eine mehrseitige Grundfläche aufweist.

15. LNG-Produktionsanlage (10) nach einem der vorhergehenden Ansprüche, wobei die Grundfläche dreieckig, rechteckig, quadratisch, fünfeckig oder sechseckig ist, wodurch im Gebrauch ein erster LNG-Tanker (70) an einer ersten lateralen Seite (72) der integrierten Speicher/Abladeeinrichtung (28) anlegt, während ein zweiter LNG-Tanker (74) an einer zweiten lateralen Seite (76) der integrierten Speicher/Abladeeinrichtung (28) anlegt.

16. LNG-Produktionsanlage (10) nach einem der vorhergehenden Ansprüche, des Weiteren umfassend eine Wellenbrechereinrichtung (100), die benachbart zu der integrierten Speicher/Abladeeinrichtung (28) an dem ausgewählten Ort positioniert ist.

17. LNG-Produktionsanlage (10) nach den Ansprüchen 1 bis 15, wobei eine erste Wellenbrechereinrichtung (102) sich in Richtung eines ersten Endes (104) der integrierten Speicher/Abladeeinrichtung (28) befindet und eine zweite Wellenbrechereinrichtung (106) sich in Richtung eines zweiten Endes (108) der integrierten Speicher/Abladeeinrichtung (28) befindet.

Revendications

1. Installation (10) de production de GNL positionnée sur un lieu (12) de production adjacent à un plan d'eau (14), l'installation (10) de production de GNL comportant :

une pluralité d'installations espacées incluant une première installation (16) qui comprend une installation (20) de traitement de gaz et une deuxième installation (28) qui comprend un compresseur, chaque installation étant munie d'autres équipements industriels liés à une fonction prédéterminée associée à la production de GNL ;

la première installation (16) étant une installation à terre et la deuxième installation (28) étant une installation intégrée de stockage/transbordement disposée sur une structure pesante dotée d'un socle (42) qui repose sur le fond marin (44) en un lieu choisi (30) au sein du plan d'eau (14) ;

la première installation (16) étant une installation de liquéfaction servant à recevoir un flux de gaz prétraité (18) provenant de l'installation (20) de traitement de gaz et à liquéfier le gaz prétraité pour produire un flux de produit de GNL (22) ;

un pipeline cryogénique (34) de l'installation (16) à terre à l'installation intégrée (28) de stockage/transbordement ; et

l'installation intégrée (28) de stockage/transbordement comprenant : un premier réservoir (32) de stockage cryogénique associé fonctionnellement à l'installation de liquéfaction (16) pour recevoir et stocker le flux de produit de GNL provenant de l'installation de liquéfaction via le pipeline cryogénique (34) ; une installation (92) de reliquéfaction de gaz d'évaporation ; et une installation (36) de transfert de GNL servant à transférer du GNL du premier réservoir (32) de stockage cryogénique à un deuxième réservoir (38) de stockage cryogénique à bord d'un transporteur (40) de GNL en fonction des besoins ;

du gaz d'évaporation étant généré pendant le transfert du GNL à travers le pipeline cryogénique (34) jusqu'au premier réservoir cryogénique (32) de l'installation intégrée (28) de stockage/transbordement ;

caractérisée en ce que

un pipeline sous-marin est posé de l'installation intégrée (28) de stockage/transbordement à l'usine (16) de traitement de gaz à terre ; et **en ce que** le gaz d'évaporation est comprimé par le compresseur et transféré à travers le pipeline sous-marin vers l'installation (16) à terre.

2. Installation (10) de production de GNL selon la revendication 1, au moins une partie du gaz d'évaporation généré pendant le transfert du GNL à travers le pipeline cryogénique (34) étant recyclée en la renvoyant à l'installation intégrée (28) de stockage/transbordement ou liquéfiée au niveau de l'installation (92) de reliquéfaction à l'emplacement en mer.

3. Installation (10) de production de GNL selon la revendication 1 ou 2, le premier réservoir (32) de stockage cryogénique de l'installation intégrée (28) de stockage/transbordement stockant le GNL à une plus haute pression en comparaison du deuxième réservoir (38) de stockage cryogénique du transporteur (40) de GNL.

