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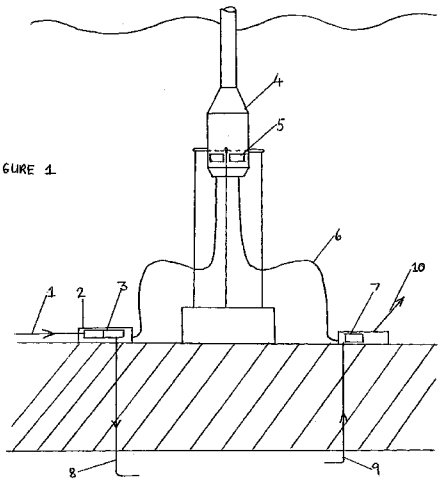
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(54) Title: CARBON CAPTURE AND STORAGE USING MINIMAL OFFSHORE STRUCTURES



(57) Abstract: A means of offshore carbon capture using minimal offshore structures has a pipeline (1) supplying sequestered carbon dioxide, and a control or power source (5) located in a minimal offshore structure (4) connected to a pipeline (8) with access to a geological formation suitable for carbon dioxide storage. The geological formation can be a depleted oil field, coal seam, or natural rock strata. Compressors (3) sited offshore can be used to pressurize the carbon dioxide. The minimal offshore structure (4) can be fixed or floating and can be powered by diesel generators (5) or by a wind turbine. EOR or CBM recovery can also be included. Also, methanol can be produced using the sequestered carbon dioxide in combination with hydrogen formed by electrolysis.

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CARBON CAPTURE AND STORAGE USING MINIMAL OFFSHORE STRUCTURES

Technical Field

This invention relates to carbon capture and storage at offshore sites.

Background Art

Currently it is widely promoted that there exists a vital need to reduce carbon dioxide emissions into the atmosphere. One method allowing substantial reduction involves the capture of carbon dioxide from the emissive source and subsequent storage preventing atmospheric pollution. Proven solutions exist for this method whereby the captured carbon dioxide is pumped into underground storage making use of depleted or near depleted oil fields or other geological formations. Also, enhanced oil recovery (EOR) has been achieved by pumping captured carbon dioxide into near depleted oil fields, so that the carbon dioxide dissolves into the oil giving it better flow properties, thus making the oil easier to extract. Another proposed solution involves the injection of the captured carbon dioxide into uneconomic coal seams in order to displace the coal bed methane (CBM) thereby releasing the methane as a potential power source and storing the carbon dioxide. However, these solutions are currently only used onshore. It has been proposed that these solutions could be used offshore but would currently be economically not viable using current technology.

Summary of Invention

We have now devised a means of alleviating the above problem and allowing economic storage of captured carbon in offshore locations. This also provides the further advantage of allowing EOR offshore, thereby giving access to many near depleted oil fields and prolonging field life. Another advantage is that this invention gives access to offshore coal seams that could be utilised for methane extraction from the coal bed, displaced by the injection of the captured carbon dioxide.

According to the present invention there is provided a means of offshore carbon capture and storage using minimal offshore structures comprising a pipeline or conduit or other device or combination or multiple thereof supplying captured carbon dioxide, a control means or power source or both, and one or more minimal offshore structures, said control means or power

source or both being located in one or more of said one or more minimal offshore structures, and said control means or power source or both having connected access to said pipeline or conduit or device.

In a preferred embodiment of the invention there is provided a supply access means to a natural or man-made geological formation suitable for carbon dioxide storage, said control means or power source or both having connected access to said supply access means. This embodiment can be used with any variations of the invention in which access to the geological formation is required.

The supply access means can be formed using previously used oil or gas production wells or associated previously used reinjection wells.

In one embodiment of the invention, the control means is provided partially by one or more fluid transmission pumps.

In one embodiment of the invention, the device supplying captured carbon dioxide is one or more artificial trees, whereby the carbon dioxide is captured from the air through a filter using a sorbent material.

In a preferred embodiment of the invention, one or more compressors are located in one or more of said one or more minimal offshore structures. The compressor(s) is (are) connected to the pipeline, and pressurizes (pressurize) the captured carbon dioxide prior to supply to said geological formation via said supply access means. The one or more compressors can be located in separate minimal structures from the control means or power source or both.

In a preferred embodiment the natural or man made geological formation for storage of carbon dioxide is a depleted offshore oil or gas field.

