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(54) **DUAL GRADIENT PIPELINE EVACUATION METHOD**

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(58) **Field of Classification Search** 166/344, 166/351, 352, 357, 366, 368, 267, 400, 401, 166/339, 170, 177.3
See application file for complete search history.

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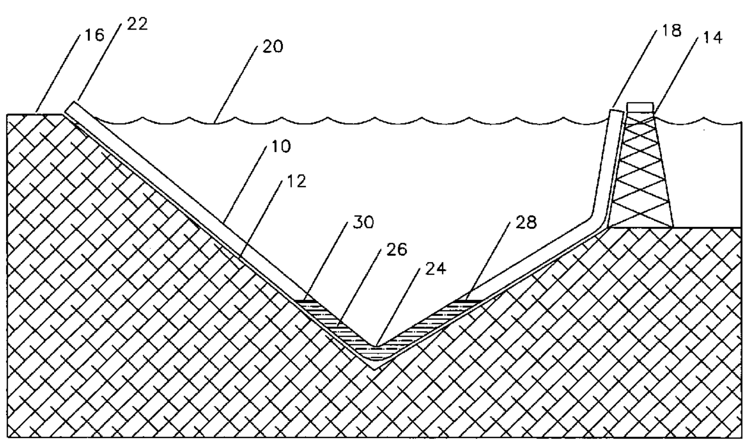
(57) **ABSTRACT**

The method of removing a first liquid from a subsea pipeline which has a central portion lower than each of the ends of the subsea pipeline by pumping a second lower density fluid into the pipeline and the either removing the second lower density fluid by either displacing it with gas or evaporating the second lower density fluid to a gas.

6 Claims, 4 Drawing Sheets



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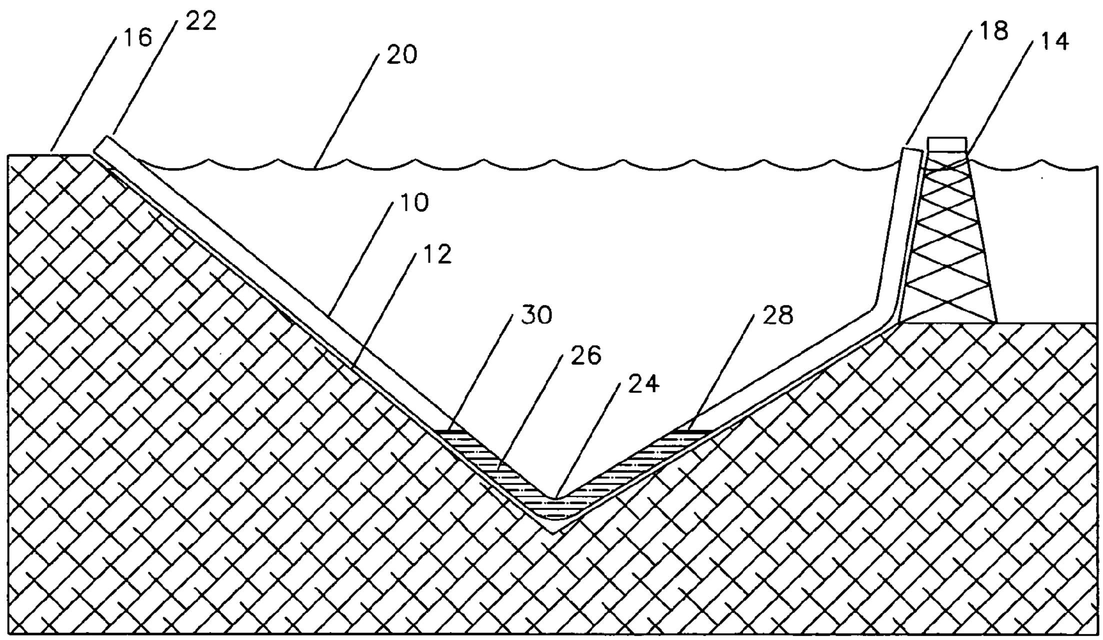

