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- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

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(54) Title: SYSTEM AND METHOD FOR PRODUCING METHANE FROM A METHANE HYDRATE FORMATION

(57) Abstract: A system for producing Methane from a Methane Hydrate formation including a completion that is disposed through a Methane Hydrate formation. An inlet of the completion disposed in the Methane Hydrate formation; and a drain for water located in a direction proximate a direction of gravity relative to the Methane Hydrate formation and gravitationally beneath the Methane Hydrate formation. A method for producing methane from a Methane Hydrate formation.

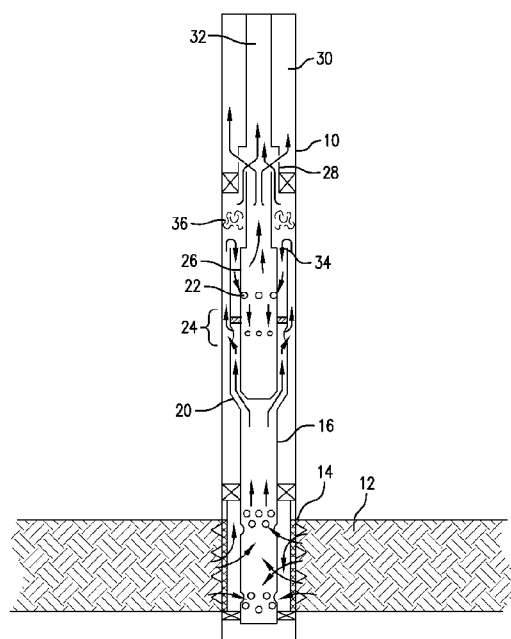


FIG. 1

SYSTEM AND METHOD FOR PRODUCING METHANE FROM A METHANE HYDRATE FORMATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Application No. 62/334752, filed on May 11, 2016, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] Methane Hydrate exists in vast quantities throughout much of planet Earth. Methane can be liberated from Methane Hydrate if the temperature and or pressure is adjusted to permit dissociation. In recent years, operators have been trying to find ways to economically produce methane as an energy resource. Unfortunately problems have been encountered in connection with configurations and methods designed to recover this resource. One problem that is quite consistent is the reformation of hydrate within the production system causing plugs to form. This of course restricts or prevents production reducing viability of the well. The art has attempted to combat the problem by the addition of chemical species such as Ethylene Glycol, Methanol or other hydrate inhibitors. While these work, they are costly and they are considered environmental hazards thereby requiring additional processing, which only adds more cost to the operation.

[0003] Other efforts have included separating liquid water from the gas phase methane. Figure 1 illustrates a system that employed this concept. Unfortunately this method continued to suffer from hydrate reformation leaving the industry at a loss for achieving acceptable production levels. Chemicals have a host of issues surrounding their use and separation didn't work. Referring to Figure 1, the system for separating water from methane gas comprises a borehole 10 extending into a methane hydrate accumulation formation 12. A sand screen assembly 14 is disposed at the methane hydrate interval to allow fluids from the formation to enter the borehole and completion string 16. Uphole of the sand screen assembly 14 is an ESP assembly 16 comprising an ESP shroud 20, surrounding an ESP intake 22, an ESP gas separator 24, and an ESP pump 26. A crossover 28 is used to swap the separated water and gaseous methane for movement in the tubing-casing annulus 30 and tubing 32, respectively, to surface. The system was intended to work by drawing water and sublimated methane from the formation 12 through screen 14, moving the fluid uphole to the OD of the shroud 20 and allowing liquid water to spill over the uphole edge 34 of the shroud while the gas collected in chamber 36 is flowed into the crossover 28 and produced to

surface. As noted however, the system did not work and suffered reformation of hydrates such that chemicals are needed to make the well produce efficiently over time, with all of the inherent drawbacks of chemical use. The art then has been left searching for some other type of solution to the problem of efficient production Methane from a Methane Hydrate formation.

[0004] The art would be highly receptive to a system and method for efficient production of Methane from a Methane Hydrate formation.

BRIEF DESCRIPTION

[0005] A system for producing Methane from a Methane Hydrate formation including a completion that is disposed through a Methane Hydrate formation; an inlet of the completion disposed in the Methane Hydrate formation; and a drain for water located in a direction proximate a direction of gravity relative to the Methane Hydrate formation and gravitationally beneath the Methane Hydrate formation.

