US 20060175061A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2006/0175061 A1**

Crichlow (43) **Pub. Date: Aug. 10, 2006**

(54) **METHOD FOR RECOVERING HYDROCARBONS FROM SUBTERRANEAN FORMATIONS**

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(21) Appl. No.: **11/279,305**

(22) Filed: **Apr. 11, 2006**

Related U.S. Application Data

(60) Provisional application No. 60/712,289, filed on Aug. 30, 2005.

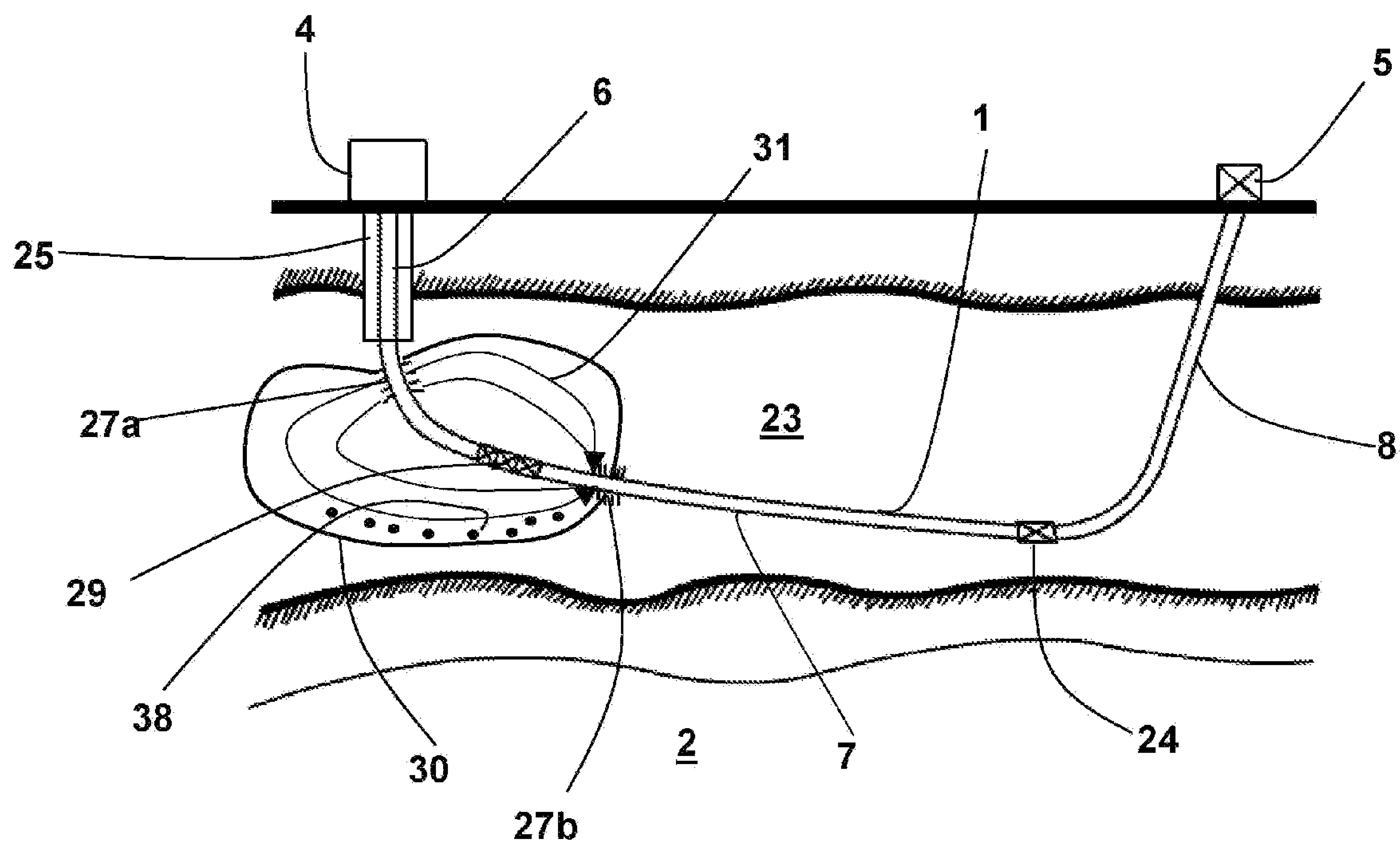
Publication Classification

(51) **Int. Cl.**
E21B 43/24 (2006.01)

(52) **U.S. Cl.** **166/302**; 166/60

(57) **ABSTRACT**

Recovery of viscous hydrocarbon from subterranean formations is assisted by using a plurality of novel U-tube type wells, each with dual wellheads, a moveable wellbore packer, a lateral section with a concentric communication zone and with sequential injection production perforations in which heat is injected into the proximal perforations and hot oil and produced fluids are produced from the distal perforations, the whole process being controlled by modulating the production flow where the wellbore fluids are controlled to act as a hydraulic seal to limit bypass of injected fluids. The injection-production displacement process moves axially along the wellbore in a sequential manner as hydrocarbon volumes are depleted by injected fluid displacement of oil and oil and water production.



