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(54) **Minimization of contaminants in a sample chamber**

(57) A formation testing apparatus and method for obtaining samples with lower levels of contaminants is provided. Such a method can remove contaminants from a fluid sample, and can include the steps of obtaining fluid from a formation and passing a first quantity of the fluid through a sample flow line (518, 520). A connection (524) between the sample flow line and a sample chamber (532) can be opened, and a first portion of the first quantity of the fluid can be drawn into the sample chamber (532) via a floating piston. The first portion can be forced out of the sample chamber (532), and this process can be repeated until sufficient contaminants have been removed. Finally, a second portion of the first quantity of the fluid can be drawn into the sample chamber as the fluid sample.

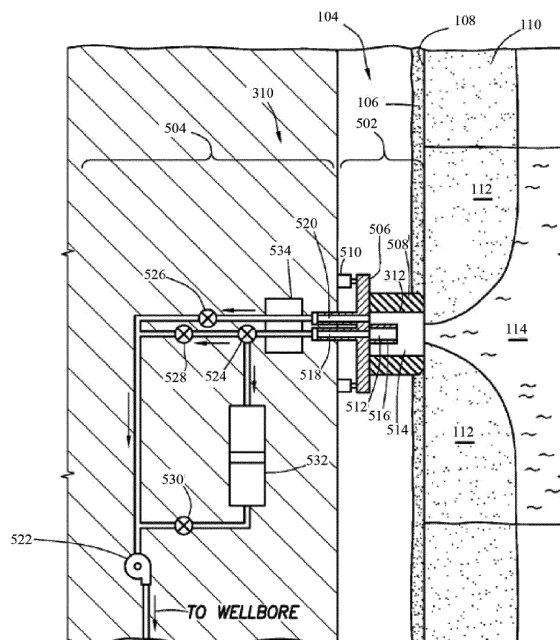


FIG. 5

## Description

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] None.

### FIELD OF THE INVENTION

[0002] Aspects relate to downhole drilling. More specifically, aspects relate to minimization of contaminants in sample chambers in downhole tools.

### BACKGROUND INFORMATION

[0003] Wellbores are drilled to locate and produce hydrocarbons. A downhole drilling tool with a bit at an end thereof is advanced into the ground to form a wellbore. As the drilling tool is advanced, a drilling mud is pumped through the drilling tool and out the drill bit to cool the drilling tool and carry away cuttings. The fluid exits the drill bit and flows back up to the surface for recirculation through the tool. The drilling mud is also used to form a mudcake to line the wellbore.

[0004] During the drilling operation, various evaluations of the formations penetrated by the wellbore can be performed. In some cases, the drilling tool may be provided with devices to test and/or sample the surrounding formation. In some cases, the drilling tool may be removed and a wireline tool may be deployed into the wellbore to test and/or sample the formation. In other cases, the drilling tool may be used to perform the testing or sampling. These samples or tests may be used, for example, to locate valuable hydrocarbons. Examples of drilling tools with testing/sampling capabilities are provided in U.S. Pat. Nos. 6,871,713, 7,234,521 and 7,114,562, the entireties of which are incorporated herein by reference.

[0005] Formation evaluation often requires that fluid from the formation be drawn into the downhole tool for testing and/or sampling. Various devices, such as probes, are extended from the downhole tool to establish fluid communication with the formation surrounding the wellbore and to draw fluid into the downhole tool. A typical probe is a circular element extended from the downhole tool and positioned against the sidewall of the wellbore. A rubber packer at the end of the probe is used to create a seal with the wellbore sidewall. Another device used to form a seal with the wellbore sidewall is referred to as a dual packer. With a dual packer, two elastomeric rings expand radially about the tool to isolate a portion of the wellbore therebetween. The rings form a seal with the wellbore wall and permit fluid to be drawn into the isolated portion of the wellbore and into an inlet in the downhole tool.

[0006] The mudcake lining the wellbore is often useful in assisting the probe and/or dual packers in making the seal with the wellbore wall. Once the seal is made, fluid from the formation is drawn into the downhole tool

through an inlet by lowering the pressure in the downhole tool. Examples of probes and/or packers used in downhole tools are described in U.S. Pat. Nos. 6,301,959; 4,860,581; 4,936,139; 6,585,045; 6,609,568; 6,719,049 and 6,964,301, the entireties of which are incorporated herein by reference.

[0007] The collection and sampling of underground fluids contained in subsurface formations is well known. In the petroleum exploration and recovery industries, for example, samples of formation fluids are collected and analyzed for various purposes, such as to determine the existence, composition and/or producibility of subsurface hydrocarbon fluid reservoirs. This aspect of the exploration and recovery process can be crucial in developing drilling strategies, and can impact significant financial expenditures and/or savings.

[0008] To conduct valid fluid analysis, the fluid obtained from the subsurface formation should possess sufficient purity, or be virgin fluid, to adequately represent the fluid contained in the formation. As used within the scope of the present disclosure, the terms "virgin fluid," "acceptable virgin fluid" and variations thereof mean subsurface fluid that is pure, pristine, connate, uncontaminated or otherwise considered in the fluid sampling and analysis field to be sufficiently or acceptably representative of a given formation for valid hydrocarbon sampling and/or evaluation.

[0009] Various challenges may arise in the process of obtaining virgin fluid from subsurface formations. Again with reference to the petroleum-related industries, for example, the earth around the borehole from which fluid samples are sought typically contains contaminants, such as filtrate from the mud utilized in drilling the borehole. This material often contaminates the virgin fluid as it passes through the borehole, resulting in fluid that is generally unacceptable for hydrocarbon fluid sampling and/or evaluation. Such fluid is referred to herein as "contaminated fluid." Because fluid is sampled through the borehole, mudcake, cement and/or other layers, it is difficult to avoid contamination of the fluid sample as it flows from the formation and into a downhole tool during sampling. A challenge thus lies in minimizing the contamination of the virgin fluid during fluid extraction from the formation.

[0010] FIG. 1 depicts a subsurface formation **102** penetrated by a wellbore **104**. A layer of mud cake **106** lines a sidewall **108** of the wellbore **104**. Due to invasion of mud filtrate into the formation during drilling, the wellbore is surrounded by a cylindrical layer known as the invaded zone **110** containing contaminated fluid **112** that may or may not be mixed with virgin fluid. Beyond the sidewall of the wellbore and surrounding contaminated fluid, virgin fluid **114** is located in the formation **102**. As shown in FIG. 1, contaminants tend to be located near the wellbore wall in the invaded zone **110**.

[0011] FIG. 2 shows the typical flow patterns of the formation fluid as it passes from subsurface formation **102** into a downhole tool **202**. The downhole tool **202** is

positioned adjacent the formation and a probe **204** is extended from the downhole tool through the mudcake **106** to the sidewall **108** of the wellbore **104**. The probe **204** is placed in fluid communication with the formation **102** so that formation fluid may be passed into the downhole tool **202**. Initially, as shown in FIG. 1, the invaded zone **110** surrounds the sidewall **108** and contains contamination. As fluid initially passes into the probe **204**, the contaminated fluid **112** from the invaded zone **110** is drawn into the probe with the fluid thereby generating fluid unsuitable for sampling. However, as shown in FIG. 2, after a certain amount of fluid passes through the probe **204**, the virgin fluid **114** breaks through and begins entering the probe.

**[0012]** Formation evaluation is typically performed on fluids drawn into the downhole tool. Techniques currently exist for performing various measurements, pretests and/or sample collection of fluids that enter the downhole tool. Various methods and devices have been proposed for obtaining subsurface fluids for sampling and evaluation. For example, U.S. Pat. Nos. 6,230,557, 6,223,822, 4,416,152, and 3,611,799, and PCT Patent Application Publication No. WO 96/30628, the entireties of which are incorporated herein by reference, describe certain probes and related techniques to improve sampling. However, it has been discovered that when the formation fluid passes into the downhole tool, various contaminants, such as wellbore fluids and/or drilling mud, may enter the tool with the formation fluids. These contaminants may affect the quality of measurements and/or samples of the formation fluids. Moreover, contamination may cause costly delays in the wellbore operations by requiring additional time for more testing and/or sampling. Additionally, such problems may yield false results that are erroneous and/or unusable. Other techniques have been developed to separate virgin fluids during sampling. For example, U.S. Pat. No. 6,301,959, the entirety of which is incorporated herein by reference, discloses a sampling probe with two hydraulic lines to recover formation fluids from two zones in the borehole. In this patent, borehole fluids are drawn into a guard zone separate from fluids drawn into a probe zone. Despite such advances in sampling, there remains a need to develop techniques for fluid sampling to optimize the quality of the sample and efficiency of the sampling process.

**[0013]** To increase sample quality, it is desirable that the formation fluid entering into the downhole tool be sufficiently "clean" or "virgin" for valid testing. In other words, the formation fluid should have little or no contamination. Attempts have been made to eliminate contaminants from entering the downhole tool with the formation fluid. For example, as depicted in U.S. Pat. No. 4,951,749, filters have been positioned in probes to block contaminants from entering the downhole tool with the formation fluid. Additionally, as shown in U.S. Pat. No. 6,301,959, a probe is provided with a guard ring to divert contaminated fluids away from clean fluid as it enters the probe. The entireties of both of these are incorporated herein

by reference.

