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(54) **Method and apparatus for completing a well**

Verfahren und Vorrichtung zum Ausrüsten eines Bohrloches

Procédé et dispositif pour la complétion de puits

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Description

[0001] The present invention relates to methods and apparatus having application in the field of well construction, completion, monitoring and control. In particular, the invention provides methods and apparatus that are particularly useful in oil or gas wells situated in weakly consolidated or unconsolidated formations requiring screen completions.

[0002] Traditional methods of completing hydrocarbon wells involve cementing a casing or liner (typically made of steel) into the well and then forming perforations at locations in the well believed to be situated in producing formations extending through the casing and cement into the formation to provide paths along which fluids can flow into the well. These flow paths can often be improved by fracturing or other stimulation methods well known in the industry. Once the well has been completed, it is relatively easy to re-enter the well with measurement tools and make measurements near the regions in which there are perforations to determine the nature and characteristics of the fluids flowing into the well from the formation at that point. Also, it is possible to seal off the perforations if it is discovered that undesirable fluids flow is encountered, for example high volume fractions or flow rates of water entering the well at that point. All of these are generally possible because the perforations constitute a relatively small extent of the well and the presence of the otherwise solid casing allows portions of the well to be sealed while well treatments are taking place.

[0003] However, there are certain, well-known situations in which this traditional approach to well completion cannot be used, in particular when the producing formation is weakly consolidated or unconsolidated, such as sand, or where the producing section of the well has been drilled in a long reach horizontal section. In the first case, the formation is too weak to allow casing to be installed, or for permanent perforations tunnels into the formation to be formed. The only effective manner to allow fluids to pass into the well is to provide a highly perforated or apertured liner, often called a "screen" or "sand screen" or "gravel pack" to be placed in the well in the formation of interest. In the past, such wells have often been left without any form of liner, sometimes called "barefoot completion" or have had slotted liners or screens inserted into the well but not secured by cement, similar to the approach to that used in unconsolidated formations as described above.

[0004] One known form of screen useful in unconsolidated formations or long reach horizontal wells is shown in Figures 1 and 2. The screen is formed in sections having a base tube 12 which is provided with holes 14 along its length and around its circumference. The screen itself is formed by a triangular section wire 16 (base outermost) that is wound around the outside of the base tube 12 between small collar sections 18 provided at each end of the base tube 12 and separated from the outer surface of the base tube by longitudinal splines 22 secured to the outer surface of the base tube so as to define an axially segmented annular chamber 24 around the base tube 12. The wire screen 16 is wound in such a way that a small space is left between adjacent windings that is small enough to prevent small particles such as sand entering the chamber 24 or base tube 12 yet not so small as to inhibit the flow of fluids into the well. While this construction allows flow in the radial direction (i.e. into the base tube, it also allows axial flow inside and outside the screen with little or no restriction. This can bring certain problems when it comes to monitoring the production in the well or treating the well or formation with treatment fluids. In the case of monitoring or measurement, since there can be flow into the well at almost any point and since there can be flow outside the base tube in axial directions (i.e. in the chamber 24), it is very difficult to relate a measurement made at any particular point in the well to the behaviour of a specific region of the formation outside the well. In the case of well treatment, pumping a fluid inside the base tube cannot guarantee placement in a zone of interest since there is nothing to force the fluid into that zone. Even the use of coiled tubing to deliver treatment fluids cannot guarantee proper placement or treatment.

[0005] Various forms of screen-type completions are known. US 5,435,393 describes one particular form in which the completion is divided into sections, each of which is provided with a controllable restriction in a passage communicating between the annular chamber and the inside of the base pipe. This restriction is used to control the pressure difference between the formation and the inside of the base pipe so as to maintain a given pressure drop along the completion.

[0006] Long horizontal producing sections are often found in offshore wells, either singly or in multi-lateral completions. Offshore wells can be completed as subsea (i.e. the wellhead is located on the sea bed) or platform (i.e. the wellhead is located on a platform at the sea surface. Subsea wells are a significantly less expensive method of developing oil and gas fields than using platforms, because the platform itself is a significant portion of the total cost. However a disadvantage of subsea wellheads is that it is very expensive to gain access to the well once it is completed. For dry wellheads on land or on platforms, interventions are made to acquire data about the reservoir and producing fluids, and about the completion itself. The data obtained is new data not known at the time of the original well design, and can be used to plan further interventions to modify the flow of fluids from the reservoir, for example shutting zones which produce water. The huge expense and operational risk of performing equivalent interventions in subsea wells means they are rarely done.

[0007] There are alternative methods of changing the flow of fluids from a reservoir without a physical intervention. Chemical treatments can be injected along the subsea flowline down the well, or along permanently installed subsea chemical injection lines. This utilizes the flowline linking the hydrocarbon gathering point and the reservoir. However, the absence of data on the reservoir identifying the specific zones needing treatment means reservoir treatments in subsea wells are also rarely done. It is also difficult to position a chemical treatment accurately in any particular zone. This limits most subsea chemical treatments to fluids which have a preference for any zone producing a specific unwanted fluid, however such indiscriminate chemical treatments risk reducing the productivity of all zones. Other chemical treatments are intended to treat the entire completion, for example scale treatments. However it is not currently possible to verify whether these chemical treatments have reached the entire completion. The lack of interventions to log, and the difficulty in verifying the placement of chemical treatments in subsea wells results in a much lower ultimate recovery than a comparable field developed from a platform.

[0008] One recent development in the field of monitoring wells after completion and during production is that of permanent monitoring using sensors fixed at locations in the well to provide continuous or repeated measurements. WO 98/12417 discloses this type of monitoring. However, if it is desired to obtain accurate information about the contribution of each part of the completion to the overall production from the well, it is currently necessary to provide multiple measurements in each part of the well to allow accurate determination of which part of the well is responsible for significant changes in its production, which can be expensive and difficult to achieve given the power and space constraints of the downhole environment.

[0009] The present invention attempts to provide solutions for some or all of the problems identified above in relation to the construction, installation and monitoring of completions and the conducting of well treatment operations.

In accordance with a first aspect of the invention, there is provided a method of monitoring fluid production in a well, comprising:

- measuring over time with qualitative sensors, variation of local parameters at a series of locations along the well, each local measurement being responsive to changes in the parameters in the region in which it is made;
- measuring fluid properties in the well over time downstream from the series of locations; and
- determining changes in the local measurements and in the measured fluid properties; and
- identifying locations of the formation contributing to the changes in the measured fluid properties by determining corresponding changes in the local measurements.

[0010] By combining a distributed measurement made within the formation and a measurement of the fluids in the well downstream of the producing formation, it is possible to identify the location in the well at which a change has occurred in the produced fluids.

[0011] It is preferred that each local measurement corresponds to a discrete location at which formation fluids enter the well.

[0012] The local parameter measurement can be any parameter that is affected by changes in the fluids flowing between the formation and the well at this location. For example, resistivity, conductance, temperature, pressure or chemical composition parameters might be measured. The sampling rate of the local measurements is preferably relatively high, particularly with respect to the flow rate of fluids in the well, such that the time at which a change is measured at a specific location can be identified relative to corresponding measurements at other locations.