[0006] A method for producing methane from a Methane Hydrate formation, including causing Methane Hydrate in a Methane Hydrate formation to change phase; collecting liquid water in a direction proximate a direction of gravity as it enters a completion of a borehole; and collecting free gas in a direction proximate a direction opposite gravity as it enters a completion of a borehole.

[0007] A method for producing Methane from a Methane Hydrate formation including passing water into a borehole in a direction that is proximate the direction water will flow under the influence of gravity; passing Methane into the borehole in a direction that is proximate a direction against the direction of gravity; and managing the water collected to a selected location.

[0008] A production system for producing Methane from a Methane Hydrate formation, the system configured to dissociate the Methane Hydrate and maintain separation of Methane gas and nongaseous material as it enters the system and resides in the system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0010] Figure 1 is an illustration of a prior art system designed for Methane production from a Methane Hydrate formation;

[0011] Figure 2 is an illustration of a system and method for Methane production from a Methane Hydrate formation as disclosed herein; and

[0012] Figure 3 is an illustration similar to Figure 2 but with a separate string for liquid disposed within the annulus of the production string.

DETAILED DESCRIPTION

[0013] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0014] Referring to Figure 2, a novel configuration of wellbore components will successfully meet the needs of the industry. Illustrated is a production operation 50 for a subsea Methane Hydrate formation. It is to be understood, however, that the system disclosed herein is not limited to subsea operations but may be employed to produce Methane from Methane Hydrate formations anywhere such a formation exists. A production system is defined as extending from a target formation to a processing system that processes produced raw fluids that may be local or remote from a wellhead. Accordingly, while the illustrated operation 50 includes a platform 52 at sea level 54 and a riser 56 extending to a wellhead 58 at the seabed 60, these are not always a part of the system since the system is equally applicable to land borne operations. More important is the description of the system beneath the seabed 60. A borehole 62 extends to and through a Methane Hydrate formation 64. The borehole comprises a completion that includes a production string 66 and an inlet that may be a sand screen assembly 68. The production string 66 includes an “inverted” ESP (Electric Submersible Pump) 69, meaning the ESP is configured to pump in a downhole direction as opposed to an uphole direction, positioned gravitationally beneath the formation 64.

[0015] It will be appreciated by one of ordinary skill in the art from the drawing that as the Methane Hydrate formation 64 begins to dissociate from a solid to a nongaseous material that is predominantly liquid (water 70) and from a solid to a gas via sublimation (Methane 72) the gas will naturally migrate to a position away from the pull of gravity relative to the water which will naturally migrate toward the pull of gravity. Because conditions are specifically tailored to cause dissociation at this location, dissociation necessarily will occur and will result in a full separation of water and Methane. It will also be appreciated from Figure 2 that the free water from the formation is collected only into the lower portion of the borehole 62 somewhat similar to a household sink drain. The water will move down into the drain 67 and feed the ESP 69, which as noted above is “inverted”. As

illustrated, the water 70 is being pumped by ESP 69 to a water disposal zone 74. The disposal zone 74 may be gravitationally beneath the Methane Hydrate formation as illustrated but also may be in a lateral borehole, or even pumped back to surface through another string that may be an entirely separate string in another borehole, a separate string 78 within the same borehole (Figure 3) or by using the annulus 80 around the production string 66 (Figure 3 still serves by ignoring separate string 78). It will be appreciated that Figure 3 employs a flow conduit 82 that extends from an ESP outlet 84, in a sealed manner, through packer 86 uphole of a free gas inlet 88 to the production string 66. This will provide access for water to the string 78 or the annulus 80 above packer 86 without contacting the gas flow in the production string 66. It should be noted that in this embodiment the ESP does not discharge in a downhole direction but still is located gravitationally beneath the formation 64 such that the water drain still functions as in each embodiment hereof.