**[0014]** Techniques have also been developed to evaluate fluid passing through the tool to determine contamination levels. In some cases, techniques and mathematical models have been developed for predicting contamination for a merged flowline. See, for example, PCT Patent Application No. WO 2005065277 and PCT Patent Application No. 00/50876, the entireties of which are hereby incorporated by reference. Techniques for predicting contamination levels and determining cleanup times are described in P. S. Hammond, "One or Two Phased Flow During fluid Sampling by a Wireline Tool," Transport in Porous Media, Vol. 6, p. 299-330 (1991), the entirety of which is hereby incorporated by reference. Hammond describes a semi-empirical technique for estimating contamination levels and cleanup time of fluid passing into a downhole tool through a single flowline.

**[0015]** Despite the existence of techniques for performing formation evaluation, conventional systems fail to adequately mitigate the problem of contamination.

## SUMMARY

**[0016]** The following presents a simplified summary of the innovation in order to provide a basic understanding of some aspects of the innovation. This summary is not an extensive overview of the innovation. It is not intended to identify key/critical elements of the innovation or to delineate the scope of the innovation. Its sole purpose is to present some concepts of the innovation in a simplified form as a prelude to the more detailed description that is presented later.

**[0017]** The innovation disclosed and claimed herein, in one aspect thereof, comprises an apparatus that facilitates removal of contaminants from a fluid sample. One embodiment of such an apparatus can include an intake section capable of sealingly engaging a borehole wall to obtain formation fluid through the wall, and a first flow line in fluid communication with the intake section. At least a portion of the formation fluid obtained by the intake section can be made to pass through the first flow line. Additionally, the apparatus can include a sample chamber with a floating piston. The floating piston can draw at least a first quantity of the portion into the sample chamber from the first flow line, and then the first quantity of the portion can be forced out of the sample chamber. This process can be repeated until sufficient contaminants have been removed, such as those contained in a dead volume between the flow line and the sample chamber. Finally, the floating piston can draw at least a second quantity of the portion into the sample chamber for storage therein as the fluid sample.

**[0018]** In another aspect of the subject innovation, the innovation can comprise a method for obtaining samples with lower levels of contaminants. Such a method can remove contaminants from a fluid sample, and can include the steps of obtaining fluid from a formation and passing a first quantity of the fluid through a sample flow

line. A connection between the sample flow line and a sample chamber can be opened, and a first portion of the first quantity of the fluid can be drawn into the sample chamber via a floating piston. The first portion can be forced out of the sample chamber, and this process can be repeated until sufficient contaminants have been removed. Finally, a second portion of the first quantity of the fluid can be drawn into the sample chamber as the fluid sample.

**[0019]** To the accomplishment of the foregoing and related ends, certain illustrative aspects of the innovation are described herein in connection with the following description and the annexed drawings. These aspects are indicative, however, of but a few of the various ways in which the principles of the innovation can be employed and the subject innovation is intended to include all such aspects and their equivalents. Other advantages and novel features of the innovation will become apparent from the following detailed description of the innovation when considered in conjunction with the drawings.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0020]** FIG. 1 is a schematic view of a subsurface formation penetrated by a wellbore lined with mudcake, depicting the virgin fluid in the subsurface formation.

**[0021]** FIG. 2 is a schematic view of a down hole tool positioned in the wellbore with a probe extending to the formation, depicting the flow of contaminated and virgin fluid into a downhole sampling tool.

**[0022]** FIG. 3 is a schematic view of downhole wireline tool having a fluid sampling device.

**[0023]** FIG. 4 is a schematic view of a downhole drilling tool with an alternate embodiment of the fluid sampling device of FIG. 3.

**[0024]** FIG. 5 is a detailed view of the fluid sampling device of FIG. 3 depicting an intake section and a fluid flow section.

**[0025]** FIG. 6 illustrates a system that can reduce levels of contaminants in a sample chamber in accordance with an embodiment of the subject innovation.

**[0026]** FIG. 7A illustrates an embodiment of another system capable of reducing levels of contaminants obtained in a sample chamber.

**[0027]** FIG. 7B illustrates an embodiment of a further system capable of reducing levels of contaminants obtained in a sample chamber.

**[0028]** FIG. 8 illustrates a method of obtaining a sample of fluid with reduced levels of contaminants.

**[0029]** FIG. 9 is a schematic view of a wellsite having a rig with a downhole tool suspended therefrom and into a subterranean formation.

### **DETAILED DESCRIPTION**

**[0030]** The innovation is now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following

description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the subject innovation. It may be evident, however, that the innovation can be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to facilitate describing the innovation.

**[0031]** It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact.

**[0032]** Referring to FIG. 3, an example environment with which aspects of the present disclosure may be used is shown. In the illustrated example, a downhole tool 302 can be provided, such as a Modular Formation Dynamics Tester (MDT) by Schlumberger Corporation, and further depicted, for example, in U.S. Pat. Nos. 4,936,139 and 4,860,581, the entireties of which are incorporated by reference herein. The downhole tool 302 can be deployable into bore hole 104 and suspended therein with a wire line (e.g., conventional, etc.) 304, or conductor or tubing (e.g., conventional or coiled tubing, etc.), below a rig 306 as will be appreciated by one of skill in the art. The illustrated tool 302 can be provided with various modules and/or components 308, including, but not limited to, a fluid sampling device 310 used to obtain fluid samples from the subsurface formation 102. The fluid sampling device 310 can be provided with a probe 312 extendable through the mudcake 106 and to sidewall 108 of the borehole 104 for collecting samples. The samples can be drawn into the downhole tool 302 through the probe 312.

**[0033]** While FIG. 3 depicts a modular wireline sampling tool that can be used for collecting samples according to one or more aspects of the present innovation, it will be appreciated by one of skill in the art that the subject innovation may be used in any downhole tool. For example, FIG. 4 shows an alternate downhole tool 402 having a fluid sampling system 404 therein. In this example, the downhole tool 402 can be a drilling tool including a drill string 406 and a drill bit 408. The downhole drilling tool 402 may be of a variety of drilling tools, such as a Measurement-While-Drilling (MWD), Logging-While Drilling

(LWD) or other drilling system. The tools **302** and **304** of FIGS. 3 and 4, respectively, may have alternate configurations, such as modular, unitary, wireline, coiled tubing, autonomous, drilling and other variations of downhole tools.

**[0034]** Referring now to FIG. 5, the fluid sampling system **310** of FIG. 3 is shown in greater detail. The sampling system **310** can include an intake section **502** and a flow section **504** capable of selectively drawing fluid into a portion of the downhole tool.

**[0035]** The intake section **502** can include a probe **312** mounted on an extendable base **30** having a seal **508**, such as a packer, capable of sealingly engaging the borehole wall **108** around the probe **312**. The intake section **502** can be selectively extendable from the downhole tool **302** via extension pistons **510**. The probe **312** can be provided with an interior channel **512** and an exterior channel **514** separated by wall **516**. In some embodiments, the wall **516** can be concentric with the probe **312**. However, the geometry of the probe and the corresponding wall may be of any geometry. Additionally, one or more walls **516** may be used in various configurations within the probe. Alternatively, an intake section can employ dual packers, as discussed elsewhere herein or in documents incorporated herein by reference.

**[0036]** The flow section **504** includes flow lines **518** and **520** driven by one or more pumps **522**. A first flow line **518** is in fluid communication with the interior channel **512**, and a second flow line **520** is in fluid communication with the exterior channel **514**. The illustrated flow section may include one or more flow control devices, such as the pump **522** and valves **524**, **526**, **528** and **530** depicted in FIG. 5, capable of selectively drawing fluid into various portions of the flow section **504**. Fluid can be drawn from the formation through the interior and exterior channels and into their corresponding flow lines.

**[0037]** In aspects, contaminated fluid may be passed from the formation through exterior channel **514**, into flow line **520** and discharged into the wellbore **104**. In the same or other aspects, fluid can pass from the formation into the interior channel **512**, through flow line **518** and either diverted into one or more sample chambers **532**, or discharged into the wellbore. Once it is determined that the fluid passing into flow line **518** is virgin fluid, a valve **524** and/or **530** may be activated using known control techniques by manual and/or automatic operation to divert fluid into the sample chamber. In accordance with aspects of the subject innovation, systems and/or methods discussed further herein can be employed to reciprocate the piston in the sample bottle to minimize contaminants obtained in the sample, particularly from fluid volume between a sample flow line and a floating piston in the sample chamber **532** (e.g., contaminants along flow line **518**, such as between valve **524** and sample chamber **532**, etc.). Upon a determination that contaminants have been sufficiently minimized, a sample of fluid can then be obtained in sample chamber **532** and retained.

**[0038]** The fluid sampling system **310** (or **404**, etc.) can also be provided with one or more fluid monitoring systems **534** capable of analyzing the fluid as it enters the probe **312**. The fluid monitoring system **534** may be provided with various monitoring devices, such as optical fluid analyzers, as will be discussed more fully herein.

**[0039]** The details of the various arrangements and components of the fluid sampling system **310** (or **404**, etc.) described above as well as alternate arrangements and components for the system **310** (or **404**, etc.) are apparent to a person of skill in the art in light of the subject disclosure and those of patents and publications incorporated by reference herein. Moreover, the particular arrangement and components of the downhole fluid sampling system **310** (or **404**, etc.) may vary depending upon factors in each particular design, use or situation. Thus, neither the system **310** (or **404**, etc.) nor the present disclosure are limited to the above described arrangements and components and may include any suitable components and arrangement. For example, various flow lines, pump placement and valving may be adjusted to provide for a variety of configurations. Similarly, the arrangement and components of the downhole tool **302** may vary depending upon factors in each particular design, or use, situation. The above description of exemplary components and environments of the tool **302** with which the fluid sampling device **310** (or **404**, etc.) of the present disclosure may be used is provided as an example only and is not limiting upon the present disclosure.