FIGURE 1

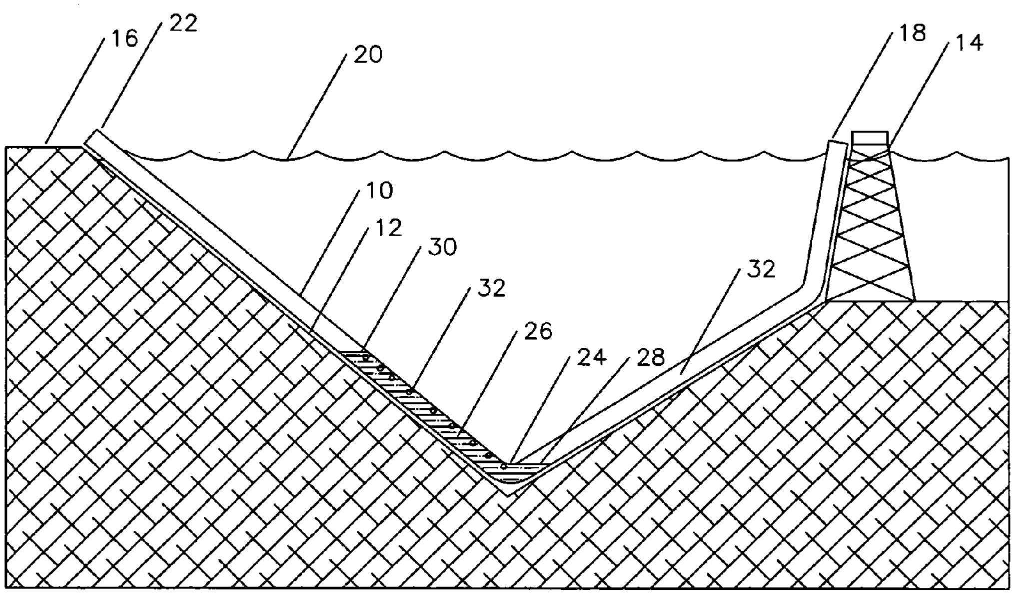

FIGURE 2

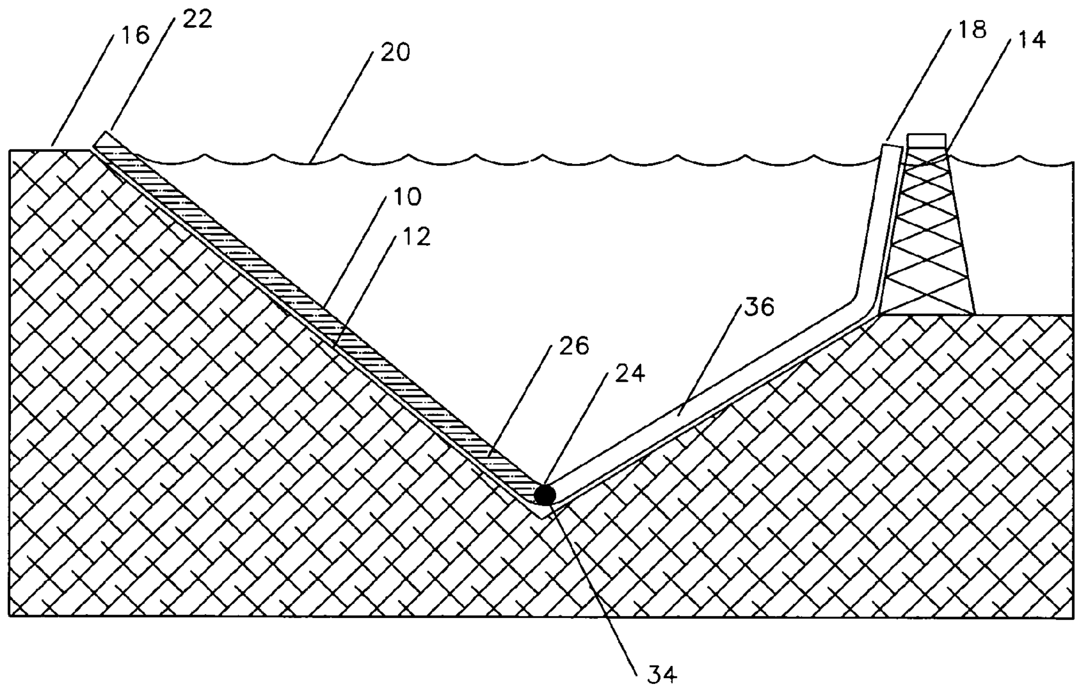

FIGURE 3

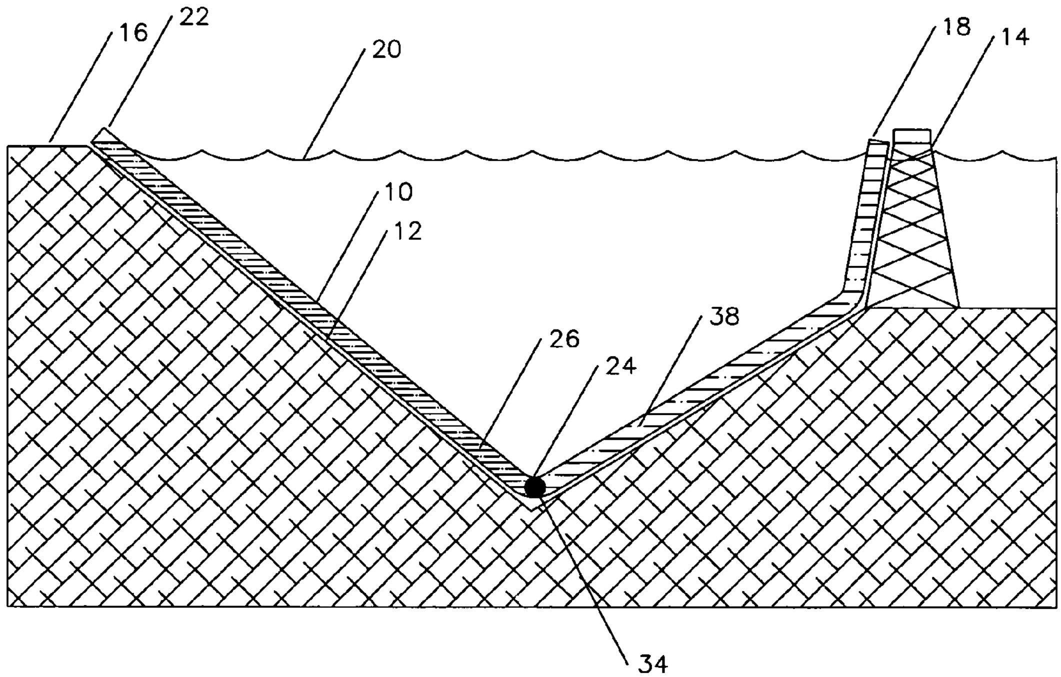

FIGURE 4

DUAL GRADIENT PIPELINE EVACUATION METHOD

TECHNICAL FIELD

This invention relates to the general subject of removing unwanted water from the lower areas of a deepwater subsea pipeline using alternate liquids of lower density.

CROSS-REFERENCE TO RELATED APPLICATIONS

Not applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

REFERENCE TO A "MICROFICHE APPENDIX"

Not applicable

BACKGROUND OF THE INVENTION

The field of this invention is that of removing unwanted water from deepwater pipelines. In some cases methane and other desirable gases will be produced from subsea wells and brought to the surface for initial processing. A prime function of this pre-processing is to remove the water from the gas.

After processing, the gasses will be returned to and along a seafloor pipeline for delivery to a remote location, also at sea level. As the high volume of gasses are passed into the pipeline, some portion of liquids will also reach the pipeline. These liquids, primarily water, will accumulate in the lowest points of the pipelines.

There are pipelines which have each end above sea level, and go through seafloor valleys as deep at 11,000 ft. deep. If a small amount of water accumulates in the pipeline, flowing gasses will simply percolate thru the water. The gas will push the water down on the near side and up on the far side until gas reaches the lowest point. At this time gas passes under the lowest point inside the pipeline and percolates up the far side. If there is enough water in the pipeline to raise the elevation of the water on the downstream side up 100 feet, it will take about 46.5 p.s.i. in gas pressure to do this (salt water is about 0.465 p.s.i./ft.). If you have gas supply pressure of 2,000 p.s.i., it will lift the gas on the downstream side by 4301 feet. If the pipeline depth is greater than 4301 feet, the pipeline is effectively completely blocked. Accumulated salt water in the 11,000 foot deep pipeline would be able to block a pressure of 5,115 p.s.i. (0.465*11,000).

BRIEF SUMMARY OF THE INVENTION

The object of this invention is to provide a method of removing unwanted liquids from a subsea pipeline by displacing the unwanted fluids with a lower density fluid which can be more easily removed by pumping.

A second object of this invention is to provide a method of removing unwanted liquids from a subsea pipeline by displacing the unwanted fluids with a more desirable fluid which can be more easily removed by evaporation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a section of a pipeline extending from an offshore platform through a subsea valley and back up to the shore, having water at the low point in the pipeline.