4. Installation (10) de production de GNL selon l'une quelconque des revendications 1 à 3, l'installation intégrée (28) de stockage/transbordement étant un brise-lames (100) pour un transporteur (40) de GNL.

5. Installation (10) de production de GNL selon l'une quelconque des revendications 1 à 4, le pipeline cryogénique (34) étant un pipeline cryogénique sous-marin ou un pipeline cryogénique sur une estacade et se raccordant à la structure pesante à un emplacement sous-marin.

6. Installation (10) de production de GNL selon l'une quelconque des revendications 1 à 4, la première installation (16) étant une installation (20) de traitement de gaz servant à recevoir des hydrocarbures bruts provenant d'un puits en production et à traiter les hydrocarbures bruts pour en éliminer les contaminants afin de produire un flux de gaz traité (18) en tant que source de charge pour une installation (16) de liquéfaction servant à recevoir le flux de gaz traité provenant d'un module de traitement de gaz et à liquéfier le gaz naturel pour produire du GNL.

7. Installation (10) de production de GNL selon l'une quelconque des revendications précédentes, la mise en service de l'installation intégrée (28) de stockage/transbordement étant effectuée sur un lieu de construction à terre ou un lieu de montage à terre avant le transport de l'installation intégrée de stockage/transbordement jusqu'au lieu (12) de production.

8. Installation (10) de production de GNL selon l'une quelconque des revendications précédentes, l'installation intégrée (28) de stockage/transbordement comprenant un compartiment (56) de stockage de lest, et l'installation intégrée (28) de stockage/transbordement étant fixée sur le lieu choisi au moyen de l'ajout d'un matériau de lest au compartiment (56) de stockage de lest.

9. Installation (10) de production de GNL selon la revendication 8, le compartiment (56) de stockage de lest étant disposé autour de la périphérie de l'installation intégrée (28) de stockage/transbordement ou disposé vers le socle de l'installation intégrée (28) de stockage/transbordement en vue du lestage.

10. Installation (10) de production de GNL selon l'une quelconque des revendications précédentes, l'installation intégrée (28) de stockage/transbordement présentant au moins un côté latéral (68) qui présente une longueur d'une taille suffisante pour permettre à un transporteur (40) de GNL d'être amarré à quai le long de la structure pesante sans dépassement du transporteur (40) de GNL au-delà d'une extrémité de la structure pesante.

11. Installation (10) de production de GNL selon l'une quelconque des revendications précédentes, l'installation intégrée (28) de stockage/transbordement pouvant être déplacée d'un premier lieu (50) de production à un deuxième lieu (52) de production.

12. Installation (10) de production de GNL selon l'une quelconque des revendications précédentes, une partie du gaz d'évaporation étant une source de combustible pour un premier système de génération électrique qui fait partie de l'installation intégrée (28) de stockage/transbordement ou une deuxième installation de génération électrique à bord du transporteur (40) de GNL.

13. Installation (10) de production de GNL selon l'une quelconque des revendications précédentes, une première partie du GNL produit par l'installation de liquéfaction étant transférée directement dans un deuxième réservoir (38) de stockage cryogénique à bord d'un transporteur (40) de GNL et une deuxième partie du GNL produit par l'installation de liquéfaction étant stockée dans le premier réservoir (32) de stockage cryogénique de l'installation intégrée (28) de stockage/transbordement.

14. Installation (10) de production de GNL selon l'une quelconque des revendications précédentes, l'installation intégrée (28) de stockage/transbordement présentant une emprise multilatérale dans une vue en plan.

15. Installation (10) de production de GNL selon l'une quelconque des revendications précédentes, l'emprise étant triangulaire, rectangulaire, carrée, pentagonale ou hexagonale, avec pour conséquence qu'en cours d'utilisation, un premier transporteur (70) de GNL accoste d'un premier côté latéral (72) de l'installation intégrée (28) de stockage/transbordement tandis qu'un deuxième transporteur (74) de GNL accoste d'un deuxième côté latéral (76) de l'installation intégrée (28) de stockage/transbordement.