**[0040]** With continuing reference to FIG. 5, the flow pattern of fluid passing into the downhole tool **302** is illustrated. Initially, as shown in FIG. 1, an invaded zone **110** surrounds the borehole wall **108**. Virgin fluid **114** is located in the formation **102** behind the invaded zone **110**. At some time during the process, as fluid is extracted from the formation **102** into the probe **312**, virgin fluid breaks through and enters the probe **312** as shown in FIG. 5. As the fluid flows into the probe, the contaminated fluid **114** in the invaded zone **110** near the interior channel **512** is eventually removed and gives way to the virgin fluid **114**. Thus, primarily virgin fluid **114** is drawn into the interior channel **512**, while the contaminated fluid **112** flows into the exterior channel **514** of the probe **312**. To facilitate such result, fluid can be pumped into and out of the sample chamber one or more times to remove contaminants initially present, or those remaining in the dead volume between the sample flow line **518** and the sample chamber **532**. Additionally, it is to be understood that while FIG. 5 illustrates a single sample chamber **532**, substantially any number of sample chambers can be used in various embodiments. Moreover, in various embodiments, systems and methods of the subject innovation can be used in connection with other fluid sampling systems, such as those described in U.S. Pat. No. 8,210,260, the entirety of which is incorporated herein by reference.

**[0041]** Turning now to FIG. 6, illustrated is a fluid sampling system **600** with multiple sample chambers that can

be used with systems and methods of the subject innovation. Although two sets of three sample chambers **532** are illustrated in system **600**, it is to be appreciated that substantially any number of sample chambers **532** can be used in connection with the subject innovation. Each sample chamber can be associated with a normally closed valve **602** and a normally open valve **604**, and throttle/seal valves **606** can be associated with the flow line from the probe/packer inlet at **608** to the wellbore outlet at **610**. These valves **602**, **604**, and **606** can be controlled by electronics (or computer, etc.) **612**. A relief valve **614** can be included to control or limit the pressure in system **600**.

**[0042]** In operation, valves **602**, **604**, and **606** can be controlled to direct fluid into sample chambers **532**. As explained herein, fluid directed into sample chambers can contain contaminants, such as from the dead volume between a sample flow line and the floating piston of the sample chamber(s) **532**. The volume of fluid in one or more of the sample chambers **532** (e.g., each sample chamber **532**) can then be pumped out of the back side of the sample chamber by using the floating piston **616** in a manner similar to a displacement unit. This action of the floating piston **616** can be controlled automatically or manually (e.g., e.g., by a user at the surface, a remote location, etc.). This fluid can be discharged into the wellbore **104**, e.g., via an optional relief valve **614** or otherwise. In some situations, this process may need to be repeated more than once in order to obtain a sample of virgin fluid. Drawing fluid into the sample chamber(s) **532** and back out via reciprocation of floating piston(s) **616** can be repeated until a sufficient level of confidence is gained that the contaminated fluid (e.g., of the dead volume in the flow line **518**, etc.) has been removed. This confidence can be gained based at least in part on any of a number of factors, which can include the relative volume of potentially contaminated fluid to that of the sample chamber (e.g., determining a number of iterations based on the ratio of the volumes, so as to ensure virgin fluid will ultimately be drawn into the sample chamber, etc.), based on a measured level of contamination of the fluid prior to entering the sample chamber **532** as determined using techniques known in the art or discussed herein (e.g., via an optical fluid analyzer (OFA), etc.), based on a measured level of contamination of fluid pumped out of the sample chamber **532**, etc. After the fluid is sufficiently free from contaminants, virgin fluid can be drawn into the sample chamber **532** for storage therein.

**[0043]** Turning to FIGS. 7A and 7B, illustrated are two alternate embodiments of a system according to the subject innovation. In FIG. 7A, as illustrated, sample chamber **532** can employ a mechanical device **702** (e.g., a spring, etc.) to force fluid back into a flow line (e.g., flow line **518**) to remove potential contaminants and ensure virgin fluid is obtained in sample chamber **532**. Similarly, in FIG. 7B, a pressure-based, pneumatic or similar device **704** (e.g., a closed nitrogen charge, etc.) can be similarly

used to push fluid back into a flow line. As illustrated, a system such as in FIG. 7B can include manual valves **706**. Embodiments similar to those of FIGS. 7A and 7B, that can employ a device to force fluid back into the flow line, can be used in systems where it is not possible to push fluid out the back side of a sample chamber **532**. The actions of mechanical and/or pressure-based devices discussed in connection with FIGS. 7A and 7B can be controlled automatically or manually (e.g., by a user at the surface, a remote location, etc.).

**[0044]** FIG. 8 illustrates a methodology **800** of improving the quality of fluid obtained in a sample chamber in accordance with aspects of the subject innovation. While, for purposes of simplicity of explanation, the one or more methodologies shown herein, e.g., in the form of a flow chart, are shown and described as a series of acts, it is to be understood and appreciated that the subject innovation is not limited by the order of acts, as some acts may, in accordance with the innovation, occur in a different order and/or concurrently with other acts from that shown and described herein. For example, those skilled in the art will understand and appreciate that a methodology could alternatively be represented as a series of interrelated states or events, such as in a state diagram. Moreover, not all illustrated acts may be required to implement a methodology in accordance with the innovation.

**[0045]** Method **800** can begin at step **802**, wherein fluid can be allowed to pass through a sample flow line, such as flow line **518**. Next, at **804**, a determination can be made that the fluid passing through the sample flow line is virgin fluid, i.e., that it is sufficiently free of contaminants. This determination can be made based on analysis such as discussed herein (e.g., via an OFA, etc.). If necessary, such as if the fluid is determined to have unacceptably high levels of contaminants, steps **802** and **804** can be repeated with further monitoring of the fluid until the fluid is determined to be virgin fluid. Next, at **806**, a connection between the sample flow line and a sample chamber can be opened. At **808**, fluid can be drawn into the sample chamber. However, this fluid may have unacceptable levels of contaminants, for example, due to the dead volume of fluid between the flow line and the sample chamber. Because of this, at **810**, the fluid can be forced out of the sample chamber to "flush" the sample chamber and remove contaminants that may be contained in it. The fluid can be forced out of the sample chamber by pushing out of the back of the sample chamber by using the floating piston, by using a mechanical device (such as a spring, etc.) to force it out of the sample chamber, by using pressure (e.g., a pneumatic device such as a closed nitrogen charge, etc.) to force the fluid out of the sample chamber, etc.

**[0046]** Next, at **812**, a determination can be made whether to re-"flush" the sample chamber by repeating steps **808** and **810**, by determining whether sufficient contaminants have been removed, i.e., whether the fluid that will next enter the sample chamber is virgin fluid.

This determination can be based on measurements of fluid before or after being drawing into and forced out of the sample chamber, based on system parameters (e.g., one or more relevant volumes, etc.), other factors, or a combination of factors. If it is determined that it is necessary to re-"flush" the sample chamber, method **800** can return to step **808**, and can repeat steps **808**, **810**, and **812** until it is determined that sufficient contaminants have been removed. If not, the method can finish at step **814**, by drawing fluid into the sample chamber to be retained therein as a representative sample of the formation (e.g., for testing, etc.).

**[0047]** FIG. 9 illustrates a wellsite system **900** that the subject innovation can be used in connection with. The wellsite system includes a surface system **902**, a downhole system **904** and a surface control unit **906**. In the illustrated embodiment, a borehole **908** can be formed by rotary drilling in a conventional manner. In light of the teachings herein, those of ordinary skill in the art will appreciate, however, that the subject innovation can be applied in downhole applications other than conventional rotary drilling, and is not limited to land-based rigs. Examples of other downhole application may involve the use of wireline tools (see, e.g., FIG. 2 or 3), casing drilling, coiled tubing, and other downhole tools.

**[0048]** The downhole system **904** includes a drill string **910** suspended within the borehole **908** with a drill bit **912** at its lower end. The surface system **902** includes the land-based platform and derrick assembly **914** positioned over the borehole **908** penetrating a subsurface formation **102**. The assembly **914** includes a rotary table **916**, kelly **918**, hook **920** and rotary swivel **922**. The drill string **910** is rotated by the rotary table **916**, energized by apparatus not shown, which engages the kelly **918** at the upper end of the drill string. The drill string **910** is suspended from a hook **920**, attached to a traveling block (also not shown), through the kelly **918** and the rotary swivel **922**, which permits rotation of the drill string relative to the hook.

**[0049]** The surface system further includes drilling fluid or mud **926** stored in a pit **928** formed at the well site. A pump **930** delivers the drilling fluid **926** to the interior of the drill string **910** via a port in the swivel **922**, inducing the drilling fluid to flow downwardly through the drill string **910** as indicated by the directional arrow **932**. The drilling fluid exits the drill string **910** via ports in the drill bit **912**, and then circulates upwardly through the region between the outside of the drill string and the wall of the borehole, called the annulus, as indicated by the directional arrows **934**. In this manner, the drilling fluid lubricates the drill bit **912** and carries formation cuttings up to the surface as it is returned to the pit **928** for recirculation.

