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(54) **TUBE-IN-TUBE DEVICE USEFUL FOR SUBSURFACE FLUID SAMPLING AND OPERATING OTHER WELLBORE DEVICES**

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(60) Provisional application No. 61/333,208, filed on May 10, 2010.

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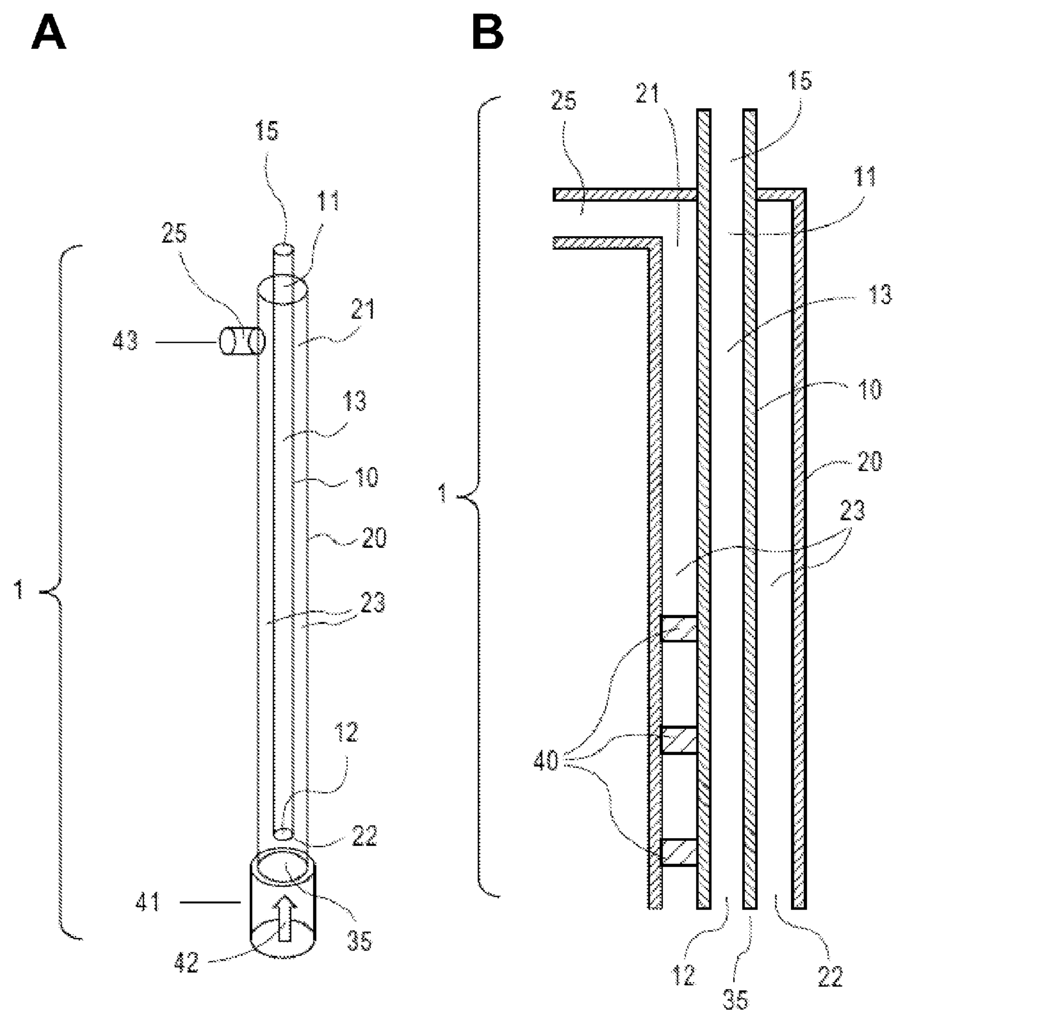
(57) **ABSTRACT**

The present invention provides for a tube-in-tube system comprising: (a) an outer conduit having a proximal end and a distal end, and (b) an inner conduit having a proximal end and a distal end, wherein the inner conduit is disposed within the outer conduit, wherein the proximal end of the inner conduit is in fluid communication with a first aperture, and the proximal end of the outer conduit is in fluid communication with a second aperture, and the distal ends of the inner and outer conduits are in fluid communication with each other and to a third aperture. The present invention also provides for a split toroidal borehole clamp.



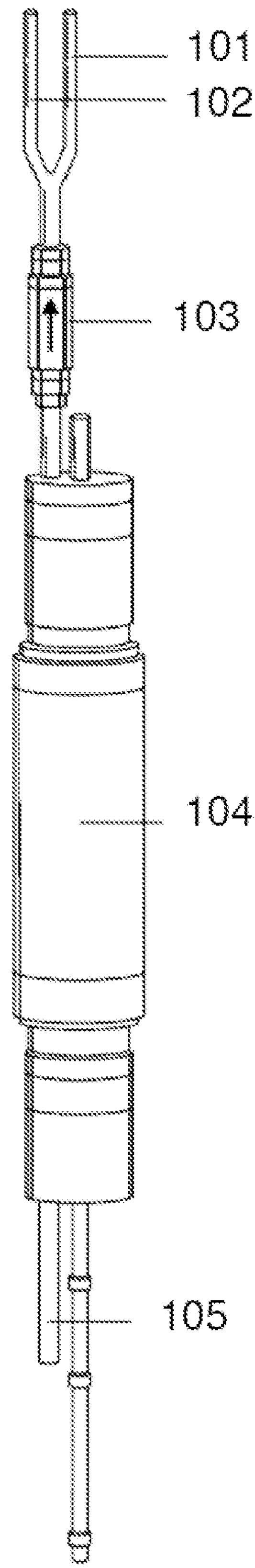


FIG. 1
(PRIOR ART)

