US 20040173363A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2004/0173363 A1

Navarro-Sorroche (43) Pub. Date: Sep. 9, 2004

(54) PACKER WITH INTEGRATED SENSORS

(76) Inventor: Juan Navarro-Sorroche, Plano, TX (US)

Correspondence Address:
David W. Carstens
Carstens, Yee & Cahoon, L.L.P.
P.O. Box 802334
Dallas, TX 75240 (US)

(21) Appl. No.: **10/379,267**

(22) Filed: **Mar. 4, 2003**

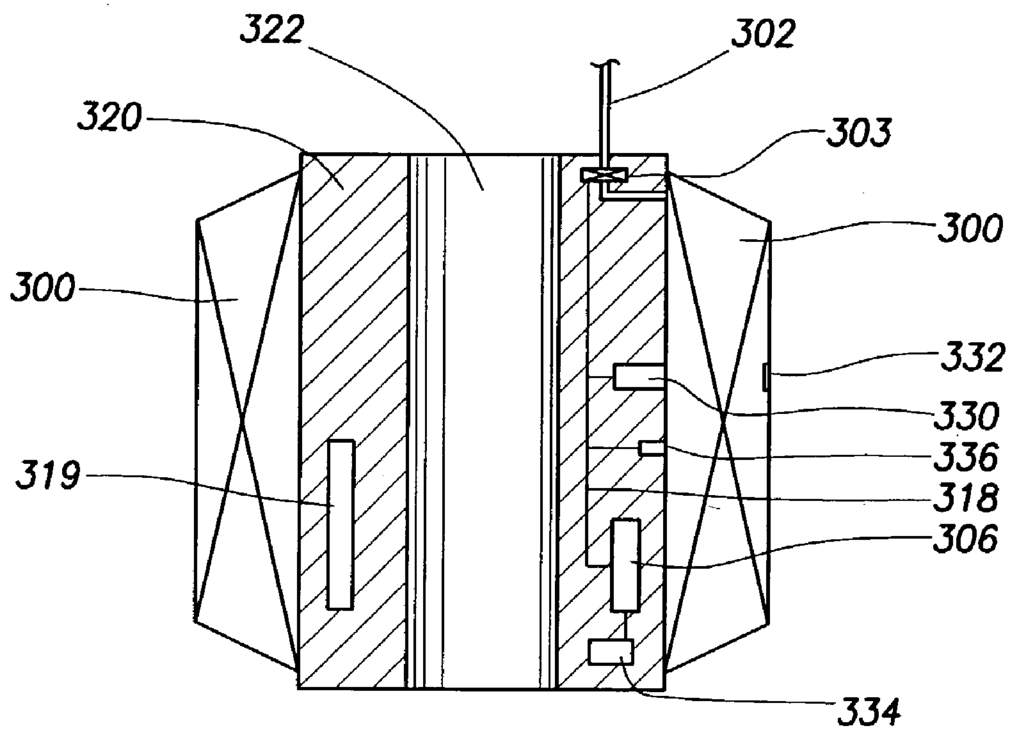
Publication Classification

(51) Int. Cl.[7] E21B 33/12

(52) U.S. Cl. 166/387; 166/179

(57) **ABSTRACT**

Sensors are included in an inflatable packer to measure the pressure inside the packer and the distance that the outside wall of the packer moves during inflation. This data is communicated to a control module that monitors and controls the operation of the packer, as well as to a central downhole and/or surface controller.



