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Description

Field of Invention

[0001] The present invention relates to a method and apparatus for monitoring properties in a formation traversed by at least one wellbore.

Background

[0002] In the oil and gas industry, the sampling of fluids and measuring formation pressure in the porous strata of the formation being drilled can provide valuable information about the formation and its ability to yield oil and/or gas. Formation pressure is one of the key properties that engineers, geologists, and petrophysicists use to characterize the mobility of oil and gas formations and estimate reserves. Formation pressure data can be collected at specific times throughout the life of the well or it can be monitored on a long-term basis. Ideally, operators would like to be able'to obtain a real time pressure profile of the well over its lifetime to aid in optimization of production.

[0003] Formation pressures can be measured using a variety of methods. The most common method involves running a wireline formation pressure tester (FPT) in either an open or cased hole completion. This method requires drilling into the formation or shooting a hole in the casing. The FPT method works well in permeable formations; however, it is limited to one data point for pressure at a specified time. Obtaining multiple data points is desirable because it is difficult to determine whether a pressure measurement reflects the virgin formation pressure or pressure after depletion. In addition, having a number of measurements over an extended period of time allows for identification of depletion even if the actual virgin formation pressure is unknown.

[0004] In tighter, less permeable formations, the traditional FPT method has limits because it takes a long time to build up to the formation pressure. In addition, the method is less accurate in formations prone to a phenomenon known as supercharging. Supercharging is the increase of formation pressure around the wellbore as a result of exposure to the higher pressure from the mud used in the drilling process. In supercharged reservoirs, the mudcake fails to adequately hold the drilling fluid in the wellbore, causing drilling fluid to penetrate the formation and create a high-pressure or "supercharged" zone. Using the FPT method under these conditions may require extrapolation or yield an inaccurate data point for pressure that is between the mud pressure and the formation pressure.

[0005] Another method used in tighter formations is the diagnostic formation injection test (DFIT). In this method, the formation is pressured up, a fracture is created beyond the supercharged area and the pressure fall off back to the formation pressure is monitored. Usually pressure is measured at the surface and the accuracy is within hundredths of psi. A gauge may also be placed downhole to obtain a more accurate measurement; however, in tight formations, it is still a challenge to get an accurate measurement within 100 psi.

[0006] Long-term build-up is another method for measuring formation pressure. Here the well is shut in for an extended period (weeks or months) and the pressure is measured as it builds back up to the current formation pressure. As with the DFIT method, measuring can be performed at the surface or downhole, but both methods require that the well be shut in with no production. The long-term build-up method traditionally yields one data point representing the pressure for the whole well. In principle, a profile could be obtained by placing a number of gauges between bridge plugs in the casing, but doing so may force the operator to abandon the well or rely on retrievable bridge plugs. The long-term build-up method will also likely damage the casing integrity because the casing has to be perforated in order to have communication between the gauge and the formation.

[0007] US Patent 5,467,823 discloses a method and apparatus of monitoring subsurface formations containing at least one fluid reservoir and traversed by at least one well. The method includes lowering a sensor to a depth level corresponding to the reservoir, positioning the sensor at this depth while isolating the section of the well where the sensor is located from the rest of the well and providing fluid communication between the sensor and the reservoir. Because this system requires isolating the section of the well where the sensor is located from the rest of the well, this could not serve as a long-term pressure measurement option. In addition, the chances of maintaining pressure isolation while achieving communication to surface over the wireline with multiple sensors are remote.

[0008] The method according to the preamble of claim 1 is known from UK patent application 2397594. In the known method an optical fiber is arranged in the cement annulus surrounding a perforated well casing to measure temperature and pressure before and after firing of the perforation guns, to monitor cement curing and acquire flow information during the life of the well.