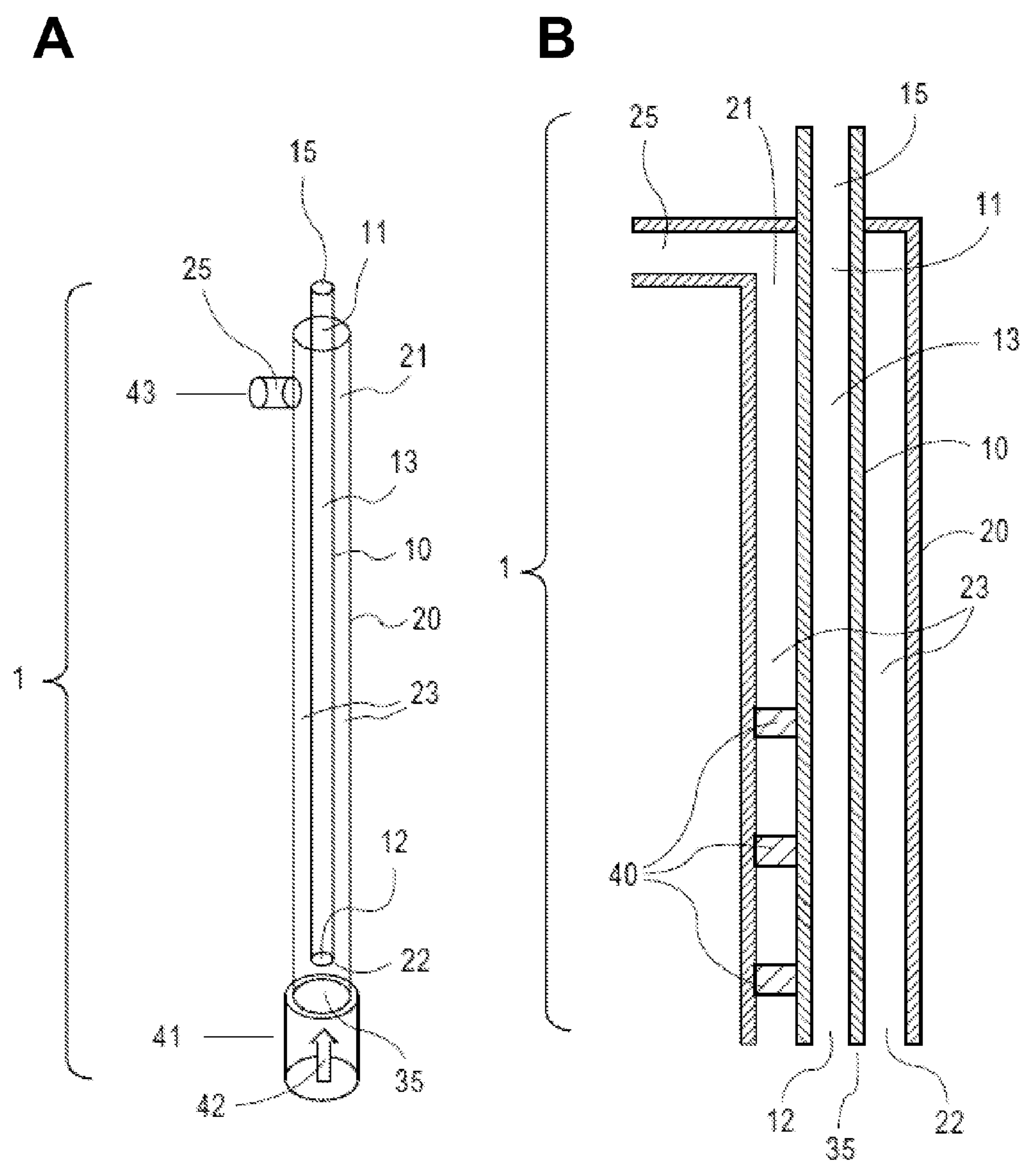


FIG. 2

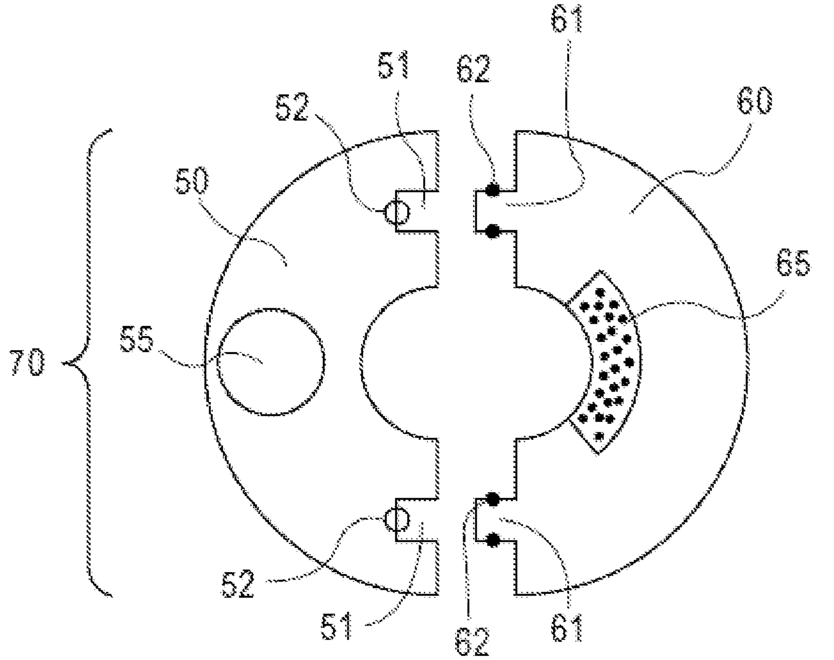


FIG. 3

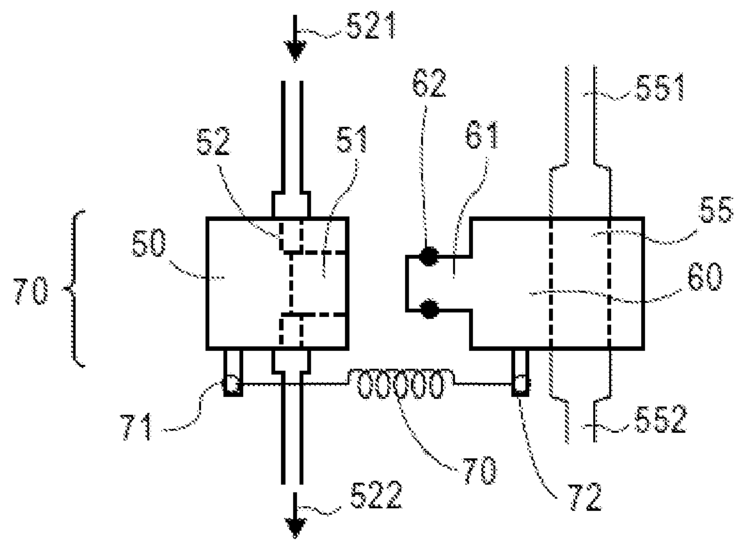


FIG. 4

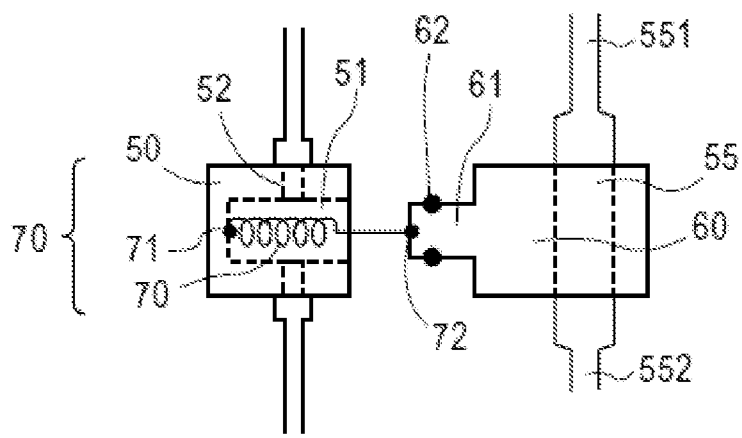


FIG. 5

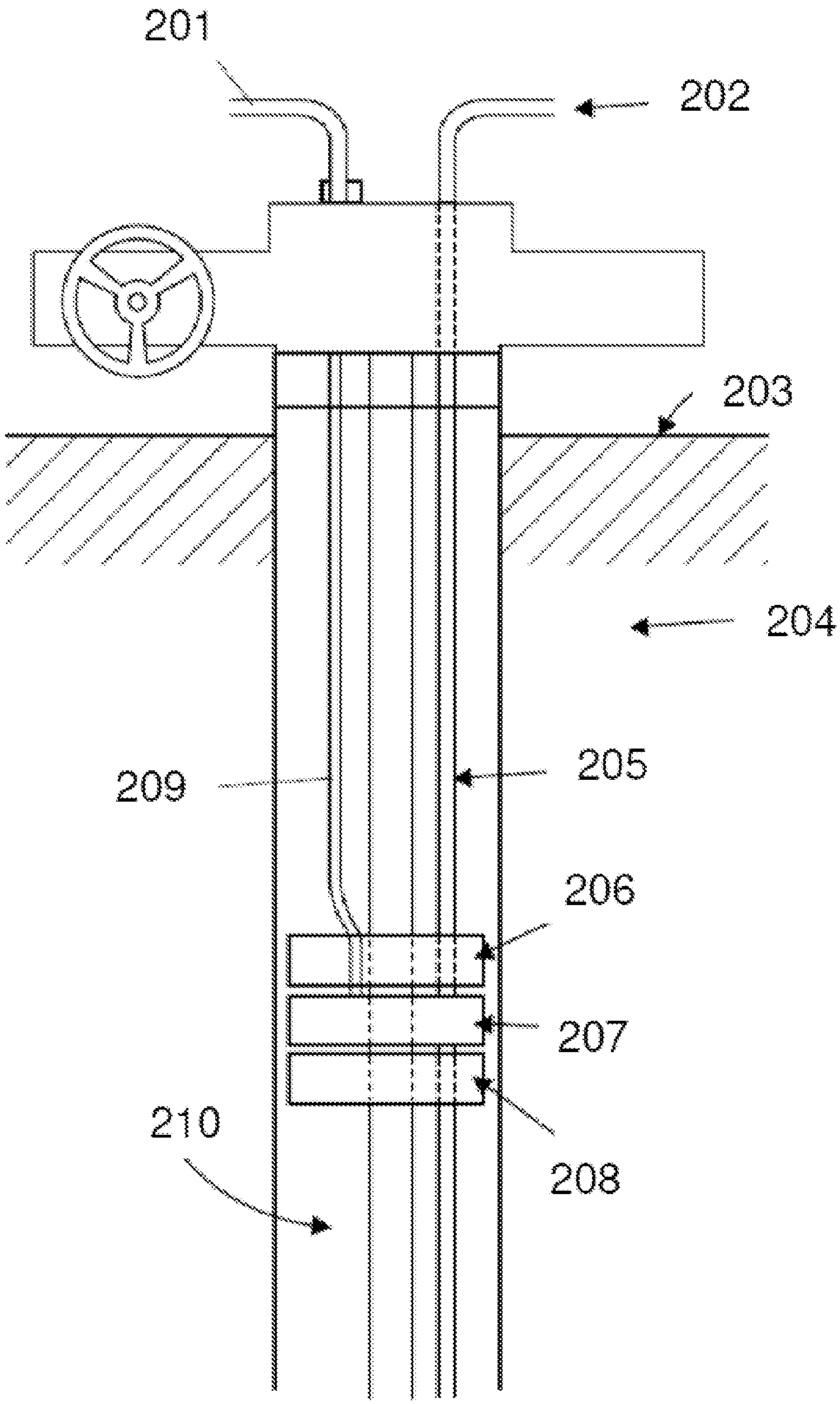


FIG. 6

TUBE-IN-TUBE DEVICE USEFUL FOR SUBSURFACE FLUID SAMPLING AND OPERATING OTHER WELLBORE DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority as a continuation application to PCT International Patent Application No. PCT/US11/35953, filed May 10, 2011, which claims priority to U.S. Provisional Patent Application Ser. No. 61/333,208, filed on May 10, 2010, which is hereby incorporated by reference.

STATEMENT OF GOVERNMENTAL SUPPORT

[0002] The invention was made with government support under Contract No. DE-AC02-05CH11231 awarded by the U.S. Department of Energy. The government has certain rights in the invention.

FIELD OF THE INVENTION

[0003] The present invention is in the field of subsurface fluid sampling and operation of borehole devices.

BACKGROUND OF THE INVENTION

[0004] Obtaining a representative downhole fluid sample from great depths is a difficult endeavor. During sampling, changes in pressure and temperature produce unwanted changes in fluid chemistry. Traditional sampling of boreholes is performed by a submersible pump or by lowering a sampling device within the wellbore. In two-phase systems, submersible pumps fail to operate and gas separators are needed, drastically changing the composition of the downhole fluid. Sampling devices lowered in the