In another embodiment, the geological formation is a coal seam.
In a preferred embodiment of the invention at least one of the minimal offshore structures is a taut moored buoyant structure. In this case the buoyant structure is tethered to a foundation

located on the seabed such that the excess buoyancy is manifested as a force in the tethers, and the tethers remain taut for a range of environmental conditions.

At least one of the taut moored buoyant structures can be preferably an unmanned facility with controls that can be remotely accessed and monitored, and with a hull that has a water surface piercing tubular section. The hull provides housing under the water surface for location of the control means or power source or both.

At least one of the taut moored buoyant structures can be an unmanned facility with a hull that supports a telescopically extendable shaft, with excess buoyancy (used to ensure taut mooring) provided by the hull or additionally provided by buoyancy devices attached to the hull.

In another embodiment, at least one of the minimal offshore structures is fixed to the seabed.

At least one of the fixed offshore structures can be an unmanned facility fixed to the seabed with a gravity base or / and piles, and with a watertight chamber having a water surface piercing tubular section. A telescopically extendable column is located on the tubular section.

At least one of the fixed offshore structures can be an unmanned facility with a watertight chamber located on the seabed that is open to the atmosphere through a shaft. Said shaft extends upwardly from the chamber. Peripheral compartments can be included that allow for ballasting or buoyancy of the structure during transport and installation. The facility allows for operations and maintenance to be performed in ambient atmospheric conditions.

At least one of the fixed offshore structures can be a minimal platform that has a deck structure supported by support columns with a base that is movable from a floating to a submerged position, and a removable barge disposed between the base and deck structure during installation. Clamps are used for clamping the deck structure to the support columns once the base is submerged. Said base is capable of providing buoyancy for sea transport and installation.

In one embodiment the power source is provided in full or partially by one or more wind turbines. The wind turbine(s) can be located on the minimal offshore structure(s).

Preferably, the power source is provided in full or partially, by diesel generators, or by gas turbines, by gas engines, or by a combination.

In another preferred embodiment of the invention the captured carbon is used to facilitate EOR. The captured carbon is pumped or forced into a depleted oil, gas, or condensate field to ease the recovery of the oil, gas or condensate. The recovered fluid from said EOR can be transmitted from the geological formation through a recovery pipeline or recovery conduit controlled or powered by a recovery control means or recovery power source or both. Previously used oil or gas production wells or associated previously used reinjection wells can be used to provide the recovery conduit. The recovery control means can be provided partially by one or more fluid transmission pumps. A storage facility can be provided for the recovered oil with connected access to said recovery pipeline.

In another embodiment of the invention the captured carbon is used to facilitate enhanced methane recovery. The captured carbon is pumped or forced into an offshore coal seam displacing and releasing the coal bed methane (CBM). The released CBM from said enhanced methane recovery can be transmitted from the coal seam through a recovery pipeline or recovery conduit controlled or powered by a recovery control means or recovery power source or both. The methane produced can be used to power gas turbines or gas engines which then can provide power to pump or pressurize the supply of captured carbon dioxide. Alternatively, the power produced can be sent back to shore using electrical cables or cabled to another offshore facility. Alternatively the methane recovered can be piped back to shore or to another offshore facility. The recovered methane can be further treated before it is piped onwards. Groups of minimal structures can be used for enhanced methane recovery in close proximity to each other in order to provide methane or power to a power production or distribution plant or hub.

In one embodiment of the invention electrolysis is performed within at least one of the minimal offshore structures. The hydrogen bi-product created by electrolysis can be

combined with the carbon dioxide and used to create methanol. The methanol so produced can be temporarily stored offshore or exported for use at another location either by pipeline or shuttle tanker. The oxygen bi-product can be returned to shore to inject into the power production process to improve combustion thus ensuring a higher quality carbon dioxide supply. This embodiment can be used with or without the supply access means to said geological formation.

Any excess carbon dioxide from these embodiments can be injected into temporary storage or into said man-made or geological formation if said supply access is included.

Any of the embodiments described can be combined if possible and if desired.

Brief Description of Drawings

For a better understanding of the invention and to show how the same may be carried into effect reference will now be made by way of example only to the accompanying drawings in which: -

Figure 1 shows a general arrangement view of a preferred means of offshore carbon capture and storage combined with EOR using minimal offshore structures (with power provided by diesel generators housed in a taut moored buoyant structure).