Summary of the Invention

[0009] The present invention relates to a method for monitoring pressure in a wellbore comprising:

providing a tubular element having an outside surface;
attaching a perforating gun to said outside surface, said gun being oriented in such a way that when fired, the perforating gun does not damage the tubular element;
connecting a sensor to the perforating gun;
inserting the tubular element into the wellbore;
securing the tubular element in the wellbore;
firing the perforating gun to penetrate the formation;

characterized in that:

the sensor is a pressure gauge mounted in close proximity to the perforating gun;
the perforation gun comprises shaped charges, which when fired expose the pressure gauge to the formation pressure; and
the pressure in the formation is monitored with the pressure gauge to obtain pressure data.

Brief Description of the Drawings

[0010] The present invention is better understood by reading the following description of non-limitative embodiments with reference to the attached drawings, wherein like parts of each of the figures are identified by the same reference characters, and which are briefly described as follows:

Figure 1 illustrates a perspective view of one embodiment of the pressure monitoring apparatus.
Figure 2 illustrates a side view of one embodiment of the pressure monitoring apparatus installed in a wellbore.
Figure 3 shows a top view of the wellbore illustrating the direction of the perforations.
Figure 4 illustrates a side view of another embodiment of the pressure monitoring apparatus installed in a wellbore.

Detailed Description of the Invention

[0011] Figure 1 shows one embodiment of an apparatus for monitoring formation properties. In this embodiment, tubular element 101 is a section of casing, liner, or other material used to maintain the integrity of the wellbore. Tubular element 101 may also be a section of tubing, cement stinger, or other device used to lower equipment into a wellbore. Perforating gun 102 and sensor 103 are mounted on the outside of tubular element 101 in close proximity to one another. Perforating gun 102 and sensor 103 may be connected either directly or via additional tubulars or hoses.

[0012] Any type of perforating gun may be used; however the direction of the perforations must point away from the casing (tubular element 101) so that when fired, the perforating gun does not damage the casing. In a wireless embodiment of the invention, perforation gun 102 may be fired by pressuring up the casing using conventional methods of wireless perforating. In an alternative embodiment, a wire may be attached to perforating gun 102 and used for firing. In this embodiment, a conventional casing conveyed wireless perforating gun with the inward facing shaped charges removed is shown.

[0013] Any type of sensor may be used including, for example, strain gauges, quartz gages, and other conventional sensing device. The embodiments in this application discuss using a pressure sensor; however, sensors that measure other well properties could be employed.

[0014] Wireless communications module 104 is shown'connected to tubular element 101. Wireless telemetry technology is known in the industry and may be used to transmit data gathered downhole to surface production facilities. In this case, wireless communications module 104 transmits the pressure data gathered from sensor 103 real time to the surface.

[0015] Figure 2 depicts the apparatus shown in Figure 1 installed in wellbore 201. A section of wellbore 201 is shown traversing formation 202 with tubular element 101 lowered inside. As in Figure 1, perforating gun 102, sensor 103, and wireless communications module 104 are mounted on the outside of tubular element 101. In Figure 2 only one section of the wellbore is shown. Because the transmission system is wireless, an operator may install numerous sensors and perforating guns in a single wellbore to obtain the desired data.

[0016] In operation, once tubular element 103 is lowered to its desired position in wellbore 201, cement 203 is optionally pumped through annulus 204, securing tubular element 101 in place. Then the casing is pressured up and perforating gun 102 is activated. Figure 3 depicts the top view of the apparatus in the wellbore to indicate the direction of the perforations. Shape charges 301 are shown connected to perforating gun 102. When fired, shaped charges 301 penetrate cement 203 and formation 202 according to paths 302 thereby exposing sensor 103 to the formation pressure. During the perforating operation, tubular element 101 remains intact and sensor 103 is not damaged even though it is in direct pressure communication with the gun and not protected from the pressure shock generated by the firing of the gun (referred to as "overpressure" in the industry). Sensor 103 gathers data, which is transmitted to surface unit 205 by wireless communication module 104, thus providing pressure data without the need to drill a dedicated observation well or compromise casing integrity.