16. Installation (10) de production de GNL selon l'une quelconque des revendications précédentes, comportant en outre une installation (100) de brise-lames

positionnée de façon adjacente à l'installation intégrée (28) de stockage/transbordement sur le lieu choisi.

17. Installation (10) de production de GNL selon les revendications 1 à 15, une première installation (102) de brise-lames étant située vers une première extrémité (104) de l'installation intégrée (28) de stockage/transbordement et une deuxième installation (106) de brise-lames étant située vers une deuxième extrémité (108) de l'installation intégrée (28) de stockage/transbordement.

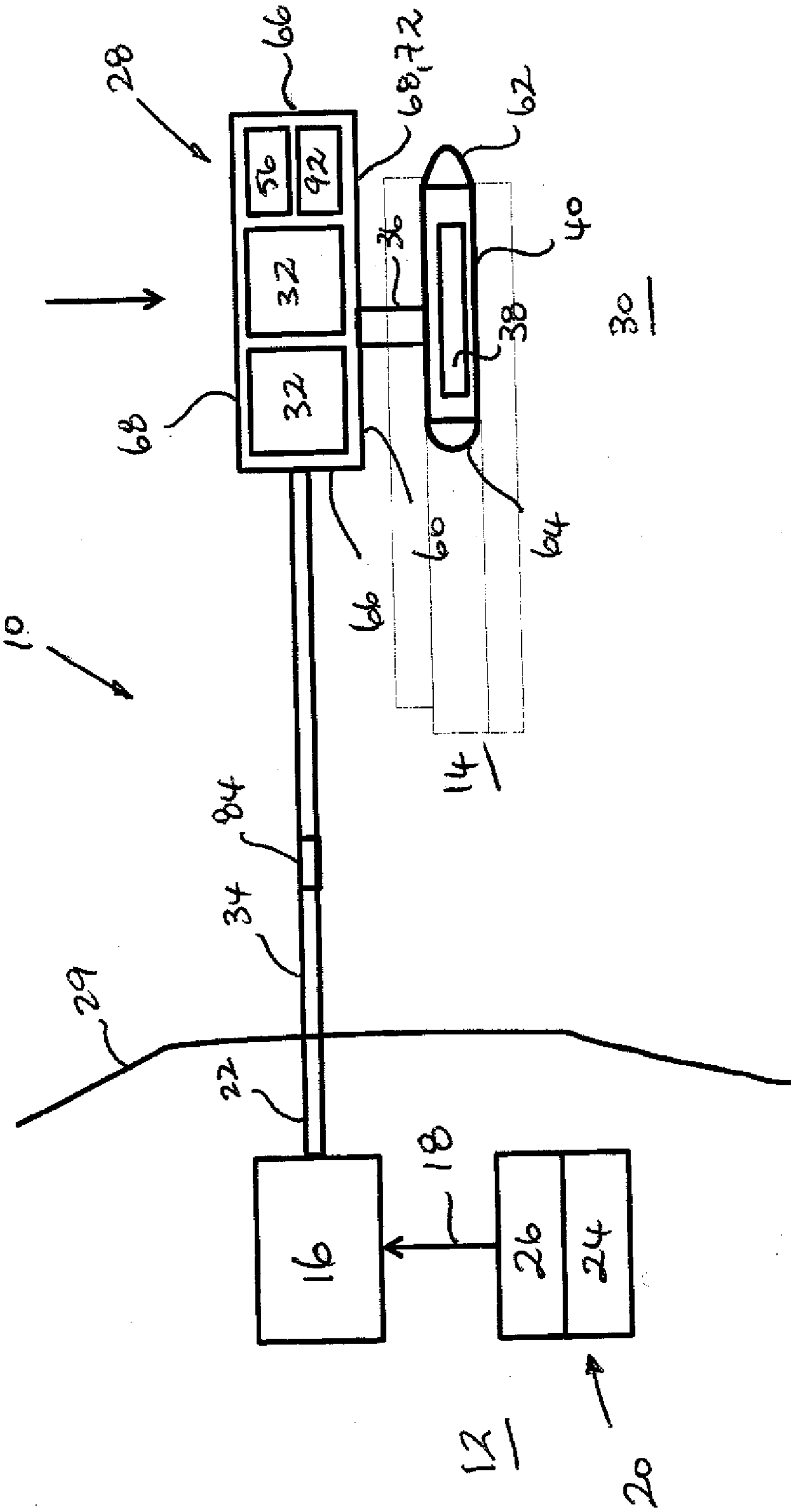
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FIG. 1