wellbore, such as the flow-through downhole Kuster sample (Kuster Co., Long Beach, Calif.), require wirelines and need to be run in and out of the borehole for each sample acquired. Because the sample obtained by the sample is of limited volume, if the well-bore is not purged prior to deploying the sample, the representativeness of the collected fluid would be in question. There are other methods used for producing fluids from deep boreholes, such as conventional gas lift systems, but these alter the chemical and physical composition of the recovered fluids and are not usually considered acceptable for geochemical sampling.

[0005] U.S. Pat. No. 6,179,056 discloses an artificial lift, concentric tubing production system for a well comprising: an upper concentric tubing string portion comprising an inner production tubing string positioned within an outer production tubing string; a flow crossover assembly connected to said upper concentric tubing string portion, said flow crossover assembly having first and second passageways, said inner production tubing string in fluid communication with said first passageway and said outer production tubing string in fluid communication with said second passageway; an electric submersible pump in fluid communication with one of said passageways of said flow crossover assembly; and a lower apparatus in fluid communication with the other of said passageways of said flow crossover assembly

[0006] U.S. Pat. No. 7,523,680 discloses a gas membrane sampling device comprising a membrane element including a liquid-tight, gas-permeable membrane, a filler material contained in and stabilizing the membrane element, and a connection cable being adapted for conducting gas out of the membrane element through a bore hole to a surface of the earth's; and a gas sensor device for geological investigations, comprising the gas membrane sampling device and an analyzing device connected with the connection cable of the gas membrane sampling device.

[0007] U.S. Patent Application Publication No. 2009/0166042 discloses a downhole optical sensing system including an optical line, two tubular conduits, one conduit being positioned within the other conduit, and the optical line being positioned within one of the conduits, and a purging medium flowed in one direction through one conduit, and flowed in an opposite direction between the conduits.

[0008] Currently, the U-tube sampler is used for sub-surface or borehole sampling. See FIG. **1**. The U-tube sampler has the disadvantage that two control lines are required for operation of the device. Installing two control lines creates complexity during the installation process and requires individual wellhead penetration. In addition, when installed permanently using grout or concrete, penetration into the void created where two lines are run in parallel is problematic.

[0009] Another problem is insufficient clamping force when deploying a geophone in a borehole. Several methods to address this issue have been disclosed in U.S. Pat. Nos. 5,302,782; 5,864,099; 6,206,133; and, 6,712,141.