[0017] Another embodiment of the invention uses a hard-wired connection to transmit the pressure data gathered downhole. Figure 4 depicts a hard-wired embodiment that is installed on the outside of a section of casing. Wellbore 401 is shown traversing formation 402. First apparatus 403 and second apparatus 404 are shown mounted on the outside of casing 405. First apparatus 403 and second apparatus 404 are connected by wire 406, which extends to the surface (not shown). First apparatus 403 and second apparatus 404 consist of perforating guns (407 and 410), sensors (408 and 411), and communications modules (409 and 412). The entire apparatus is secured in the wellbore using cement 413. In this embodiment, the data collected by sensors 408 and 411 is transmitted using wire 406 to the surface (not shown). Transmission with a wire may be less reliable than using wireless communication because the wire might be damaged during placement in the hole or when zones are perforated for production. However, hard-

wired transmission systems are advantageous because they provide higher frequency data, can transmit data for longer periods, and enable deeper measurements to be contained. Furthermore the wire may also be used to fire the perforating guns.

[0018] Although the system of some embodiments of the present invention was developed for tight, low permeability reservoirs, some embodiments of the invention may also be useful in high permeability reservoirs. In many areas, multiple reservoirs penetrated by a single wellbore are produced and managed separately because of legal or reservoir management requirements. Some embodiments of the present invention enable the operator to have a single well produce one horizon, while acting as a pressure observation well for one or more other reservoirs, thus obviating the need to drill dedicated pressure observers.

[0019] Advantages of the embodiments of the invention include one or more of the following:

(i) Provides accurate pressure measurement in tight low permeability formations
(ii) Maintains casing integrity
(iii) Allows for simultaneous production and monitoring
(iv) Avoids need to drill separate observation well
(v) May be used in high permeability formations in which multiple reservoirs are penetrated by single wellbore
(vi) Uses multiple bullets, improving the chance of establishing pressure communication with formation.

[0020] Those of skill in the art will appreciate that many modifications and variations are possible in terms of the disclosed embodiments, configurations, materials, and methods without departing from their spirit and scope. Accordingly, the scope of the claims appended hereafter and their functional equivalents should not be limited by particular embodiments described and illustrated herein, as these are merely exemplary in nature.

Claims

1. A method for monitoring pressure in a wellbore(201) comprising:

providing a tubular element(101) having an outside surface;
attaching a perforating gun(102) to said outside surface, said gun(102) being oriented in such a way that when fired, the perforating gun does not damage the tubular element(101);
connecting a sensor(103) to the perforating gun (102) ;
inserting the tubular element(101) into the wellbore(201);
securing the tubular element(101) in the wellbore (201) ;
firing the perforating gun(102) to penetrate the formation(202) ;

characterized in that:

the sensor(103) is a pressure gauge mounted in close proximity to the perforating gun(102);
the perforating gun(102) comprises shaped charges(301), which when fired expose the pressure gauge(103) to the formation pressure; and
the pressure in the formation is monitored with the pressure gauge(103) to obtain pressure data.

2. The method of claim 1 further comprising attaching a wireless communications module(104) to the outside of the tubular element(101).

3. The method of claim 2 wherein the tubular element (101) is a casing(405).

4. The method of claim 3 wherein the securing is performed by cementing the casing(405) against the formation(202).

5. The method of claim 4 wherein the firing is performed by pressuring up the casing(405) to detonate a plurality of shaped charges(301).

6. The method of claim 5 further comprising transmitting the pressure data to a surface control unit using the wireless communications module(104).

7. The method of claim 6 further comprising producing oil from the formation(202).

8. The method of claim 1 further comprising connecting the sensor(103) to a surface control unit using a hard wire connection (406) .