**[0050]** The drill string **910** further includes a bottom hole assembly (BHA), generally referred to as BHA **936**, near the drill bit **912** (in other words, within several drill collar lengths from the drill bit). The bottom hole assembly includes capabilities for measuring, processing, and storing information, as well as communicating with the sur-

face. The BHA **936** can include one or more of drill collars **938**, **940**, or **942** for performing various other measurement functions.

**[0051]** The BHA **936** includes the formation evaluation assembly **944** for determining and communicating one or more properties of the formation **102** surrounding borehole **908**, such as formation resistivity (or conductivity), natural radiation, density (gamma ray or neutron), and pore pressure. The BHA also includes a telemetry assembly **946** for communicating with the surface unit **906**. The telemetry assembly **946** includes drill collar **942** that houses a measurement-while-drilling (MWD) tool. The telemetry assembly further includes an apparatus **948** for generating electrical power to the downhole system. While a mud pulse system is depicted with a generator powered by the flow of the drilling fluid **924** that flows through the drill string **910** and the MWD drill collar **942**, other telemetry, power and/or battery systems may be employed.

**[0052]** Formation evaluation assembly **944** includes drill collar **940** with stabilizers or ribs **950** and a probe **952** positioned in the stabilizer. The formation evaluation assembly is used to draw fluid into the tool for testing. The probe **952** may be similar to the probe as described elsewhere herein or in documents incorporated by reference. Flow circuitry and other features may also be provided in the formation evaluation assembly **944**. The probe may be positioned in a stabilizer blade as described, for example, in U.S. Patent Application Publication No. 2005/0109538, the entirety of which is incorporated by reference herein.

**[0053]** Sensors are located about the wellsite to collect data, for example in real time, concerning the operation of the wellsite, as well as conditions at the wellsite. For example, monitors, such as cameras **954**, may be provided to provide pictures of the operation. Surface sensors or gauges **956** are disposed about the surface systems to provide information about the surface unit, such as standpipe pressure, hook load, depth, surface torque, rotary rpm, among others. Downhole sensors or gauges **958** may be disposed about the drilling tool and/or wellbore to provide information about downhole conditions, such as wellbore pressure, weight on bit, torque on bit, direction, inclination, collar rpm, tool temperature, annular temperature and toolface, among others. Additional formation evaluation sensors **960** may be positioned in the formation evaluation sensors to measure downhole properties. Examples of such sensors are described elsewhere herein or in documents incorporated by reference. The information collected by the sensors and/or cameras is conveyed to the surface system, the downhole system and/or the surface control unit.

**[0054]** The telemetry assembly **946** uses mud pulse telemetry to communicate with the surface system. The MWD tool **942** of the telemetry assembly **946** may include, for example, a transmitter that generates a signal, such as an acoustic or electromagnetic signal, which is representative of the measured drilling parameters. The

generated signal is received at the surface by transducers (not shown), that convert the received acoustical signals to electronic signals for further processing, storage, encryption and use according to conventional methods and systems. Communication between the downhole and surface systems is depicted as being mud pulse telemetry, such as the one described in U.S. Pat. No. 5,517,464, the entirety of which is incorporated herein by reference. It will be appreciated by one of skill in the art that a variety of telemetry systems may be employed, such as wired drill pipe, electromagnetic or other known telemetry systems. It will be appreciated that when using other downhole tools, such as wireline tools, other telemetry systems, such as the wireline cable or electromagnetic telemetry, may be used.

**[0055]** The telemetry system provides a communication link **962** between the downhole system **904** and the surface control unit **906**. An additional communication link **964** may be provided between the surface system **902** and the surface control unit **906**. The downhole system **904** may also communicate with the surface system **902**. The surface unit may communicate with the downhole system directly, or via the surface unit. The downhole system may also communicate with the surface unit directly, or via the surface system. Communications may also pass from the surface system to a remote location **964**.

**[0056]** One or more surface, remote or wellsite systems may be present. Communications may be manipulated through each of these locations as necessary. The surface system may be located at or near a wellsite to provide an operator with information about wellsite conditions. The operator may be provided with a monitor that provides information concerning the wellsite operations. For example, the monitor may display graphical images or other data concerning wellbore output.

**[0057]** The operator may be provided with a surface control system **966**. The surface control system includes surface processor **968** to process the data, and a surface memory **970** to store the data. The operator may also be provided with a surface controller **972** to make changes to a wellsite setup to alter the wellsite operations. Based on the data received and/or an analysis of the data, the operator may manually make such adjustments. These adjustments may also be made at a remote location. In some cases, the adjustments may be made automatically.

**[0058]** Drill collar **938** may be provided with a downhole control assembly **974**. The downhole control assembly includes a downhole processor for processing downhole data, and a downhole memory for storing the data. A downhole controller may also be provided to selectively activate various downhole tools. The downhole control assembly may be used to collect, store and analyze data received from various wellsite sensors. The downhole processor may send messages to the downhole controller to activate tools in response to data received. In this manner, the downhole operations may be automated to

make adjustments in response to downhole data analysis. Such downhole controllers may also permit input and/or manual control of such adjustments by the surface and/or remote control unit. The downhole control system may work with or separate from one or more of the other control systems.

**[0059]** The wellsite setup includes tool configurations and operational settings. The tool configurations may include for example, the size of the tool housing, the type of bit, the size of the probe, the type of telemetry assembly, etc. Adjustments to the tool configurations may be made by replacing tool components, or adjusting the assembly of the tool.

**[0060]** For example, it may be possible to select tool configurations, such as a specific probe with a predefined diameter to meet the testing requirements. However, it may be necessary to replace the probe with a different diameter probe to perform as desired. If the probe is provided with adjustable features, it may be possible to adjust the diameter without replacing the probe.

**[0061]** Operational settings may also be adjusted to meet the needs of the wellsite operations. Operational settings may include tool settings, such as flow rates, rotational speeds, pressure settings, etc. Adjustments to the operational settings may typically be made by adjusting tool controls. For example, flow rates into the probe may be adjusted by altering the flow rate settings on pumps that drive flow through sampling and contamination flowlines. Additionally, it may be possible to manipulate flow through the flowlines by selectively activating certain valves and/or diverters (e.g., those illustrated in FIGS. 5, 6, 7A, and 7B).

**[0062]** What has been described above includes examples of the innovation. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the subject innovation, but one of ordinary skill in the art may recognize that many further combinations and permutations of the innovation are possible. Accordingly, the innovation is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

## Claims

1. An apparatus that facilitates removal of contaminants from a fluid sample, comprising:
  - an intake section configured to sealingly engage a borehole wall to obtain formation fluid through the borehole wall;
  - a first flow line in fluid communication with the

- intake section, wherein at least a portion of the formation fluid obtained by the intake section passes through the first flow line; and a sample chamber comprising a floating piston, wherein the floating piston is configured to draw at least a first quantity of the portion into the sample chamber from the first flow line, wherein the first quantity of the portion is forced out of the sample chamber, and wherein the floating piston is configured to draw at least a second quantity of the portion into the sample chamber for storage therein as the fluid sample.
2. The apparatus of claim 1, wherein the floating piston is configured to draw the first quantity into the sample chamber through a front end of the sample chamber, and the floating piston is configured to force the first quantity out through a back end of the sample chamber.
  3. The apparatus of claim 1, further comprising a mechanical device configured to force out the first quantity from the sample chamber.
  4. The apparatus of claim 3, wherein the mechanical device comprises a spring.
  5. The apparatus of claim 1, further comprising:
    - a pressure-based device configured to force the first quantity out of the sample chamber.
  6. The apparatus of claim 5, wherein the pressure-based device comprises a closed nitrogen charge.
  7. The apparatus of claim 1, wherein the floating piston is configured to draw at least a third quantity of the portion into the sample chamber from the first flow line before the floating piston draws at least the second quantity of the portion, wherein the third quantity of the portion is forced out of the sample chamber.
  8. The apparatus of claim 7, wherein the second quantity is drawn into the sample chamber based at least in part on a determination that insufficient contaminants have been removed.
  9. The apparatus of claim 1, further comprising:
    - a second flow line in fluid communication with the intake section, wherein at least a second portion of the formation fluid obtained by the intake section passes through the second flow line, and wherein the second portion comprises more contaminants than the first quantity.
  10. The apparatus of claim 1, wherein the floating piston is automatically controlled.
  11. The apparatus of claim 1, wherein the intake section comprises a probe.
  12. The apparatus of claim 1, wherein the intake section comprises dual packers.
  13. A method of removing contaminants from a fluid sample, comprising:
    - obtaining fluid from a formation;
    - passing a first quantity of the fluid through a sample flow line;
    - opening a connection between the sample flow line and a sample chamber;
    - drawing a first portion of the first quantity of the fluid into the sample chamber via a floating piston;
    - forcing the first portion out of the sample chamber; and
    - drawing a second portion of the first quantity of the fluid into the sample chamber as the fluid sample.
  14. The method of claim 13, wherein the drawing the first portion into the sample chamber comprises drawing the first portion in through a front end of the sample chamber, and wherein the forcing the first portion out of the sample chamber comprises employing the floating piston to force the first portion out of the back of the sample chamber.
  15. The method of claim 13, wherein the forcing the first portion out of the sample chamber comprises using a mechanical device to force the first portion out of the sample chamber.
  16. The method of claim 15, wherein the mechanical device comprises a spring.
  17. The method of claim 13, wherein the forcing the first portion out of the sample chamber comprises employing a pressure-based device to force the first portion out of the sample chamber.
  18. The method of claim 17, wherein the pressure-based device comprises a closed nitrogen charge.
  19. The method of claim 13, further comprising:
    - determining whether sufficient contaminants have been removed from the first quantity.
  20. The method of claim 19, further comprising:
    - drawing at least one additional portion of the first quantity of the fluid into the sample chamber via the floating piston prior to drawing the second portion; and

forcing the at least one additional portion out of the sample chamber.