SUMMARY OF THE INVENTION

[0010] The present invention provides for a tube-in-tube system comprising: (a) an outer conduit having a proximal end and a distal end, and (b) an inner conduit having a proximal end and a distal end, wherein the inner conduit is disposed within the outer conduit, wherein the proximal end of the inner conduit is in fluid communication with a first aperture, and the proximal end of the outer conduit is in fluid communication with a second aperture, and the distal ends of the inner and outer conduits are in fluid communication with each other and to a third aperture.

[0011] In some embodiments of the invention, the tube-in-tube system is a well-bore sampler comprising: (a) an outer conduit having a proximal end and a distal end, and (b) an inner conduit having a proximal end and a distal end, wherein the inner conduit is disposed within the outer conduit, wherein the proximal end of the inner conduit is in fluid communication with a first aperture in fluid communication with a high pressure gas source, and the proximal end of the outer conduit is in fluid communication with a second aperture in fluid communication with a sample collector, or vice versa, and the distal ends of the inner and outer conduits are in fluid communication with each other and to a third aperture in fluid communication with a downhole or well-bore. In some embodiments of the invention, the tube-in-tube system is a well-bore sampler.

[0012] In some embodiments of the invention, the well-bore sampler further comprises a check valve in fluid communication with the third aperture, wherein the check valve permits fluid moving in the direction towards the distal ends of the inner and outer conduits, but does not permit fluid moving in the direction away from the distal ends of the inner and outer conduits. In some embodiments of the invention, the tube-in-tube system further incorporates a sliding end packer for isolation of wellbore fluids. In some embodiments of the invention, the well-bore sampler further incorporates an inlet filter (such as a 40 μm sintered stainless steel filter) in order to remove particulates that can interfere with the operation of the check valve.

[0013] In some embodiments of the invention, the tube-in-tube system is used to introduce inflation fluids to a pneumatic packer. The tube-in-tube system replaces an inflation control line and permits the introduction of a fluid, such as a high viscosity inflation fluid, for packer activation, and subsequent removal of the fluid using a low viscosity gas to de-activate the pneumatic packer. The tube-in-tube system thus having the advantage of being able to activate and de-activate a packer using a single control line.

[0014] In some embodiments of the invention, the tube-in-tube system is used to activate a downhole device using the introduction of a fluid and then deactivate the device by removal of the fluid. The benefit of the tube-in-tube over a single control line is that the single control line is limited to activation using gaseous low-viscosity fluids, whereas the tube-in-tube permits the introduction of heavy high-viscosity fluids for device activation and the removal of the heavy high-viscosity fluid using a low viscosity gas.

[0015] An advantage of the invention is that the tube-in-tube system only requires one control line. The U-tube sampling system has two separate control lines. As such, the use of the tube-in-tube system reduces the number of control lines by half, as compared to the use of the U-tube sampling system. This also means that the use of the tube-in-tube system in place of the U-tube sampling system results in having twice the number of possible sampling systems in place. The functioning of the tube-in-tube system can fully take the place of the U-tube sampling system.

[0016] Another advantage of the tube-in-tube system is that current commercially available tubes can be used, such as stainless steel tubes.

[0017] The present invention also provides for a method of obtaining a well-bore sample comprising: (a) inserting a well-bore sampler of the present invention comprising the tube-in-tube system into a well-bore such that the fluid table reaches within the length of the tube-in-tube system, wherein the first aperture is in fluid communication to a high pressure gas source and the second aperture in fluid communication with a sample collector, (b) venting or evacuating the passageways of the inner and outer conduits by introducing an inert gas, such as nitrogen gas, from the high pressure gas source through the first aperture, into the passageway of the inner conduit, and then into the passageway of the outer conduit to force any fluid and/gas in the tube-in-tube system such that the passageways within the tube-in-tube system below the fluid table is filed with the inert gas, (c) releasing the pressure of the inert gas in passageways of the tube-in-tube system, such as by opening at least one end of the inner or outer conduit to the atmosphere, such that sample fluid in the well-bore fills the passageways of the inner and outer conduits up to the level of the fluid table, (d) introducing an inert gas, such as nitrogen gas, from the high pressure gas source through the first aperture, into the passageway of the inner conduit, and then into the passageway of the outer conduit to force the sample fluid through the second aperture into the sample collector, and, optionally repeating steps (c) and (d) to collect further samples of sample fluid. During the venting or evacuating step (b) and introducing step (d), the pressure caused by the inert gas closes a check valve distal to the tube-in-tube system.

[0018] The well-bore sampler of the present invention is capable of providing minimally contaminated or essentially non-contaminated aliquot or aliquots of multiphase fluids from deep reservoirs and allows for accurate determination of dissolved gas composition. The well-bore sampler of the present invention can be permanently or semi-permanently deployed in a wellbore to provide the ability to periodically (or continuously) acquire samples.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The foregoing aspects and others will be readily appreciated by the skilled artisan from the following description of illustrative embodiments when read in conjunction with the accompanying drawings.

[0020] FIG. **1** shows the prior art U-tube sampling system.

[0021] FIG. **2** shows the tube-in-tube system. Panel A shows the 3-D view of one embodiment of the tube-in-tube system of the present invention. Panel B shows the cross-section of one embodiment of the tube-in-tube system of the present invention.