9. The method of claim 8 wherein the inserting is performed by a cement stinger.

10. The method of claim 8 wherein the inserting is performed by a tubing.

Patentansprüche

1. Verfahren zur Drucküberwachung in einem Bohrloch (201), umfassend:

Bereitstellen eines röhrenförmigen Elements (101) mit einer Außenfläche;
Anbringen einer Perforationskanone (102) an

die Außenfläche, wobei die Kanone (102) so ausgerichtet ist,
dass die Perforationskanone beim Abfeuern das röhrenförmige Element (101) nicht beschädigt;
Anschließen eines Sensors (103) an die Perforationskanone (102);
Einführen des röhrenförmigen Elements (101) in das Bohrloch (201);
Sichern des röhrenförmigen Elements (101) im Bohrloch (201);
Abfeuern der Perforationskanone (102), um in die Formation (202) einzudringen;

dadurch gekennzeichnet, dass
der Sensor (103) ein Druckmessgerät ist, das in unmittelbarer Nähe zur Perforationskanone (102) befestigt wird;
die Perforationskanone (102) Hohlladungen (301) enthält, welche beim Abfeuern das Druckmessgerät (103) dem Formationsdruck aussetzen; und
der Druck in der Formation mit dem Druckmessgerät (103) überwacht wird, um Druckdaten zu erhalten.

2. Verfahren nach Anspruch 1, des Weiteren umfassend das Anbringen eines drahtlosen Kommunikationsmoduls (104) an die Außenseite des röhrenförmigen Elements (101).

3. Verfahren nach Anspruch 2, wobei das röhrenförmige Element (101) ein Bohrrohr (405) ist.

4. Verfahren nach Anspruch 3, wobei das Sichern durch Kitten des Bohrrohrs (405) an die Formation erfolgt.

5. Verfahren nach Anspruch 4, wobei das Abfeuern durch eine Druckerhöhung im Bohrrohr (405) erfolgt, um eine Vielzahl von Hohlladungen (301) zur Explosion zu bringen.

6. Verfahren nach Anspruch 5, des Weiteren umfassend die Übermittlung von Druckdaten zu einer an der Oberfläche liegenden Kontrolleinheit unter Verwendung des drahtlosen Kommunikationsmoduls (104).

7. Verfahren nach Anspruch 6, des Weiteren umfassend die Gewinnung von Öl aus der Formation (202).

8. Verfahren nach Anspruch 1, des Weiteren umfassend das Anschließen des Sensors (103) an eine an der Oberfläche liegende Kontrolleinheit unter Verwendung einer festverdrahteten Verbindung (406).

9. Verfahren nach Anspruch 8, wobei das Einführen mittels eines Zementstingers erfolgt.

10. Verfahren nach Anspruch 8, wobei das Einführen mittels einer Rohrleitung erfolgt.

Revendications

1. Procédé pour surveiller la pression dans un trou de forage (201), comprenant les étapes consistant à :

mettre en oeuvre un élément tubulaire (101) ayant une surface externe ;
fixer un canon perforateur (102) sur ladite surface externe, ledit canon (102) étant orienté de sorte qu'une fois déclenché, le canon perforateur n'endommage pas l'élément tubulaire (101) ;
raccorder un capteur (103) au canon perforateur (102) ;
insérer l'élément tubulaire (101) dans le trou de forage (201) ;
fixer l'élément tubulaire (101) dans le trou de forage (201) ;
déclencher le canon perforateur (102) pour pénétrer dans la formation (202) ;

caractérisé en ce que
le capteur (103) est une jauge de pression montée à proximité étroite du canon perforateur (102) ;
le canon perforateur (102) comprend des charges façonnées (301), qui, lorsqu'elles sont mises à feu, exposent la jauge de pression (103) à la pression de la formation ; et
la pression dans la formation est surveillée avec la jauge de pression (103) pour obtenir des données de pression.

2. Procédé selon la revendication 1, comprenant en outre la fixation d'un module de communications sans fil (104) à l'extérieur de l'élément tubulaire (101).

3. Procédé selon la revendication 2, dans lequel l'élément tubulaire (101) est un cuvelage (405).

4. Procédé selon la revendication 3, dans lequel la fixation est effectuée par cimentation du cuvelage (405) contre la formation (202).