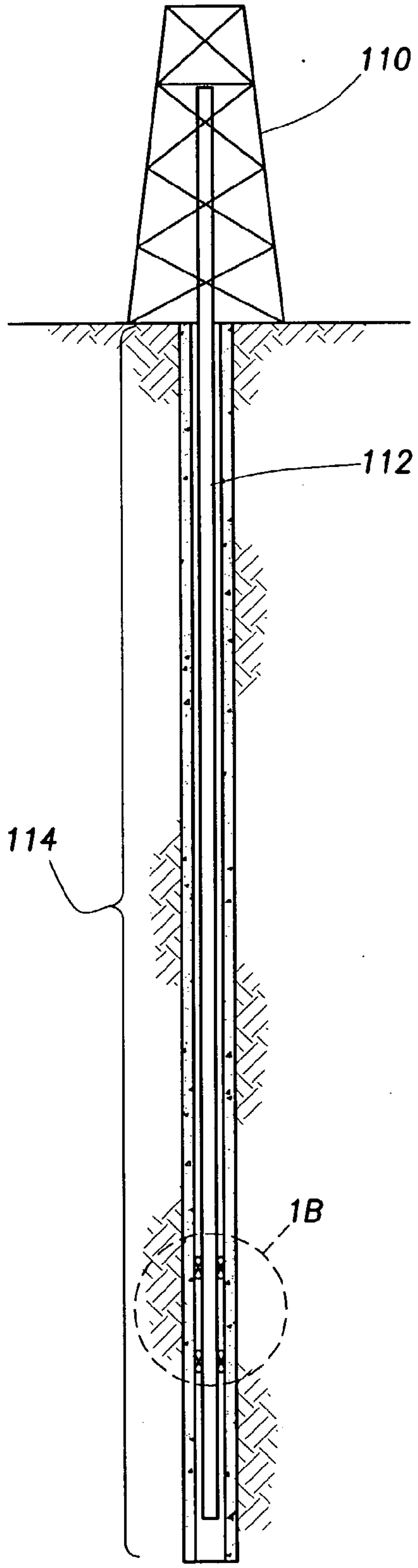


FIG. 1A
(PRIOR ART)