[0013] The fluids properties measured downstream of the local measurements are typically flow rates, preferably volumetric flow rates. The flow rates measured at the downstream location are used to quantify change of flow into the well whose particular location has been identified by the local measurement. Also, by determining the physical location of a local sensor and determining the time between a change being measured at the local sensor and a measured at the downstream location, the flow rate determined at the downstream location can be confirmed or calibrated.

[0014] In accordance with a second aspect of the invention, there is provided apparatus for completing a well, comprising:

- an base pipe; and
- an permeable screen surrounding the base pipe and defining a chamber outside the base pipe and inside the screen;

wherein the base pipe is provided with an apertured portion of limited axial extent providing fluid communication between the chamber and the inside of the base pipe such that fluid entering the chamber through the permeable screen passes into the base pipe only via the apertured portion; and, in use, the screen and apertured portion cause a relatively low pressure drop between the outside of the apparatus and the inside of the base pipe.

[0015] In accordance with a third aspect of the invention, there is provided a method of completing a well, comprising:

- installing a series of tubular members in the well connected in an end-to-end arrangement, each tubular member comprising an elongate base pipe and an elongate screen surrounding the base pipe and provided with multiple apertures distributed along its length, the screen and the base pipe together defining an annular chamber between them,

wherein the base pipe is provided with an apertured portion of limited axial extent providing fluid communication between the chamber and the inside of the base pipe such that fluid entering the chamber through the permeable screen passes into the base pipe only via the apertured portion.

[0016] Preferably, the base pipe has a series of longitudinal splines formed around its outer surface, the splines acting to segment the chamber into a series of axial segments. These splines can be formed by wires fixed to the outer surface of the base pipe, for example.

[0017] It is particularly preferred that a collar section is provided on the base pipe near to the apertured portion, the collar defining a manifold that communicates with the annular chamber and the apertured portion such that fluid flowing from the annular chamber into the base pipe flows through the manifold. In one embodiment, the collar is located at one end of the base pipe and a simple collar is located at the other end, the two collars defining the ends of the permeable screen and annular chamber.

[0018] The collar can also include a sensor system and/or a sealing system for closing off flow through the apertured portion. The sensor system and/or sealing system can be provided with connections for a data and power network.

[0019] In on particular embodiment, the apertured portion of the base pipe is located in a part connecting two screen sections, the collar is located at the end of one of the two screens and is connected to the connecting part by the manifold.

[0020] The collar can be provided with ports between the annular chamber and the manifold and the base pipe provided with one or more apertures connecting to the manifold.

[0021] In accordance with a fourth aspect of the invention, there is provided a method of treating a well that has been completed as described above, comprising pumping a treatment fluid from the surface into the well while measuring local parameters in each tubular member; detecting the arrival of the treatment fluid from the measurement of local parameters; and ceasing pumping so as to leave the treatment fluid in a region of the well to be treated.

[0022] In accordance with a fifth aspect of the invention, there is provided a completion system, comprising:

- a tubular member for location in a well, the member including at least on opening allowing communication between the interior and exterior of the member; and
- a closure system located adjacent the or each opening and including a source of stored energy which, on activation, operates to close the or each opening.

[0023] It is preferred that the openings in the tubular member are confined to a region of limited axial extent. It is particularly preferred that the openings are near a collar on the outside of the tubular member. In one such arrangement, the closure system can be located in or on a manifold.

[0024] The closure system can comprise a reservoir of expandable fluid and an activator. On operation, the activator ruptures the reservoir and allows the fluid to enter the manifold where it expands to prevent fluid flowing therethrough. Alternatively, the closure system can comprise a heating system for activating a sealing fluid pumped into the manifold from the surface.

[0025] It is particularly preferred that the closure system is reversible to allow reopening.

[0026] The present application will now be described by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a prior art sand screen;
Figure 2 shows a detail of the screen shown in Figure 1;
Figure 3 shows a sand screen incorporating embodiments of the invention;
Figures 4 a - c show cross sections of the screen of Figure 3;
Figure 5 shows a schematic view of a well completed using the sand screen shown in Figure 3;
Figure 6 shows an alternative form of well completion to that shown in Figure 5;
Figure 7 shows plots of measurements made over time for a well completed as shown in Figure 5;
Figure 8 shows schematically a method of well treatment according to an embodiment of the invention; and
Figure 9 shows a sealing system according to an embodiment of the invention.

[0027] Referring now to the drawings, the sand screen shown in part in Figure 3 is similar to that of Figures 1 and 2 and corresponding parts are given corresponding reference numbers in the 100 series. The screen 110 shown in Figure 3 is also formed in two sections: a base pipe 112 and a wire screen 116 extending between collar sections 118 on the outside of the base pipe 112 defining a chamber 124 (Figure 4a). The collar section 118' is formed on a connector section 112' of the base pipe 112 and is provided with an end plate 130 having ports 132 which connect the chamber 124 to a manifold 134 within the collar (Figure 4b). The ports 132 are provided between the wires or splines 122 supporting the screen 116. The other end of the screen 116 is connected to a simple end plate (not shown).

[0028] The manifold 134 is in the form of a shroud which encircles the base tube 112' (Figure 4 c) and directs the fluids into a delivery pipe 136 which is connected to an aperture 138 in the base pipe 112' such that the only fluid communication path between the chamber 124 and the inside of the base pipe 112' is via the ports 132, manifold 134 and aperture 138.

[0029] The ports 132, manifold 134 and aperture 138 are dimensioned such that there is essentially no restriction of flow of fluids from the screen 116 into the base pipe 112, i.e. there is essentially no pressure drop between the screen 116 and the inside of the pipe 112', the inner diameter of the base pipe 112 being the only significant restriction to flow from the formation into the well.

[0030] The collar is also provided with a sensor package and associated electronics 140 which are connected to a power and data communication system 142 running along the well from the surface. The sensor can be any one of a number of permanent or long term sensors that can be installed in a well and which are responsive to fluid or other environmental parameters such as pressure or temperature, chemical composition, conductivity or dielectric, or electrodes responsive to resistivity or inductance either in the formation itself or the fluids entering the screen.

[0031] The manifold 134 also includes a sealing system 144 that is connected to the same data and power network 142 as the sensor system 140. The operation of the sealing system 144 is described in more detail below.

[0032] Figure 5 shows an example of a well completed using screens of the type shown in Figure 3. The well shown in Figure 5 is an offshore, subsea well (well head located on sea bed). The well extends vertically downwardly 154 from the well head 150 and the proceeds in a substantially horizontal section 156 through the producing reservoir 158. The vertical section of the well is completed in a conventional manner with steel casing 160 cemented into the borehole. The horizontal section 158 is completed using a series of screens 110 of the type described above connected in an end to end manner. The sensors 140 and sealing systems 144 are connected to a network 148 running through the well and connected to a power and data acquisition unit 162 at the well head 150. The effect of installing the screens described above is to divide the well into a series of finite producing elements as all of the fluids entering a given screen enter the base pipe at a single location, that of the aperture connecting to the manifold. Thus each screen has the effect of focussing the production in that region into a specific point in the well.