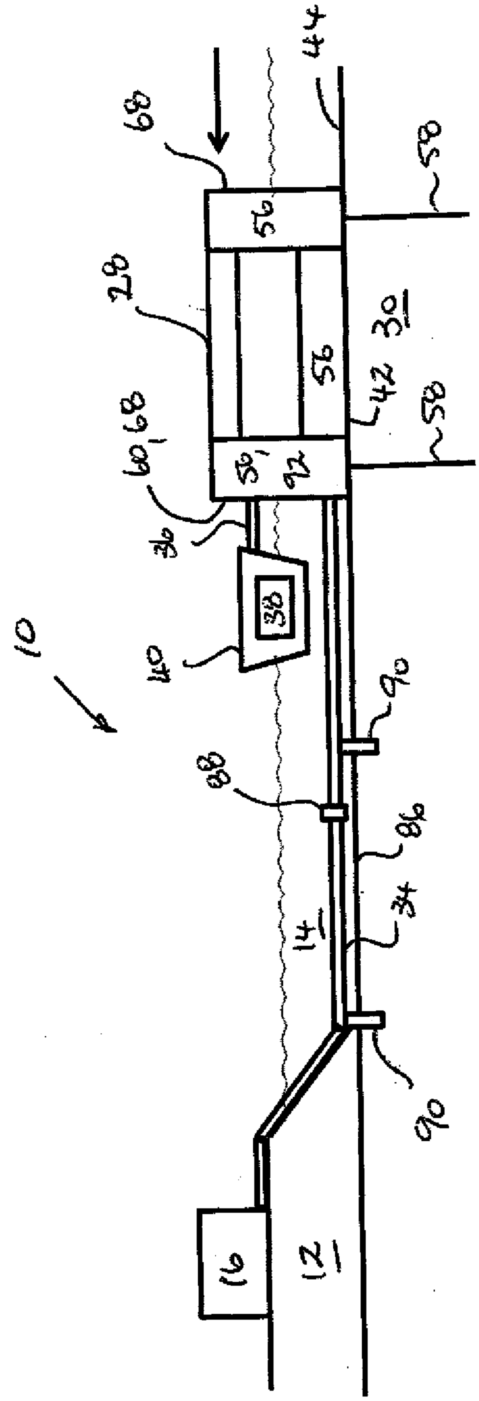

FIG. 2

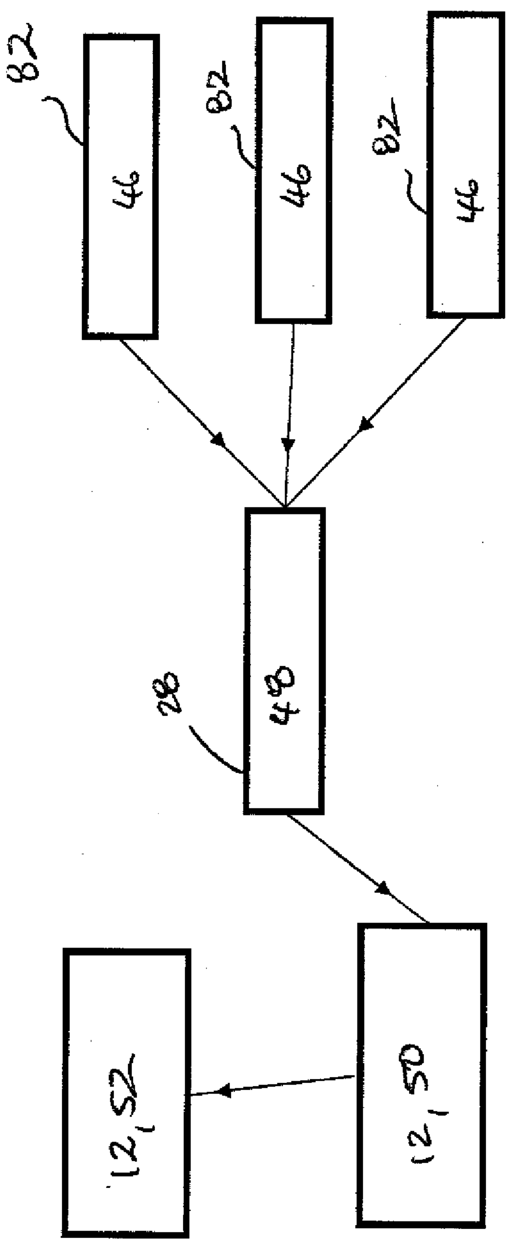

FIG. 3