[0022] FIG. **3** shows the plan view of the split toroidal borehole clamp of the present invention.

[0023] FIG. **4** shows the side view of the split toroidal borehole clamp of the present invention wherein a spring is dispose outside of the piston bore of the toroidal clamp.

[0024] FIG. **5** shows the side view of the split toroidal borehole clamp of the present invention wherein the spring is disposed within the piston bore or cylinder of the toroidal clamp.

[0025] FIG. **6** shows the cross-section of a split toroidal borehole clamp of the present invention deployed within a borehole.

DETAILED DESCRIPTION OF THE INVENTION

[0026] Before the present invention is described, it is to be understood that this invention is not limited to particular embodiments described, as such may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting, since the scope of the present invention will be limited only by the appended claims.

[0027] Where a range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit unless the context clearly dictates otherwise, between the upper and lower limits of that range is also specifically disclosed. Each smaller range between any stated value or intervening value in a stated range and any other stated or intervening value in that stated range is encompassed within the invention. The upper and lower limits of these smaller ranges may independently be included or excluded in the range, and each range where either, neither or both limits are included in the smaller ranges is also encompassed within the invention, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included in the invention.

[0028] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, the preferred methods and materials are now described. All publications mentioned herein are incorporated herein by reference to disclose and describe the methods and/or materials in connection with which the publications are cited.

[0029] As used in the specification and the appended claims, the singular forms "a", "an", and "the" include plural references unless the context clearly dictates otherwise. Thus, for example, reference to a "support" includes a single support as well as a plurality of supports.

[0030] The terms "optional" or "optionally" as used herein mean that the subsequently described feature or structure may or may not be present, or that the subsequently described event or circumstance may or may not occur, and that the description includes instances where a particular feature or structure is present and instances where the feature or structure is absent, or instances where the event or circumstance occurs and instances where it does not.

[0031] These and other objects, advantages, and features of the invention will become apparent to those persons skilled in the art upon reading the details of the invention as more fully described below.

[0032] In one embodiment of the tube-in-tube system (FIG. **2** shows a cross-section), the tube-in-tube system **1** comprises: (a) an outer conduit **20** having a passageway **23**, a proximal end **21**, and a distal end **22**, and (b) an inner conduit **10** having a passageway **13**, a proximal end **11**, and a distal end **21**, wherein the inner conduit **10** is disposed within the outer conduit **20**, wherein the proximal end **11** of the inner conduit is in fluid communication with a first aperture **15**, and the proximal end **21** of the outer conduit is in fluid communication with a second aperture **25**, and the distal end **12** of the inner conduit and the distal end **22** of the outer conduit are in fluid communication with each other and to a third aperture **35**. Optionally, there is one or more supports **40** connected to the inner conduit **10** and outer conduit **20** to maintain a fixed distance between the inner conduit **10** and the outer conduit **20**. Optionally, the system comprises a "tee" fitting is connected at and/or above the surface of the ground to end **43** of second aperture **25**, wherein the "tee" fitting is in fluid communication with second aperture **25**. Optionally, the system comprises a check valve **41** connected to the third aperture **35**. The arrow **42** indicates the direction of flow of fluid through check valve **41** which is towards the surface of the ground. In some embodiments of the invention, each check valve can be a ball check valve.

[0033] In some embodiments of the invention, the distal end **22** of the outer conduit and the distal end **12** of the inner conduit are in fluid communication with the third aperture **35** using a fitting, such as a compression fittings, such as one commercially available from Swagelok Company (Solon, Ohio). In some embodiments of the invention, the distal end **22** of the outer conduit and the distal end **12** of the inner conduit are joined to the fitting through a welded coupling.

[0034] In some embodiments of the invention, the proximal end **11** and proximal end **21** are secured using a "tee" fitting, such as one commercially available from Swagelok Company (Solon, Ohio). Using such a tee fitting, fluids can be conducted from proximal end **21** through a tube which serves as second aperture **25**. Using a bored through reducer, such as one commercially available from Swagelok Company (Solon, Ohio), the tubing at proximal end **11** continues out through the reducer which is secured in the tee fitting and serves as the second conduit for fluid.

[0035] In some embodiments of the invention, the outer conduit has an outer diameter that ranges from 0.2 inch to 1.0 inch. In some embodiments of the invention, the outer conduit has an outer diameter that ranges from 0.3 inch to 0.6 inch. In some embodiments of the invention, the outer conduit has an outer diameter that ranges from 0.35 inch to 0.4 inch. In some embodiments of the invention, the outer conduit has an outer diameter of about 0.375 inch. In some embodiments of the invention, the outer conduit has a wall thickness that ranges from 0.02 inch to 0.1 inch. In some embodiments of the invention, the outer conduit has a wall thickness that ranges from 0.04 inch to 0.06 inch. In some embodiments of the invention, the outer conduit has a wall thickness that ranges from about 0.035 inch to 0.049 inch. In some embodiments of the invention, the outer conduit has a wall thickness of about 0.049. In some embodiments of the invention, the outer conduit has an outer diameter of about 0.375 inch, and a wall thickness of about 0.049.