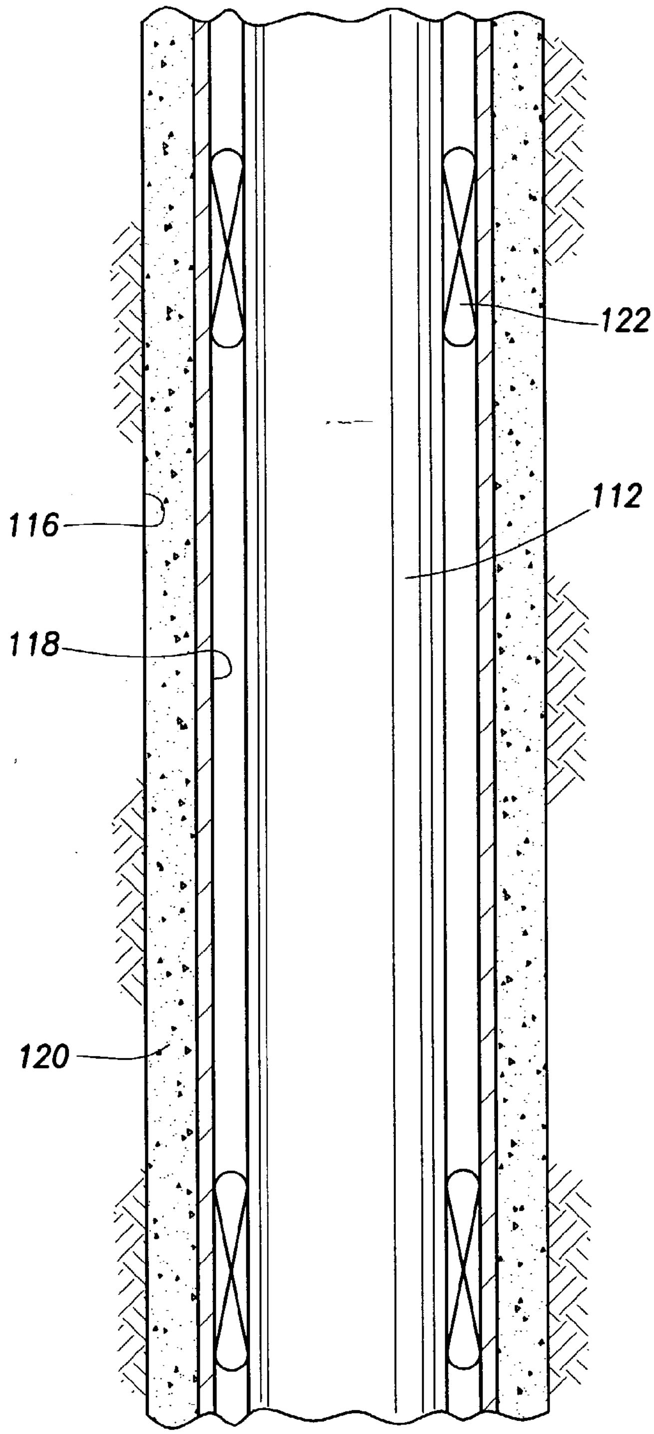


FIG. 1B
(PRIOR ART)

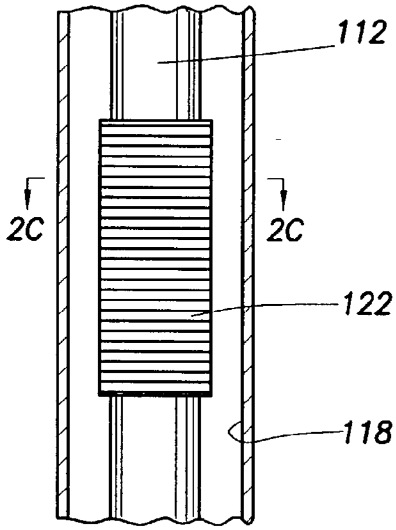


FIG.2A
(PRIOR ART)

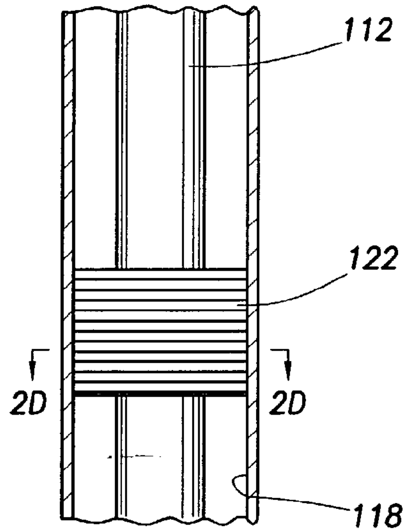


FIG.2B
(PRIOR ART)

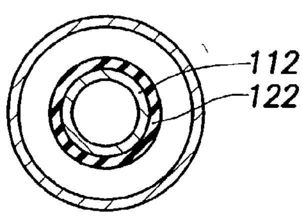


FIG.2C
(PRIOR ART)

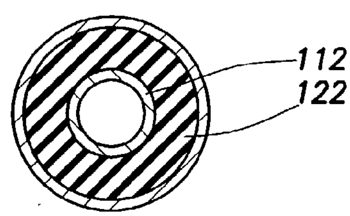


FIG.2D
(PRIOR ART)