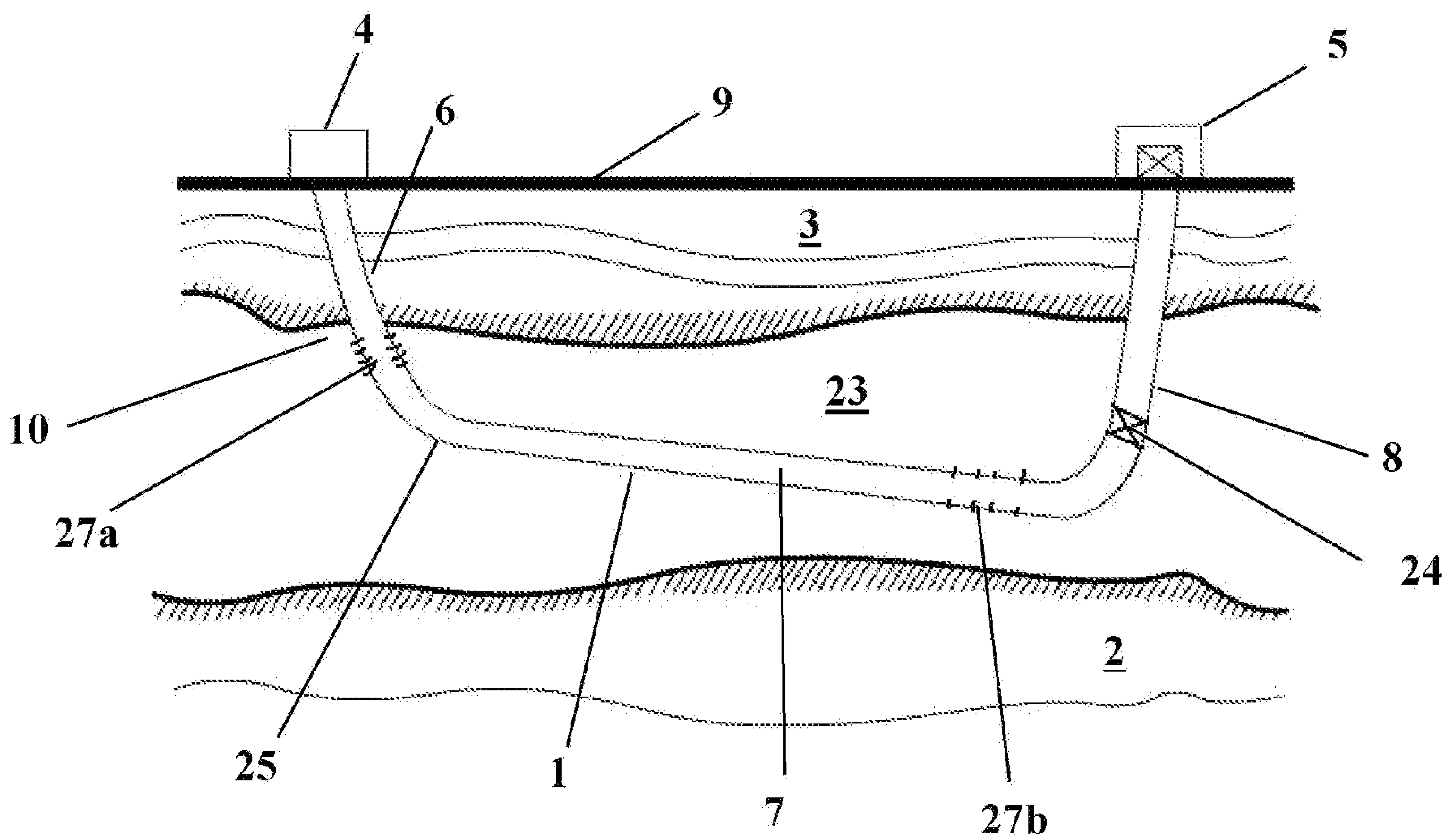


Fig. 1

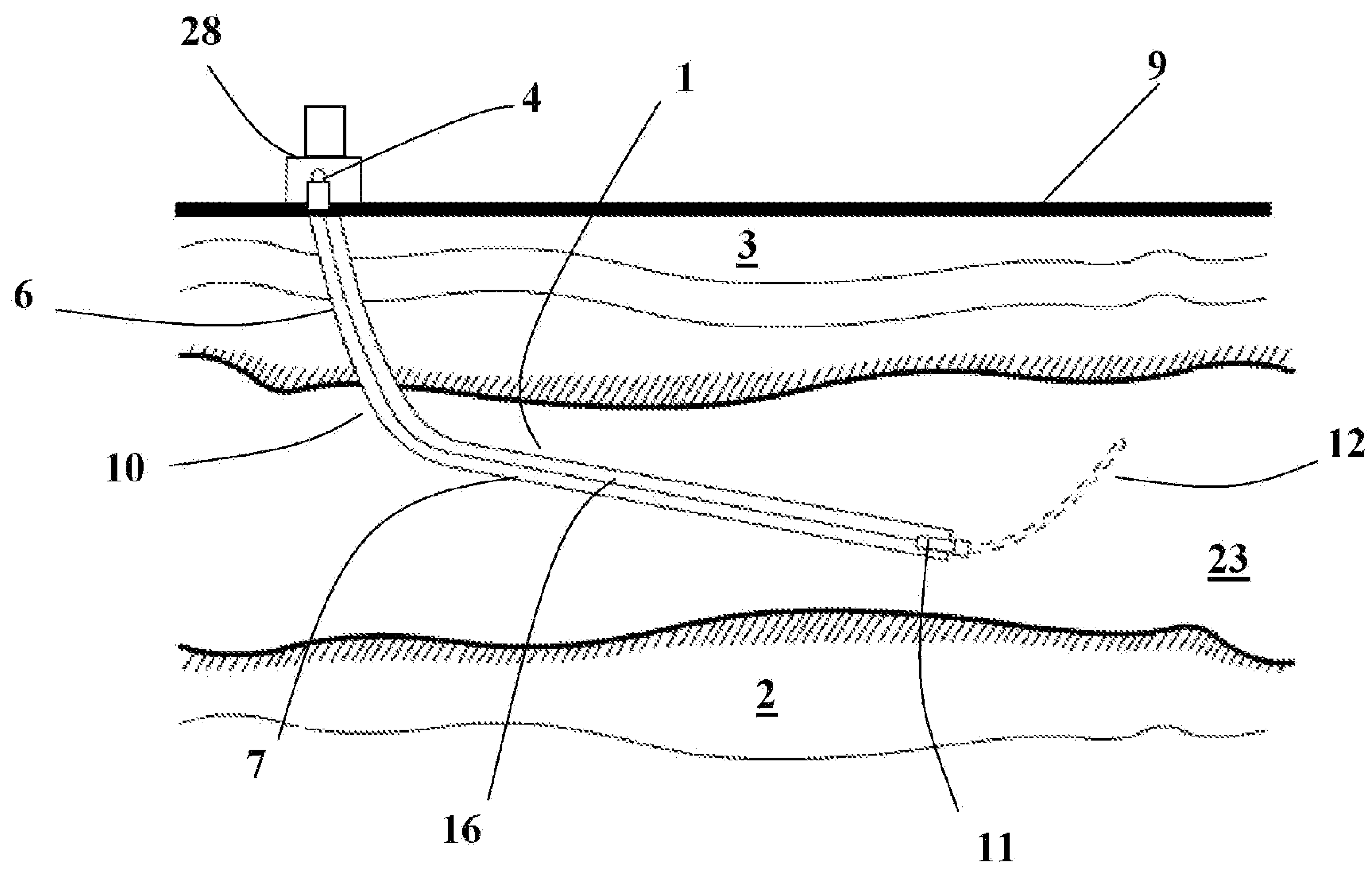


Fig. 2

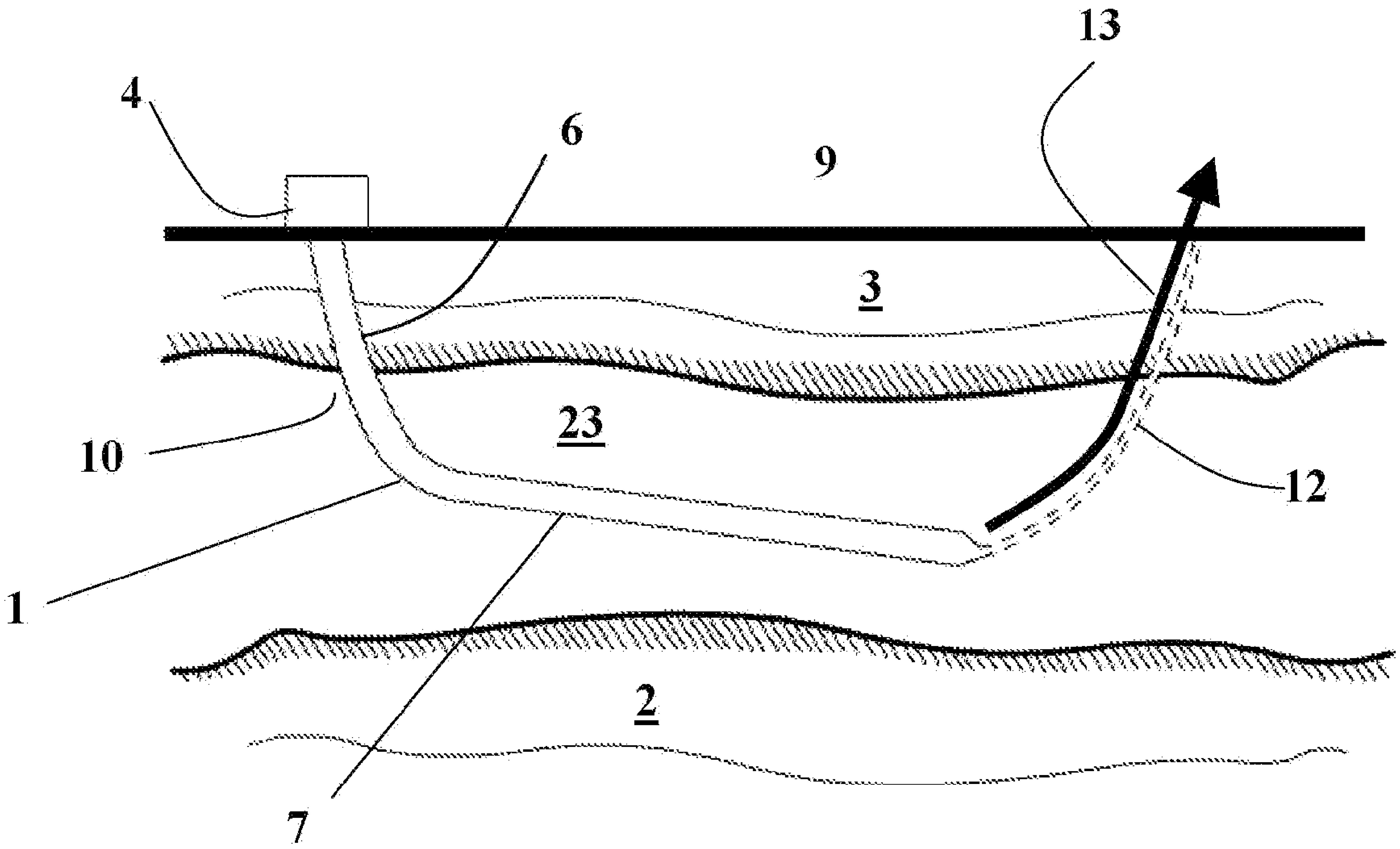


Fig. 3

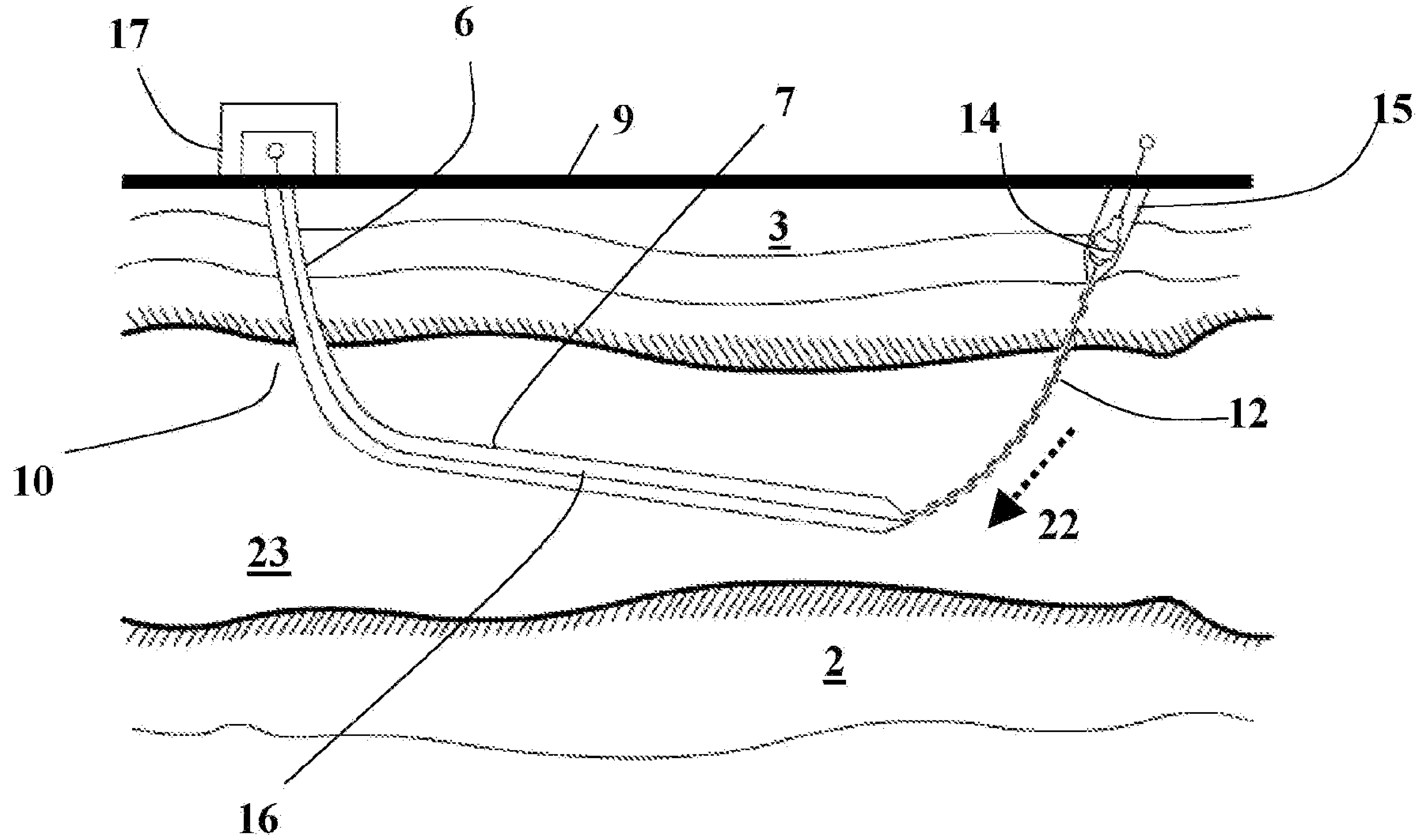


Fig. 4

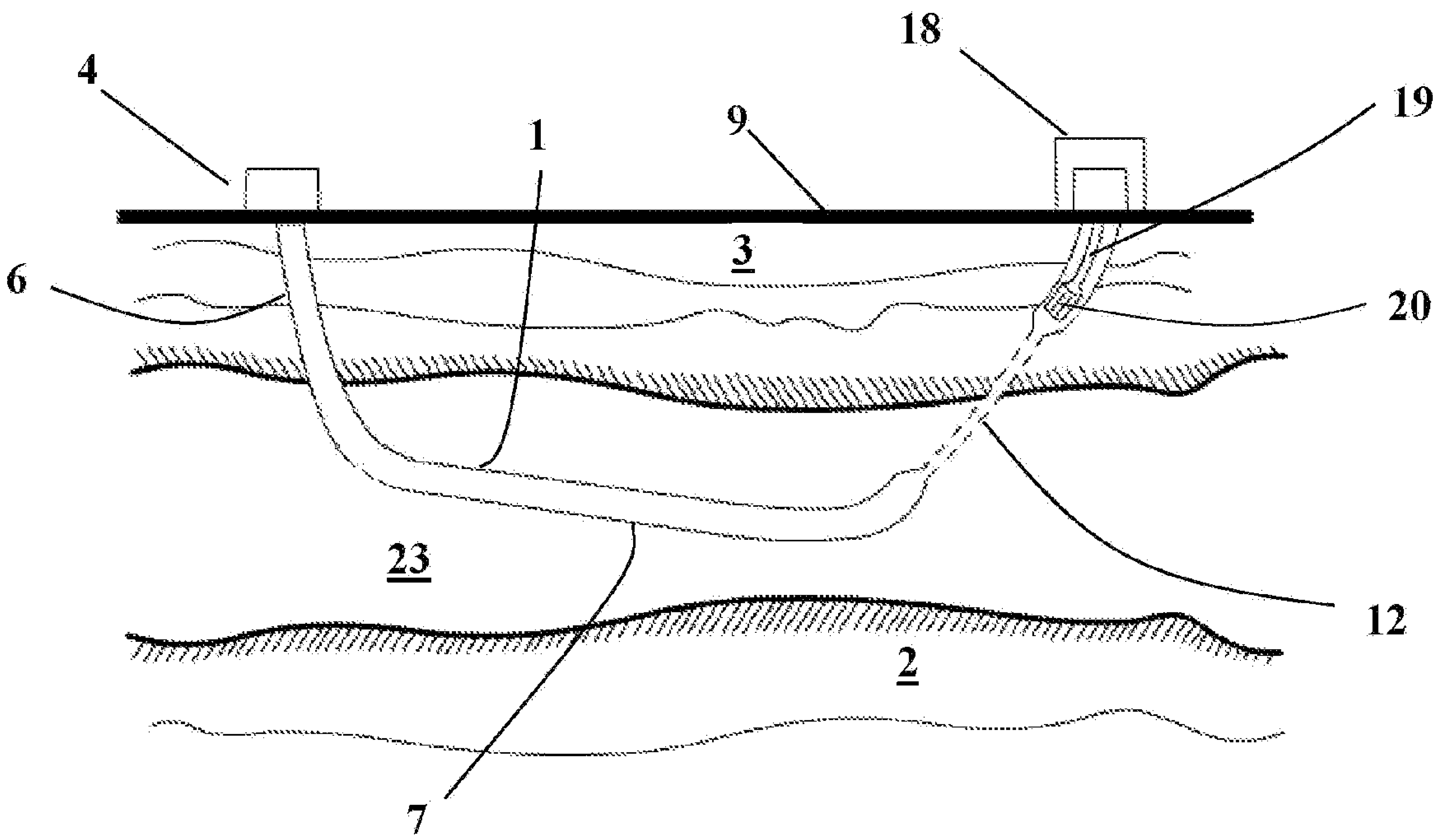


Fig. 5

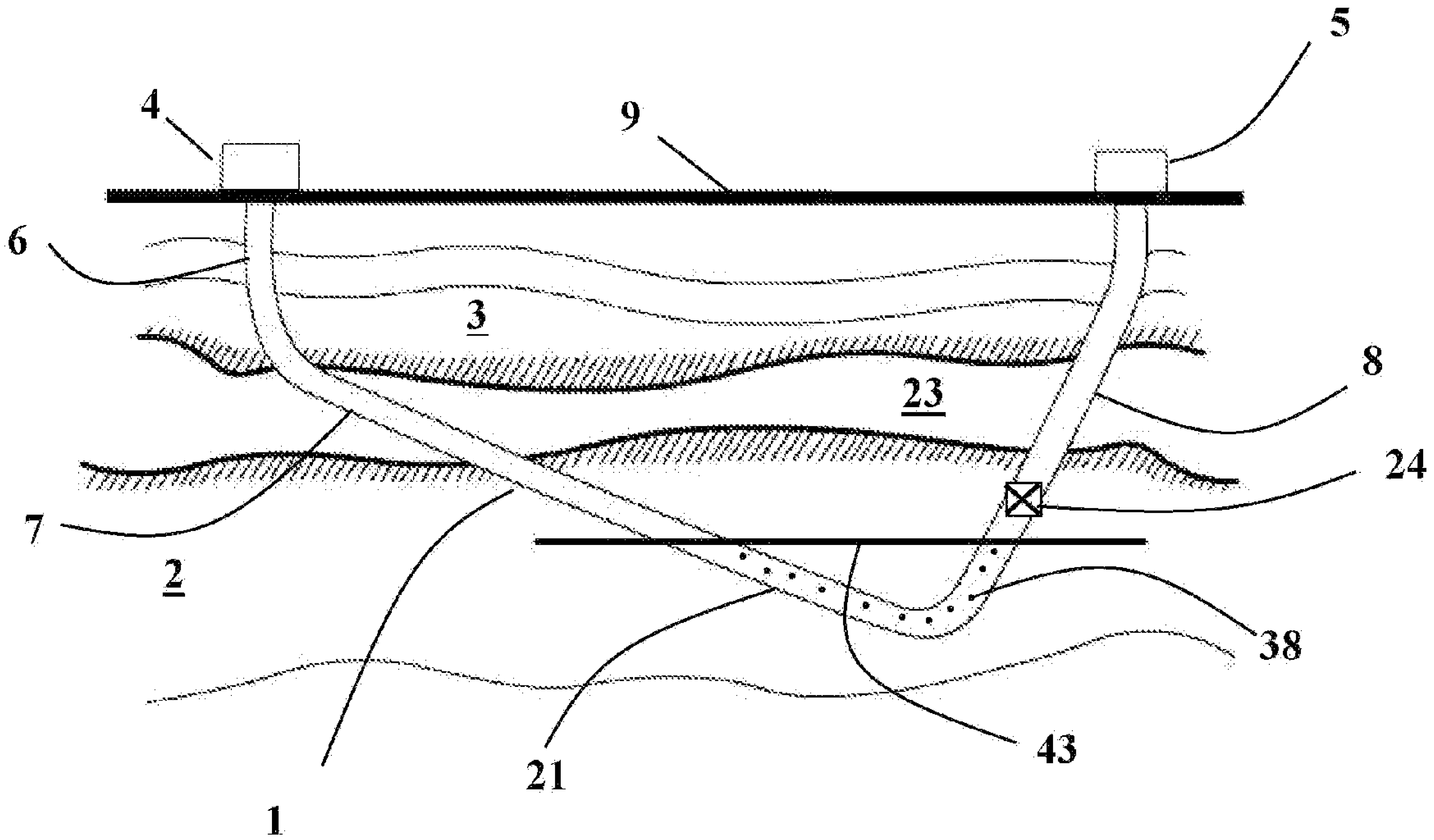


Fig. 6

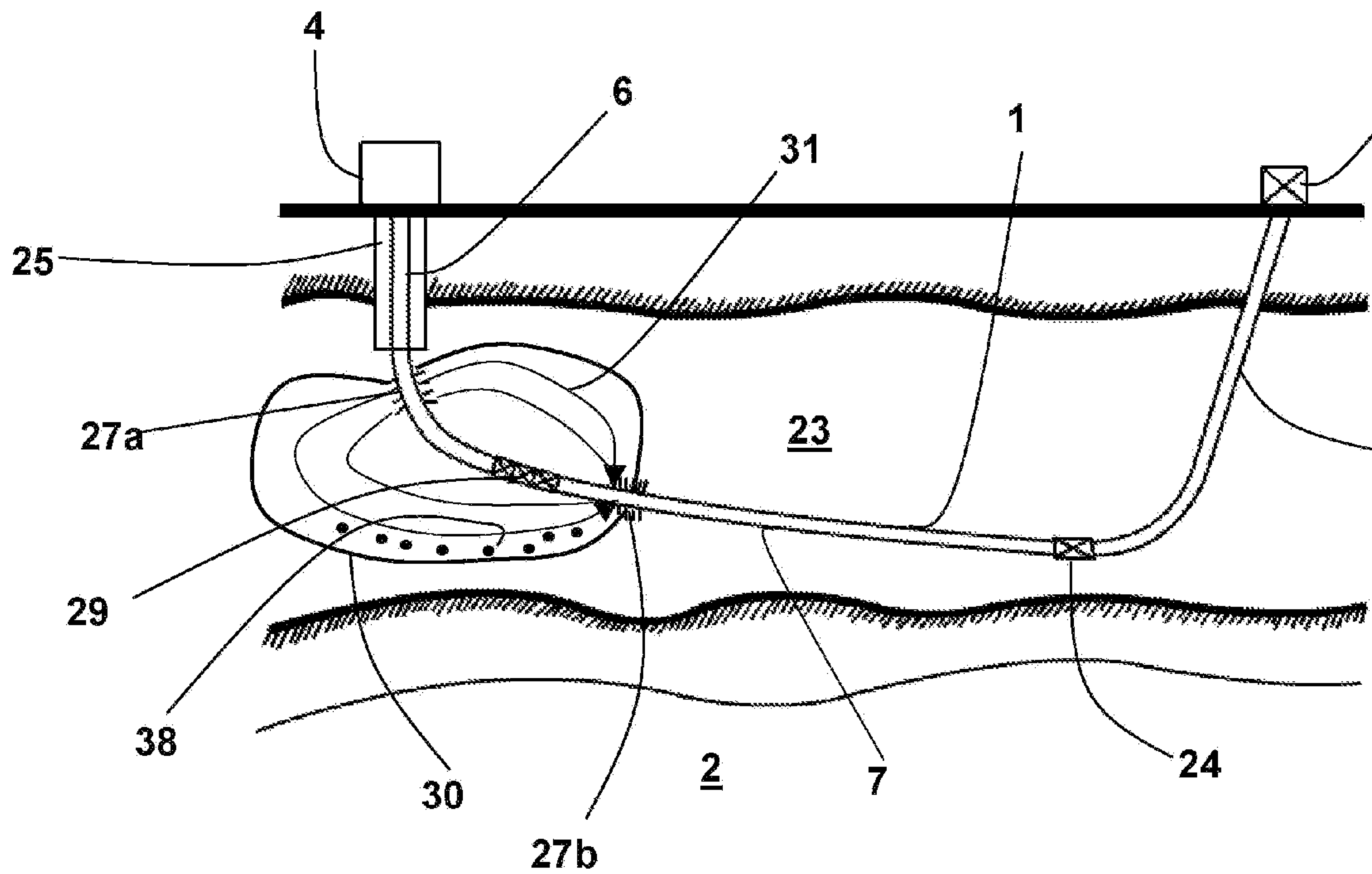


Fig. 7

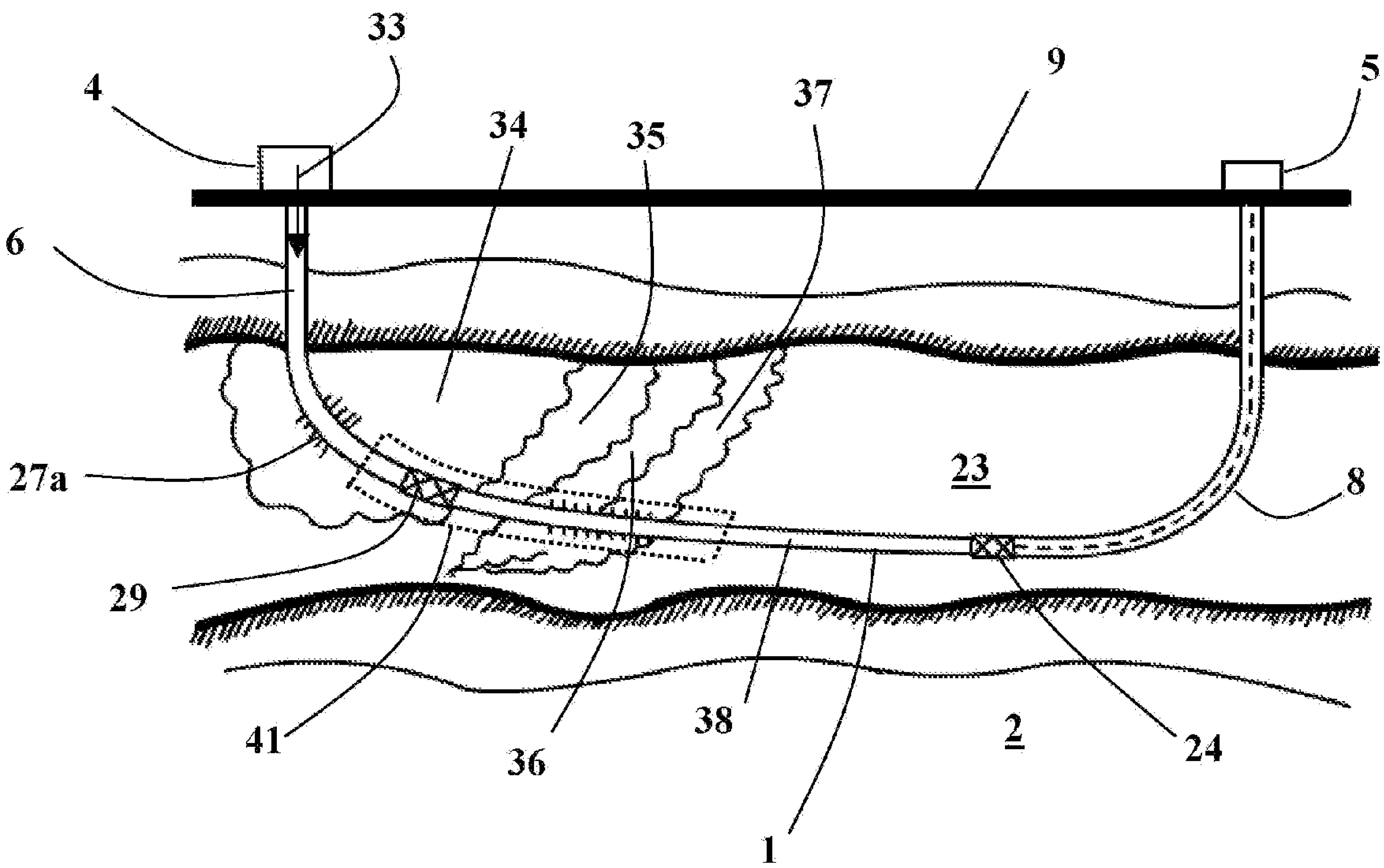


Fig. 8

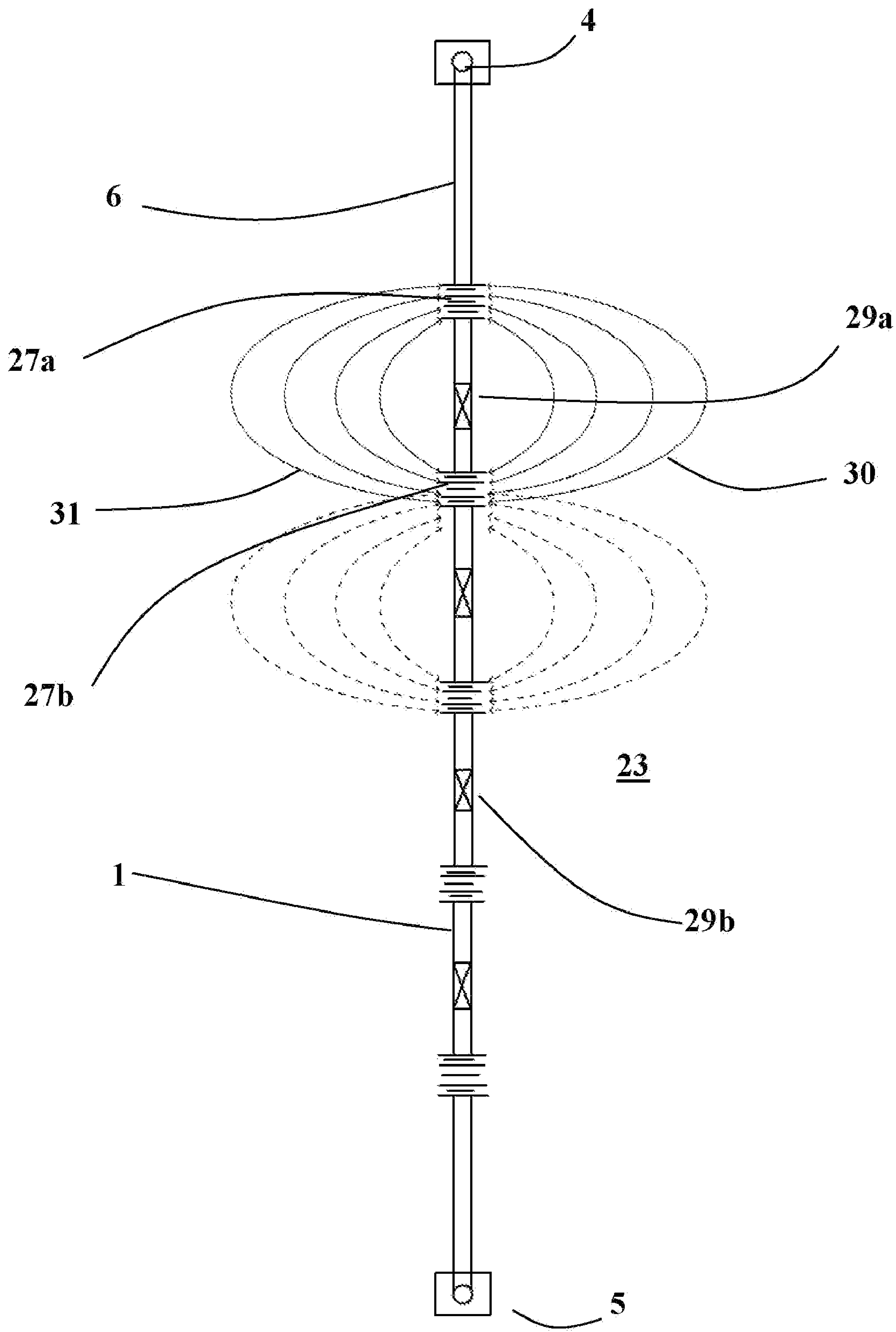


Fig. 9

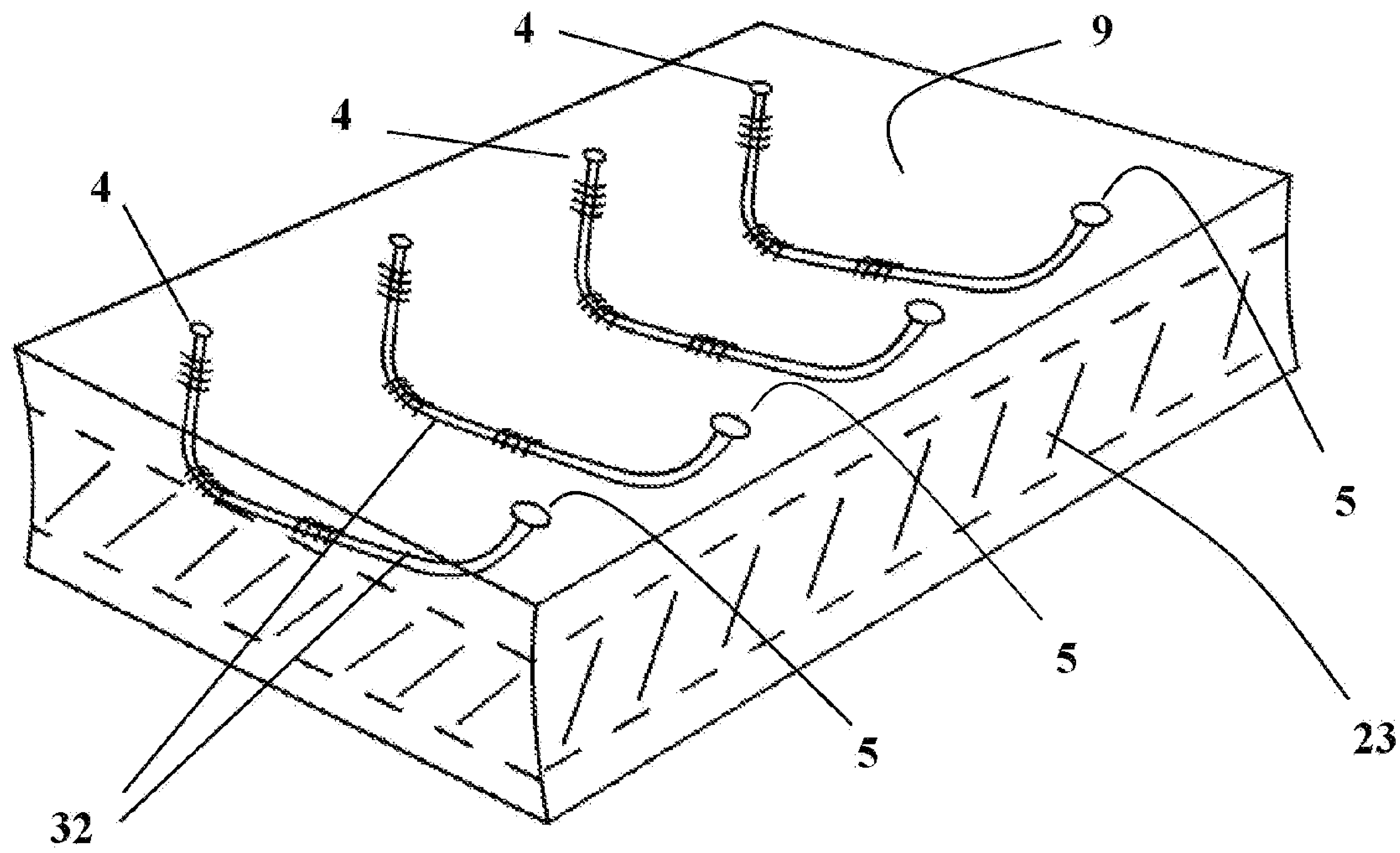


Fig. 10

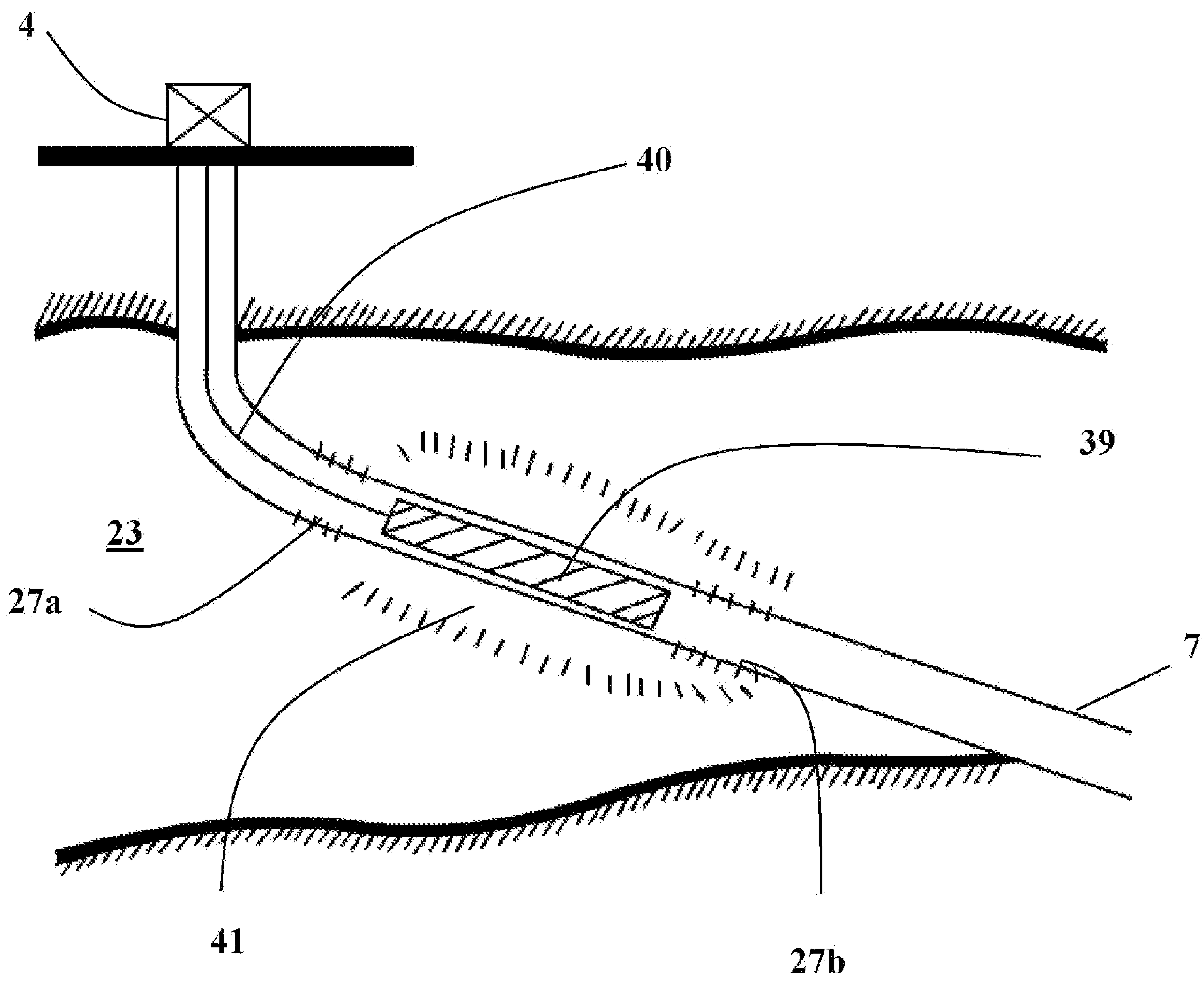


Fig. 11

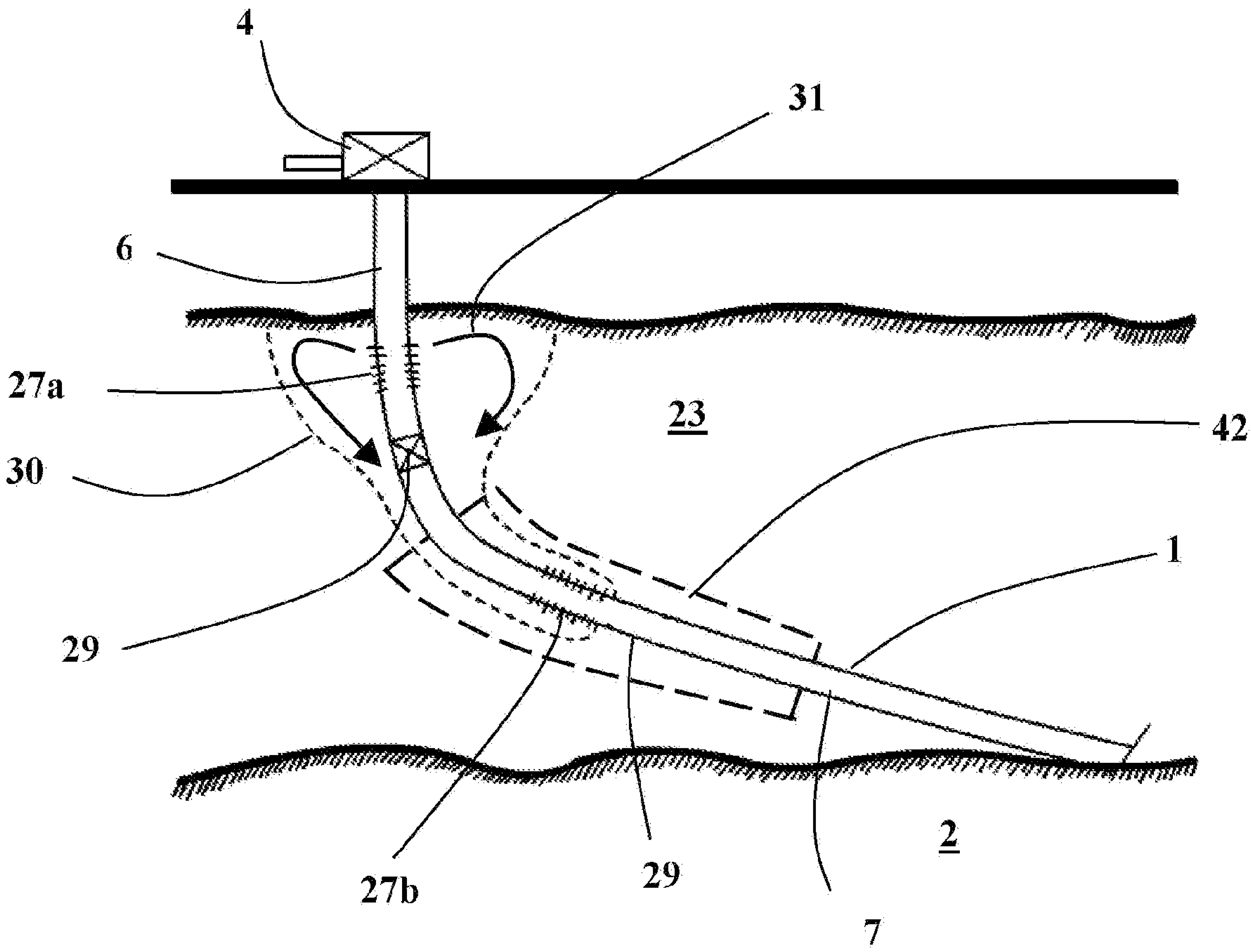


Fig. 12

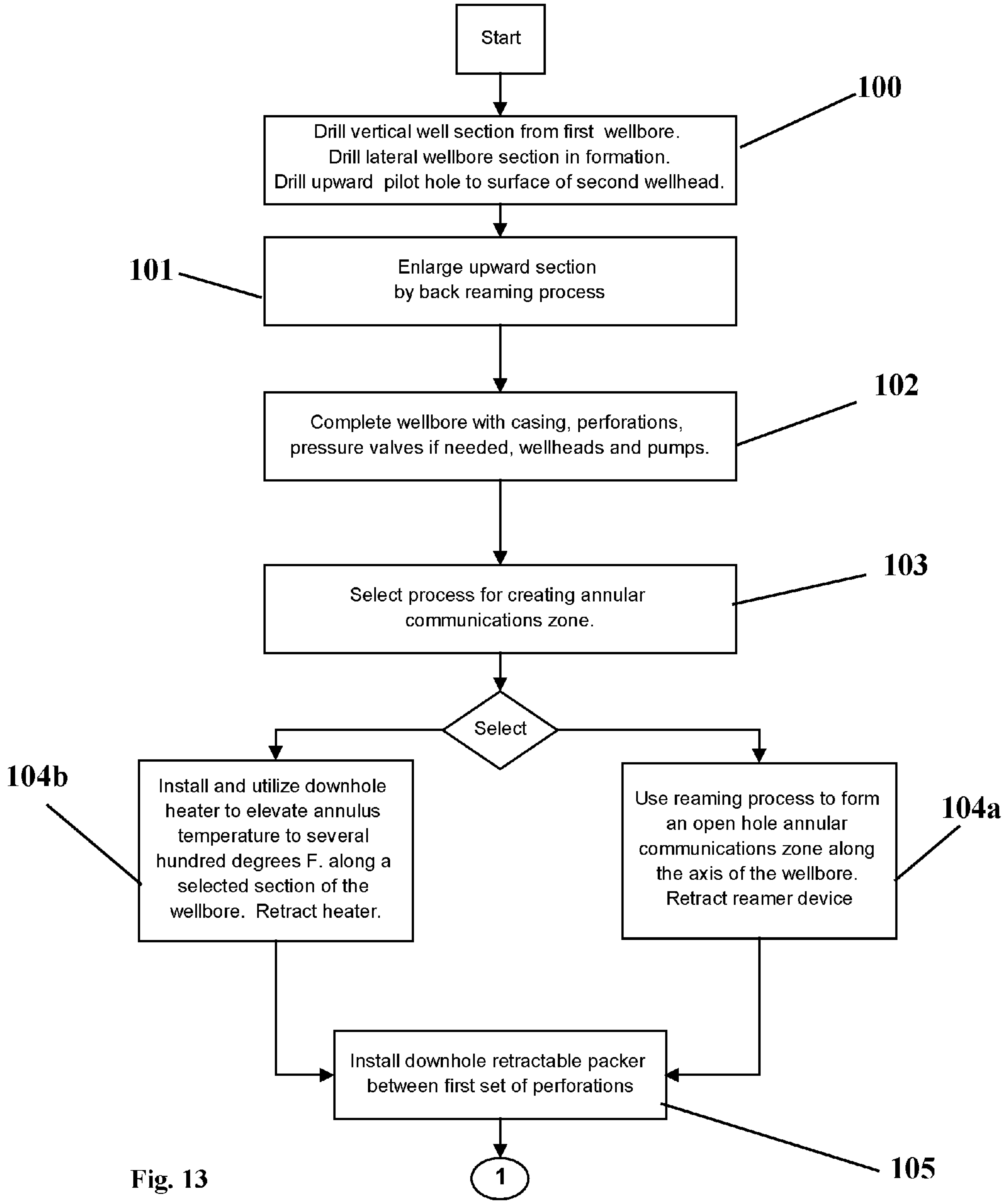

Start
Drill vertical well section from first wellbore.
Drill lateral wellbore section in formation.