[0036] In some embodiments of the invention, the inner conduit has an outer diameter that ranges from 0.1 inch to 0.5 inch. In some embodiments of the invention, the inner conduit has an outer diameter that ranges from 0.2 inch to 0.3 inch. In some embodiments of the invention, the inner conduit has an outer diameter of about 0.25 inch. In some embodiments of the invention, the inner conduit has a wall thickness that ranges from 0.02 inch to 0.07 inch. In some embodiments of the invention, the inner conduit has a wall thickness that ranges from 0.03 inch to 0.04 inch. In some embodiments of the invention, the inner conduit has a wall thickness that ranges from about 0.035 inch to 0.049 inch. In some embodiments of the invention, the inner conduit has a wall thickness of about 0.035. In some embodiments of the invention, the inner conduit has an outer diameter of about 0.25 inch, and a wall thickness of about 0.035.

[0037] The inner diameter of the outer conduit is always greater than the outer diameter of the inner conduit. In some embodiments of the invention, the outer conduit has an outer diameter of about 0.375 inch, and a wall thickness of about 0.035, and the inner conduit has an outer diameter of about 0.25 inch, and a wall thickness of about 0.035.

[0038] The tube-in-tube system of the present invention is useful for the collecting of borehole fluid samples, especially high frequency recovery of representative and uncontaminated aliquots of a rapidly changing two-phase fluid (such as supercritical CO_2-brine) fluid. Samples can be collected from depths up to 5 km depth. Such samples can provide insights into the coupled hydro-geochemical issues affecting CO_2 sequestration.

[0039] The tube-in-tube system of the present invention is also useful for the introduction of gas or fluid, or a mixture thereof into a borehole, or a device within a borehole. One such device is a split toroidal borehole clamp (see FIG. **3**).

[0040] In some embodiment of the invention, the tubing of the tube-in-tube system can be installed in oil or gas wells using a "capillary injector head", such as one manufactured by National Oilwell Varco (Houston, Tex.). Manufacturers make small capillary injectors (such as a ¼ inch or ⅜ inch tubing) so that operators can inject chemicals into wells or perform gas lifting. Such units are commercially available.

[0041] A tube-in-tube sampler can be installed using the capillary for performing multiple level sampling. This is an alternative to wireline sample which needs to be retrieved after the collection of each sample. With the tube-in-tube sampler installed through a capillary injector head multiple samples from different depths can be obtained with only one trip into the well.

[0042] In some embodiment of the invention, the tubing of the tube-in-tube system can be installed in oil or gas wells using a "spooling unit", such as one commercially available from Weatherford International Ltd. (Zurich, Switzerland). Using a commercially available spooling unit, the tube-in-tube can be permanently or temporarily deployed in a well.

[0043] The split toroidal borehole clamp of the present invention has one or more, or all, of the following advantages:

[0044] (1) Capable of generating a known significant side force (many times the weight of the sensor) to lock the sensor against the wall of a borehole.

[0045] (2) The toroidal clamp is releasable.

[0046] (3) Standard production tubing is capable of fitting inside the clamp.

[0047] (4) The clamp has room for one or more control lines to fit on the inside.

[0048] (5) The clamp should isolate the sensor from the production tubing to reduce, substantially reduce, or prevent, the coupling of tube waves from the tubing to the sensor.

[0049] (6) There should be a means to deploy more than one clamp on a single string and have all of them clamped through a single actuation signal.

[0050] The split toroidal borehole clamp of the present invention allows a tubing deployed sensor to be pushed against a borehole wall using a strong force generated by a hydraulic cylinder that is built into a split toroidal ring. A liquid or gas is used to increase the rigidity of the clamp by pushing the two portions of the clamp away from each other in order to push a sensor, such as a geophone, against the borehole wall. A suitable liquid is a hydraulic fluid. A suitable gas would be able to expand in pushing the ring clamp. The split toroidal borehole clamp can be designed to fit around the tubing the sensor is deployed on.

[0051] Optionally a suitable centralizer mechanism can be deployed with the split toroidal borehole clamp to ensure that when the sensor is deployed it is physically decoupled from the deployment tubing. The split toroidal borehole clamp is robust in that it comprises two moving parts, a first portion and a second portion. In some embodiments, the first and second portions form essentially two halves of the split toroidal borehole clamp. Pass-through's are provided on the inside of the split toroidal borehole clamp so that control lines can pass through the clamp.

[0052] FIG. **3** shows the plan view of one embodiment of the split toroidal borehole clamp **70** of the present invention. The clamp comprises a first portion **50** and a second portion **60**. The first portion **50** comprises one or more (such as two) piston cylinders **51**. The second portion **60** comprises one or more (such as two) pistons **61** which fit the piston cylinders **51**. There are an equal number of pistons **61** and piston cylinders **51**. FIG. **3** shows two pistons **61** on one portion **60** of the clamp and two piston cylinders **51** in the other portion **50** of the clamp. Optionally, there can be any number of pistons **61**/piston cylinder pairs **51**. Optionally, one portion of the clamp can have one or pistons **61** and one or more piston cylinders **51**, with the other portion of the clamp having the corresponding pistons **61** and piston cylinders **51**. FIG. **3** shows O-ring seals **62** on the pistons **61** to ensure a sufficiently tight seal. Optionally, the O-rings seals **62** can be disposed in the piston cylinders **51**. Optionally, the O-ring seals **62** can be replaced by seals with similar functionality that are not O-rings. FIG. **3** shows the first portion **50** comprising a sensor **55**. The pistons **61** in the piston cylinders or bores **51** are used to spread the toroidal clamp open and force one or more sensor **55**, such a geophone, against the wall of the borehole. The first portion **50** of the clamp comprises a sensor **55**, such as a geophone. The second portion **60** of the clamp comprises an area for control lines to pass through **65**. Optionally, the sensor **55** and the area for control lines to pass through **65** can be switched between the two portions of the clamp, or on the same portion of the clamp.