[0033] A flow measurement device 164 is positioned in the well downstream of the horizontal section 158. This device can be any suitable flow meter such as a venturi device, spinner, electromagnetic device or combination of these. One particularly preferred form of meter is the EWM Electric Watercut Meter of Schlumberger that comprises a capacitive measurement system and an electromagnetic measurement system downstream of a venturi. Such a meter can measure flow rates for mixtures of 0 - 100% water.

[0034] A similar completion with an alternative form of sensor system is shown in Figure 6. In this case, instead of the discrete sensors in each collar, the system comprises a distributed continuous sensor 166, particularly a distributed fibre optic temperature sensor which is installed in a U tube extending along the well. Such a system is available from Sensa of UK and is operated from the well head without the need to be connected to the data and power network 148 downhole. Such a system can be operated to give discrete measurements at any given location in the well, in a similar manner to a series of discrete sensors.

[0035] In use, the flow meter 164 measures the total flow rate of the fluids produced from the well. Any changes in production are reflected in this flow rate measurement. However, from this measurement alone, it is not possible to identify where the event causing the change in production has taken place and so is not useful for identifying selective treatment options if the change is an undesirable one, such as water breakthrough. Clearly a change in production of fluids for a given screen or screens will be reflected in the measurements made by the associated sensors 140 located in the collars (or the associated discrete measurement is a distributed sensor is used) but in view of the restrictions on space and power, it is typically not possible to provide a full multiphase flow sensor in each collar and so it is essentially impossible to obtain accurate quantitative measurements in each collar to identify the particular change in production that is detected by the flow meter downstream. Most of the sensors that can be installed in the screen are essentially non-quantitative in respect of flow, or are of unreliable or unknown accuracy and therefore very difficult to interpret. However, each sensor will be sensitive to the fact that a change in production is occurring and therefore the location(s) of the changing production can be identified by correlating a detected change in the sensor(s) one or more screens with a measured change in the production from the well as measured by the flow meter.

[0036] By simultaneously measuring the local parameters in the reservoir on the screens and the fluid properties downstream, it is possible to use the qualitative local measurement to identify the location of the change of fluid flow into the well.

[0037] Because it is possible to identify the location of the change in production to within one or two screen lengths, it is possible to design well treatment actions that address only this region rather than all regions as has been the case in the past. Where a well includes multilateral completions from a main well, a flow meter can be installed in each completion to provide the benefits outlined above.

[0038] In Figure 7, there is shown a plot of the reading from the downstream flow meter in terms of % water (W%) in the flowing fluids vs. time (T). An array of instrumented screens of the type described above (S_1 - S_{14}) is monitored over the same time period with respect to the resistivity measured at each screen. What is monitored over time for the array is the change Δ in the measurement rather than the absolute measurement itself. At time T_1, the flow meter shows an increase in water cut of the produced fluids. An examination of the screen measurements for the same time period shows that the readings from screen S_4 changed during that time period indicating that water influx started in the region of screen S_4. At time T_2, the flow meter indicated an increase in water cut. In this case, the sensor at screen S_7 showed a change, indicating the location of new water influx. A further change in water cut occurred at time T_3 and is indicated on screen sensor S_{12}. In each case, it is a change Δ in the measurement from a screen sensor that is needed to identify the location of the event causing the change, not the absolute measurement from that sensor. At all other times or other locations, the sensors have a substantially constant reading suggesting that there has been no change in the fluids produced.

[0039] In the case described above, the increase in water cut after times T_1 and T_2 might still be sufficiently low that remedial action in the well is not justified, but with the increase at T_3 might then increase the water cut to a degree that it will be worthwhile performing a well treatment to shut off the water influxes and allow the well to continue at low water cut production. Knowing the location of the water breakthrough allows a treatment to be designed which only addresses these locations and allows the other parts of the well to continue production unchanged.

[0040] While the example given above uses the example of increased water production as the change detected, it could be any change in production, for example a change in the type of oil produced at a given screen might also be detected. This can be important in flow assurance, especially for wells with long subsea tie-backs.

[0041] The construction of the screens described above also allows treatments to be provided at the level of each individual screen because flow into the base pipe is all focused through the chamber. Thus it is possible to exercise effective control at the individual screen level to modify flow from the formation into the well. For example, in the case described above, water breakthrough only occurs at screens S_4, S_7 and S_{12}. Therefore, shutting off those screens will allow the well to continue producing oil only (and hence avoid the need for separators or the like) while only reducing the production from the well marginally. This can be repeated each time water breakthrough occurs until the reduction in overall production is sufficient to justify installation of separators and producing the well as a mixture of oil and water (often involving opening the shut off screens as well).

[0042] The local sensors in each screen can also be used to monitor the progress of treatment fluids pumped through the well. In a typical subsea completion, the only way previously to ensure accurate placement of a well treatment has been to locate a vessel over the well head and perform a well intervention using a coiled tubing deployed into the reservoir. This is a very expensive and time consuming operation. Using a completion of the type described above, it is possible to pump a well treatment fluid down the well from the surface and monitor its progress in real time using the local sensors in each screen. Figure 8 shows such a process in a schematic form. The well in question is a subsea well having a well head 250 on the sea bed 252 which is connected to a production platform 254 by means of a pipeline 256 running along the sea bed 252. The well extends down from the well head 250 in to the producing reservoir 258 where it runs in an essentially horizontal path and is completed with instrumented screens 260 as described above. Although only one well is shown here, there may be multiple wells connected to a single well head which will have valves allowing individual wells to be isolated from the others.

[0043] In order to conduct well treatments, fluids are pumped into the well from the platform 254. This can be done from a treatment skid or the like located on the platform 254, or, as is shown here, from a support boat 262 which connects to the pipeline 256 via the platform 254. A slug of treatment fluid 264 is injected into the pipeline from the boat 262 and is pumped down the well using a suitable fluid as is known in the art. For example, the treatment in question can be an annular chemical packer which includes a highly conductive chemical additive as a marker. As the slug 264 passes each screen 260, a portion of the fluid enters the manifold 266 where its presence causes a change in the reading from the sensor 268. Thus, by monitoring the measurements from the screens 260, the progress of the slug 264 through the well can be determined. This data can be represented in graphical form on a display unit 270 on the platform 254 or support boat 262 from which pumping is controlled. When the sensors 268 indicate that the slug 264 has reached the screen identified in the previous monitoring step, pumping can be stopped or the pump rate can be increased to shear the fluid so as to decrease its viscosity and enable it to be pumped from the base pipe into the chamber and screen. The fluid then sets and seal off production from the or each particular screen.