Drill upward pilot hole to surface of second wellhead.
100
Enlarge upward section by back reaming process
101
Complete wellbore with casing, perforations, pressure valves if needed, wellheads and pumps.
102
Select process for creating annular communications zone.
103
Select
Install and utilize downhole heater to elevate annulus temperature to several hundred degrees F. along a selected section of the wellbore. Retract heater.
104b
Use reaming process to form an open hole annular communications zone along the axis of the wellbore. Retract reamer device
104a
Install downhole retractable packer between first set of perforations
105
1

Fig. 13

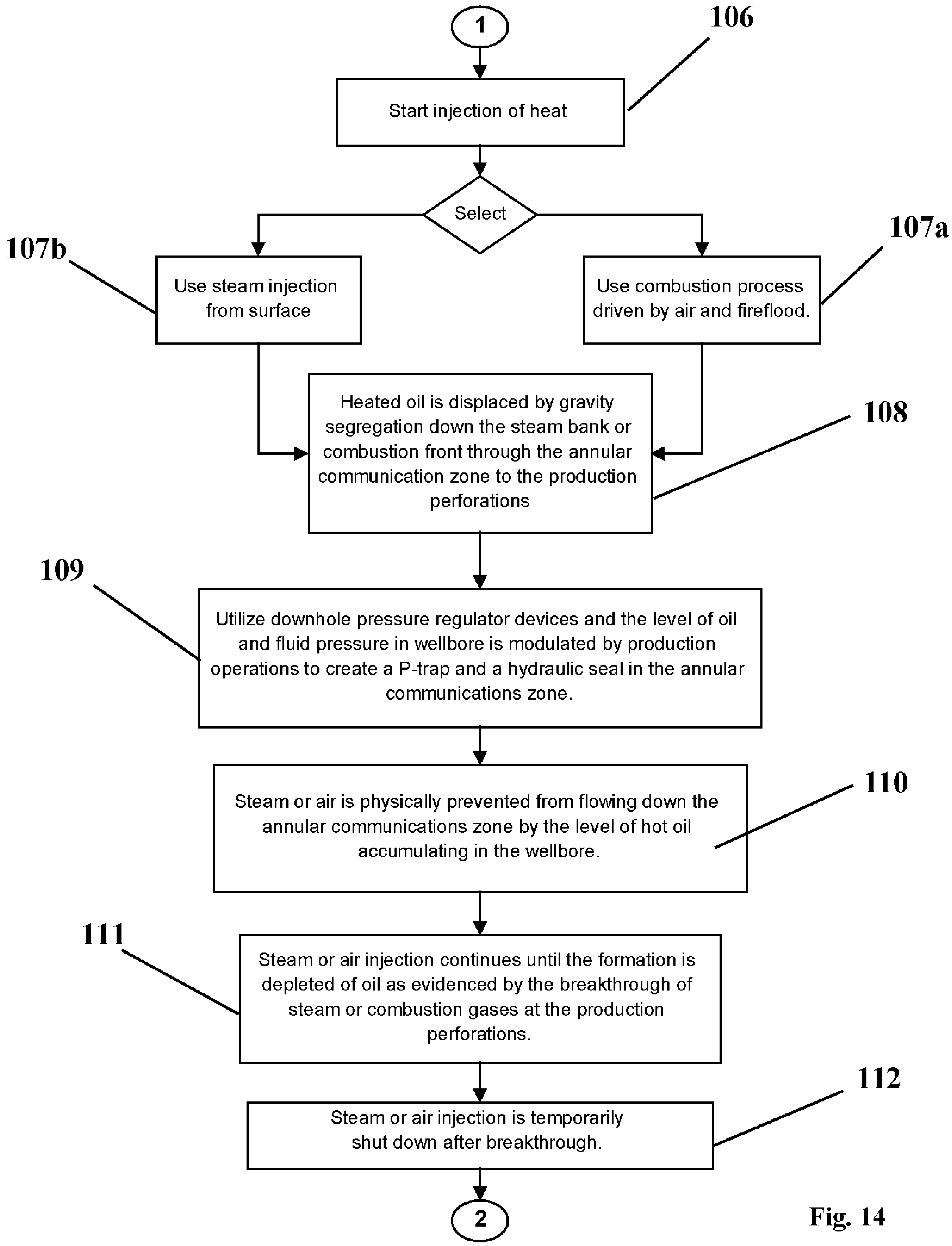

1
106
Start injection of heat
Select
107b
Use steam injection from surface
107a
Use combustion process driven by air and fireflood.
Heated oil is displaced by gravity segregation down the steam bank or combustion front through the annular communication zone to the production perforations
108
109
Utilize downhole pressure regulator devices and the level of oil and fluid pressure in wellbore is modulated by production operations to create a P-trap and a hydraulic seal in the annular communications zone.
Steam or air is physically prevented from flowing down the annular communications zone by the level of hot oil accumulating in the wellbore.
110
111
Steam or air injection continues until the formation is depleted of oil as evidenced by the breakthrough of steam or combustion gases at the production perforations.
Steam or air injection is temporarily shut down after breakthrough.
112
2