**21.** The method of claim 20, further comprising:

selecting the number of additional portions drawn, wherein the number of additional portions is selected to remove sufficient contaminants from the first quantity.

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(PRIOR ART)

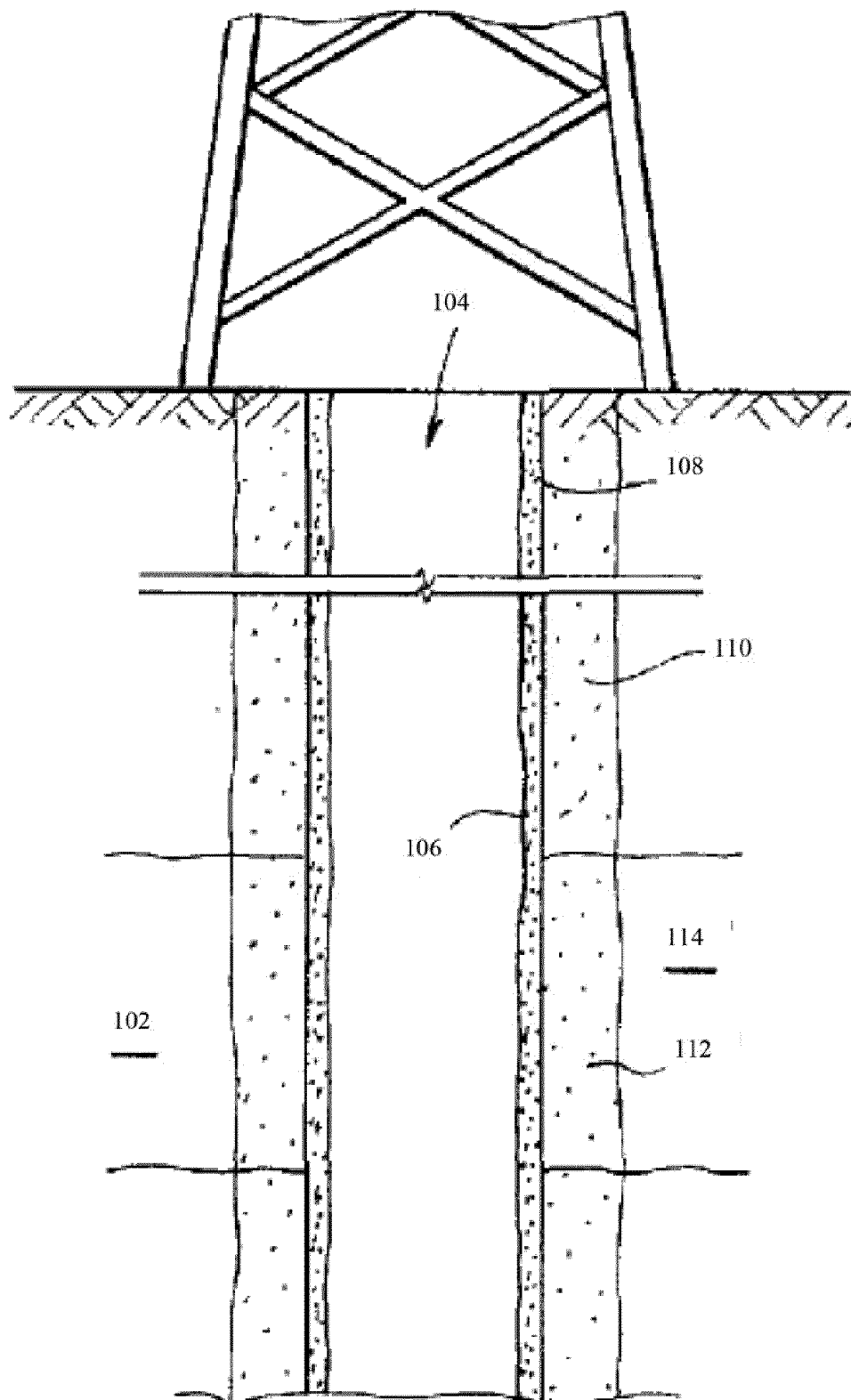


FIG. 1

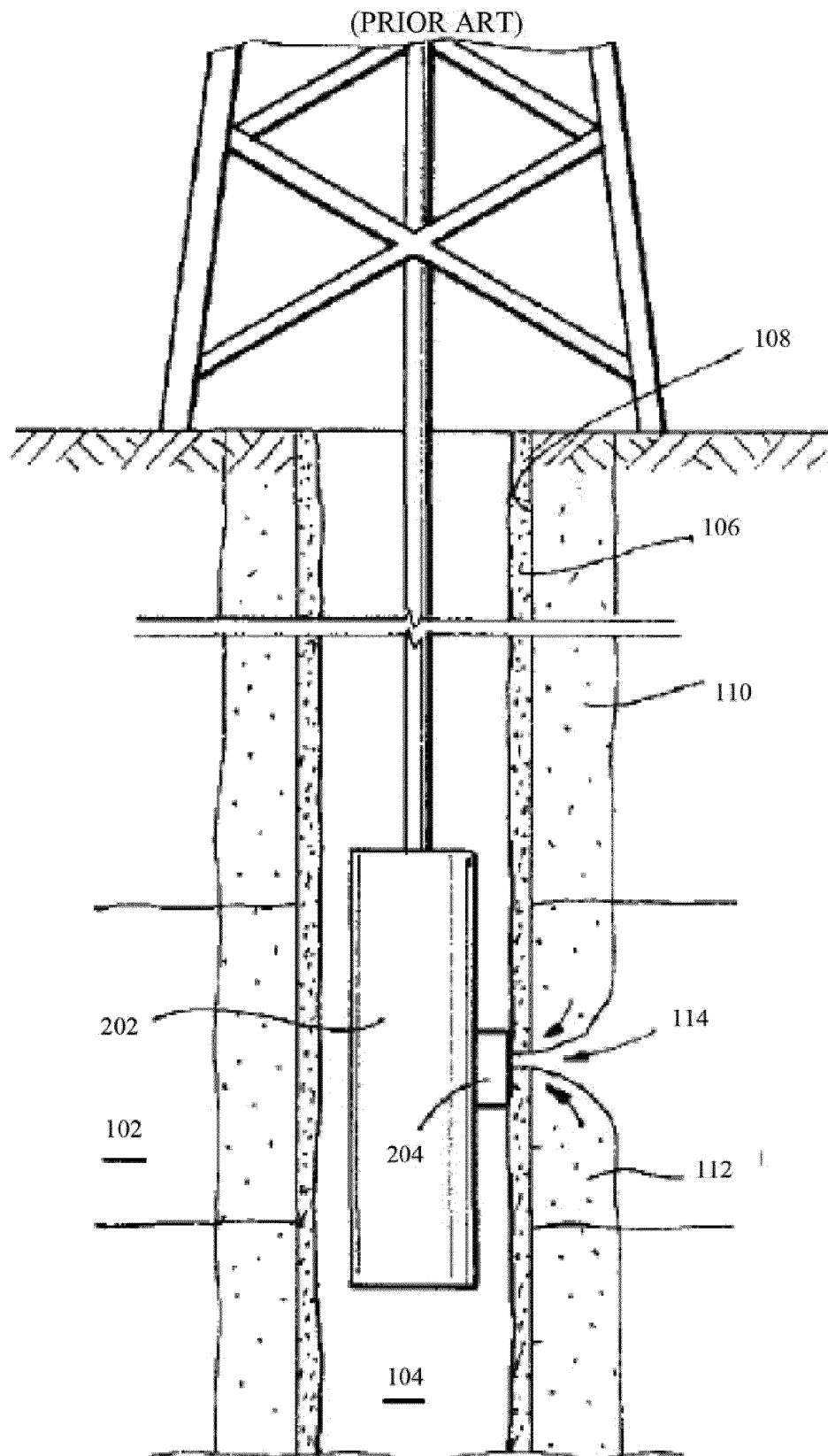


FIG. 2