[0016] The water 70 freed in the dissociation process is pure water and so can be deposited underground, released into the sea, used to irrigate nearby crops, collected in a receptacle of some sort (hold of a ship, large container, etc.) and contained for use later, etc. The dissociated gas is also pure and hence the gas migrating into the borehole above the level of the water migrating into the borehole has no water associated therewith and cannot then reform hydrates in the production string. This is a significantly different result than the prior art and is surprising to those of ordinary skill in the art since the art already has learned that separating the water and the gas is ineffective from the system described in the background section of this application. What heretofore the art failed to understand is that it was not the idea of separating water from gas that was the failure but that the configuration designed to have that effect failed to achieve the goal, unbeknownst to the art. What actually occurs is that the action of the water and gas moving through the screen and up the borehole to the ESP shroud edge 34 at high velocity causes a significant amount of entrainment of water in the gas flow and gas in the water flow. Accordingly, the system of Figure 1 never did get the water and the gas separated and hence suffered from reformation of hydrate when pressure and temperature conditions within the system became conducive to hydrate re-formation. Due to the length of a production system and the external changing conditions around a borehole and a riser (for a seabed located formation) it is extremely difficult if not impossible to ensure conditions are never conducive to hydrate formation. Experience has shown us that it is not possible to reliably and economically control those conditions since the previous attempts (other than very expensive heating apparatus and chemical additive methodologies) have been unsuccessful. Practicing in accordance with the present teaching however, substantially

eliminates or reduces the potential for hydrate formation to such an extent as to be negligible because the base materials necessary to hydrate formation (water and Methane) are not commingled at all in the completion system. More specifically, a production system for producing Methane from a Methane Hydrate formation, in accordance with the teachings hereof is configured to dissociation the Methane Hydrate and maintain separation of Methane gas and nongaseous material as it enters the system and resides in the system. It is in this way that hydrate reformation is avoided.

[0017] The method for producing Methane from a Methane Hydrate formation includes passing water into a borehole in a direction that is proximate the direction water will flow under the influence of gravity; passing Methane into the borehole in a direction that is proximate a direction against the direction of gravity; managing the water collected to a selected location and producing the Methane to a containment vessel that may be on a seabed, on ground, on a floating vessel such as shown at 52, etc. The passing of Methane may be passive or active. Draining the water into the borehole in a direction water will flow under gravity is illustrated in Figure 2 where the water moves to a portion of the borehole gravitationally beneath the formation 64. It is then assisted by the ESP although it is possible that a particular formation could provide a destination for the water that it can achieve without the assistance of the pump and hence it is contemplated that the system and method might not require the ESP. The gas on the other hand does of course migrate in a direction different than the water does with respect to gravity because the density of the gas is so much less than the density of the water. The gas is allowed to move into the completion and is ported to surface or other containment vessel for further processing or use.

[0018] Set forth below are some embodiments of the foregoing disclosure:

[0019] Embodiment 1: A system for producing Methane from a Methane Hydrate formation including a completion that is disposed through a Methane Hydrate formation; an inlet of the completion disposed in the Methane Hydrate formation; and a drain for water located in a direction proximate a direction of gravity relative to the Methane Hydrate formation and gravitationally beneath the Methane Hydrate formation.

[0020] Embodiment 2: The system in any of the preceding embodiments, further comprising a pump disposed in the drain and configured to pump water.

[0021] Embodiment 3: The system in any of the preceding embodiments, wherein the pump is connected to a flow conduit that reverses direction of the water and conveys the water to a separate pathway in the same borehole.

[0022] Embodiment 4: The system in any of the preceding embodiments, wherein the separate pathway is an annulus defined by a production string of the completion.

[0023] Embodiment 5: The system in any of the preceding embodiments, wherein the separate pathway is within the annulus and in a separate string.

[0024] Embodiment 6: The system in any of the preceding embodiments, wherein the pump is an inverted Electric Submersible Pump.

[0025] Embodiment 7: The system in any of the preceding embodiments, wherein the inlet is a sand screen assembly.

[0026] Embodiment 8: The system in any of the preceding embodiments, wherein the drain is connected to a water disposal zone.

[0027] Embodiment 9: The system in any of the preceding embodiments, wherein the water disposal zone is a formation.

[0028] Embodiment 10: The system in any of the preceding embodiments, wherein the water disposal zone is a lateral borehole.

[0029] Embodiment 11: The system in any of the preceding embodiments, wherein the water disposal zone is a container.

[0030] Embodiment 12: The system in any of the preceding embodiments, wherein the water disposal zone is a sea.