Fig. 14

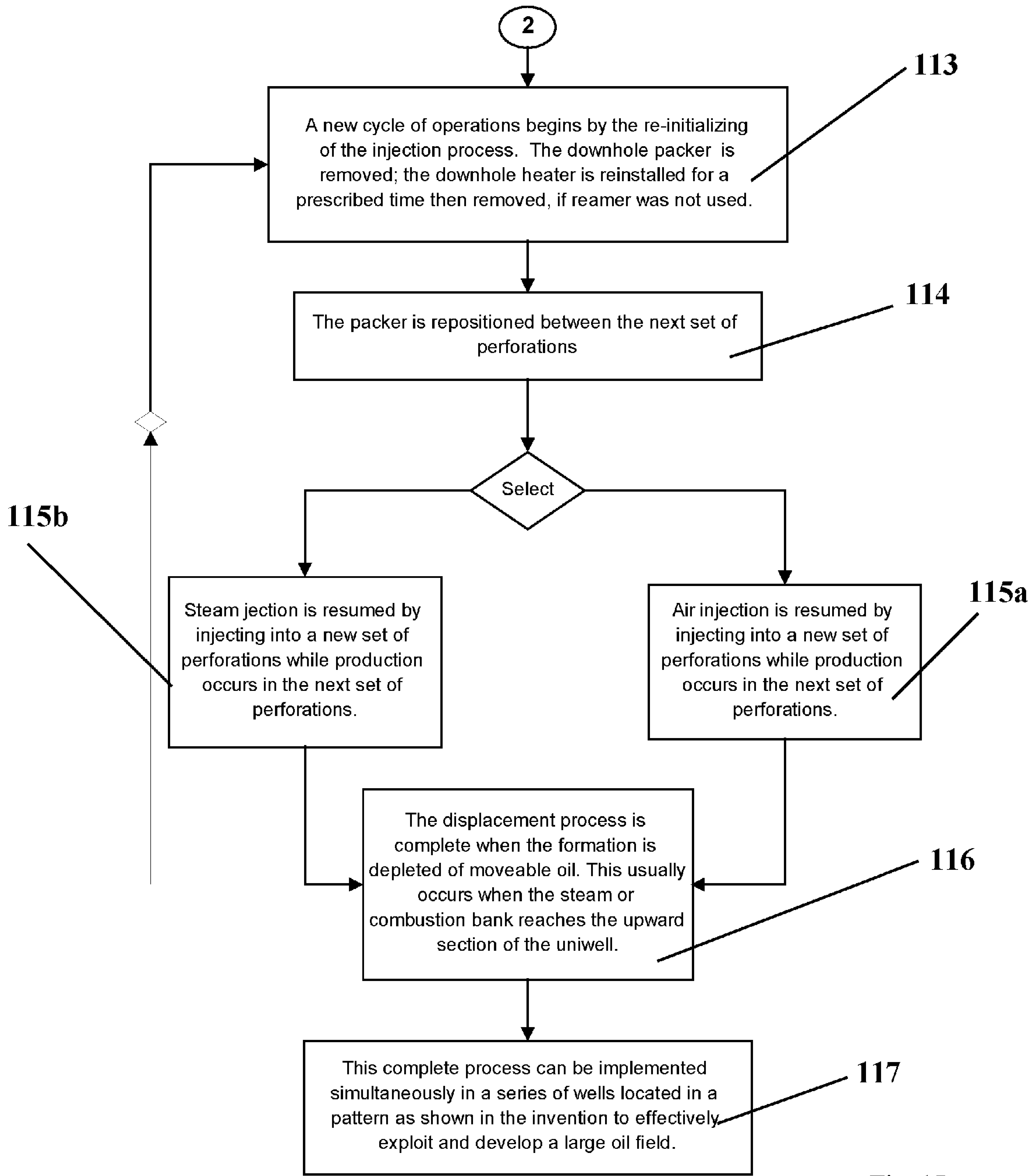

2
A new cycle of operations begins by the re-initializing of the injection process. The downhole packer is removed; the downhole heater is reinstalled for a prescribed time then removed, if reamer was not used.
113
The packer is repositioned between the next set of perforations
114
Select
115b
Steam jection is resumed by injecting into a new set of perforations while production occurs in the next set of perforations.
Air injection is resumed by injecting into a new set of perforations while production occurs in the next set of perforations.
115a
The displacement process is complete when the formation is depleted of moveable oil. This usually occurs when the steam or combustion bank reaches the upward section of the uniwell.
116
This complete process can be implemented simultaneously in a series of wells located in a pattern as shown in the invention to effectively exploit and develop a large oil field.
117

Fig. 15

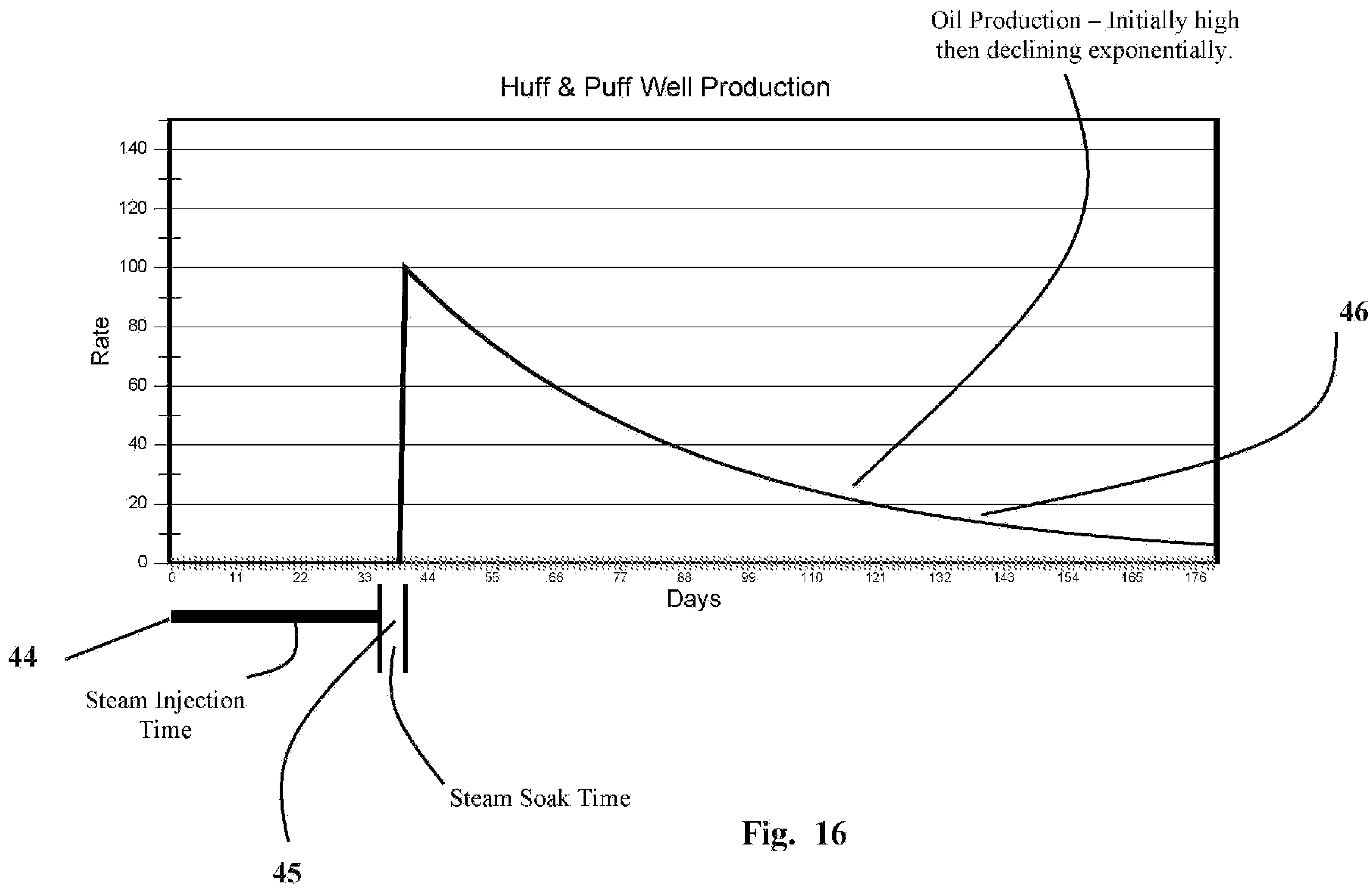

Oil Production – Initially high then declining exponentially.
Huff & Puff Well Production
Rate
140
120
100
80
60
40
20
0
0 11 22 33 44 55 66 77 88 99 110 121 132 143 154 165 176
Days
46
44
Steam Injection Time
Steam Soak Time
45

Fig. 16

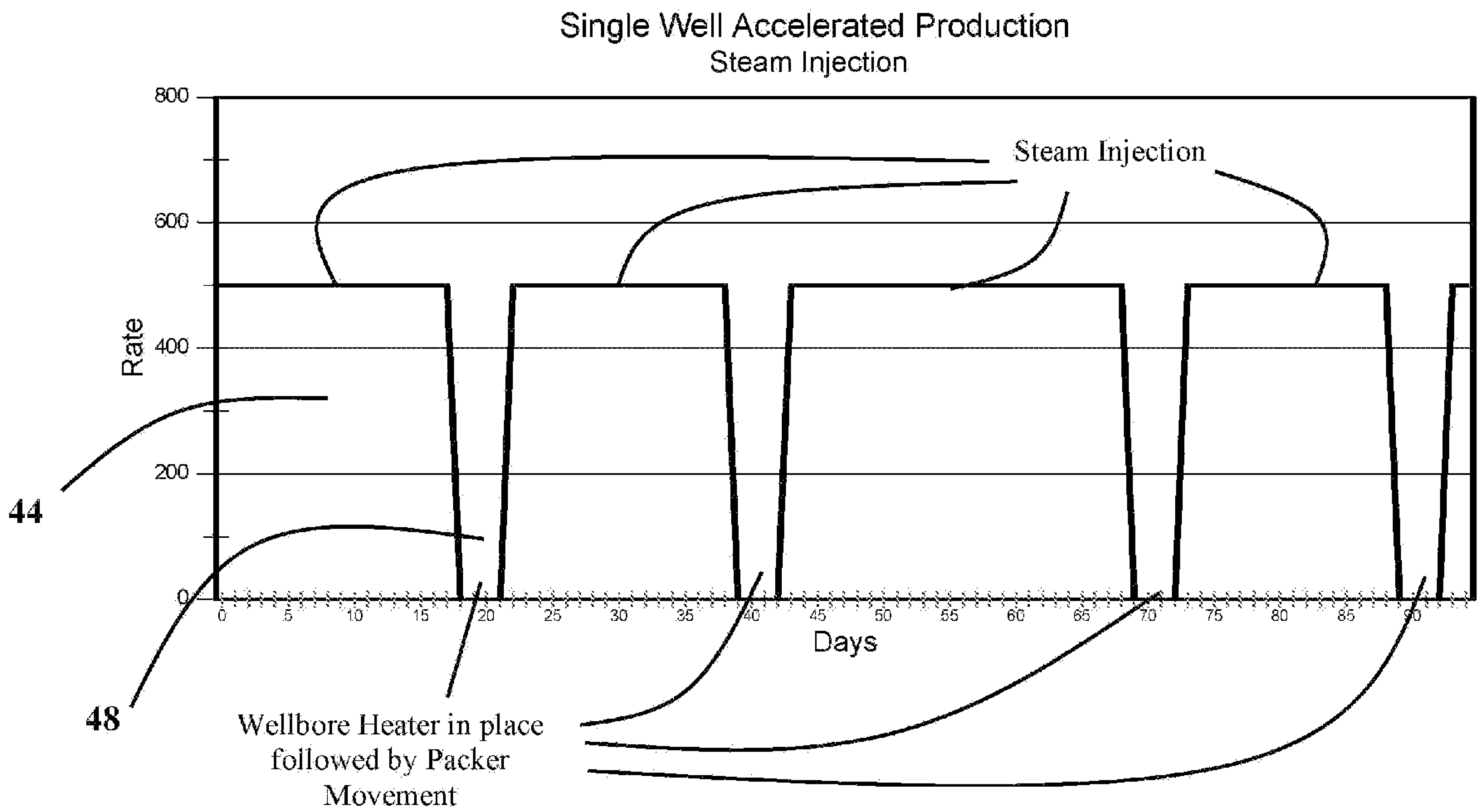

Single Well Accelerated Production
Steam Injection
Steam Injection
800
600
400
200
0
Rate
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
Days
44
48
Wellbore Heater in place followed by Packer Movement