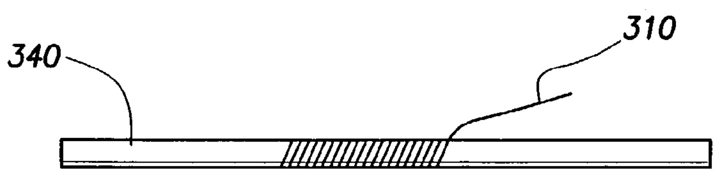


FIG.6

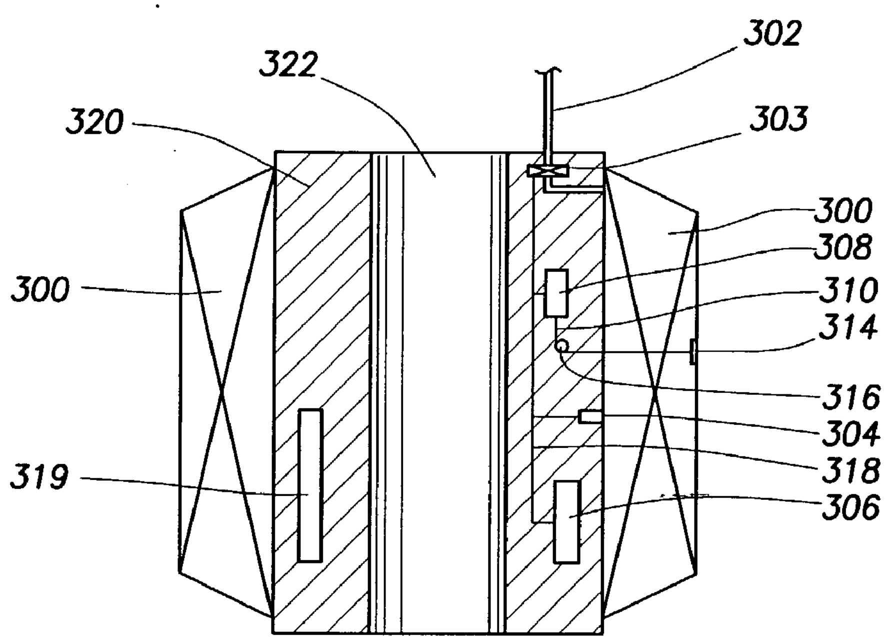

302
322
320
303
300
308
300
310
314
316
304
319
318
306

FIG. 3

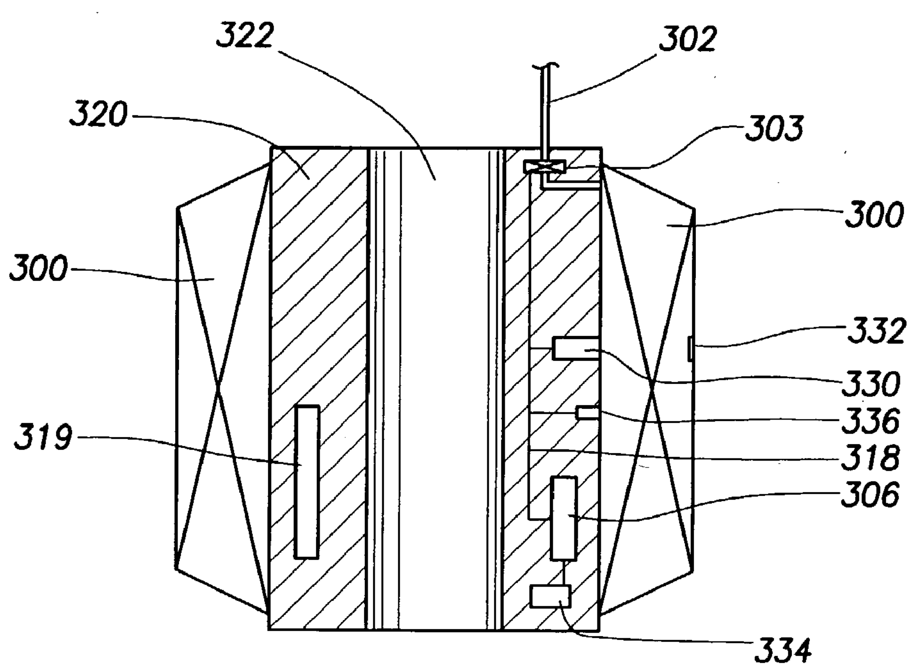

322
302
320
303
300
300
332
330
336
319
318
306
334

FIG. 4

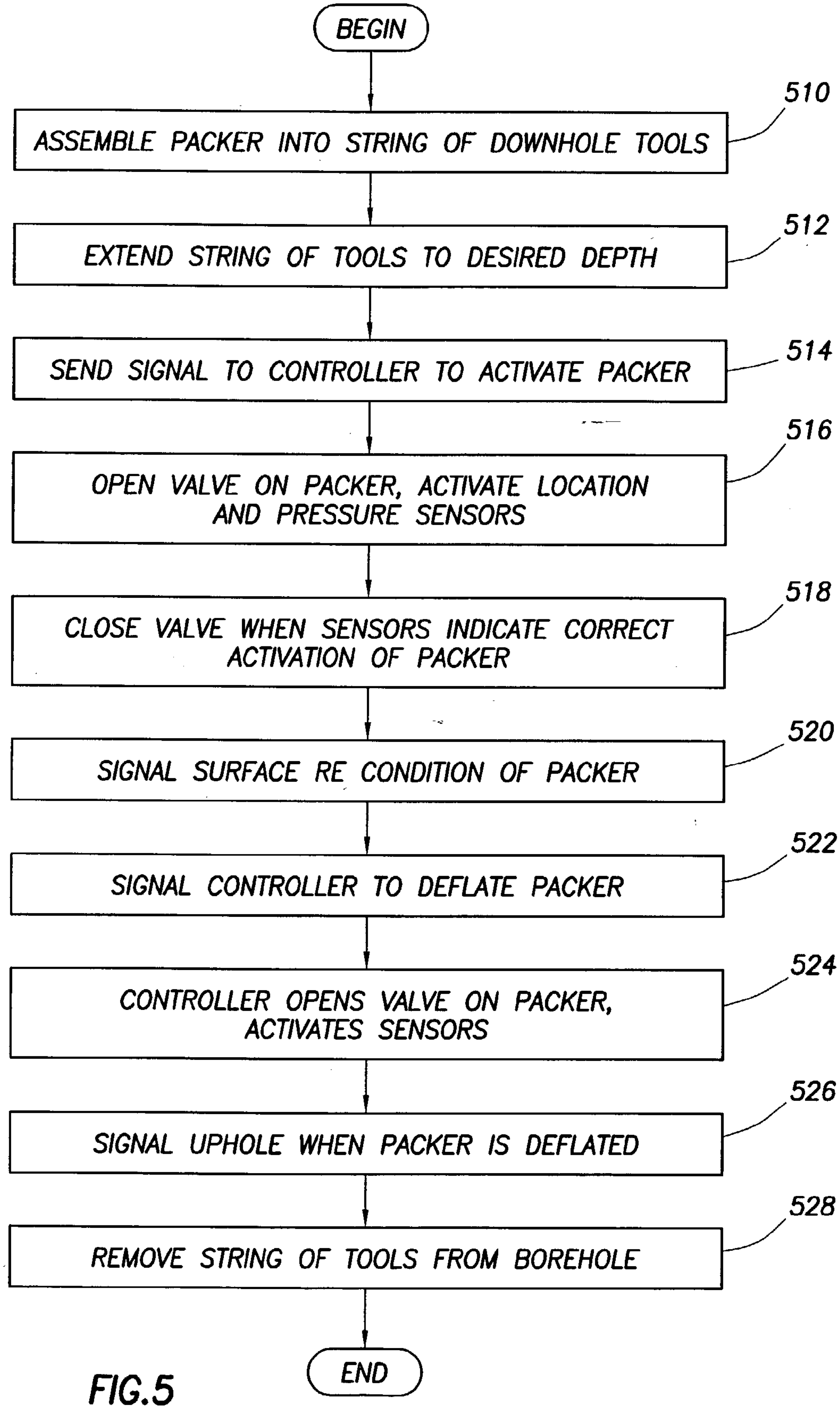

BEGIN
510
ASSEMBLE PACKER INTO STRING OF DOWNHOLE TOOLS
512
EXTEND STRING OF TOOLS TO DESIRED DEPTH
514
SEND SIGNAL TO CONTROLLER TO ACTIVATE PACKER
516
OPEN VALVE ON PACKER, ACTIVATE LOCATION AND PRESSURE SENSORS
518
CLOSE VALVE WHEN SENSORS INDICATE CORRECT ACTIVATION OF PACKER
520
SIGNAL SURFACE RE CONDITION OF PACKER
522
SIGNAL CONTROLLER TO DEFLATE PACKER
524
CONTROLLER OPENS VALVE ON PACKER, ACTIVATES SENSORS
526
SIGNAL UPHOLE WHEN PACKER IS DEFLATED
528
REMOVE STRING OF TOOLS FROM BOREHOLE
END

FIG.5

PACKER WITH INTEGRATED SENSORS

TECHNICAL FIELD

[0001] The present invention relates to the detection of equipment status in a borehole. More specifically, it relates to detecting the amount of expansion and the pressure inside a hydraulically controlled packer.