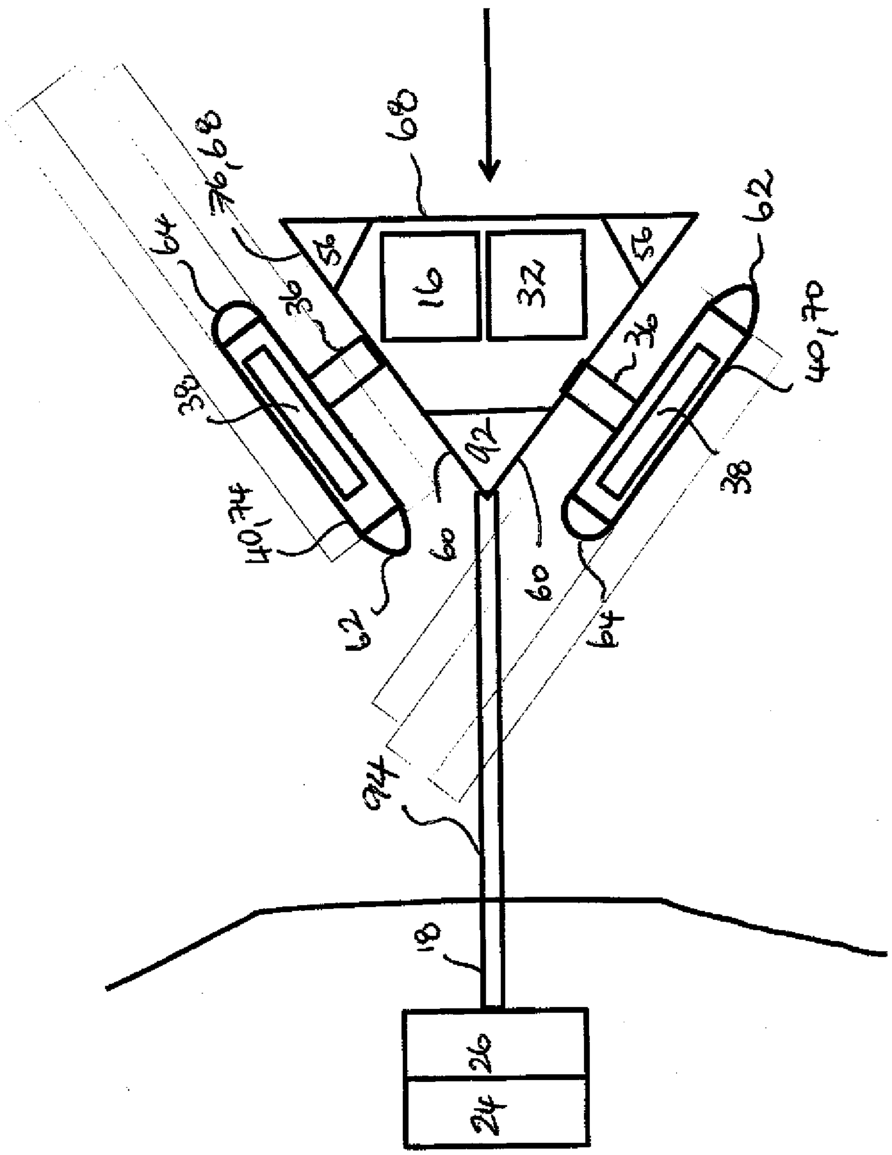
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FIG. 4