[0044] An alternative form of control of flow through a screen can be obtained using the sealing system installed in the chamber of each screen. One example of a sealing system in accordance with an embodiment of the invention is shown in Figure 9. The sealing system is located in the manifold 300 near to the point where the flow enters the base pipe 302 and comprises a reservoir 304 containing a sealing fluid and a heating coil 306 around the manifold 300 at that point that is connected to the data and power network. In use, when it is desired to shut off a given screen, a signal is sent to the relevant sealing system to cause an expandable sealing fluid to be released from the reservoir 304. This can be done using a small detonator cap, electromagnetic device or even by heating using the coil 306. This serves to rupture the reservoir which releases the sealing fluid into the chamber where it expands. The heating coil 306 can then be used to set the fluid and prevent flow through the manifold 300. While the objective is that the expanded sealing fluid should fill the chamber and prevent fluid flow into the base pipe, it is often enough that the expanded fluid provide sufficient flow restriction in the chamber that the pressure drop is too great for fluid to flow. The pressure drop required for this is relatively small in many cases.

[0045] It is also possible to use the heating coil 306 to break the seal by raising the temperature even higher provided that a suitable breakable sealing fluid is used. This allows screens to be reopened in the future. Alternatively, a mechanical system for reopening can be used.

Claims

1. A method of monitoring fluid production in a well, comprising:

- measuring over time with qualitative sensors (140), variation of local parameters at a series of locations along the well, each local measurement being responsive to changes in the parameters in the region in which it is made;
- measuring fluid properties (164) in the well over time downstream from the series of locations; and
- determining changes in the local measurements and in the measured fluid properties; and
- identifying locations of the formation contributing to the changes in the measured fluid properties by determining corresponding changes in the local measurements.

2. A method as claimed in claim 1, wherein each local measurement corresponds to a discrete location at which formation fluids enter the well.

3. A method as claimed in claim 1 or 2, wherein the local parameter measurement is a parameter that is affected by changes in the fluids flowing between the formation and the well at this location.

4. A method as claimed in claim 3, wherein the local parameter measurement measures resistivity, conductance, temperature, pressure or chemical composition.

5. A method as claimed in any preceding claim, wherein the sampling rate of the local measurements is relatively high, particularly with respect to the flow rate of fluids in the well, such that the time at which a change is measured at a specific location can be identified relative to corresponding measurements at other locations.

6. A method as claimed in any preceding claim, wherein the fluid properties measured downstream of the local measurements are flow rates

7. A method as claimed in claim 6, where the flow rates are volumetric flow rates.

8. A method as claimed in claim 6 or 7, wherein the flow rates measured at the downstream location are used to identify the particular location of a change of flow into the well as measured by the local measurement.

9. A method as claimed in claim 6, 7 or 8, comprising determining the physical location of a local sensor which detects a change and determining the time between a change being measured at the local sensor and a flow rate measured at the downstream location, and confirming the flow rate measured downstream from these measured changes and time.

Patentansprüche

1. Verfahren zum Überwachen der Fluidproduktion in einem Bohrloch, das umfasst:

- Messen der Veränderung lokaler Parameter an einer Reihe von Orten längs des Bohrlochs über die Zeit hinweg mit qualitativen Sensoren (140), wobei jede lokale Messung in Reaktion auf Änderungen der Parameter in dem Bereich, in dem sie ausgeführt wird, erfolgt;
- Messen von Fluideigenschaften (164) in dem Bohrloch unterhalb der Reihe von Orten über die Zeit hinweg;
- Feststellen von Änderungen in den lokalen Messungen und in den gemessenen Fluideigenschaften; und
- Identifizieren von Orten der Formation, die zu Änderungen in den gemessenen Fluideigenschaften beitragen, indem entsprechende Änderungen in den lokalen Messungen festgestellt werden.

2. Verfahren nach Anspruch 1, bei dem jede lokale Messung einem diskreten Ort entspricht, an dem Formationsfluide in das Bohrloch eintreten.

3. Verfahren nach Anspruch 1 oder 2, bei dem der gemessene lokale Parameter ein Parameter ist, der durch Änderungen in den Fluiden, die an diesem Ort zwischen der Formation und dem Bohrloch strömen, beeinflusst wird.

4. Verfahren nach Anspruch 3, bei dem die Messung des lokalen Parameters den ohmschen Widerstand, die Konduktanz, die Temperatur, den Druck oder die chemische Zusammensetzung misst.

5. Verfahren nach einem vorhergehenden Anspruch, bei dem die Abtastrate der lokalen Messungen verhältnismäßig hoch ist, insbesondere in Bezug auf die Durchflussmenge von Fluiden im Bohrloch, so dass der Zeitpunkt, zu dem eine Änderung an einem bestimmten Ort gemessen wird, in Bezug auf entsprechende Messungen an anderen Orten identifiziert werden kann.

6. Verfahren nach einem vorhergehenden Anspruch, bei dem die Fluideigenschaften, die unterhalb der lokalen Messungen gemessen werden, Durchflussmengen sind.

7. Verfahren nach Anspruch 6, bei dem die Durchflussmenge Volumendurchflussmengen sind.

8. Verfahren nach Anspruch 6 oder 7, bei dem die Durchflussmengen, die an dem im Bohrloch unten befindlichen Ort gemessen werden, für die Identifizierung des bestimmten Ortes einer Änderung des Durchflusses im Bohrloch, die durch die lokale Messung gemessen wird, verwendet werden.

9. Verfahren nach Anspruch 6, 7 oder 8, das das Bestimmen des physikalischen Ortes eines lokalen Sensors, der eine Änderung erfasst, das Bestimmen der Zeit zwischen einer bei dem lokalen Sensor gemessenen Änderung und einer bei dem im Bohrloch unten befindlichen Ort gemessenen Durchflussmenge sowie das Bestimmen der unten im Bohrloch gemessenen Durchflussmenge anhand dieser gemessenen Änderungen und der gemessenen Zeit umfasst.

Revendications

1. Procédé de surveillance d'une production de fluides dans un puits, comprenant:

- la mesure par rapport au temps à l'aide de capteurs qualitatifs (140) d'une variation de paramètres locaux en une série de positions le long du puits, chaque mesure locale étant sensible à des variations des paramètres dans la région dans laquelle elle est effectuée;
- la mesure par rapport au temps des propriétés (164) des fluides en aval de la série de positions;
- la détermination de variations dans les mesures locales et dans les propriétés mesurées des fluides; et
- l'identification des positions de la formation contribuant aux variations dans les propriétés mesurées des fluides en déterminant des variations correspondantes dans les mesures locales.

2. Procédé selon la revendication 1, dans lequel chaque mesure locale correspond à une position discrète à laquelle des fluides de la formation pénètrent dans le puits.

3. Procédé selon la revendication 1 ou 2, dans lequel la mesure des paramètres locaux est un paramètre qui est affecté par des variations dans l'écoulement de fluides entre la formation et le puits à cette position.