5. Procédé selon la revendication 4, dans lequel la mise à feu est effectuée en élevant la pression du cuvelage (405) pour faire détoner une pluralité de charges façonnées (301).

6. Procédé selon la revendication 5, comprenant en outre la transmission des données de pression à une unité de commande de surface en utilisant le module de communications sans fil (104).

7. Procédé selon la revendication 6, comprenant en

outre la production de pétrole provenant de la formation (202).

8. Procédé selon la revendication 1, comprenant en outre la connexion du capteur (103) à une unité de commande de surface en utilisant une connexion câblée (406).

9. Procédé selon la revendication 8, dans lequel l'insertion est effectuée par un poussoir en ciment.

10. Procédé selon la revendication 8, dans lequel l'insertion est effectuée par un tubage.

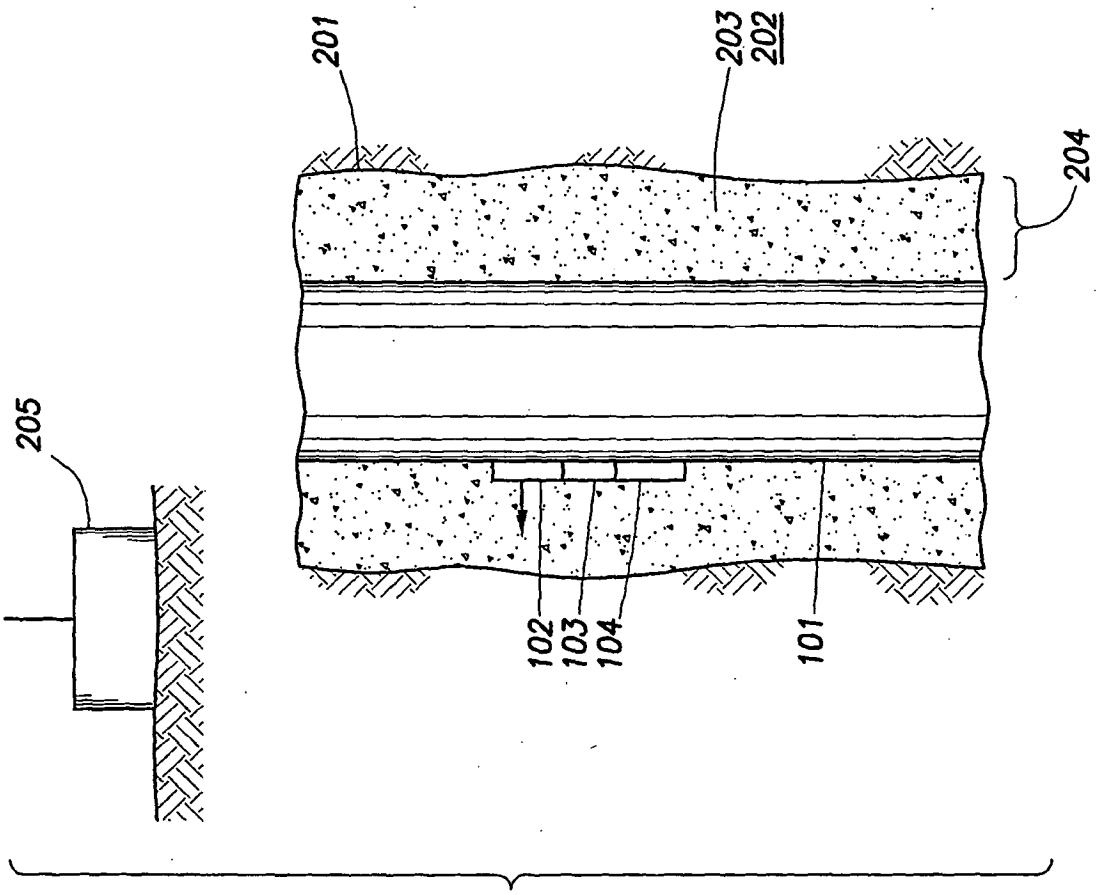


FIG.2

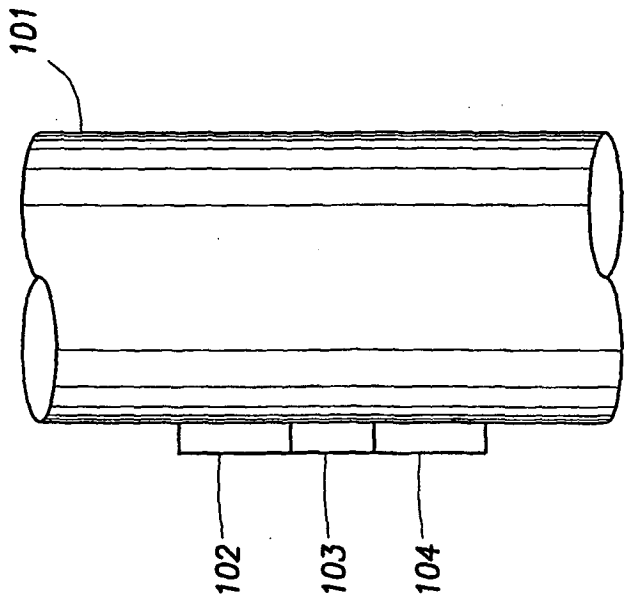


FIG.1

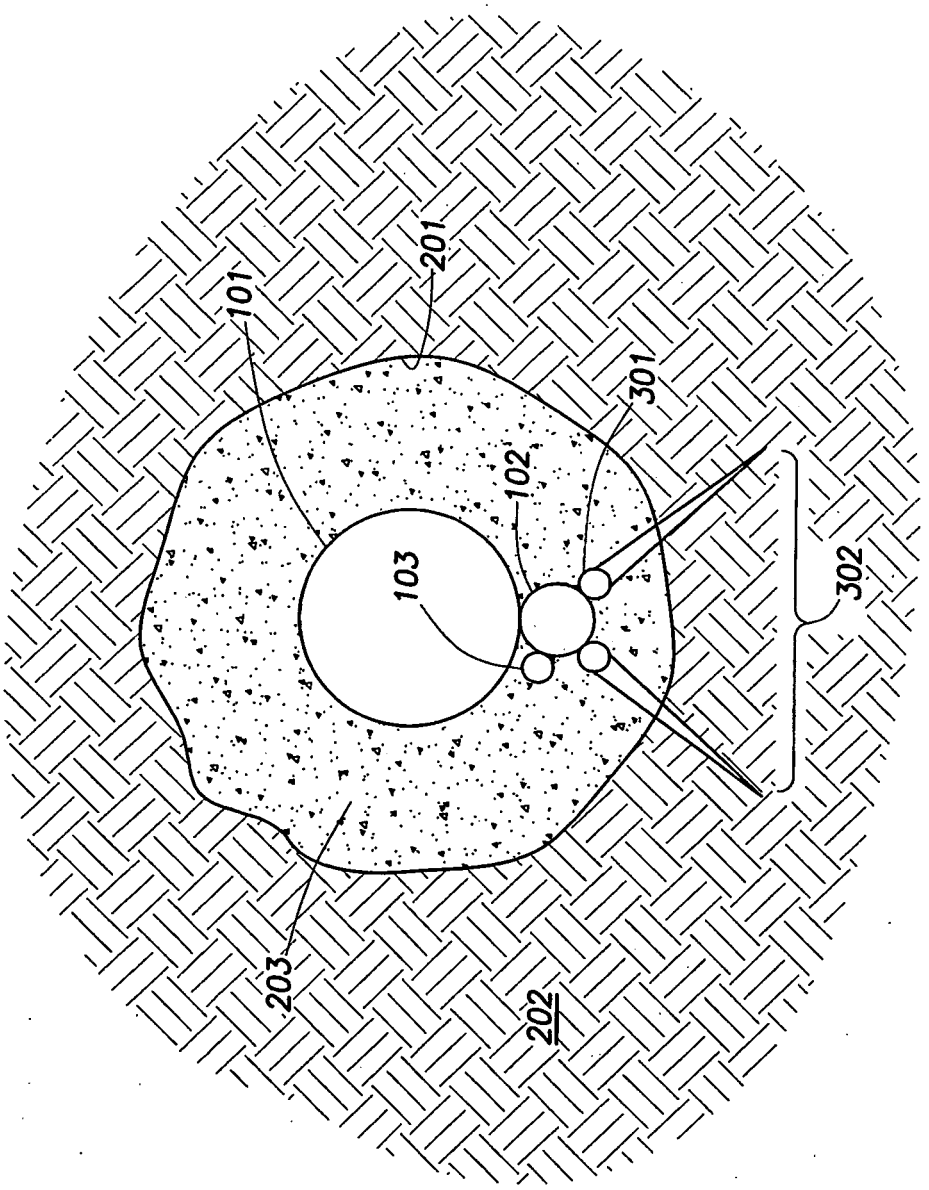


FIG.3

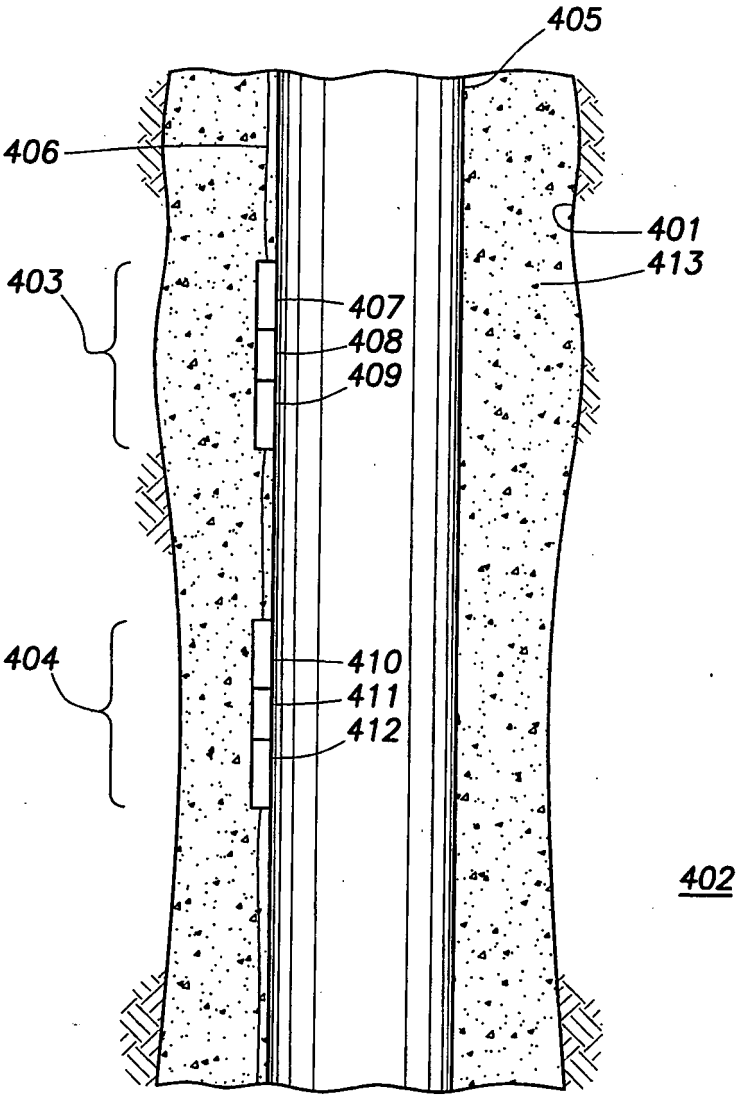


FIG.4

REFERENCES CITED IN THE DESCRIPTION

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