Fig. 17

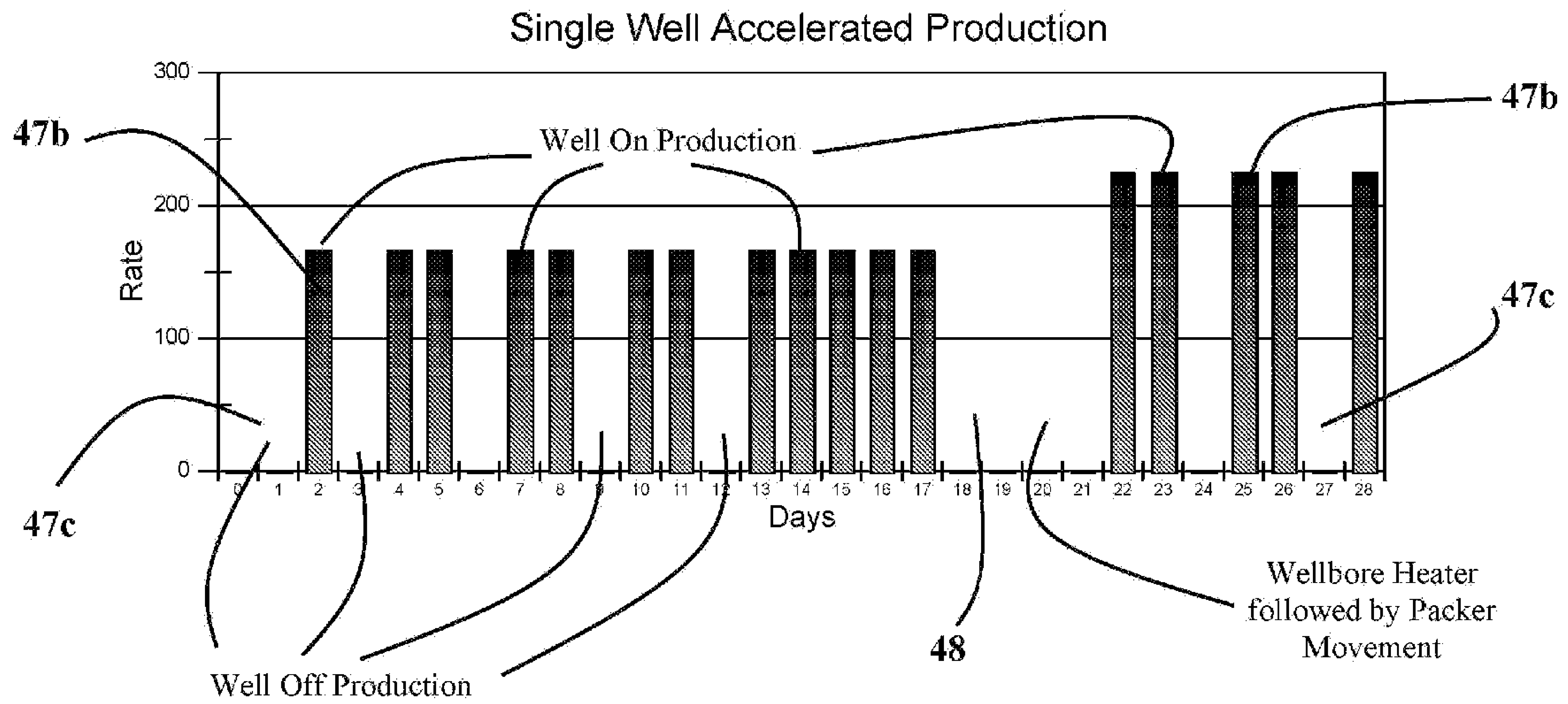
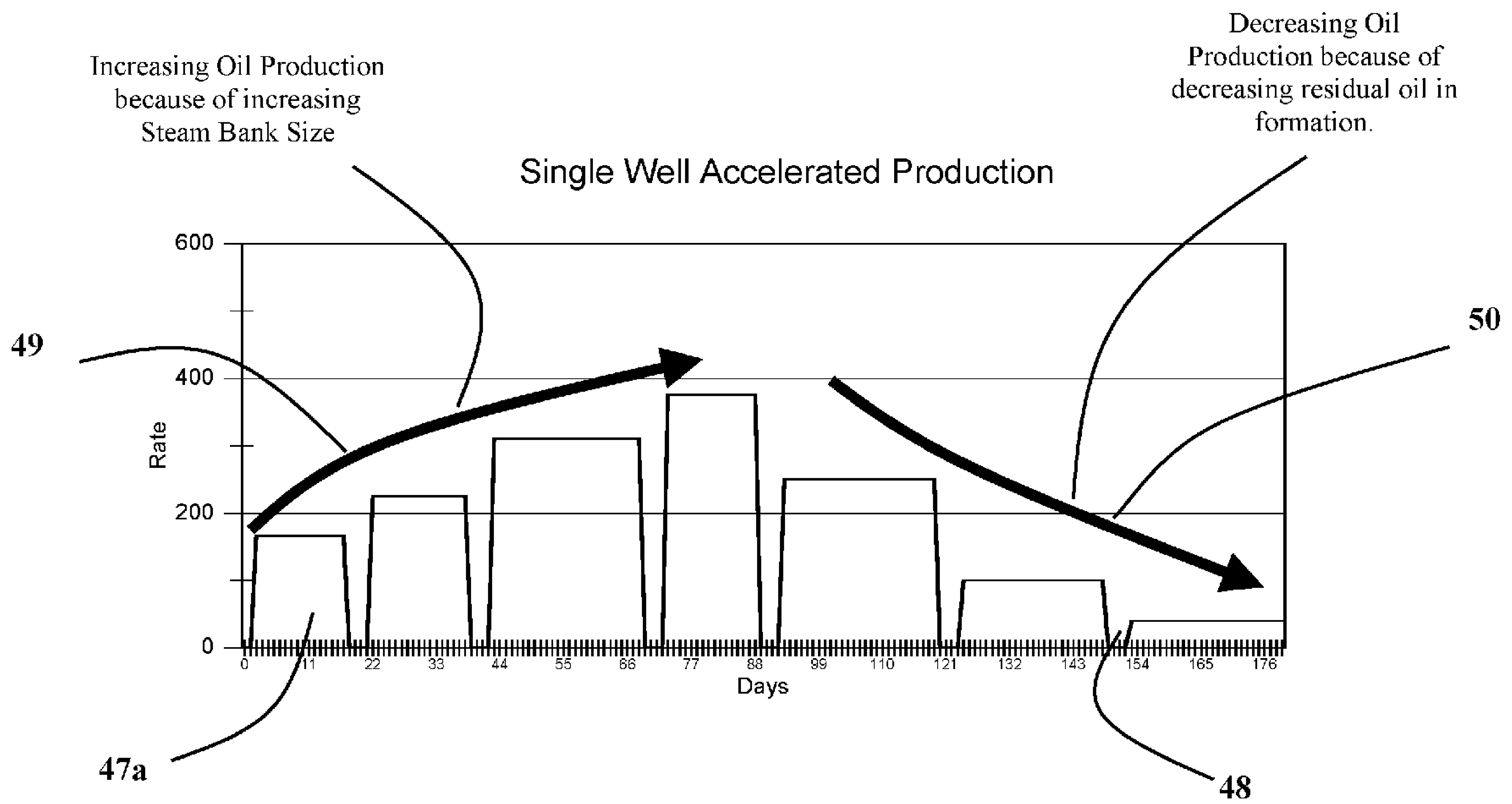

Single Well Accelerated Production
300
200
100
0
Rate
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Days
47b
Well On Production
47b
47c
47c
Well Off Production
48
Wellbore Heater
followed by Packer
Movement

Fig. 18



Increasing Oil Production because of increasing Steam Bank Size
Decreasing Oil Production because of decreasing residual oil in formation.
Single Well Accelerated Production
600
400
200
0
Rate
0
11
22
33
44
55
66
77
88
99
110
121
132
143
154
165
176
Days
49
50
47a
48

Fig. 19

METHOD FOR RECOVERING HYDROCARBONS FROM SUBTERRANEAN FORMATIONS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from provisional application 60/712,289 filed Aug. 30, 2005 and Disclosure Document 521,535 by Dr. Henry Crichlow.

INTRODUCTION

[0002] This invention relates generally to a new technology application and a new type of oil well for recovery of viscous hydrocarbons from subterranean oil bearing formations. The technology involves the novel use and application of equipment and techniques in which horizontal wells are drilled from the surface down to and across an oil bearing formation and back up to the surface, in a manner similar to that of drilling under a river crossing when laying pipelines across country. This new type of horizontal well is called a Uniwell™ because it has two surface wellheads one at each end of the axis of the horizontal system. Either wellhead can be used for either injection or production as needed by the operator.

[0003] The technology is a new application using some elements of an existing technology, which has hitherto been used in horizontal pipeline crossing installations and some technology elements, which have been used in conventional oil well drilling.

FIELD OF THE INVENTION

[0004] THIS INVENTION is a unique new approach to drilling horizontal wells for oil recovery. The invention is particularly suited to making heavy oil formations and tar sands producible by a single wellbore drilled using a specialized form of horizontal directional drilling. The invention however is not limited to recovery of heavy oils only; it can be used for many oil recovery processes such as tar sands and oil shale.

[0005] With this invention, the operator can drill a new type of well that has all the operational benefits of a horizontal well and in addition this drilling can be implemented either by using modified equipment that is readily available in allied industries such as pipeline laying or by modifying existing oil well drilling rigs. This novel drilling approach effectively lowers costs and increases efficiencies because it can utilize available equipment to drill wells with greater productive capacity. This approach allows wells to be drilled over large lateral distances, up to as much as 5,000 feet in shallow depth oilfields. At greater depths the lateral extension is limited by the rig capability and mechanical limitations of torque and drag in the drilling process. With this innovation, in field practice, which involves in part, the injection and production from the same well, albeit at different ends of the horizontal axis, increased levels of oil recovery are achievable. It is also possible to produce from the same wellhead by using concentric tubular strings and allowing the produced fluid to be removed from the same wellhead.

BACKGROUND OF THE INVENTION

[0006] Introduction:

[0007] Heavy hydrocarbons in the form of petroleum deposits are distributed worldwide and the heavy oil reserves are measured in the hundreds of billions of recoverable barrels. Because of the relatively high oil viscosity which can exceed 10^6 Cp, these crude deposits are essentially immobile and cannot be easily recovered by conventional primary and secondary means. The only economically viable means of oil recovery is by the addition of heat to the oil deposit, which significantly decreases the viscosity of the oil by several orders of magnitude and allows the oil to flow from the formation into the producing wellbore. Today, the steam injection can be done in a continuous fashion or intermittently as in the so-called "huff and puff" or cyclic steam process. Oil recovery by steam injection involves a combination of physical processes including, gravity drainage, steam drive and steam drag to move the heated oil from the oil zone into the producing wellbore.

[0008] The most significant oil recovery problem with heavy oil, tar sands and similar hydrocarbonaceous material is the extremely high viscosity of the native hydrocarbons. The viscosity ranges from 10,000 cp at the low end of the range to 5,000,000 cp at reservoir conditions. The viscosity of steam at injection conditions is about 0.020 cp. Assuming similar rock permeability to both phases steam and oil, then the viscosity ratio provides a good measure of the flow transmissibility of the formation to each phase. Under the same pressure gradient, gaseous steam can therefore flow from 500,000 to 250,000,000 times easier through the material than the oil at reservoir conditions. Because of this viscosity ratio, it is imperative and critical to any recovery application that the steam be confined or limited to an area of the reservoir by a seal. This seal can be physical, hydraulic or pneumatic and essentially must provide a physical situation which guarantees no-flow of any fluid across an interface. This can be implemented by several means. Without this "barrier" the steam will bypass, overrun, circumvent, detour around the cold viscous formation and move to the producer wellbore. This invention addresses and resolves this major obstructive element in heavy oil recovery.

[0009] Horizontal wells have played a prominent part in recovery of oil. These wells can be as much as 4 times as expensive as conventional vertical wells but the increased expense is offset by the increased rates of oil production and faster economic returns. Several patents have described various approaches to using horizontal wellbores. The need for horizontal wells requires a more efficient economical and easily deployable system for developing and drilling these horizontal wells. This novel utilization proposed herein addresses the needs and teaches a method of horizontal well drilling and a production mechanism that is more easily implemented, allows a larger portion of the reservoir to be exposed and allows more oil recovery to occur.

[0010] By implementing the new processes which are taught in this application by this invention the oilfield operator can see improved performance, lower costs, better oilfield management, and allow for efficient and orderly development of petroleum resources.

[0011] Improvements have been made in enhancing the contact of the steam with the native heavy oil by the introduction of horizontal well technology, which allows greater recovery than with the customary vertical wells. This current invention provides a further extension of the horizontal technology in which a novel drilling methodology is applied to the drilling effort to allow wells of much larger lateral extent, potentially larger diameters and thereby more efficient recovery systems. This invention also describes the use of the single wellbore as the injection and production system simultaneously without the need for additional concentric or multiple complicated tubular systems in the well.

[0012] No fully operational cases of horizontal drilling with two wellheads have been reported in the oil and gas drilling industry. To date, horizontal directional drilling with two wellheads, i.e. with an entry and exit wellhead, has been a technology limited almost exclusively to the pipeline construction industry in which the engineers routinely use the horizontal directional drilling techniques to cross rivers by drilling a horizontal well from one side of the river bank, several feet under the river bottom and across to the other bank. Refs.1 and Ref. 2 are horizontal directional drilling publications, which show examples where this technology has been successfully used in river crossings like the Chinese Yangtze River where the crossing was 5,538 feet laterally and 170 feet below the ground level. Some environmental uses have developed recently in which horizontal wells are drilled under immovable structures like buildings to allow liquid contaminants to be siphoned off or produced from subsurface layers.

[0013] Prior Art:

[0014] Various methods and processes have been disclosed for recovery of oil and gas by using horizontal wells. There have been various approaches utilized with vertical wellbores, to heat the reservoirs by injection of fluids and also to create a combustion front in the reservoir to displace the insitu oil from the injection wellbore to the production wellbore.

[0015] Wilson in U.S. Pat. No. 5,165,491 provides a mechanism for putting more weight on the drill bit by utilizing the weighted heavy drill collars in the general vertical portion of the well such that the maximum weight component is available on the bit.

[0016] U.S. Pat. No. 5,467,834 provides the method and apparatus for drilling the curved portion of a horizontal well by using a flexible composite drill pipe. U.S. Pat. No. 6,202,761 further elaborates on the process of drilling the initial curved portion of the wellbore by placing a window turning shoe and drilling out a window through the casing.

[0017] Keller in U.S. Pat. No. 5,803,666 indicates a process to allow a pilot hole to be back-reamed in making a horizontal crossing with an inverted liner to support the wall of the wellbore.

[0018] Landers in WO 99/66168 describes a drilling apparatus for horizontal wells using a horizontal cutting jet blaster device under very high hydraulic pressure. U.S. Pat. No. 5,934,390 by Uthe discusses a similar jet drilling approach.

[0019] Rozendaal in patent application US2002/0066598 A1 discloses a reaming device which allows the pilot hole drilled by horizontal drilling machines used in underground utilities for gas, water, electric and phone lines to be reamed to a larger diameter.

[0020] U.S. Pat. No. 6,357,537 illustrates the typical use of conventional horizontal directional drilling equipment and the drilling process. This patent and others like it show the use of the drilling technology limited to shallow utility type crossings.

[0021] Rankin et al. in patent US2002/0096362 A1 describe a back-reamer device used to enlarge a pilot hole. This device is steer-able and allows the back-reaming process to maintain correct alignment.