4. Procédé selon la revendication 3, dans lequel la mesure des paramètres locaux mesure la résistivité, la conductance, la température, la pression ou la composition chimique.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel la vitesse d'échantillonnage des mesures locales est relativement élevée, en particulier par rapport au débit des fluides dans le puits, de telle sorte que le moment auquel une variation est mesurée à une position spécifique peut être identifié par rapport à des mesures correspondantes à d'autres positions.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel les propriétés mesurées des fluides en aval des mesures locales sont des débits.

7. Procédé selon la revendication 6, dans lequel les débits sont des débits volumétriques.

8. Procédé selon la revendication 6 ou 7, dans lequel les débits mesurés à la position en aval sont utilisés pour identifier la position particulière d'une variation d'écoulement dans le puits mesurée par la mesure locale.

9. Procédé selon la revendication 6, 7 ou 8, comprenant la détermination de la position physique d'un capteur local qui détecte une variation, la détermination de la durée entre une variation mesurée au capteur local et un débit mesuré à la position aval, et la confirmation du débit mesuré en aval à partir de ces variation et durée mesurées.

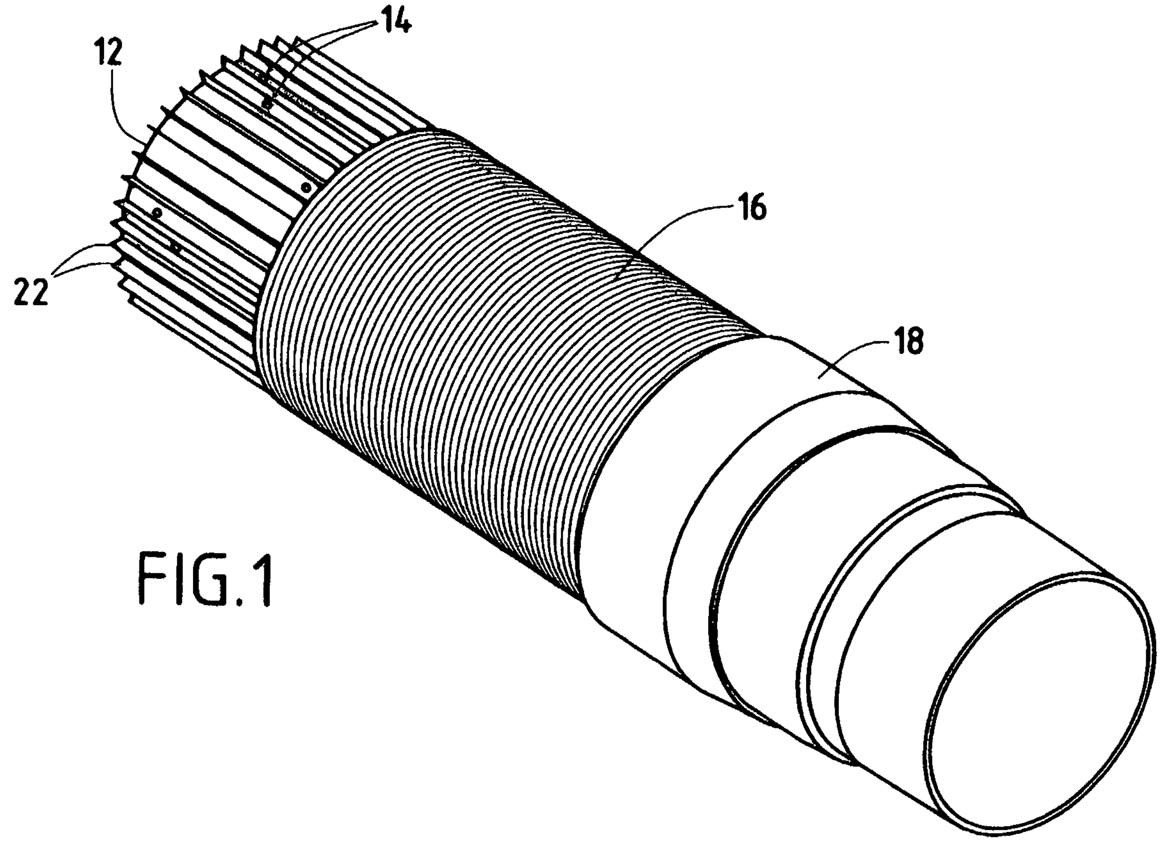

FIG.1

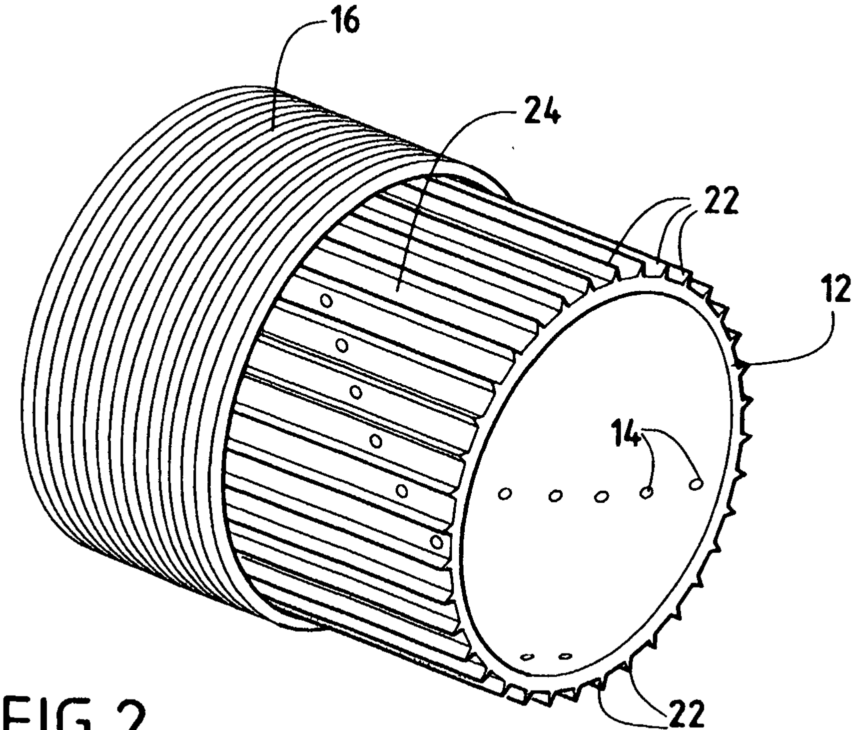

FIG.2

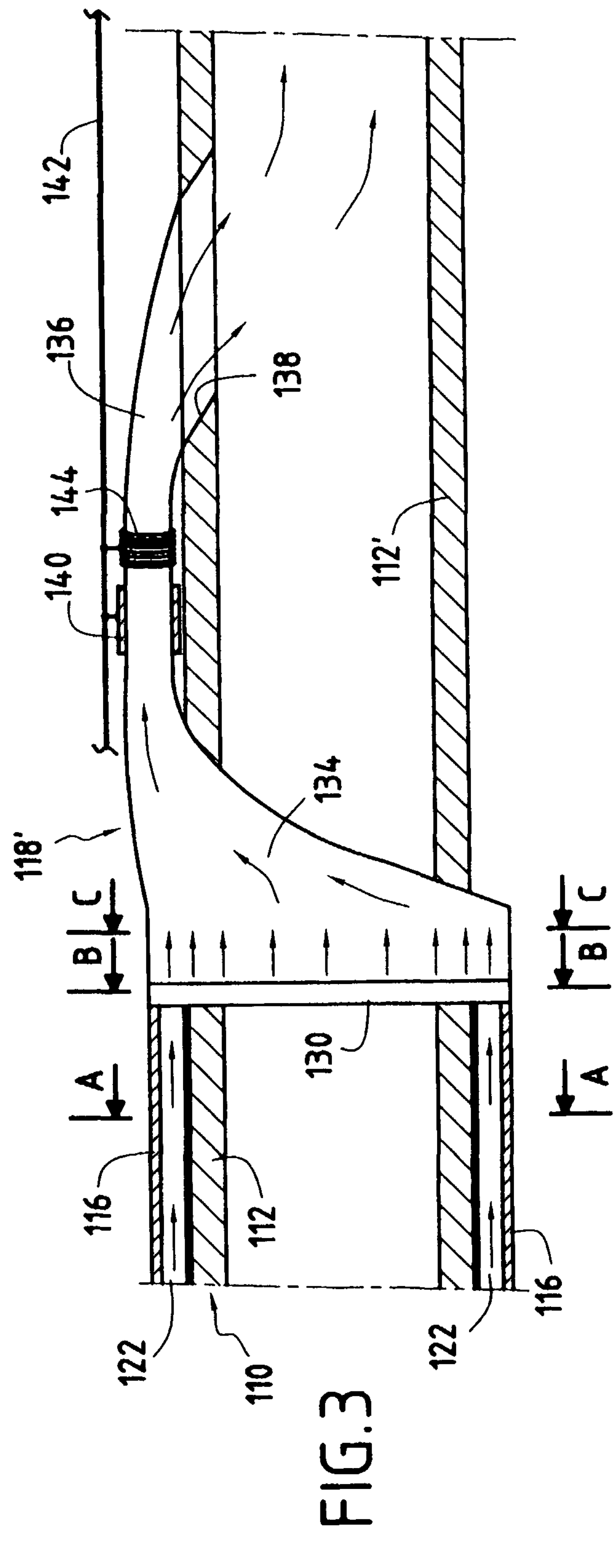

FIG.3

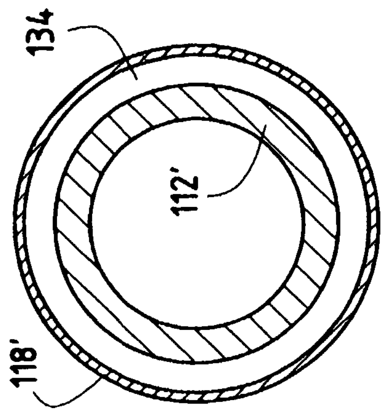

FIG.4C

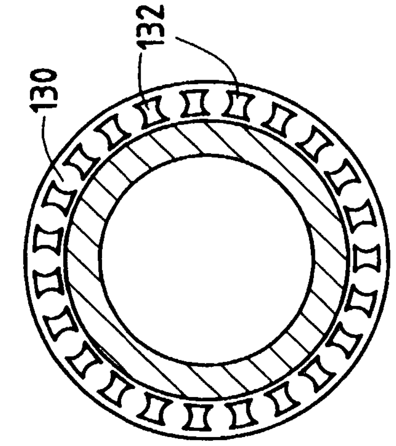

FIG.4B

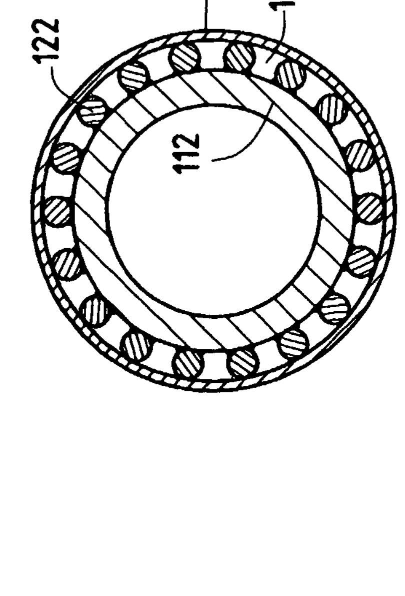

FIG.4A

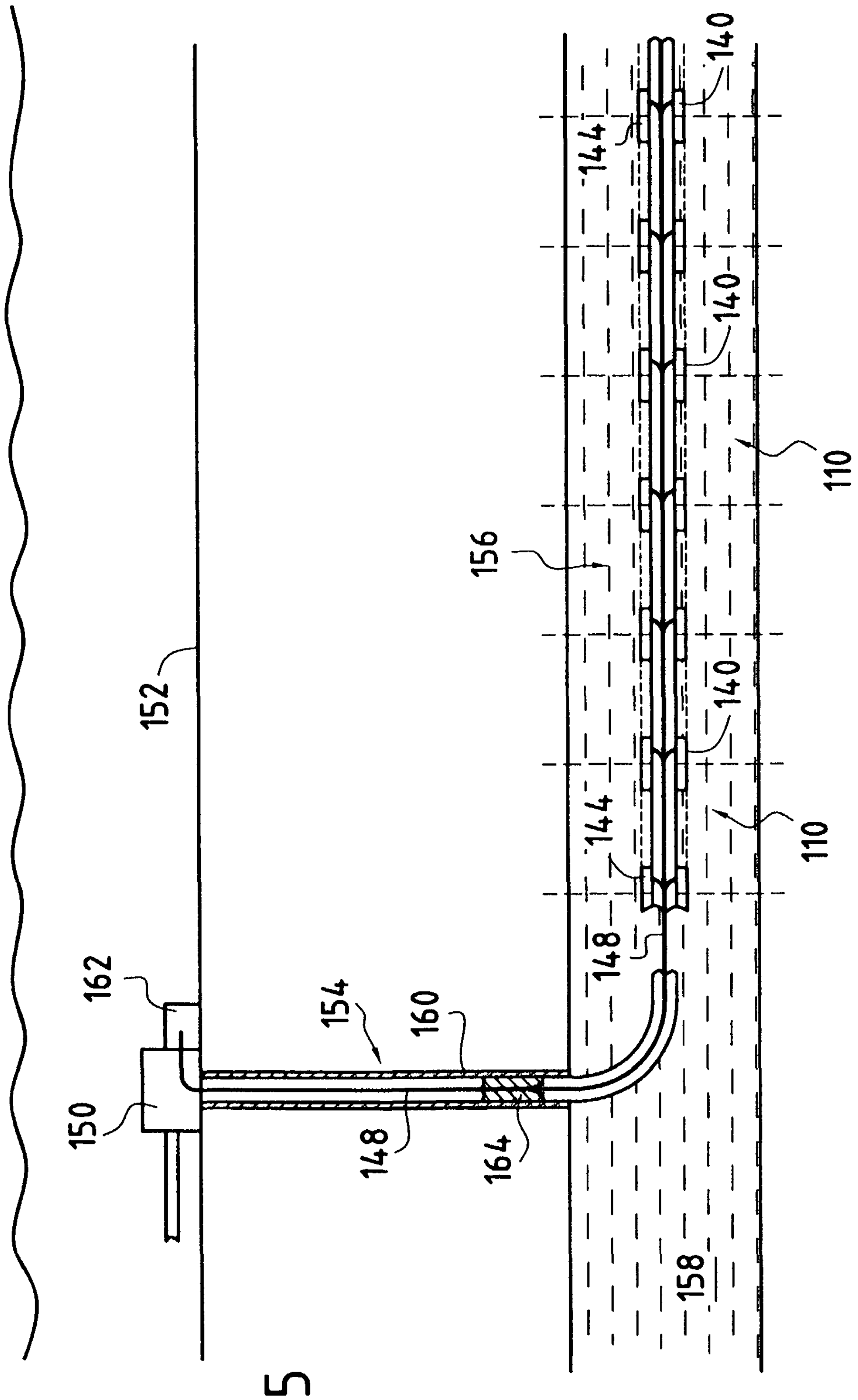
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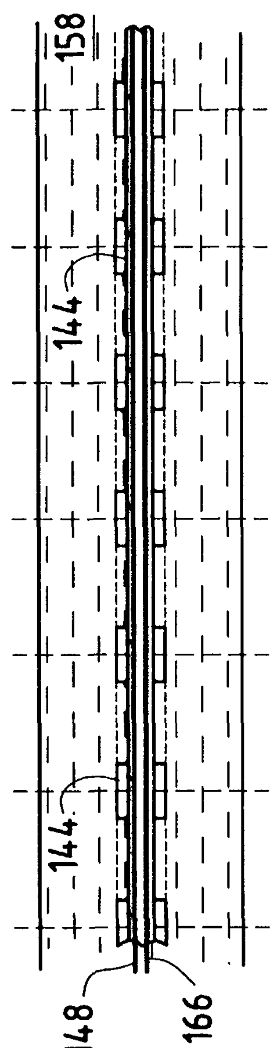
FIG.5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166