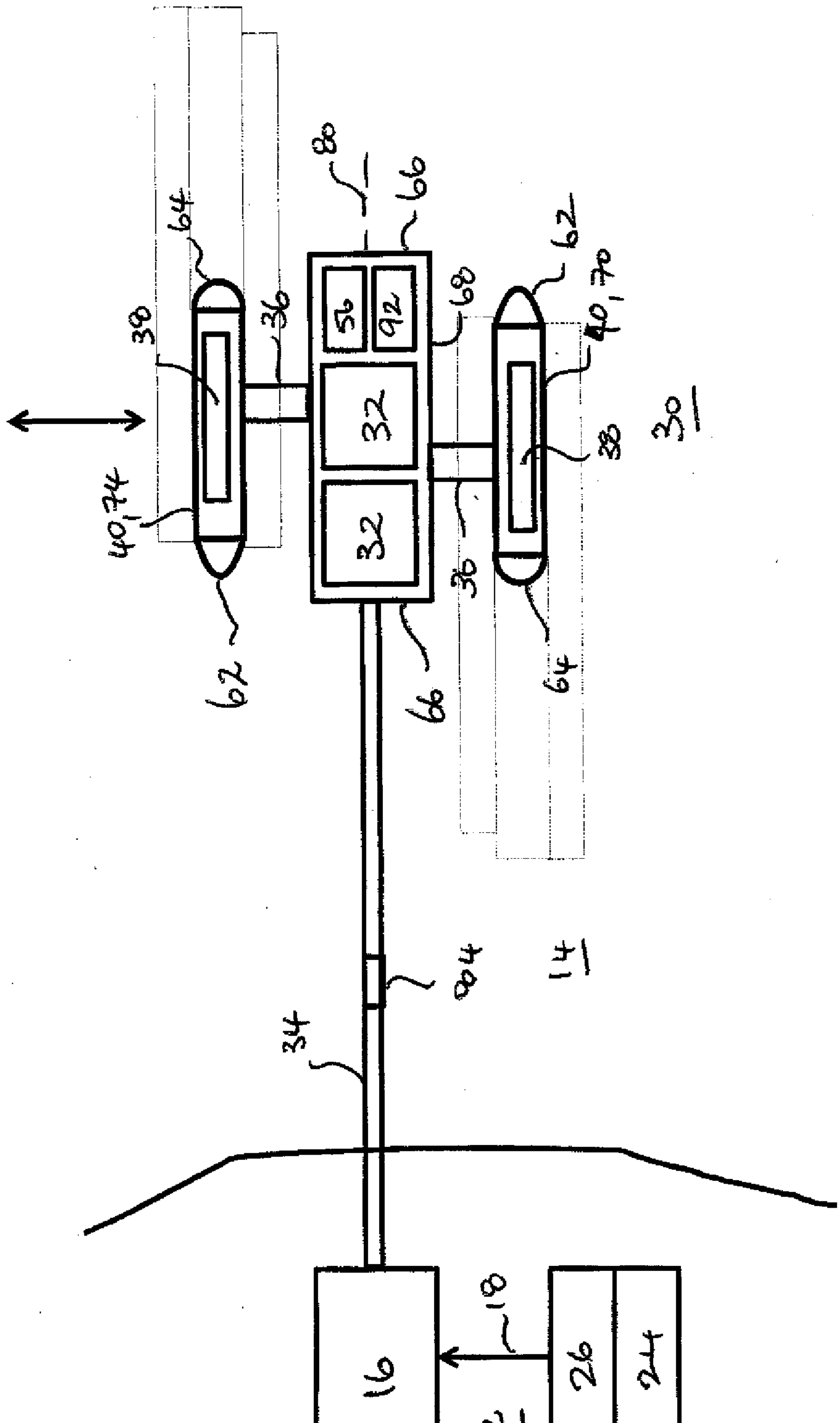

FIG. 5

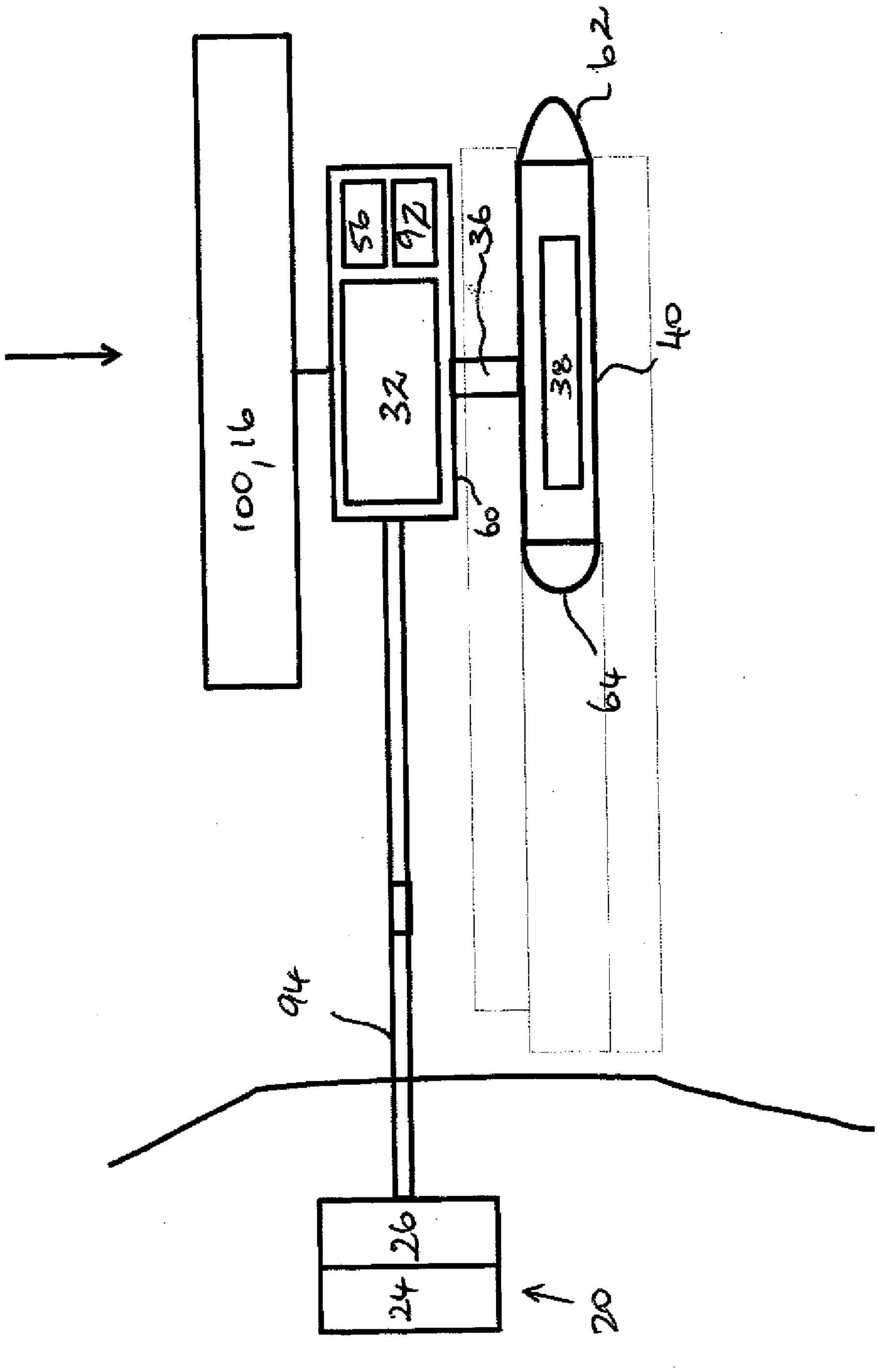