BACKGROUND OF THE INVENTION

[0002] In the field of oil and gas drilling, where a borehole may extend a mile or further below the surface, it has long been desirable to have knowledge of the position and configuration of the equipment that one can no longer see. One specific case in point is the use of packers.

[0003] **FIG. 1A** shows a simplified schematic of a cross-section through a well, which can be nearing completion. A derrick **110** supports a string of pipe **112**, which is run into a cased borehole **114**. **FIG. 1B** is an enlargement of a portion of **FIG.** 1A, showing the wall **116** of the borehole, casing **118**, casing cement **120**, pipe **112**, and packers **122**. The packers **122** provide a seal between the outside of the pipe **112** and the inside of the casing, so that one section of the cased borehole **114** can be isolated from another. This can be to allow pressure to be exerted in a specific formation, e.g., for fracturing a producing formation, to be able to separately draw out the oil and gas produced at different depths, or for other reasons

[0004] There are numerous types of packers, which differ in their material and form, but an exemplary packer uses hard rubber parts to seal between the downhole tubing and the casing or borehole. These packers will have a toroidal, or doughnut-shaped, section of rubber on the outside wall of the drill string. **FIG. 2A** shows a view of such a packer as it is inserted into the borehole. At this point in time, the rubber making up the packer lies close to the pipe supporting it, so that there is no interference with the walls of the borehole as the packer is inserted. A view looking downward at the packer is seen in **FIG. 2B**. Once the packer is in position, the pipe supporting the packer is manipulated so that the rubber is compressed in a longitudinal direction. As the toroid is forced into a smaller distance longitudinally, it bulges outward to seal against the inside of the casing, as seen in **FIG. 2C**. **FIG. 2D** is a view looking down the borehole at the expanded packer. Another type of packer is inflatable and can be filled with a liquid, once it is in position. So far, however, this type of packer has been used much less as it will not hold against a large differential pressure across the packer.

[0005] As mentioned above, one of the problems in judging whether the packer is correctly seated is the inability to visualize the packer or to receive direct feedback about what is happening with the packer. Judging the proper seating of the packer(s) involves monitoring indirect feedback at the surface, primarily in the form of surface pressure changes. This can involve conducting pressure tests, where a liquid is pumped into the sealed portion to be sure that the packer holds under necessary pressures. No information is directly available from the packer on its displacement or its internal condition. It would be desirable to obtain information from the packer so that it could be more clearly determined if it is properly positioned.

SUMMARY OF THE INVENTION

[0006] In the innovative packer, sensors are included in an inflatable packer to measure the pressure inside the packer and the distance that the outside wall of the packer moves during inflation. This data is communicated to a control module that monitors and controls the operation of the packer, as well as to a central downhole and/or surface controller.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

[0008] **FIG. 1A** shows a simplified schematic of a cross-section through a prior art well.

[0009] **FIG. 1B** is an enlargement of a portion of **FIG.** 1A,

[0010] **FIGS. 2A and 2B** show a prior art packer before and after activation.

[0011] **FIGS. 2C and 2D** show a top view of the packers of **FIGS. 2A and 2B** respectively.

[0012] **FIG. 3** shows a first embodiment of the innovative packer.

[0013] **FIG. 4** shows an alternate embodiment of the innovative packer.

[0014] **FIG. 5** is a flowchart demonstrating a method of using the innovative packer.