[0022] Balton in U.S. Pat. No. 5,402,851 teaches a method wherein multiple horizontal wells are drilled to intersect or terminate in close proximity to the vertical well bore. The vertical wellbore is used to actually produce the reservoir fluids. The horizontal wellbore provides the conduits, which direct the fluids to the vertical producing wellbore.

[0023] Butler et al in U.S. Pat. No. 4,116,275 use a single horizontal wellbore with multiple tubular strings internal to the largest wellbore for steam recovery of oil. Steam was injected via the annulus and after a soak period the oil is produced from the inner tubing strings.

[0024] U.S. Pat. No. 5,626,193 by Nzekwu et al disclose a single horizontal well with multiple tubing elements inside the major wellbore. This horizontal well is used to provide gravity drainage in a steam assisted heavy oil recovery process. This invention allows a central injector tube to inject steam and then the heated produced fluids are produced backwards through the annular region of the same wellbore beginning at the farthest or distal end of the horizontal wellbore. The oil is then lifted by a pump. This invention shows a method where the input and output elements are the same single wellbore at the surface.

[0025] U.S. Pat. No. 5,215,149 Lu, uses a single wellbore with concentric injection and production tubular strings in which the injection is performed through the annulus and production occurs in the inner tubular string, which is separated by a packer. This packer limits the movement of the injected fluids laterally along the axis of the wellbores. In this invention the perforations are made only on the top portion of the annular region of the horizontal well. Similarly the production zone beyond the packer is made on the upper surface only of the annular region. These perforated zones are fixed at the time of well completion and remain the same throughout the life of the oil recovery process.

[0026] Huang in U.S. Pat. No. 4,700,779 describes a plurality of parallel horizontal wells used in steam recovery in which steam is injected into the odd numbered wells and oil is produced in the even numbered wells. Fluid displacement in the reservoir occurs in a planar fashion.

[0027] U.S. Pat. Nos. 6,951,247, 6,929,067, 6,923,257, 6,918,443, 6,932,155, 6,929,067, 6,902,004, 6,880,633, 20050051327, 20040211569 by various inventors and assigned to Shell Oil Company have provided a very exhaustive analysis of the oil shale recovery process using a plurality of downhole heaters in various configurations. These patents utilize a massive heat source to process and pyrolize the oil shale insitu and then to produce the oil shale products by a myriad of wellbore configurations. These patents teach a variety of combustors with different geometric shapes one of which is a horizontal combustor system which has two entry points on the surface of the ground, however the hydrocarbon production mechanism is considerably different from those proposed herein by this subject invention.

[0028] Shell U.S. Pat. No. 6,953,087 shows that heating of the hydrocarbon formation increases rock permeability and porosity. This heating also decreases water saturation by vaporizing the interstitial water. The combination of these changes increases the fluid transmissibility of the formation rock in the heated region.

[0029] U.S. Pat. No. 6,948,563 illustrates that increases in permeability may result from a reduction of mass of the heated portion due to vaporization of water, removal of hydrocarbrons, and/or creation of fractures. In this manners fluids may more easily flow through the heated portion.

[0030] U.S. Pat. No. 3,994,341 teaches a vertical closed loop system inside the wellbore tubulars in which a vertical wellbore is used to generate a vertical circulation of hot fluids which heat the wellbore and nearby formation. Hot fluids and drive fluids are injected into upper perforations which allow the driven oil to be produced from the bottom of the formation after being driven towards the bottom by the drive fluid.

[0031] U.S. Pat. No. 6,7255,922 utilizes a plurality of horizontal wells to drain a formation in which a second set of horizontal wells are drilled from and connected to the first group of horizontal wells, These wells from a dendritic pattern arrangement to drain the oil formation,

[0032] U.S. Pat. No. 6,729,394 proposes a method of producing from a subterranean formation through a network of separate wellbores located within the formation in which one or more of these wells is a horizontal wellbore, however not intersecting the other well but in fluid contact through the reservoir formation with the other well or wells.

[0033] U.S. Pat. No. 6,708,764 provides a description of an undulating well bore. The undulating well bore includes at least one inclining portion drilled through the subterranean zone at an inclination sloping toward an upper boundary of the single layer of subterranean deposits and at least one declining portion drilled through the subterranean zone at a declination sloping toward a lower boundary of the single layer of subterranean deposits. This embodiment looks like a waveform situated in the rock formation.

[0034] U.S. Pat. No. 5,167,280 teaches single concentric horizontal wellbores in the hydrocarbon formation into which a diffusible solvent is injected from the distal end to effect production of lowered viscosity oil backwards at the distal end of the concentric wellbore annulus.

[0035] U.S. Pat. No. 5,655,605 attempts to use two wellbores sequentially drilled from the surface some distance apart and then to have these wellbores intersect each other to form a continuous wellbore with two surface wellheads. This technology while theoretically possible is operationally difficult to hit such a small underground target, i.e the axial cross-section of a typical 8-inch wellbore using a horizontal penetrating drill bit. It further teaches the use of the horizontal section of these intersecting wellbores to collect oil produced from the formation through which the horizontal section penetrates. Oil production from the native formation is driven by an induced pressure drop in the collection zone by a set of valves or a pumping system which is designed into the internal concentric tubing of this invention. The 5,655,605 patent also describes a heating mechanism to lower the viscosity of the produced oil inside the collection horizontal section by circulating steam or other fluid through an additional central tubing located inside the horizontal section. At no time does the steam or other hot fluid contact the oil formation where viscosity lowering by heat transfer is needed to allow oil production to occur.

[0036] U.S. Pat. No. 4,532,986 teaches an extremely complex dual well system including a horizontal wellbore and a connecting vertical wellbore which is drilled to intersect the horizontal well. The vertical well contains a massively complex moveable diverter system with cables and pulleys attached to the two separate wellheads to allow the injection of steam. This system is used to inject steam from the vertical wellhead into the horizontal wellbore cyclically and sequentially while the oil is produced from the wellhead at the surface end of the horizontal well.

[0037] U.S. Pat. No. 4,037,658 teaches the use of two vertical shafts or wells connected by a cased horizontal shaft or “hole” with a flange in the vertical well. This type of downhole flange connection is extremely difficult if not impossible to implement in current oilfield practice. Two types of fluids are used in this patent, one inside the horizontal shaft as a heater fluid and one in the formation as a drive fluid. Both fluids are injected either intermittently of simultaneously from the surface wellheads. The laboratory demonstration in this patent shows that the annular steam zone is very conductive to oil production and allows premature steam breakthrough. Based on this demonstrated observation, it is difficult if not impossible, to conceive a situation taught by this patent in which the injected steam as drive fluid will not preferentially flow under the hundreds of pounds injection pressure along the heated annular zone and thus bypassing the cold viscous oil saturated formation. It is noted that the cold viscous formation has an almost zero mobility. This patent essentially teaches a system in which the injected steam shall be cycled through the horizontal tube and the annular zone in the formation under field conditions providing little if any sweep efficiency.

[0038] U.S. Pat. No. 3,986,557 claims a method using a horizontal well with two wellheads that can inject steam into a tar sand formation mobilizing the tar in the sands. In this patent, during the injection of the steam it is hoped that the steam will enter the formation and not continue directly down the open wellbore and back to the surface of the opposite wellhead. It is difficult to visualize the steam entering a cold highly viscous formation while a highly open wellbore is available for fluid flow away from the formation. Furthermore, U.S. Pat. No. 3,986,557 teaches that the steam is simultaneously injected through perforations into the cold bitumen formation while hot oil is flowing through the same perforations, in the opposite direction through the rock pore structure, against the invading high pressure steam. This situation is not only physically impossible but it thermodynamically impossible for the hot fluid to flow “against the pressure gradient”.

[0039] U.S. Pat. No. 4,445,574 teaches the drilling of a single well with two wellheads. This well is perforated in the horizontal section and a working fluid is injected into the wellbore to produce a mixture of reservoir oil and injected working fluid. Similar to the U.S. Pat. No. 3,986,557 patent it is difficult from a hydraulic point of view to visualize and contemplate the working fluid entering the formation while an open wellbore is available for fluid flow horizontally and vertically out the distal end of this wellbore.

[0040] U.S. Pat. No. application 20050045325 describes a recovery mechanism for heavy oil hydrocarbons in which a pair of wells is used. A vertical injector well is horizontally separated from a vertical production well. The hot fluid, steam or air is injected into the bottom portion of the injector and is expected to displace the very viscous immobile oil from the cold reservoir and push this hot oil through the cold oil saturated formation eventually to the producer. The invention expects oil flow to occur by drilling a web or radial channels from the injector to the producer. It is inconceivable that viscous cold oil, or even lower viscosity hot oil will preferably flow along these channels while extremely low viscosity high-pressure steam will flow through the cold formation. Flow in porous media dictates that hot, saturated steam will completely bypass cold viscous oil and the process will be a quick steam recycle process from injector to producer.

[0041] Ref. 4, the Society of Petroleum Engineers (SPE), 222 Palisades Creek Dr., Richardson, Tex. 75080, U.S.A, publishes several hundred papers on heavy oil recovery.

[0042] SPE paper 37115 describes a single-well technology applied in the oil industry which uses a dual stream well with tubing and annulus: steam is injected into the tubing and fluid is produced from the annulus. The tubing is insulated to reduce heat losses to the annulus. This technology tries to increase the quality of steam discharged to the annulus, while avoiding high temperatures and liquid flashing at the heel of the wellbore.

[0043] SPE paper 78131 published an engineering analysis of thermal simulation of wellbore in oil fields in western Canada and Calif., U.S.A.

[0044] SPE paper 53687 shows the production results during the first year of a thermal stimulation using dual and parallel horizontal wells using the SAGD technology in Venezuela.

[0045] SPE paper 50429 presents an experimental horizontal well where the horizontal well technology was used to replace ten vertical injection wells with a single horizontal well with limited entry. The limited-entry perforations enabled steam to be targeted at the cold regions of the reservoir.

[0046] SPE paper 75137 describes a THAI—'Toe-to-Heel Air Injection' system involving a short-distance displacement process, that tries to achieve high recovery efficiency by virtue of its stable operation and ability to produce mobilized oil directly into an active section of the horizontal producer well, just ahead of the combustion front. Air is injected via a separate vertical or a separate horizontal wellbore into the formation at the toe end of different horizontal producer well and the combustion front moves along the axis of the producer well.

[0047] SPE paper 50941 presents the "Vapex" method which involves injection of vaporized hydrocarbon solvents into heavy oil and bitumen reservoirs; the solvent-diluted oil drains by gravity to a separate and different horizontal production well or another vertical well. S

[0048] PE paper 20017 teaches a computer simulation of a displacement process using a concentric wellbore system of three wellbore elements and complex packers in which steam is injected in a vertical wellbore similar to that in the U.S. Pat. No. 3,994,341 patent. Simulated steam injection occurs through one tubing string and circulates in the wellbore from just above the bottom packer to the injection perforations near the top of the tar sand. This perforations near the top of the tar sand. This circulating steam turns the wellbore into a hot pipe which heats an annulus of tar sand and provides communication between the steam injection perforations near the top of the tar sand and the fluid production perforations near the bottom of the tar sand. This process requires 7 years to increase oil production from 20 BOPD to 70 BOPD.

[0049] SPE paper 92685 describes U-tube well technology in which two separate wellbores are drilled and then connected to form a single wellbore. The U-tube system was demonstrated as a means of circumventing hostile surface conditions by drilling under these obstacles.

[0050] SPE 76727 describes that steam displacement in an underground hydrocarbon reservoir occurs because of three components driving oil production. These are gravity drainage, steam drag and steam drive. Gravity drainage is caused by the oil column height and the difference in density between the hot oil and the steam vapor. Steam drag is caused by the relative motion between the steam and oil and the steam dragging the oil along. Steam drive is the force created by the steam pushing the oil ahead of the steam as it moves through the reservoir.

[0051] Ref. 5 shows conclusively that the gravity drainage effect is the most critical factor in oil recovery in heavy oil systems undergoing displacement by steam.

[0052] Very few of these prior art systems have been used in the industry with any success because of their technical complexity, operational difficulties, and being physically impossible to implement or being extremely uneconomical systems.

[0053] Shortcomings of prior art can be related a combination of effects. These include;

[0054] the inability of the method to inject the hot fluid into a cold highly viscous oil in the formation;

[0055] the inability to overcome the viscosity effect, wherein the viscosity of steam is less than 0.020 cp under the reservoir conditions which makes the flow of steam through porous media 5,000,000 times easier than cold high viscosity oil of 100,000 cp. This flow ratio is based directly on the viscosity ratios of 100,000/0.02;

[0056] the inability of the method or process to prevent bypass of injected fluid directly from the injector source towards the producing sink;

[0057] the inability of the method or process to provide an effective seal to prevent high pressure injected steam from bypassing cold viscous oil impregnated formation and moving directly from the injector source towards the producing sink;

[0058] the inability of the method or process to form a viable communication zone from the steam zone or chamber to the producing sink while preventing bypass and early breakthrough of steam;

[0059] the inability of the process to utilize the significant gravity drainage effects created by the low density of the hot steam compared to condensed water and hot oil;

[0060] the inability of the method to heat the formation effectively by physical contact between the steam and the rock formation such that the latent heat, which the major source of heat energy compared to the sensible heat, can be transferred to the rock and hydrocarbons efficiently;

[0061] the requirement of long injection lead times of months to years of hot fluid injection, before there is any production response of the displaced oil;

[0062] the use of overly complex equipment of questionable operational effectiveness to implement the method in the field.

[0063] For example, in U.S. Pat. No. 3,994,341, this embodiment which although on the surface resembles the invention herein differs significantly since the U.S. Pat. No. 3,994,341 patent forms a vertical passage way only by circulating a hot fluid in the wellbore tubulars to heat the nearby formation, the 3,994,341 patent claims the drive fluid promotes the flow of the oil by vertical displacement downwards to the producing perforations at the bottom, the U.S. Pat. No. 3,994,341 patent teaches that the production perforations are set at the bottom of the vertical formation, a distance which can be several hundred feet. In this U.S. Pat. No. 3,994,341 embodiment, since no control mechanism like a back pressure system or pressure control system is taught, it is obvious that the high pressure drive steam, usually at several hundred pounds pressure, will preferentially flow down the vertical passageway immediately on injection and bypass the cold formation with its highly viscous crude and extremely low transmissibility. The same argument of steam bypass applies to U.S. Pat. No. 4,037,658 which teaches a horizontal tube arrangement instead.