FIG. 6

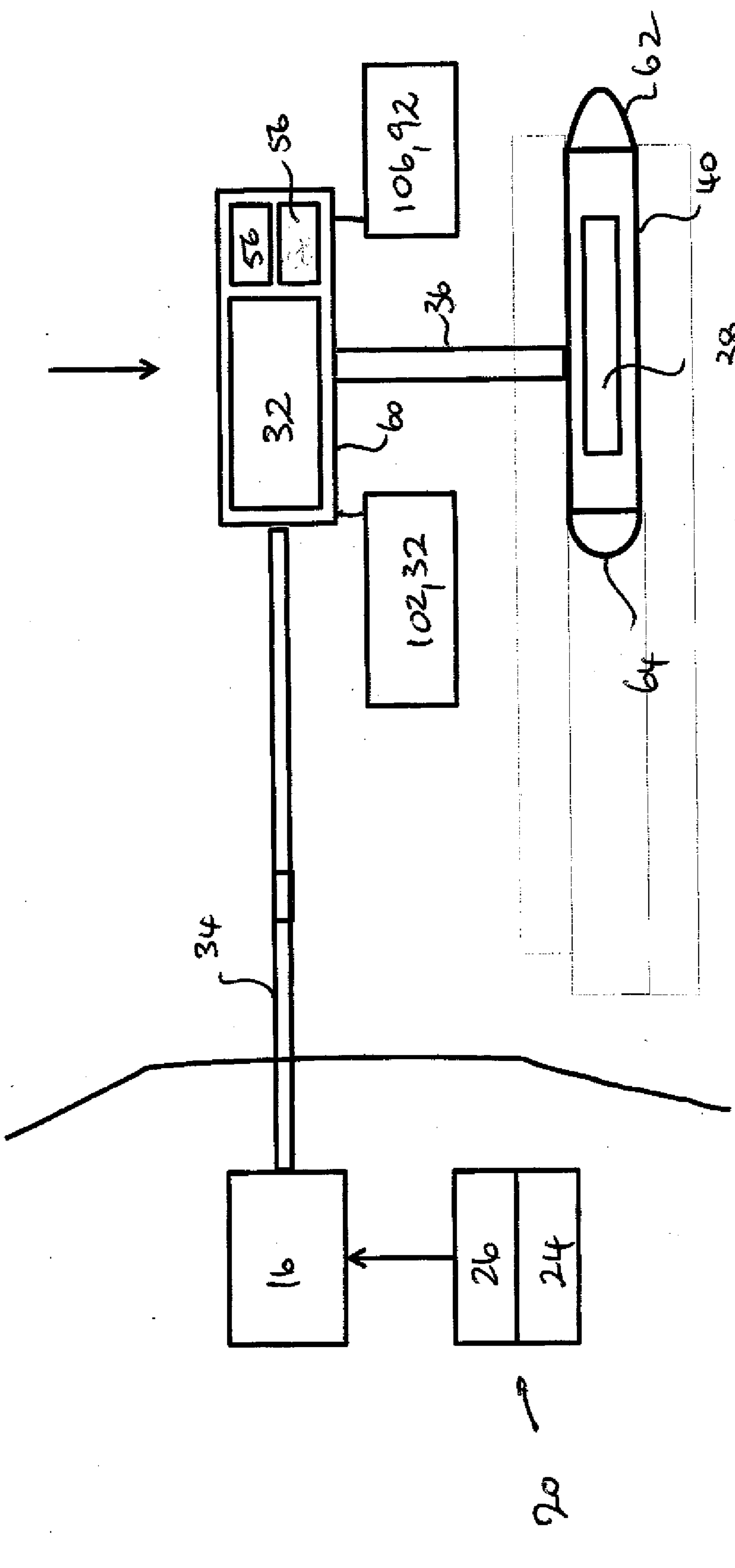

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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