[0053] FIG. **4** shows a side view of the split toroidal borehole clamp **70** of the present invention wherein a spring **70** is disposed outside of the piston bore or cylinder **51** of the toroidal clamp. The spring **70** is attached is the first portion of the clamp **50** at attachment **71**, and attached is the second portion of the clamp **60** at attachment **72**. Hydraulic fluid or gas enters the clamp **70** into piston cylinder **51** by way of direction **521**, and, optionally, can further flow to another clamp at a deeper depth of the borehole by continuing in direction **522**. Electrical cable **551** provides electrical power (from the surface) to the sensor **55**, and, optionally, electrical cable **552** can provide electrical power to another clamp at a deeper depth of the borehole.

[0054] FIG. **5** shows a side view of the split toroidal borehole clamp **70** of the present invention wherein the spring **70** is disposed within the piston bore or cylinder **51** of the toroidal clamp. The spring **70** is attached is the first portion of the clamp **50** at attachment **71**, and attached is the second portion of the clamp **60** at attachment **72**. Electrical cable **551** provides electrical power (from the surface) to the sensor **55**, and, optionally, electrical cable **552** can provide electrical power to another clamp at a deeper depth of the borehole.

[0055] Optionally, if no springs are used, a vacuum or low pressure in the hydraulic fluid tubing keeps the two portions, or two halves, of the clamp together.

[0056] In some embodiments of the present invention, a system comprising two or more split toroidal borehole clamp are set up so that the tightening and loosening of the clamps are synchronized. In some embodiments, the system comprises three, four, five or more than five split toroidal borehole clamps.

[0057] FIG. **6** shows the cross-section of a split toroidal borehole clamp of the present invention deployed within a borehole. Deploying the split toroidal clamp with centralizers decouples the tubing used to hang instrumentation down the well from the seismic sensors.

[0058] Optionally, the split toroidal borehole clamp can be operated using the tube-in-tube system to supply hydraulic fluid to the borehole clamp. Such a system has the added benefit that the hydraulic fluid can be removed using a gas and the two halves of the borehole clamp are thus retracted.

[0059] In some embodiments of the invention, the tube-in-tube system is fitted to operate a pneumatic packer wherein the tube-in-tube system is used to inflate either a fixed end or sliding end type inflatable packer. The use of an incompressible fluid, such as water or glycol, reduces the potential for leakage of a much lower viscosity inflation fluid, such as nitrogen or argon.

[0060] It is to be understood that, while the invention has been described in conjunction with the preferred specific embodiments thereof, the foregoing description is intended to illustrate and not limit the scope of the invention. Other aspects, advantages, and modifications within the scope of the invention will be apparent to those skilled in the art to which the invention pertains.

[0061] All patents, patent applications, and publications mentioned herein are hereby incorporated by reference in their entireties.

[0062] While the present invention has been described with reference to the specific embodiments thereof, it should be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation, material, composition of matter, process, process step or steps, to the objective, spirit and scope of the present invention. All such modifications are intended to be within the scope of the claims appended hereto.

What is claimed is:

1. A tube-in-tube system comprising: (a) an outer conduit having a proximal end and a distal end, and (b) an inner conduit having a proximal end and a distal end, wherein the inner conduit is disposed within the outer conduit, wherein the proximal end of the inner conduit is in fluid communication with a first aperture, and the proximal end of the outer conduit is in fluid communication with a second aperture, and the distal ends of the inner and outer conduits are in fluid communication with each other and to a third aperture

2. The system of claim **1**, wherein the tube-in-tube system is a well-bore sampler the first aperture in fluid communication with a high pressure gas source, and the second aperture in fluid communication with a sample collector, or vice versa, and the third aperture in fluid communication with a down-hole or well-bore.

3. The system of claim **2**, further comprising a check valve in fluid communication with the third aperture, wherein the check valve permits fluid moving in the direction towards the distal ends of the inner and outer conduits, but does not permit fluid moving in the direction away from the distal ends of the inner and outer conduits.

4. The system of claim **3**, further comprising a sliding end packer, in fluid communication with the check valve, for isolation of wellbore fluids.

5. The system of claim **4**, further comprising an inlet filter in fluid communication with the sliding end packer, wherein the inlet filter (such as a 40 μm sintered stainless steel filter) removes particulates that can interfere with the operation of the check valve.

6. The system of claim **5**, wherein the inlet filter comprises an at least 40 μm sintered stainless steel filter.

7. The system of claim **1**, further comprising one or more split toroidal borehole clamps.

8. A split toroidal borehole clamp comprising a first portion comprising one or more piston cylinders and a second portion comprising one or more pistons which fit the piston cylinders, wherein the first or second portion together fit within the wall of a borehole and the pistons and the piston cylinders are used to spread the toroidal clamp open and force one or more sensor against the wall of the borehole.

9. The split toroidal borehole clamp of claim **8**, wherein one sensor is a geophone.

10. The split toroidal borehole clamp of claim **8**, wherein each piston is fitted with one or more O-rings seals.

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