[0031] Embodiment 13: A method for producing methane from a Methane Hydrate formation, including causing Methane Hydrate in a Methane Hydrate formation to change phase; collecting liquid water in a direction proximate a direction of gravity as it enters a completion of a borehole; and collecting free gas in a direction proximate a direction opposite gravity as it enters a completion of a borehole.

[0032] Embodiment 14: A method for producing Methane from a Methane Hydrate formation including passing water into a borehole in a direction that is proximate the direction water will flow under the influence of gravity; passing Methane into the borehole in a direction that is proximate a direction against the direction of gravity; and managing the water collected to a selected location.

[0033] Embodiment 15: The method in any of the preceding embodiments, further comprising producing the Methane to a containment vessel.

[0034] Embodiment 16: The method in any of the preceding embodiments, wherein the passing water is drawing water using a pump configured to pump water in a direction other than a direction in which the Methane is passed.

[0035] Embodiment 17: The method in any of the preceding embodiments, wherein the passing Methane is passive.

[0036] Embodiment 18: The method in any of the preceding embodiments, wherein the passing Methane is active.

[0037] Embodiment 19: A production system for producing Methane from a Methane Hydrate formation, the system configured to dissociate the Methane Hydrate and maintain separation of Methane gas and nongaseous material as it enters the system and resides in the system.

[0038] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Further, it should further be noted that the terms “first,” “second,” and the like herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another. The modifier “about” used in connection with a quantity is inclusive of the stated value and has the meaning dictated by the context (e.g., it includes the degree of error associated with measurement of the particular quantity).

[0039] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited.

CLAIMS

What is claimed is:

1. A system for producing Methane from a Methane Hydrate formation (64) comprising:
 - a completion that is disposed through a Methane Hydrate formation (64);
 - an inlet of the completion disposed in the Methane Hydrate formation (64); and
 - a drain (67) for water (70) located in a direction proximate a direction of gravity relative to the Methane Hydrate formation (64) and gravitationally beneath the Methane Hydrate formation (64).
2. The system as claimed in claim 1 further comprising a pump (69) disposed in the drain (67) and configured to pump water (70).
3. The system as claimed in claim 2 wherein the pump (26) is connected to a flow conduit (82) that reverses direction of the water (70) and conveys the water (70) to a separate pathway in the same borehole (62).
4. The system as claimed in claim 3 wherein the separate pathway is an annulus (80) defined by a production string (66) of the completion.
5. The system as claimed in claim 4 wherein the separate pathway is within the annulus (80) and in a separate string (78).
6. The system as claimed in claim 1 wherein the pump (69) is an inverted Electric Submersible Pump (69).
7. The system as claimed in claim 1 wherein the drain (67) is connected to a water disposal zone (74).
8. The system as claimed in claim 7 wherein the water disposal zone (74) is a formation.
9. A method for producing methane from a Methane Hydrate formation (64), comprising:
 - causing Methane Hydrate in a Methane Hydrate formation (64) to change phase;
 - collecting liquid water (70) in a direction proximate a direction of gravity as it enters a completion of a borehole (62); and
 - collecting free gas in a direction proximate a direction opposite gravity as it enters a completion of a borehole (62).
10. A method for producing Methane from a Methane Hydrate formation (64) comprising:

passing water (70) into a borehole (62) in a direction that is proximate the direction water (70) will flow under the influence of gravity;

passing Methane into the borehole (62) in a direction that is proximate a direction against the direction of gravity; and

managing the water (70) collected to a selected location.

11. The method as claimed in claim 10 further comprising producing the Methane to a containment vessel.

12. The method as claimed in claim 10 wherein the passing water (70) is drawing water (70) using a pump (69) configured to pump water in a direction other than a direction in which the Methane is passed.

13. The method as claimed in claim 10 wherein the passing Methane is passive.

14. The method as claimed in claim 10 wherein the passing Methane is active.

15. A production system for producing Methane from a Methane Hydrate formation (64), the system configured to dissociate the Methane Hydrate and maintain separation of Methane gas and nongaseous material as it enters the system and resides in the system.