DETAILED DESCRIPTION OF THE DRAWINGS

[0015] A first embodiment of the disclosed packer will now be discussed in further detail with reference to **FIG. 3**. This drawing shows only the short section of the pipe string that contains the inflatable packer. It will be noted that this drawing is not done to scale so that the innovative features can be emphasized. Seen in the drawing is the inflatable packer **300**, which wraps completely around the section of pipe **320** containing it. Not present in the drawing are the threaded ends to the pipe section by which the packer is made up as part of a string of tools. The pipe **320** contains a passageway **322** through which fluids can be pumped into the well or production fluids removed from the well. Packer **300** is of the inflatable type, where a fluid can be pumped into the packer **300** through a hydraulic line **302** to expand the packer. In the presently preferred embodiment, the fluid used is a magnetorheological fluid, comprising iron particles in an oil base. With a magnetorheological hydraulic fluid, the flow of hydraulic fluid into and out of the packer can be controlled through the use of an electromagnet **303**. Further information regarding the use of magnetorheological fluids in drilling and production can be found in co-pending application Ser. No. 10/090,054, filed Mar. 1, 2002.

[0016] Two sensors are included as part of this innovative packer. The first of these sensors is a fiber optic pressure transducer **304**. This transducer has at least one surface that is positioned to detect the pressure within the interior of the packer **300**. The pressure detected is transformed into an electrical signal, which is sent to controller **306**. Another type of transducer is used to detect the inflation of the packer. In this embodiment, a rotary potentiometer **308** is used, the basic concept of which is shown in **FIG. 6**. A length of cable **310** is wound around a spindle **340**, so that as cable **310** is pulled out of the potentiometer **308**, the spindle is rotated a number of turns proportional to the distance the cable travels. These rotations are translated into another electrical signal, which is again sent to the controller **306**. As seen in the figure, one end of cable **310** is attached to the outer wall **312** of the packer **300** by a cable clamp **314**. The cable between the potentiometer **308** and cable clamp **314** runs over pulley **316**, which allows a change of direction. As the packer is inflated, the cable **310** is pulled out of potentiometer **308**, causing an appropriate signal to be generated. The shaft of the potentiometer **308** is spring-loaded so that it remains in its zero position until the packer is inflated. The sensors **304**, **308**, controller **306**, and the electromagnet **303** that controls the flow of fluid into the packer **300** are connected by bus **318** to each other and to a battery **319**, which provides power.

[**0017**] **FIG. 4** shows an alternate embodiment of the innovative packer **300**. In this embodiment, ultrasound transducer **330** bounces a signal off a metal plate **332** attached to the wall of the packer **300** to measure the inflation of the packer **300**. From the signals bounced back from the device **332**, the transducer **330** can determine the distance the wall of the packer **300** has moved during inflation. The pressure can be measured in this embodiment can be another form of pressure transducer **304**, such as a quartz pressure transducer or a pressure gauge transducer. Like the prior embodiment, this information can be collected by a controller, which controls the electromagnetic valve used for inflating the packer **300**. Additionally, a signal can be sent uphole via transmitter **334**, where the pressure and displacement can be monitored and the action of the packer further controlled by the operator. This signal can be sent by any of the known methods of sending messages to the surface.

[**0018**] A method of using the disclosed embodiments of the invention will now be described with reference to the flowchart shown in **FIG. 5**. The method begins with the packer being inserted into a string of tools (step **510**) that will be used for finishing the hole or during production, depending on the type of packer used. A hydraulic line will be also be attached to the packer, as is well known in the art, although the valve to the packer will be closed so that the packer will not be unintentionally inflated. Once the string of tools is completed, further pipe is added to extend the string to the required depth (step **512**). This depth will have been determined by the operator to place the packer(s) at appropriate locations relative to the formation of interest. In a presently preferred embodiment, the sensors are not powered at the time the packer is being installed and positioned, although tests may be run to sure that it is functioning correctly. After positioning, a signal is sent (step **514**) to the controller **306** to activate the packer and the sensors. At this time, the controller will open the electromagnetic valve (step **516**) to allow hydraulic fluid into the interior of the packer chamber **300**. At the same time, the sensors **304**, **308** will be activated to detect the movement of the outside wall of the packer and the pressure within the packer itself. The controller **306** will monitor these signals. In a properly functioning packer, the pressure will rise gradually while the packer expands until the outside wall of the packer contacts the casing of the hole. Once the sensor detecting the location of the outer wall of the packer indicates that the casing is contacted, the packer will continue to be filled and pressurized until pressure sensor indicates that the predetermined pressure for sealing is reached. At that point, the controller **306** will shut (step **518**) the valve **303**. Optionally, the controller will also send signals (step **520**) back to the operator on the surface, so that the process can be monitored topside. If the packer installation is not permanent, then the packer can optionally be removed when necessary by reversing the steps. In this instance, a signal is sent (step **522**) to the controller **306**, instructing it to deflate the packer. The valve is opened (step **524**) so that the hydraulic fluid can be pumped out and the monitors are used to detect (step **526**) when the packer is returned to its resting, deflated position. When that point is reached, the string can be withdrawn (step **528**) as is known in the art.