Figure 2 shows a general arrangement view of a means of offshore carbon capture and storage combined with methanol production using a minimal offshore structure (with power provided by wind energy).

Description of embodiments

Referring to Figure 1, there is shown a preferred means of offshore carbon capture and storage using minimal offshore structures consisting of a pipeline 1 conveying captured carbon dioxide, a minimal subsea base 2, housing compressors 3, a taut moored buoyant structure 4 housing diesel generators 5, power supply cables 6, a transmission pump 7, a supply pipe 8 to a subsea oil field, a recovery pipe 9 from the subsea oil field for recovering oil (EOR), and a pipeline 10 conveying the recovered oil to a storage facility.

The subsea base 2 is a minimal structure that protects the compressors 3 housed within. The compressors 3 provide further pressure to the captured carbon dioxide from the pipeline 1. Power to the compressors 3 is provided by the diesel generators 5 housed within the taut moored structure 4. Power cables 6 lead from the diesel generators 5 to the compressors 3 (and to the pump 7).

The captured carbon is injected into the subsea oil field through the supply pipeline 8 by the pressure provided by the compressors 3. The pipeline 9 is used to recover oil from the oil field facilitating EOR. Transmission pump 7 is used to pump oil from the subsea field through pipeline 9 and on into pipeline 10 conveying the oil to a storage facility. The pump 7 is housed in a small structure. Power for the pump 7 is supplied by some of the power cables 6 leading from the generators 5. The pipelines 8 and 9 are connected to previously used wells.

The taut moored buoyant structure 4 is an unmanned facility with controls that can be remotely accessed and monitored. There is a radio / satellite link attached at the top of the buoyant structure 4 well above the water splash zone. Exhausts for the diesel generators 5 exit the buoyant structure 4 above the splash zone. Fuel is stored in the buoyant structure 4 and is replenished via supply ship on a two monthly basis.

The buoyant structure 4 consists of two tubular sections, one being a larger diameter storage chamber. Conical sections are used at the intersections of the tubulars and at the bottom of the structure, in order to reduce wave forces. The larger diameter chamber is used to store power-generating equipment needed for the control, monitoring and power systems. This chamber is located below the water surface at a level designed to avoid large forces from wave action. The upper surface piercing tubular section is small enough to minimise wave forces but large enough to allow access for maintenance. The lower conical section is small enough to minimise wave forces, but large enough to allow storage of a quantity of fuel or ballast material. The quantity of ballast material stored can be adjusted to suit localised wave conditions in order to stabilise the buoyant structure 4 motions. The size of the tubular sections is designed to provide adequate buoyancy to maintain tension in the flexible

connectors (providing the taut mooring) and dynamic stability during adverse weather conditions. Thus the structure 4 can be adjusted to suit different locations with differing wave climates.

Referring to Figure 2 there is shown a means of offshore carbon capture and storage using minimal offshore structures consisting of a pipeline 1 conveying captured carbon dioxide from a power plant onshore, a fixed offshore structure 11 supporting a wind turbine 12, power generators 13, electrolysis equipment 14, methanol production equipment 15, a pipeline 16 for transfer of methanol, a pipeline 17 for transfer of oxygen back to the power plant, a pipeline 18 for injection of excess carbon dioxide, and a pipeline 19 for hydrogen transfer.

The fixed offshore structure 11 has a watertight chamber formed from concrete and reinforced concrete including a base situated on the seabed. It also has a shaft which (can be telescopic) extends upwards from the chamber and supports the wind turbine 12 at the top. The structure 11 can be formed using multiple chambers if desired and can be self buoyant for tow out purposes. It can be fixed to the seabed using pin piles, suction piles, or epoxy grout.

The power generators 13, the electrolysis equipment 14, and the methanol production equipment 15 are housed within the offshore structure 11.

The wind turbine 12 supplies power to the power generators 13 which provide power for the electrolysis equipment 14, methanol production equipment 15, and all pipeline transfer pumps (not shown). An alternative back-up power supply can also be provided.

The electrolysis equipment 14 produces oxygen which is piped back to the power plant in the pipeline 17. Also produced is hydrogen which is piped into the methanol equipment 15 using pipeline 19.
Carbon dioxide from the power plant is piped into the methanol equipment 15 using pipeline 1. The hydrogen and carbon dioxide are combined in the methanol production equipment 15 to produce the methanol which is then piped through pipeline 16 for storage or other use.

Any excess carbon dioxide is transferred for storage into a depleted oil field using pipeline 18.