FIG.6

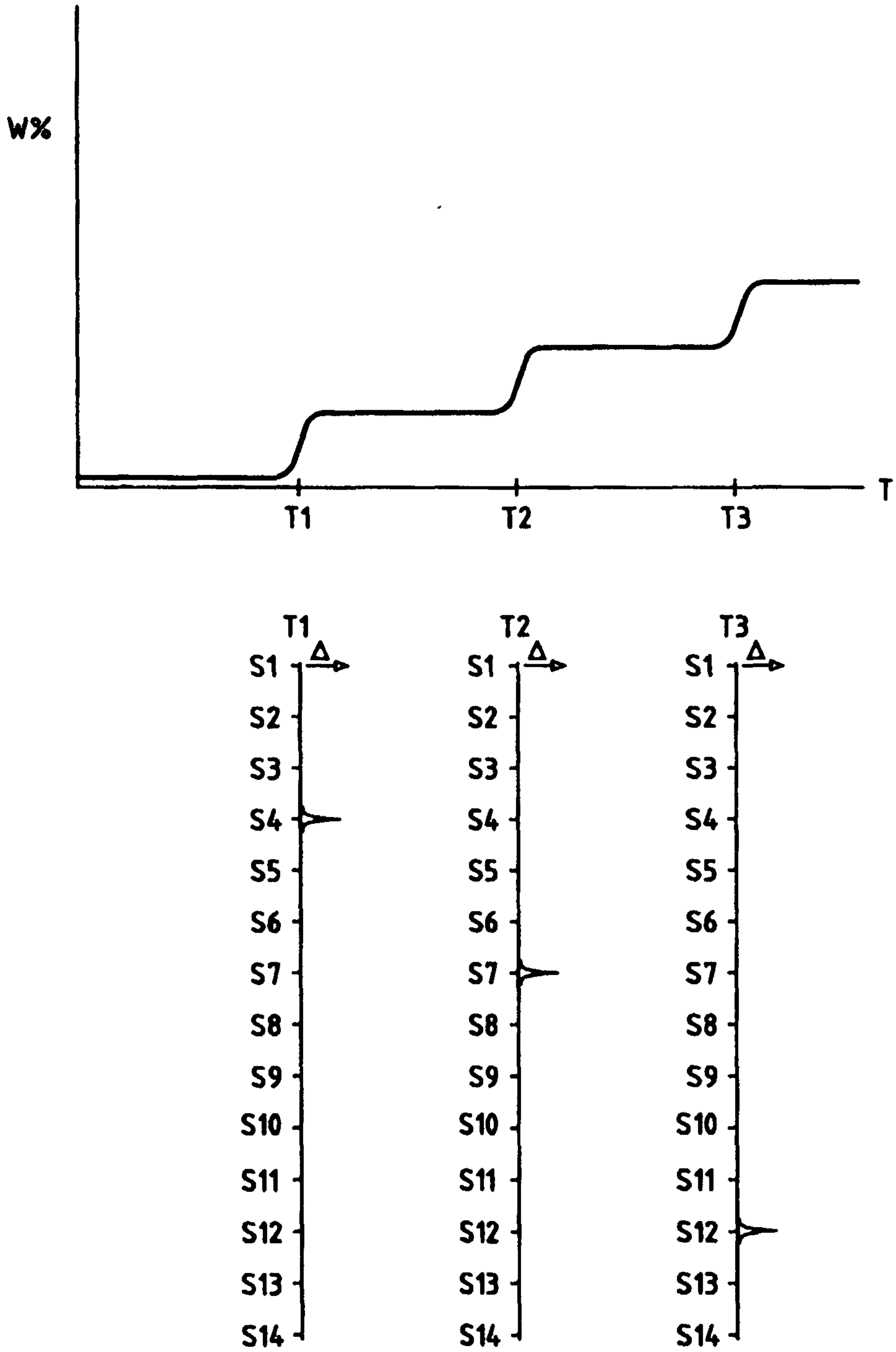

FIG.7