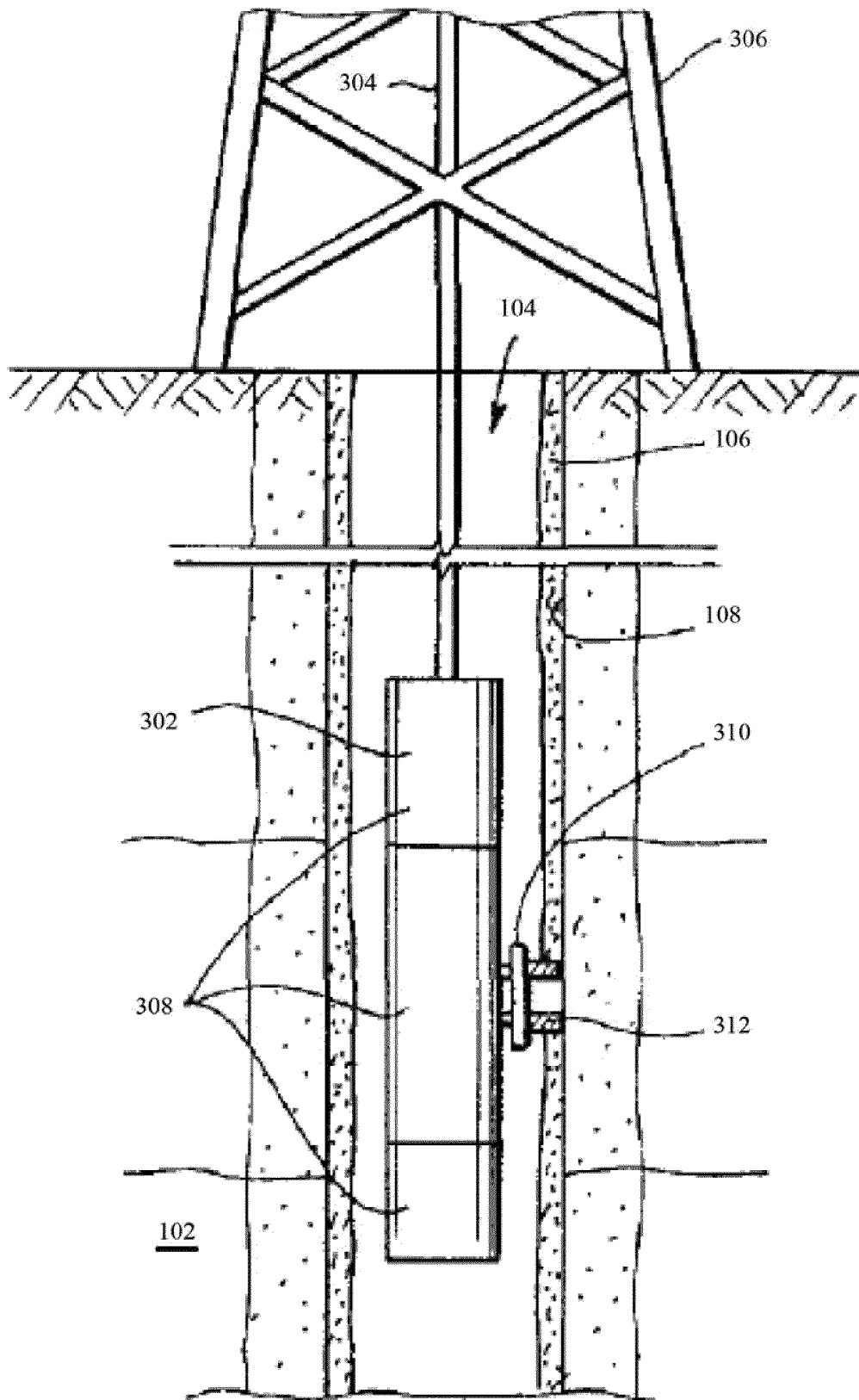


FIG. 3

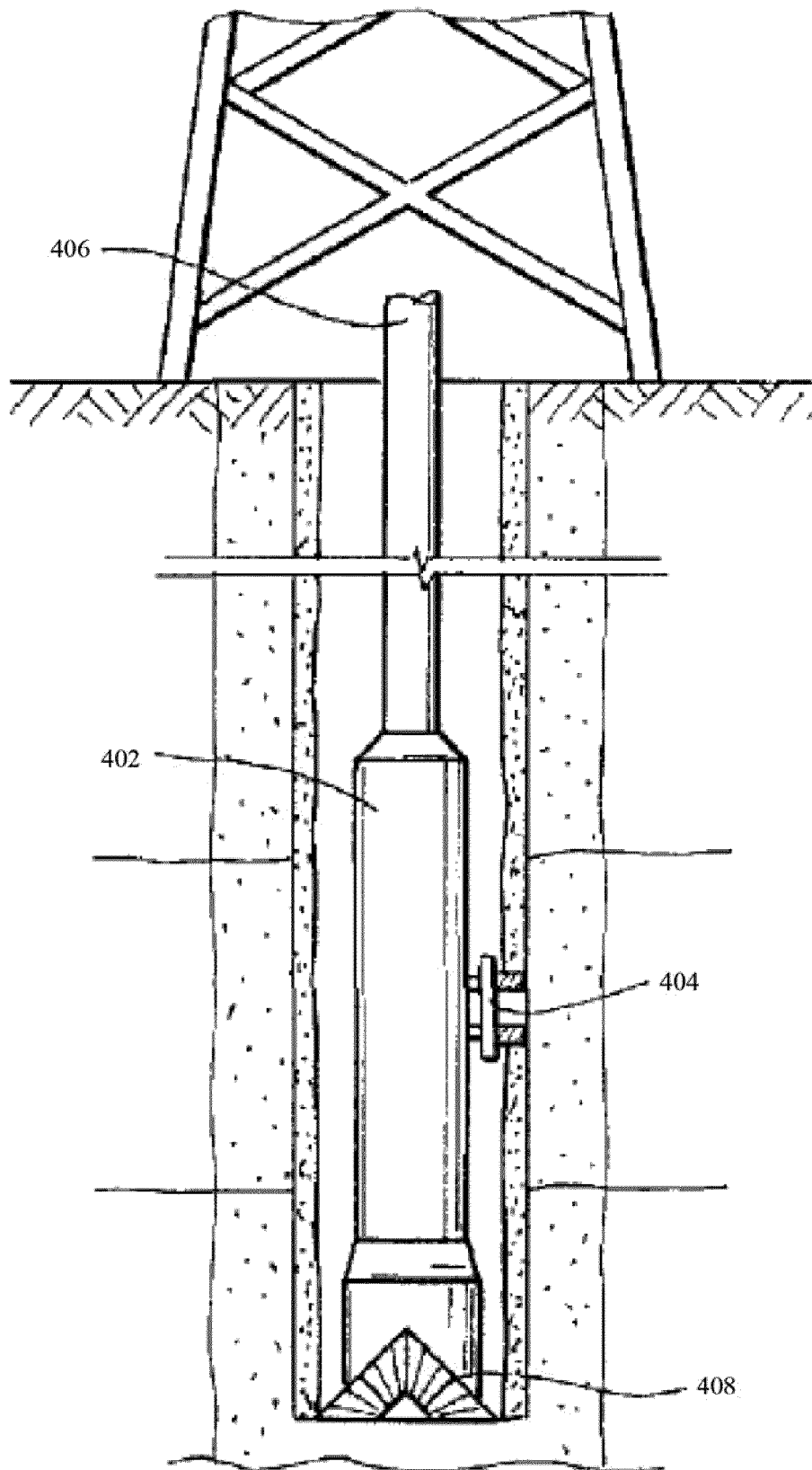


FIG. 4

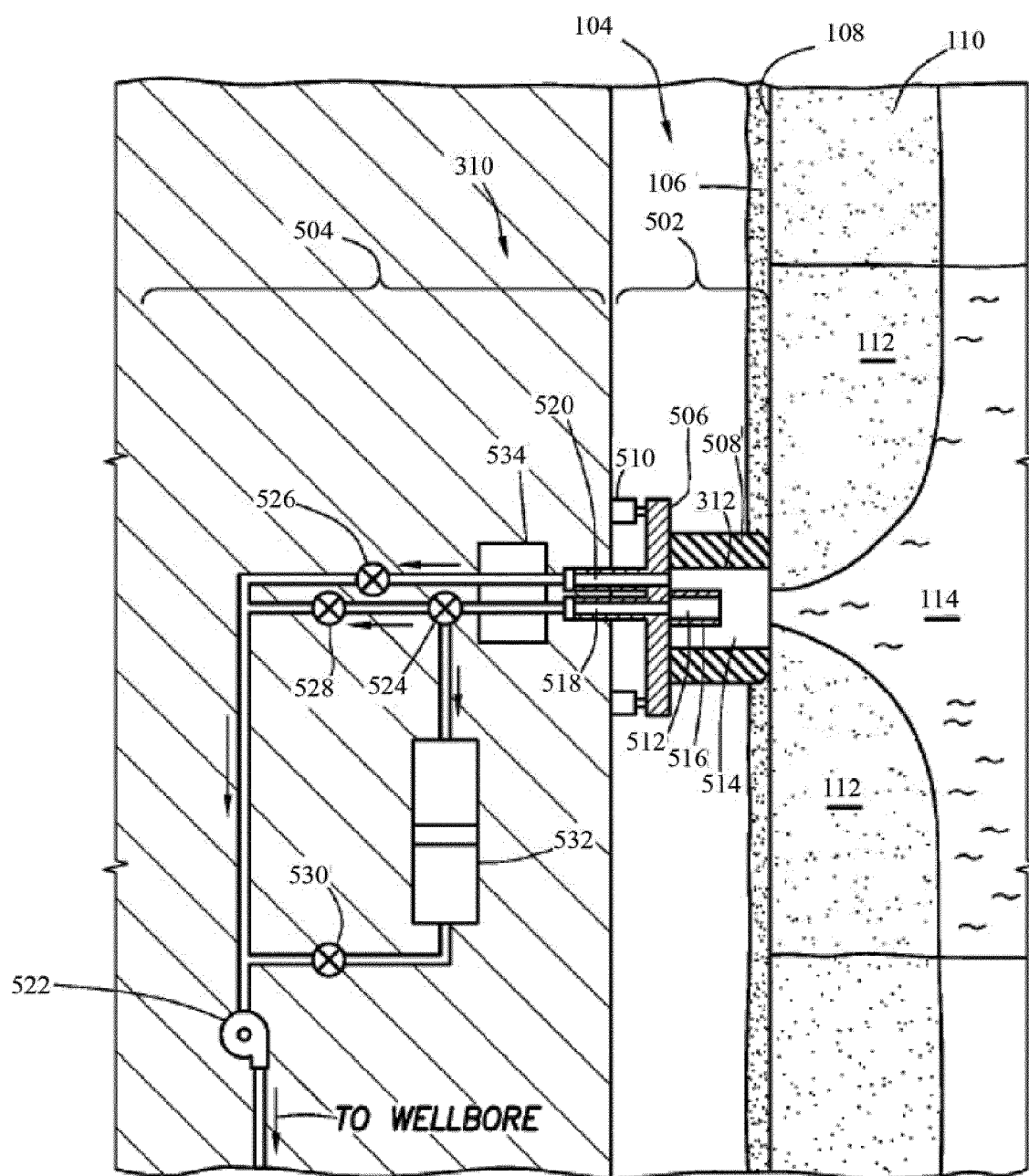


FIG. 5

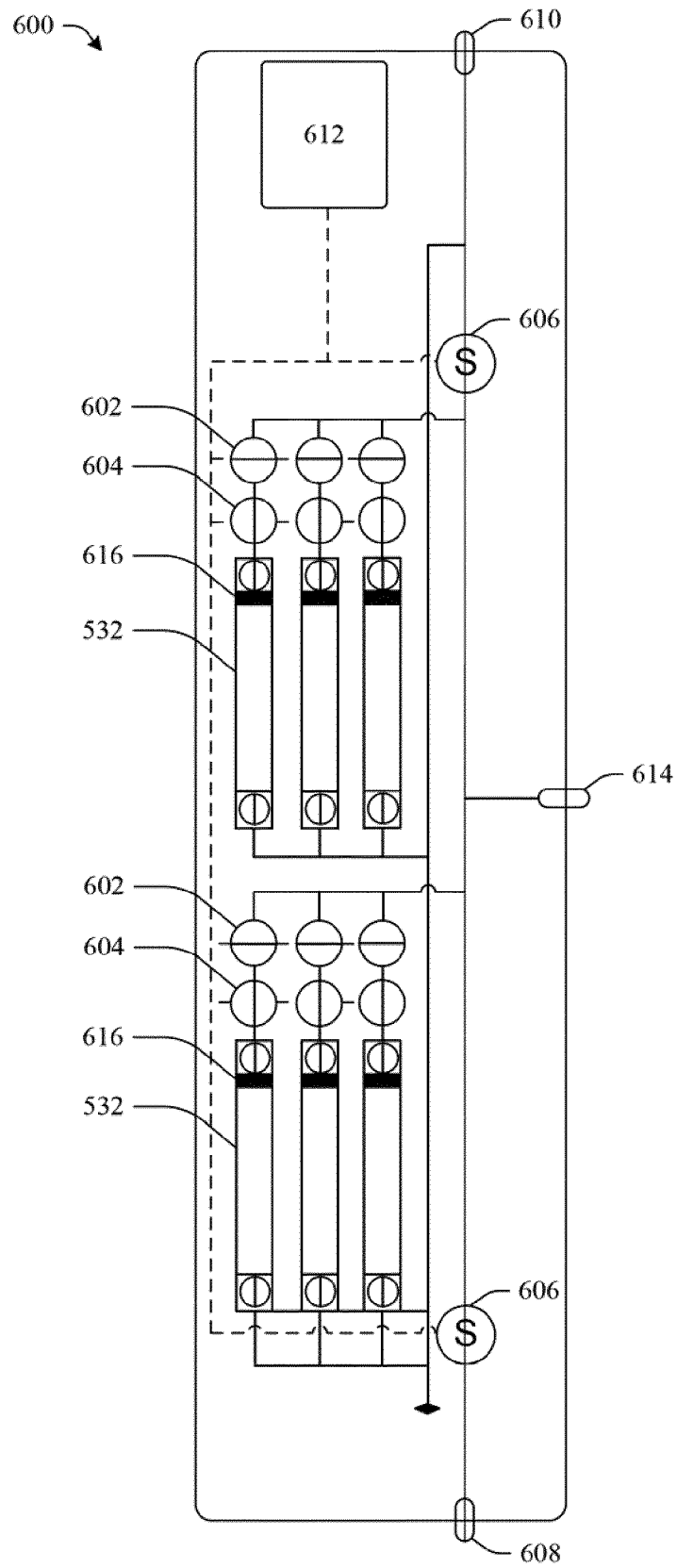


FIG. 6

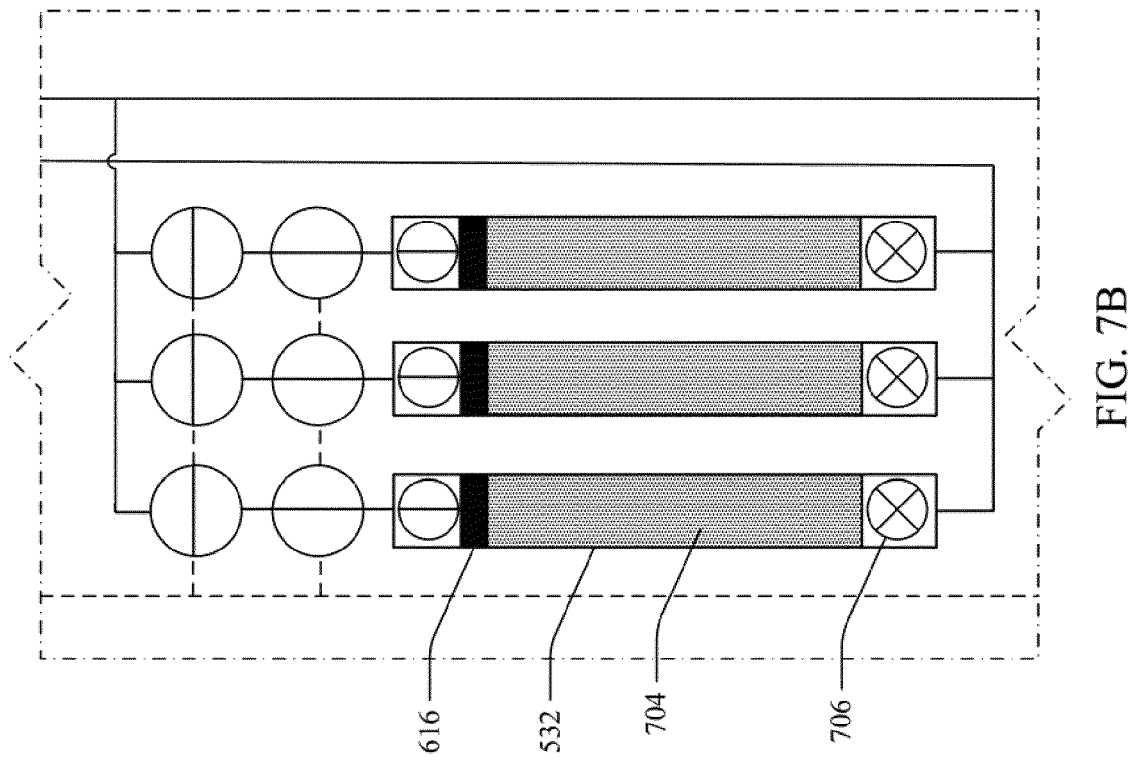


FIG. 7A

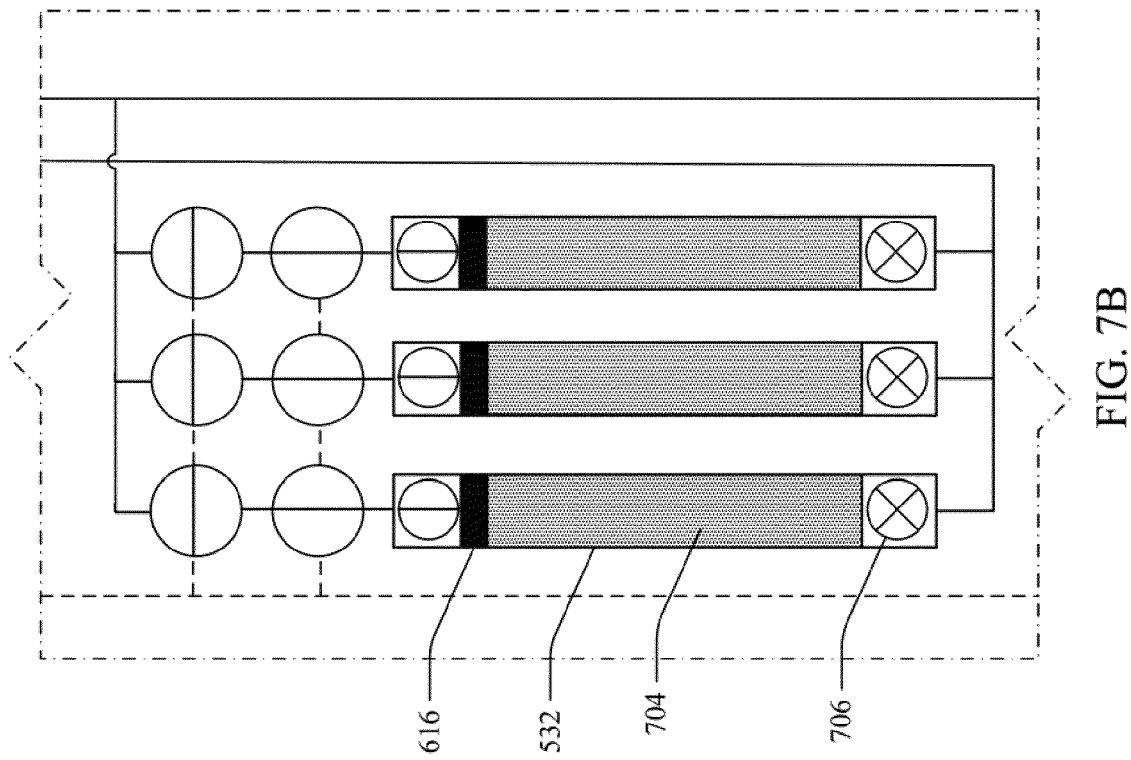


FIG. 7B

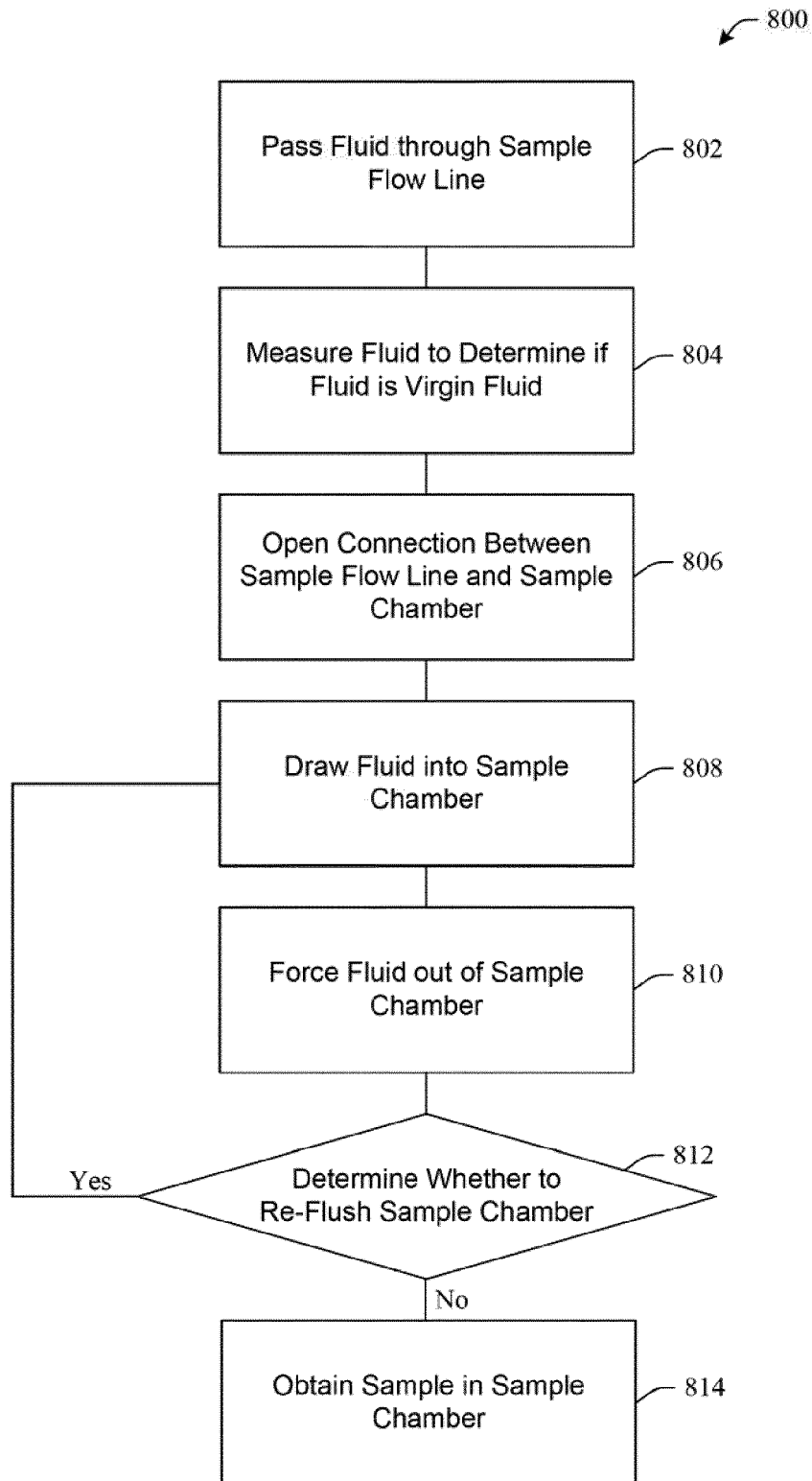


FIG. 8

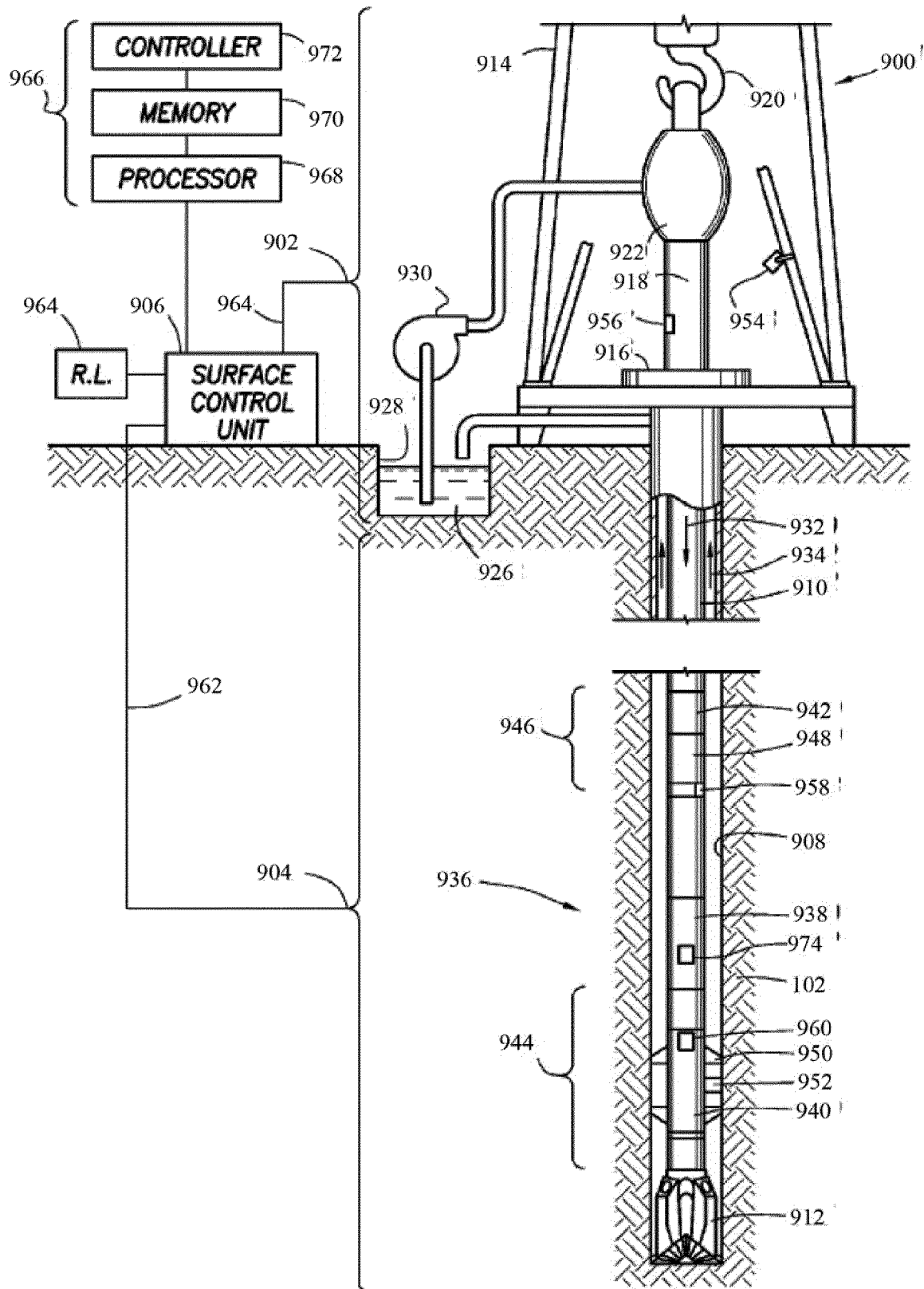


FIG. 9

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description

- US 6871713 B [0004]
- US 7234521 B [0004]
- US 7114562 B [0004]
- US 6301959 B [0006] [0012] [0013]
- US 4860581 B [0006]
- US 4936139 B [0006]
- US 6585045 B [0006]
- US 6609568 B [0006]
- US 6719049 B [0006]
- US 6964301 B [0006]
- US 6230557 B [0012]
- US 6223822 B [0012]
- US 4416152 A [0012]
- US 3611799 A [0012]
- WO 9630628 A [0012]
- US 4951749 A [0013]
- WO 2005065277 A [0014]
- WO 0050876 W [0014]
- US 4936139 A [0032]
- US 4860581 A [0032]
- US 8210260 B [0040]
- US 20050109538 A [0052]
- US 5517464 A [0054]

### Non-patent literature cited in the description

- **P. S. HAMMOND.** One or Two Phased Flow During fluid Sampling by a Wireline Tool. *Transport in Porous Media*, 1991, vol. 6, 299-330 [0014]