CLAIMS

1. A means of offshore carbon capture and storage using minimal offshore structures comprising a pipeline or conduit or other device or combination or multiple thereof supplying captured carbon dioxide, a control means or power source or both, and one or more minimal offshore structures, said control means or power source or both being located in one or more of said one or more minimal offshore structures, and said control means or power source or both having connected access to said pipeline or conduit or device.

2. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 1, wherein there is provided a supply access means to a natural or man-made geological formation suitable for carbon dioxide storage, said control means or power source or both having connected access to said supply access means.

3. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 2, wherein said supply access means is formed using previously used oil or gas production wells or associated previously used reinjection wells.

4. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 2, wherein said control means is provided partially by one or more fluid transmission pumps.

5. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 2, wherein one or more compressors are located in one or more of said one or more minimal offshore structures, said one or more compressors having connection means to the pipeline, and said one or more compressors having facility to pressurize the captured carbon dioxide prior to supply to said geological formation.

6. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 5, wherein the one or more compressors are located in separate minimal structures from the control means or power source or both.

7. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 2, wherein the natural or man made geological formation for storage of carbon dioxide is a depleted or partially depleted offshore oil or gas field.

8. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 2, wherein the natural or man made geological formation for storage of carbon dioxide is a coal seam.

9. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 2, wherein at least one of said one or more minimal offshore structures is a taut moored buoyant structure.

10. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 9, wherein at least one of the taut moored buoyant structures is an unmanned facility with controls that can be remotely accessed and monitored, with a hull that has a water surface piercing tubular section and provides housing under the water surface for location of the control means or power source or both.

11. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 9, wherein at least one of the taut moored buoyant structures is an unmanned facility with a hull that supports a telescopically extendable shaft, with excess buoyancy provided by the hull or additionally provided by buoyancy devices attached to the hull.

12. A means of offshore carbon capture and storage using minimal offshore structures as claimed in any preceding claim, wherein at least one of said one or more minimal offshore structures is fixed to the seabed.

13. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 12, wherein at least one of the fixed offshore structures is an unmanned facility fixed to the seabed with a gravity base or / and piles, and has a watertight chamber having a water surface piercing tubular section, with a telescopically extendable column supported thereon.

14. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 12, wherein at least one of the fixed offshore structures is an unmanned facility with a watertight chamber located on the seabed that is open to the atmosphere through a shaft extending upwardly therefrom.

15. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 12, wherein at least one of the fixed offshore structures is a minimal platform that has a deck structure supported by support columns with a base that is movable from a floating to a submerged position, and a removable barge disposed between the base and deck structure during installation, with said base capable of providing buoyancy for sea transport and installation.

16. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 1, wherein the power source is provided in full or partially by one or more wind turbines.

17. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 16, wherein at least one of said one or more wind turbines is located on said one or more minimal offshore structures.

18. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 1, wherein the power source is provided in full, except where provided in full by other means, or is provided partially, by diesel generators, or by gas turbines, by gas engines, or by a combination.

19. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 1, wherein the captured carbon is forced into an offshore oil, gas, or condensate field in order to facilitate Enhanced oil, gas, or condensate recovery (EOR).

20. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 19, wherein the recovered fluid from said EOR is transmitted from

the oil, gas, or condensate field through a recovery pipeline or recovery conduit controlled or powered by a recovery control means or recovery power source or both.

21. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 20, wherein the recovery conduit is provided using previously used oil or gas production wells or associated previously used reinjection wells.

22. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 20, wherein the recovery control means is provided partially by one or more fluid transmission pumps.

23. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 20, wherein a storage facility is provided for the recovered oil with connected access to said recovery pipeline.

24. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 8, wherein the captured carbon is forced into an offshore coal seam in order to facilitate enhanced methane recovery.

25. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 24, wherein the recovered methane from said enhanced methane recovery is transmitted from the coal seam through a recovery pipeline or recovery conduit controlled or powered by a recovery control means or recovery power source or both.

26. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 25, wherein the methane produced is used to power gas turbines or gas engines.

27. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 26, wherein the electrical power produced is used to provide power to pump or pressurize the supply of captured carbon dioxide.

28. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 26, wherein the electrical power produced is sent back to shore or to another offshore facility using electrical cables.

29. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 25, wherein the recovered methane is piped back to shore or to another offshore facility with or without further treatment.

30. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 25, wherein groups of minimal structures are used to provide methane, with or without further treatment, or electrical power to a central power production or distribution hub or plant.

31. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 1 or Claim 2, wherein electrolysis is performed within at least one of said one or more minimal offshore structures.

32. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 31, wherein the hydrogen bi-product created by electrolysis is combined with the carbon dioxide and used to create methanol.

33. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 32, wherein the methanol so produced is temporarily stored offshore or exported for use at another location either by pipeline or shuttle tanker.

34. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 31, wherein the oxygen bi-product is returned to shore to inject into the power production process to improve combustion thus ensuring a higher quality carbon dioxide supply.

35. A means of offshore carbon capture and storage using minimal offshore structures as claimed in Claim 31, wherein excess carbon dioxide is injected into temporary storage or into said man-made or geological formation.

36. A means of offshore carbon capture and storage using minimal offshore structures substantially as herein described and illustrated in the accompanying drawings.

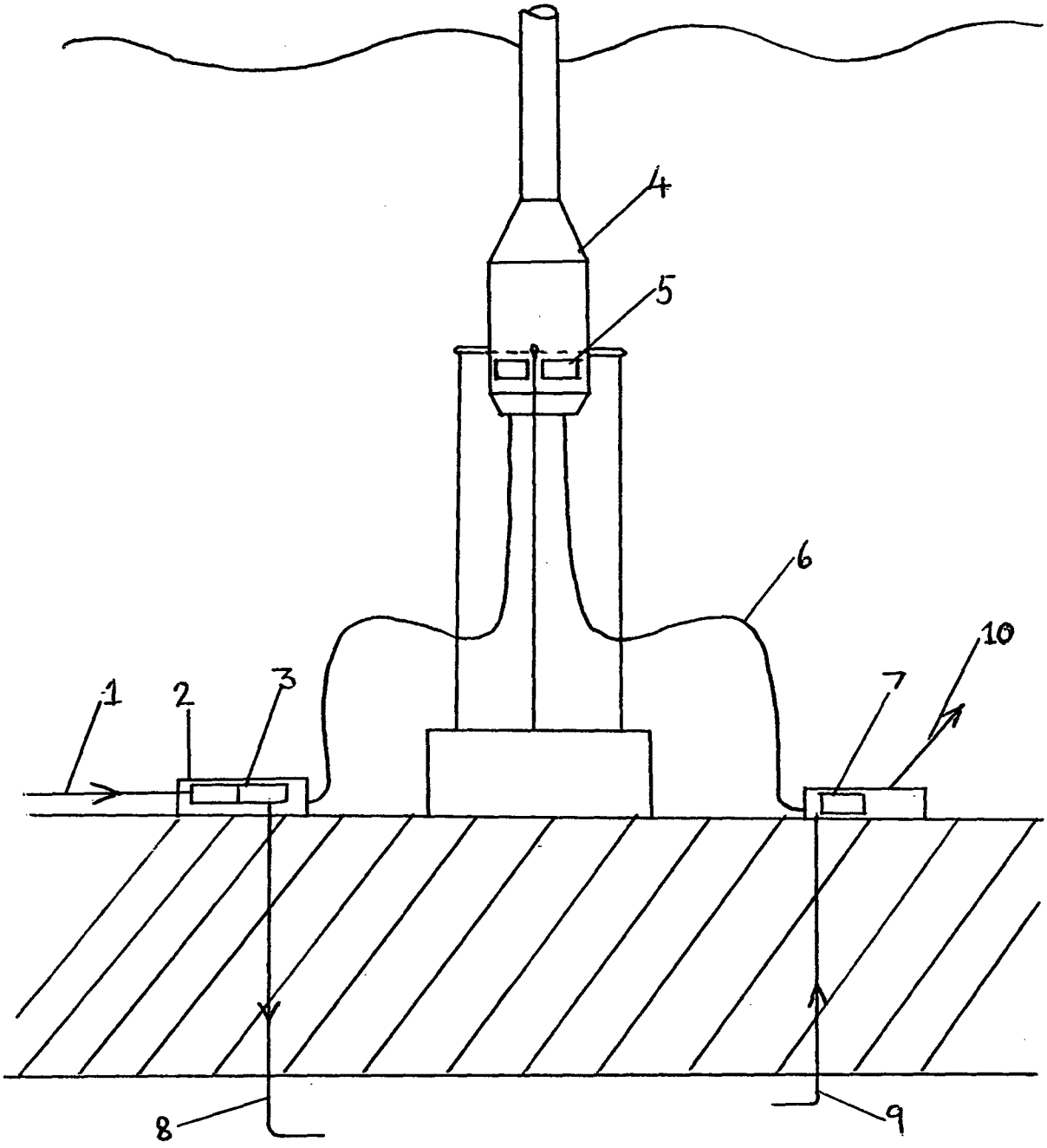


FIGURE 1

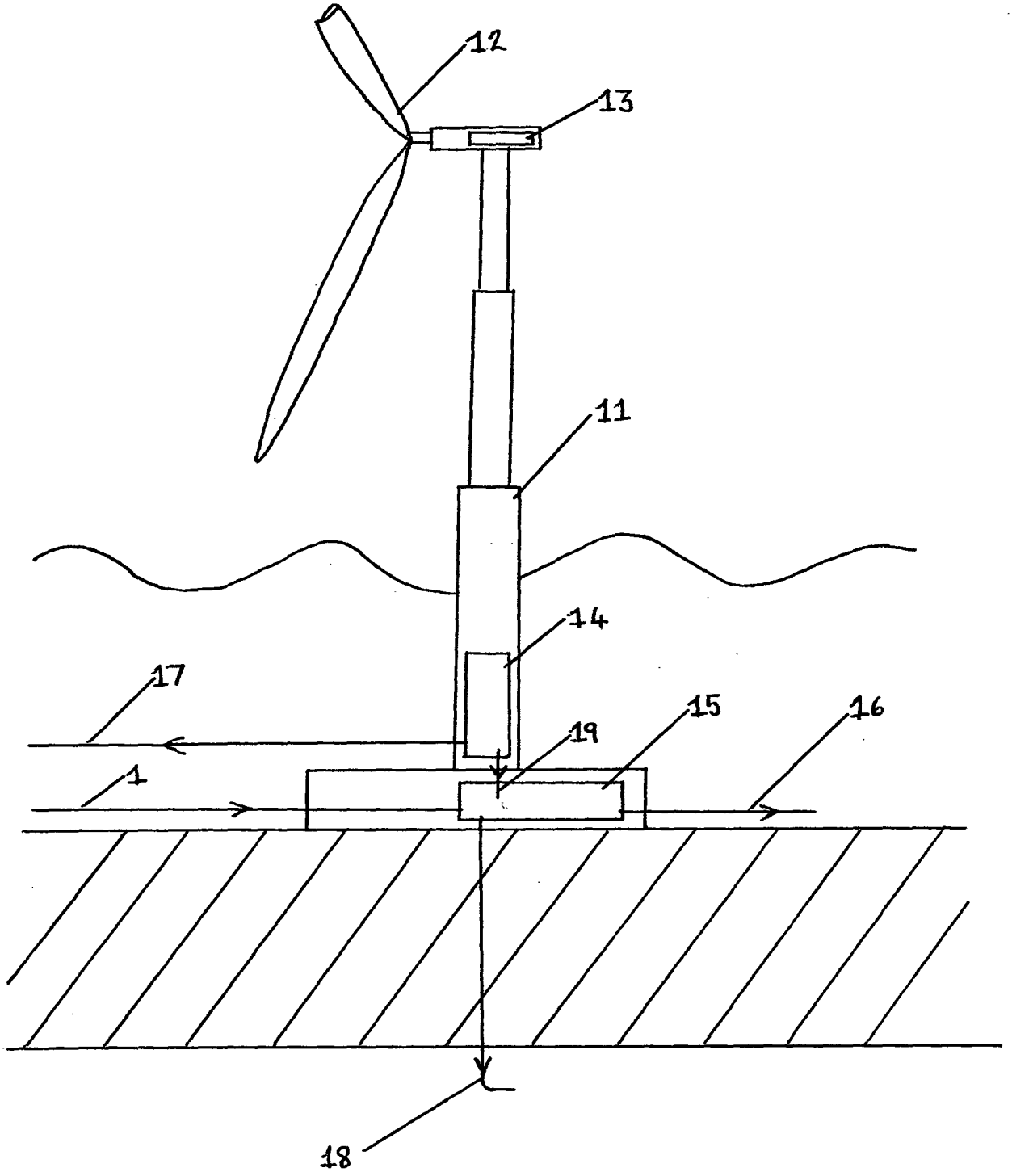


FIGURE 2