FIG. **2** is a section of the pipeline of FIG. **1** showing the water displaced towards the downstream side of the low point by gas pressure from the upstream side and gas percolating through the water.

FIG. **3** is a section of the pipeline of FIGS. **1** and **2** showing water being displaced using gas and a pig.

FIG. **4** is a section of the pipeline of FIG. **3** using a low density liquid as the driving means to remove the water from the pipeline.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. **1**, a pipeline **10** is shown on the seafloor **12** between offshore platform **14** and the shore **16**. Upstream end **18** of pipeline **10** is approximately at sea level **20** as is the downstream end at **22**. The lowest point or "valley" in the pipeline **24** can be as deep as 11,000 feet deep. Water **26** is shown in the pipeline and is presently shown with its upstream end **28** at approximately at the same level as downstream end **30**.

Referring now to FIG. **2**, the upstream gas pressure **32** has been increased to force the water at the upstream end **28** down to the level of the upper side of the low point of the pipeline at **24**. The water at the downstream end **30** is pushed up enough that gas bubbles **32** are percolating through the water **26**. The differing head pressure of the water is the gas pressure differential required to accomplish this. Again, this head pressure is generally calculated by the difference in height times 0.465 p.s.i. per foot. Additional flows of gas in the pipeline will not remove the water, but simply pass through the water until enough water accumulates such that it will no longer flow at all.

Referring now to FIG. **3**, a pipeline pig **34** which seals against the bore of the pipeline has been pushed to the "valley" **24** by a working media **36**. As discussed above it would take approximately 5,115 p.s.i. gas to accomplish this if air is the working media.

The compression of gas to these pressures at high volumes associated with large diameter and long subsea pipelines is time consuming and expensive. Finding very large compressors in remote areas operating at that range of pressure would be problematic. The internal volume of a 32 inch diameter pipe **200** miles long is about 4.5 million cu. ft. which would represent an average standard air volume of about 750 million cu. ft. As air has substantial oxygen in it, it has more than a chance of auto-igniting or "dieseling" and generating high and damaging pressures. Nitrogen can be used in place of air without the danger of explosions, but would be very high in cost and supply in remote areas is unlikely.

Referring now to FIG. **4**, consider that instead of gas on the upstream side of the pig **34** a different liquid **38** is used. Liquefied propane/butane is a relatively incompressible liquid when subjected to a pressure of at least 28 psi for butane and 112 psi for propane at 68 degrees F. or lower, and is present as a "condensate" in most pipelines. When a liquid at that temperature, the density of butane is 58% that of sea water and that of propane is 50%.

If a 50/50 mixture of propane and butane were to be used as the media for pushing the dewatering pig, more than 50% of the head pressure necessary would be provided by the weight of the liquid mixture in the pipeline. An additional pressure of only 2,400 psi would be required. Further, to pump a liquid instead of a gas it is inherently a much more efficient operation. This means that instead of 5,115 p.s.i. of difficult gas compression, only 2400 p.s.i. of relatively easy liquid pumping would be required.

After the pipeline pig passes the valley and continues up the opposite side, the required pumping pressure would go from a maximum of 2400 p.s.i. to 0 p.s.i. when the mixture reached sea level at the outlet end. At that point as the pipeline if full of mixture, there are two methods of removing the mixture from the pipeline. As it is approximately ½ as heavy as the water was, adequate gas pressure may be available to simply pump it out using a second pig. Secondly, if the downstream end of the pipeline is simply vented at low pressure, the propane/butane mixture will simply evaporate, although it may take a while.

The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

That which is claimed is:

1. The method of removing a first liquid from a subsea gas pipeline which has an intermediate portion which is lower than the ends of said subsea pipeline, comprising:

displacing said first liquid from said subsea pipeline by pumping a second liquid into said pipeline, and

allowing at least a portion of said second liquid to evaporate to a gas.

2. The method of claim **1** further comprising said first liquid is water.

3. The method of claim **1** further comprising said second liquid is propane.

4. The method of claim **1** further comprising said second liquid is butane.

5. The method of claim **1** further comprising said second liquid is a propane/butane mixture.

6. The method of claim **1**, further comprising separating said first liquid from said second liquid during said pumping operations with a pig which seals in the bore of said subsea gas pipeline.

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