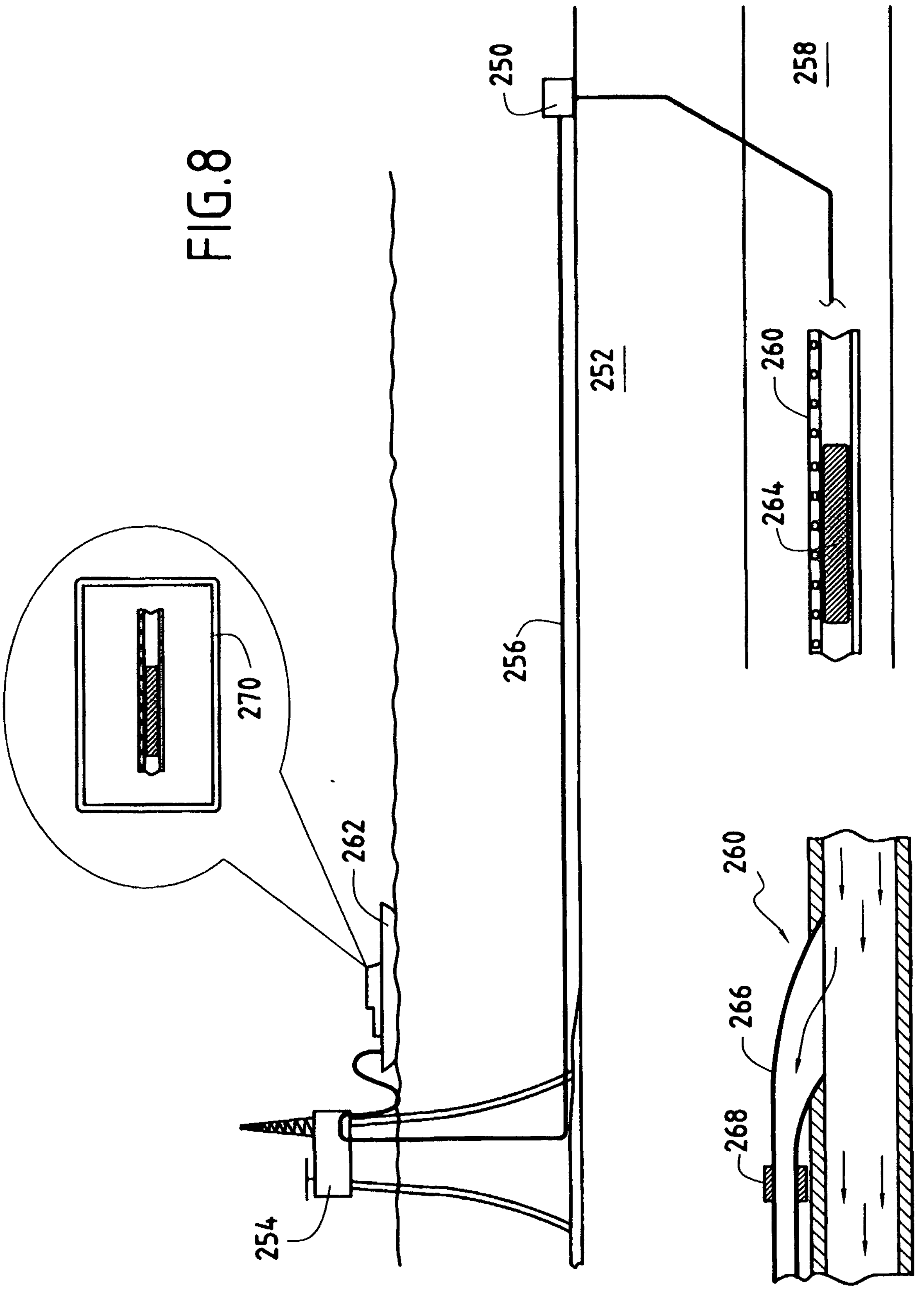

FIG.8

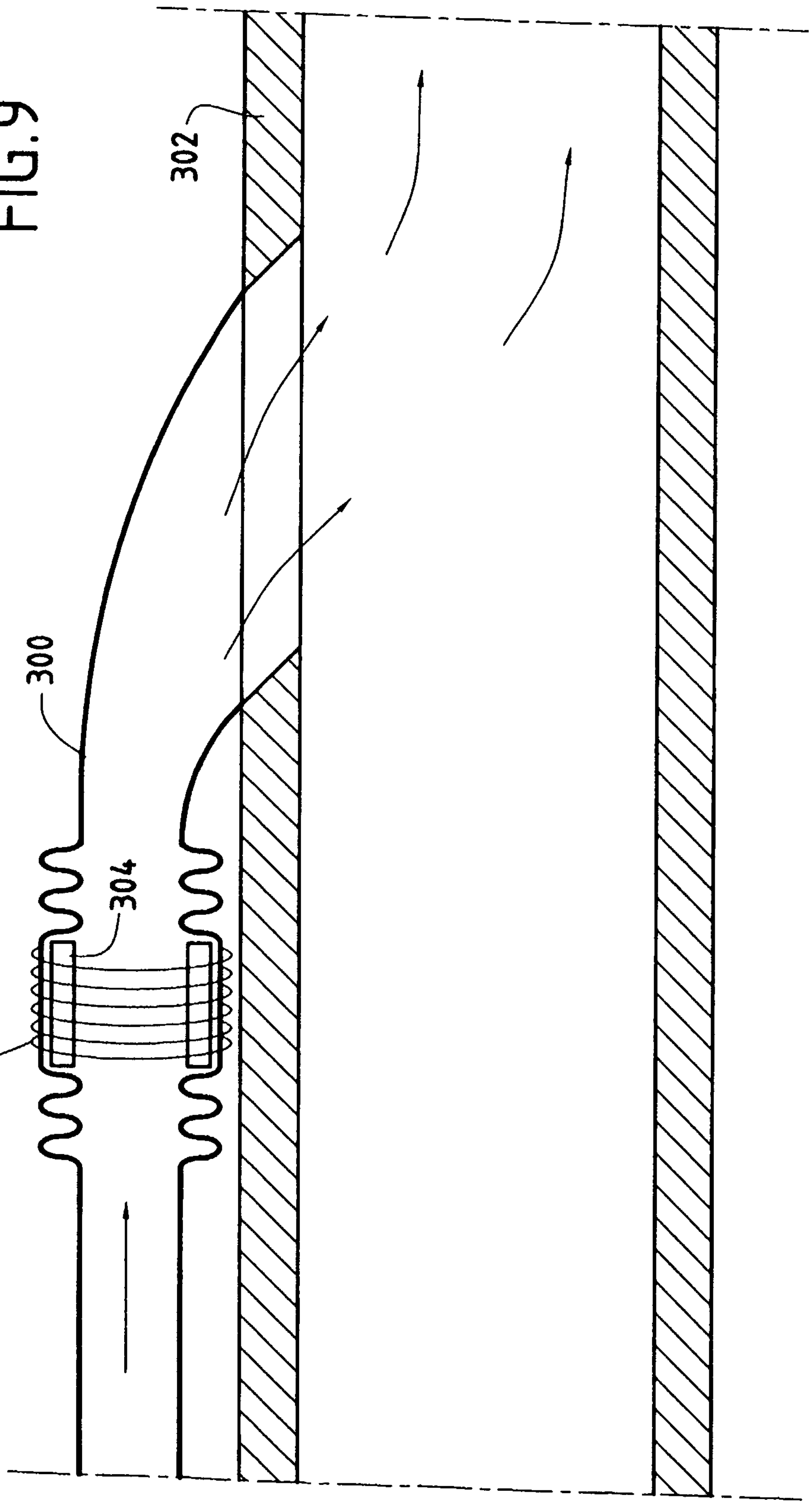

FIG.9