[**0019**] Thus, it can be seen that the innovative changes to a packer will provide much needed information, both to automatic controllers downhole and to the operators on the surface. The advantages of the innovative packer include the following: 1) a direct indication about the integrity of the packer seal is provided, 2) the safety of the overall packer operation is increased, and 3) operating time is saved by avoiding lengthy surface pressure tests to check the integrity of the packer seal.

[**0020**] It will be understood by one of ordinary skill in the art that numerous variations will be possible to the disclosed embodiments without going outside the scope of the invention as disclosed in the claims.

We claim:

1. A packer for use in a borehole, said packer comprising:

a base portion having a bore therethrough and having threaded ends for connection to a string of tools used in a borehole;

an inflatable portion connected to be pressurized by hydraulic fluid; and

a sensor connected to detect a condition related to the deployment of said packer.

2. The packer of claim 1, wherein said sensor detects the pressure inside said inflatable portion.

3. The packer of claim 1, wherein said sensor detects the location of the outer wall of said packer relative to the inner wall of said packer.

4. The packer of claim 1, wherein said sensor is a rotary potentiometer.

5. The packer of claim 1, wherein said sensor is an ultrasound transducer.

6. The packer of claim 1, wherein said sensor is a fiber optic pressure transducer.

7. The packer of claim 1, wherein said inflatable portion is pressurized with magnetorheological fluid.

8. A system for working in a borehole, said system comprising:

a string of tools connected together to accomplish a task related to the production of hydrocarbons from said borehole;

a packer connected to be a part of said string of tools, said packer comprising a sensor connected to detect a condition related to the deployment of said packer.

9. The system of claim 8, wherein said sensor detects the pressure inside said packer.

10. The system of claim 8, wherein said sensor detects the distance an outer wall of said inflatable packer has moved.

11. The system of claim 8, wherein said sensor is a rotary potentiometer.

12. The system of claim 8, wherein said sensor is an ultrasound transducer.

13. The system of claim 8, wherein said sensor is a fiber optic pressure transducer.

14. The system of claim 8, wherein said inflatable portion is pressurized with magnetorheological fluid.

15. A method of using a packer in a borehole, said method comprising:

positioning said packer at a predetermined position within said borehole;

inflating said packer using hydraulic fluid; and

receiving information regarding a condition related to the inflation of said packer from a sensor implanted in said packer.

16. The method of claim 15, wherein said sensor detects the pressure inside said packer.

17. The system of claim 15, wherein said sensor detects the distance an outer wall of said packer has moved.

18. The system of claim 15, wherein said sensor is a rotary potentiometer, an ultrasound transducer, or a fiber optic pressure transducer.

19. The system of claim 8, wherein said packer is pressurized with magnetorheological fluid.

20. A method of using a packer in a borehole, said method comprising the steps of:

attaching a packer containing at least one sensor to a string of tools;

lowering said string of tools, containing said packer, into a cased borehole;

setting said packer while utilizing said at least one sensor to detect the state of said packer.

21. The method of claim 20, wherein said packer is an inflatable packer.

22. The method of claim 20, wherein said sensor is chosen from the group comprising a rotary potentiometer, a fiber-optic pressure transducer, an ultrasound transducer, a quartz pressure transducer, and a pressure gauge transducer.

* * * * *