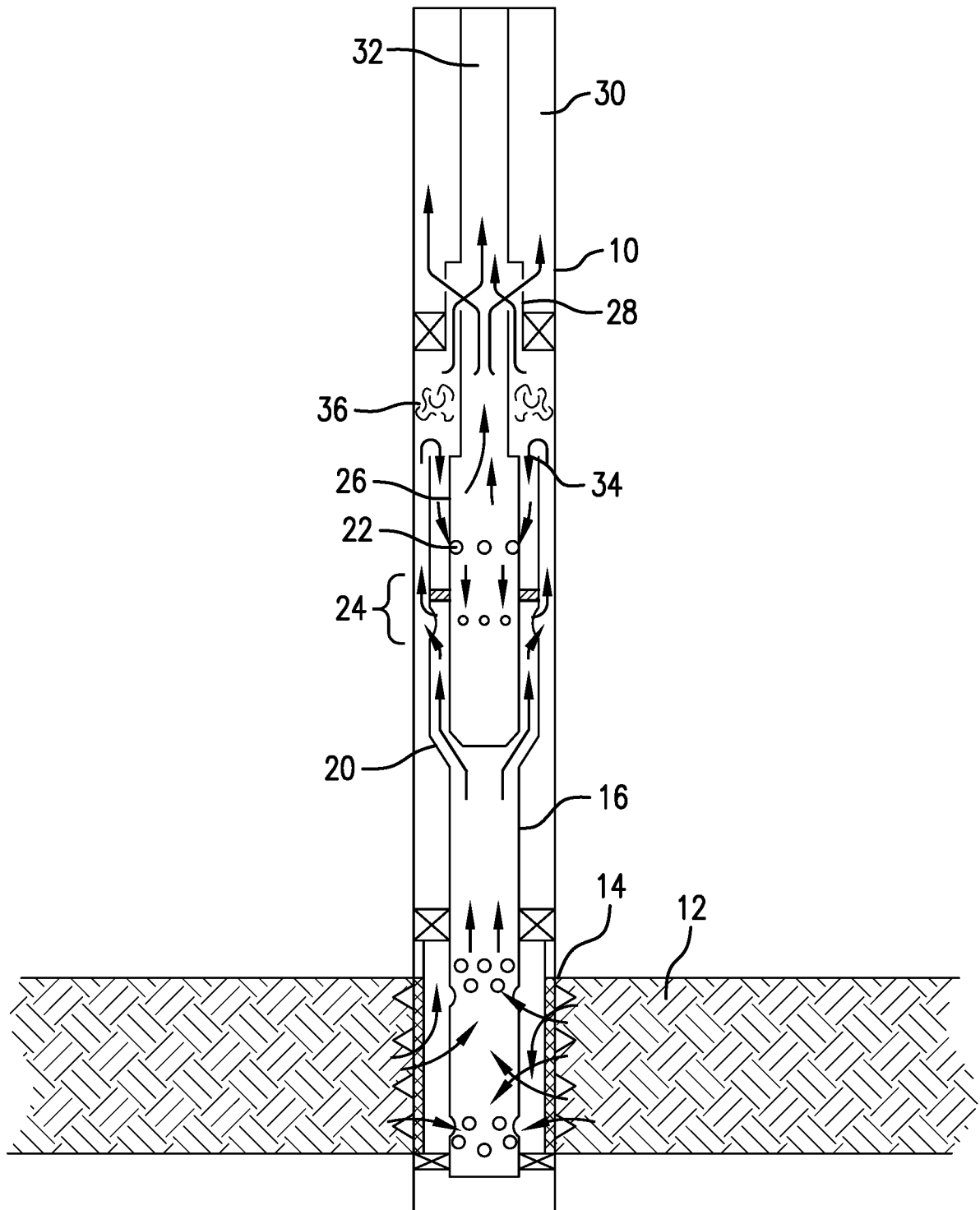


FIG. 1

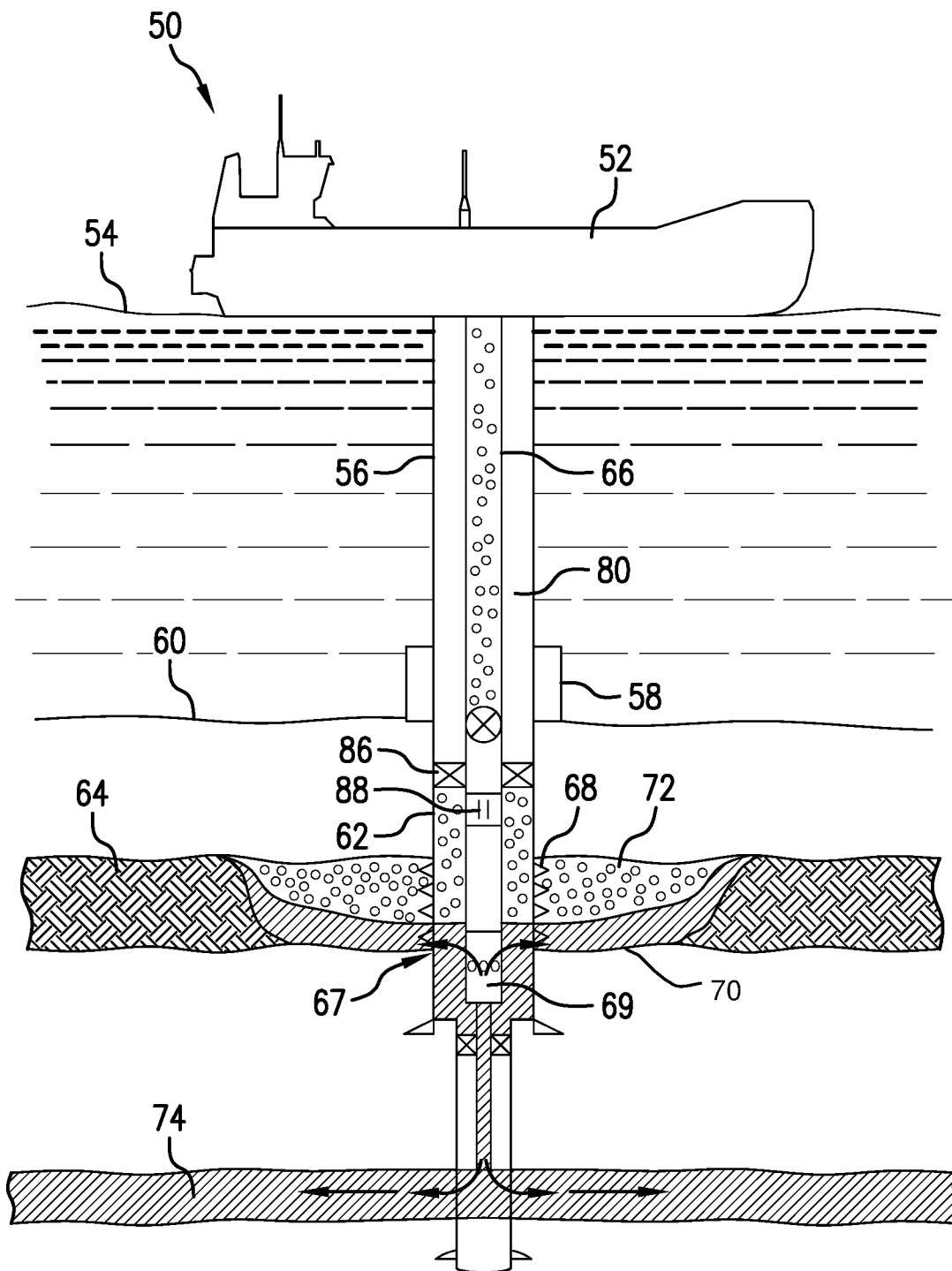


FIG.2

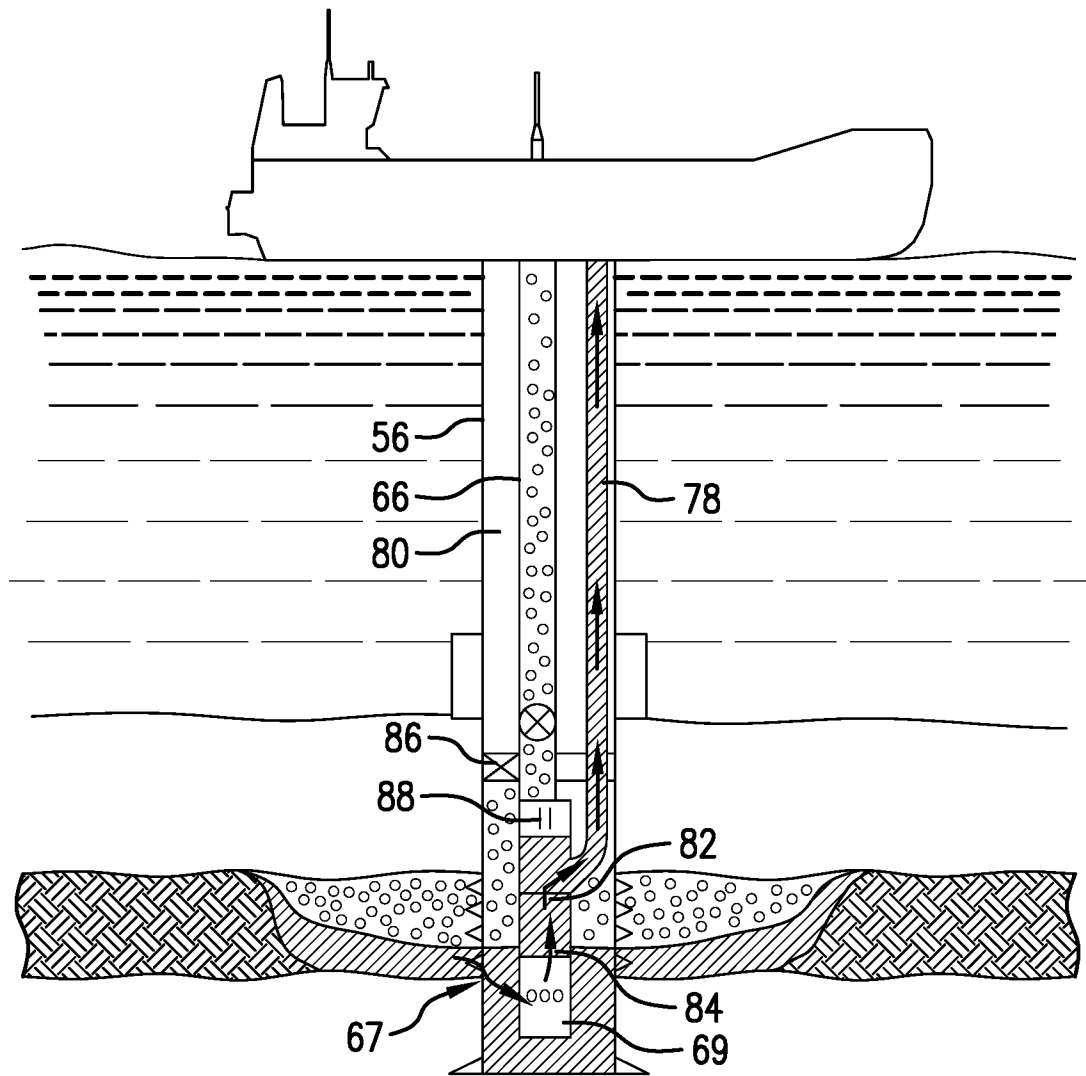


FIG.3

A. CLASSIFICATION OF SUBJECT MATTER**E21B 43/16(2006.01)i, E21B 43/20(2006.01)i, F04D 13/10(2006.01)i**

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 43/16; E21B 43/12; E21B 7/12; C10G 53/04; E21B 43/00; E21B 43/24; E21B 36/00; E21B 43/20; F04D 13/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: methane, hydrate, water, gas, separator, pump, drain, pathway, conduit, completion

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013-0068455 A1 (BROWN et al.) 21 March 2013 See paragraphs [0024]–[0026] and figure 1A.	15
Y		1–14
Y	JP 09-158662 A (POWER REACTOR AND NUCLEAR FUEL DEV. CORP.) 17 June 1997 See paragraph [0019] and figure 3.	1–14
A	US 2011-0209869 A1 (SMITH, DAVID R.) 01 September 2011 See paragraphs [0028]–[0046] and figures 1–3.	1–15
A	US 2004-0099422 A1 (LUSH et al.) 27 May 2004 See paragraphs [0010]–[0044] and figures 1–2.	1–15
A	US 2014-0042058 A1 (SELL OIL COMPANY) 13 February 2014 See paragraphs [0008]–[0021] and figure 4.	1–15



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

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"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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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