[0064] Secondly, the large distance between the top of the formation and the bottom of the formation will cause condensation of the drive steam allowing essentially hot water to be produced at the bottom with low quality steam, both fluids being re-circulated back to the surface. In addition the mechanism to heat the near wellbore can only be based on conductive heat transfer through the steel casing. Since there is no formation rock contact with the steam fluid in which latent heat transfer to formation fluids and rock is the major heat transport system, the U.S. Pat. No. 3,994,341 method is incapable of delivering sufficient heat in a reasonable time to heat the formation sufficiently lower the viscosity of the oil, raise the porosity and permeability of the formation as taught in the present patent application.

[0065] To date, the majority of producing or injection horizontal well embodiments shown in the petroleum industry have but a single wellhead and are all limited by several physical and operational problems associated with the physical nature of the embodiments. This new embodiment shown herein removes many of the problems associated with the prior art.

[0066] In this new embodiment, using 3 drilling phases, a horizontal well is drilled downward to the target formation and across the target producing formation at the required depth and at a predetermined angle and then upward back to the surface. Inside the formation the wellbore is drilled at a slant such that the essential gravity flow component of the recovery process can be optimized. In this phase of the drilling process, a typical drilling plan with a conventional drilling bottom hole assembly is used. At the end of the horizontal or lateral portion, the start of the upward leg of the well is initiated. Since drilling "uphill" is operationally more difficult with heavy drill pipe and working against gravity, a novel solution is needed. This invention also teaches this novel solution.

[0067] In this upward portion a smaller bottom hole assembly with a smaller drill bit used. A small pilot hole is drilled on the upward portion to allow for operational ease and to minimize any problems in the drilling process. This smaller hole requires less drilling torque produces less drag and requires less weight on the bit. The portion is drilled in two phases. It also minimizes drilling fluid loss and any damage to the near surface water zones. This is one novel and innovative part of this embodiment since the well involves drilling holes of varying diameters drilled in two or more sequential sections in which the last section is being drilled upwards to the surface of the ground. In one embodiment when the pilot hole is completed, the upward section can be enlarged by back reaming it to a larger size by using a reamer bit that is pulled from the exit side backward toward the horizontal leg of the well. This approach is similar to that used in river crossings in the pipe laying industry. In another embodiment an option is to use a conventional rig and ream the hole in the usual manner by drilling forward. This sequence of operations provides a novel approach to building the upward section of the well bore. In both cases the near surface groundwater must be protected by casing put in place or by using low loss fluids during the drilling process.

[0068] All of the prior art relates to horizontal directional drilling used primarily for river crossings, highway crossings involved in pipeline laying, optical fiber laying and environmental remediation. No effort to date has used this technology effectively for oil recovery in a manner and form such as the uniwell™ described herein.

[0069] It is seen that the above prior art techniques have several shortcomings and disadvantages that can be avoided by the current invention while improving the recovery process efficiency and lowering the costs.

[0070] There is a long felt need in the industry for a means of moving the heated low viscosity crude oil that has been contacted by the steam in the steam zone to a place or location where it can be produced without having to move it through a cold heavily viscous oil impregnated formation. This problem has continued to baffle the contemporary and prior art with possibly the only exception being the SAGD patent which uses two horizontal wells closely juxtaposed in a vertical plane. Even this SAGD approach has inherent difficulties in initiating the hot oil flow between the two wellbores. Trying to push the hot oil through a cold formation is an intractable proposition. The subject invention offers a solution to this need and provides the mechanism by which the solution can be implemented using conventional equipment and procedures.

[0071] THIS NEW INVENTION provides an improvement in the method whereby the operator drills a specially designed horizontal well which is drilled from the surface down to the producing formation and continues back up to the surface as shown in the figures herein. This continuous wellbore behaves simultaneously as both an injector and a producer. The techniques proposed herein uses a combination of drilling activities that are known separately and distinctly in the industry, but have not yet been utilized in this integrated manner shown in this new invention.

[0072] THIS INVENTION allows the operator to rapidly drill a specialized horizontal well to the producing formation which allows efficient recovery of heavy oil from the subterranean formation. This new drilling technology can be applied to the following systems; heavy oil deposits, tar sands and oil shale systems.

[0073] THIS INVENTION allows the orderly development of oil reserves, especially heavy oil reserves by allowing the efficient and cost effective production of these deposits.

SUMMARY OF THE INVENTION

[0074] An object of this invention is to provide an improved method for recovery of oils from subterranean formations by exploiting the advantages provided by gravity drainage in the displacement process of heavy oils in porous formations using steam or combustion driven displacement processes. The use of a single modified well bore, with a downward, lateral and upward section, the uniwell™, has several engineering benefits including cost reduction, better fluid displacement and more engineering control of the injection and oil recovery process.

[0075] The invention presented herein utilizes two of the three components on steam displacement discussed in the prior art. These are gravity drainage and steam drive. There is very little relative motion between the steam and the oil so there is very little steam drag if any at all in this invention.

[0076] A more specific objective is to provide an improved means of drilling a producing wellbore in subterranean formations by using a sequential drilling method to build and drill the upward portion of the well after the lateral portion is drilled.

[0077] Another specific objective is to provide a means by which the operational difficulties created by using heavy drill pipe and drilling "uphill" can be overcome. The drilling of the upward portion of the wellbore is implemented by using a pilot hole, a new oilfield concept, in which a small pilot hole is drilled upwards with a very small drilling assembly and bit and then the bore of this section can be enlarged afterwards.

[0078] Another specific objective is to provide a means for enlarging the upward section of the wellbore by using a back reaming process with a back reaming bit from the exit end to the horizontal lateral.

[0079] Another specific objective is to provide a means for enlarging the upward section of the wellbore by using a forward reaming process from the exit end to the horizontal lateral by using a typical conventional drilling rig with a forward drilling reaming bit.

[0080] Another specific objective is to provide for maximum gravity drainage during oil production by drilling the lateral portion at an angle selected to maximize oil production while allowing maximum steam effect on the formation during steam recovery processes.

[0081] Another specific objective is to provide a means whereby the lateral portion of the uniwell™ can be extended below the target oil zone to allow maximum contact and drainage within the oil zone of the injected steam and still provide the necessary gradient needed for gravity drainage of heated oil.

[0082] Another specific objective is to provide a means where the upward portion of the uniwell™ can begin below the oil zone and be extended upwards to the surface to accommodate the extended lateral wellbore as described above.

[0083] Another specific objective is to provide a means whereby the same wellbore perforations along the horizontal section of the wellbore can be used sequentially for either injection or production as required by the operator.

[0084] Another specific objective is to use the movable packer between the injection and production perforations, which forces the steam to exit the wellbore and enter the oil zone at a preset location upstream of the production perforations.

[0085] Another specific objective is after the initial oil region is depleted, to unseat and move the movable packer between the injection and production perforations a preset distance along the axis of the wellbore and reseat it to allow the steam displacement process to continue throughout the reservoir in a new undepleted oil zone.

[0086] Another specific objective is to provide a means to considerably reduce the distance the heated oil has to move from the steam injection point to be produced in the wellbore through the producing formations.

[0087] Another specific objective is to provide a concentric communication channel in the formation, which allows the heated oil to move from the upper steam zone to the perforations in the lower production zone.

[0088] Another specific objective is to provide a means whereby oil production begins as early as possible during the injection process compared to existing technologies like Steam Assisted Gravity Drainage (SAGD) and conventional Thermal Enhanced Oil Recovery (TEOR).

[0089] Another specific objective is to minimize the need to preheat the producing elements of the wellbore and the near wellbore region for a long time to raise the temperature and to lower oil viscosity in order to initiate oil production into the cold producer region.

[0090] Another specific objective is to maximize steam zone growth by keeping the steam vertically isolated and higher within the oil formation thus allowing greater steam growth and less potential for steam breakthrough.

[0091] Another specific objective is to allow the steam to replace oil and to pressure up the steam bank at the top, which helps to displace low viscosity, heated oil downwards along the interface of steam/cold reservoir oil to the producing perforations where there exists a pressure sink because oil is being removed during production.

[0092] Another specific objective is to minimize the effects of a bottom water drive on degrading the steam efficiency since the short distance between steam and oil production perforations allows steam to maintain contact with new oil and not be diffused into the bottom water and dissipate its heat content to the higher heat capacity interstitial water.

[0093] Another specific objective is to allow the horizontal wellbore to be drilled close to the bottom of the formation where a water zone exists by making the perforations on the upper side of the lateral wellbore using specialized perforating techniques available in the industry. This allows the injected steam to enter the oil zone preferentially and to stay out of the bottom water zone, while the hot produced oil can be produced from the perforations downstream of the injector point.

[0094] Another specific objective is to preclude the need for two wellbores in the same vertical plane, to recover oil as shown in some conventional SAGD technologies, since in thin zones, it is impossible to successfully drill two workable oil wells within the same thin zone using existing drilling equipment.

[0095] Another specific objective is to overcome the need for two vertically separated wellbores within close tolerances as proposed in SAGD which is expensive and depends on critical placement of two wells within a vertical axis of 2 meters or less to guarantee hot oil dripping from the top well will not bypass the bottom well.

[0096] Another specific objective is to allow the steam to be injected in a horizontal or planar manner into the reservoir. This planar flow from the horizontal axis of the wellbore creates smaller pressure gradients as opposed to pure radial flow in the customary steam injection process.

[0097] Another specific objective is to create smaller pressure gradients by the inward horizontal flow along a significant wellbore distance during the production phase and therefore lower the possibility of coning of fluids, in this case steam and formation water. The coning of steam and/or water is an unwanted condition in this type of recovery system since it wastes energy and produces water that replaces oil.

[0098] Another specific objective is to drill the wellbore with different diameters in different sections particularly in the lateral portion and the upward leg to minimize costs, increase production and control well bore location.

[0099] Another specific objective is to use the accumulated oil in the lateral and upward portion of the wellbore to act as an U-tube device, which behaves similarly to a P-trap in a household drain, allowing the steam to remain on the injector side of the wellbore and maximize growth of the steam zone in the reservoir where it is more effective.

[0100] Another specific objective is to use the produced oil, which accumulates in the lateral and upward portion of the wellbore to act as a backpressure system such that the steam bank is prevented from break through by flowing down the wellbore.

[0101] Another specific objective is to use the bottom hole pump and by controlling surface production rates thereby allowing the reservoir pressure to be maintained at a level such that no steam is produced because of the back pressure in the production wellbore.

[0102] Another specific objective is to use the slim-hole drilling in the upward portion of the wellbore to minimize damage to near surface water zones on the "punch-out" or exit side of the wellbore since drilling occurs through a small rock volume limiting the potential for surface zone damages.

[0103] Another specific objective is to use the slim-hole drilling in the upward portion of the wellbore to minimize damage to near surface water zones since the drilling time is very short and fluid loss during the short time is minimized.

[0104] Another specific objective is to use a plurality of parallel uniwells™ simultaneously over a large areal extent to maximize reservoir recovery by minimizing the heat losses laterally from a single uniwell™ and to provide a steam drive process that increases production by literally having a steam front move through the reservoir as a vertical plane.

BRIEF DESCRIPTION OF THE DRAWINGS

[0105] The present invention consists of the wellbore and associated components shown in the figures below:

[0106] **FIG. 1** Shows an overview of the uniwell™, with the downward, the horizontal lateral and the upward sections of the wellbore.

[0107] **FIG. 2** Shows the completed downward and lateral portion of the uniwell™ with the initiation of the pilot hole using a smaller bottom-hole drilling assembly.

[0108] **FIG. 3** Shows the completion of the pilot hole.

[0109] **FIG. 4** Shows and the initiation of the back reaming process to enlarge the pilot hole.

[0110] **FIG. 5** Shows and the initiation of the forward reaming process to enlarge the pilot hole.

[0111] **FIG. 6** Shows the extension of the lateral section of the wellbore below the oil zone and into the under-burden to allow maximum contact of steam in the oil zone. Also shown is upward section.

[0112] **FIG. 7** Shows a field use of the embodiment in steam recovery of heavy oil.

[0113] **FIG. 8** Shows a field use of the embodiment in an in-situ combustion recovery of heavy oil or tar sands.

[0114] **FIG. 9** Shows the flow lines in plan view of a single uniwell™ during a sequence of operational phases in which the movable packer is unseated, moved and re-seated after local oil depletion occurs.

[0115] **FIG. 10** Shows a plurality of uniwells™ located in parallel in a reservoir system.

[0116] **FIG. 11** Shows initial heating of the near wellbore zone to allow communication pathway for heated oil. This is done by a removable downhole heater or less effectively by circulating a hot fluid like steam.

[0117] **FIG. 12** Shows the reamed out open-hole zone which is concentric to the wellbore and used for hot oil communication from the injection zone steam bank to the production perforations.

[0118] **FIG. 13** Shows a block diagram of the operational aspects of the invention.

[0119] **FIG. 14** Shows a block diagram continuing the operational aspects of the invention.

[0120] **FIG. 15** Shows a block diagram continuing the operational aspects of the invention.

[0121] **FIG. 16** Shows the graph of production during a typical operation of the prior art in which a "huff and puff" steam field operation is implemented.

[0122] **FIG. 17** Shows the graph of the almost continuous steam injection operations implemented in this invention, with the non-injection periods for wellbore annulus heating and moving of retractable packers.

[0123] **FIG. 18** Shows the on-off oil production graph in a more detailed version of a part of the production cycle early in the life of the field operations.

[0124] **FIG. 19** Shows the graph of the growth trend in oil production rates as the steam injection continues followed by the natural decline accompanying oil reserves depletion.

Item No.	Description of Elements
1	Uniwell Wellbore
2	Underburden Formations
3	Overburden Formations
4	Entry wellhead on input side.
5	Exit wellhead on punch-out side.
6	Downward section of horizontal well bore
7	Lateral or horizontal section of wellbore
8	Completed upward section of horizontal wellbore
9	Surface of ground
10	Kick off point for start of curved portion of wellbore
11	Drilling Assembly
12	Pilot Hole
13	Upward section of horizontal wellbore after pilot drilling
14	Back reamer Bit
15	Enlarged Wellbore of upward section
16	Drill Pipe
17	Pull back drill rig used in back reaming process
18	Drill rig used in forward reaming process
19	Drill Pipe used in forward reaming process
20	Forward Reaming Bit
21	Overshoot Extension of lateral into underburden
22	Direction of Bit Travel
23	Subterranean Oil Zone
24	Downhole Pump
25	Casing Tubular pipe
26	Liner tubular pipe
27a	Perforations for injection
27b	Perforations for production
28	Drilling Rig
29	Moveable Oilfield Packer
30	Injected Steam Zone or Steam Bank
31	Hot oil flow direction
32	Parallel wellbores
33	Injected gases for combustion front
34	Burned zone behind combustion front
35	Combustion Front
36	Zone of vaporized oil
37	Light Hydrocarbon Zone
38	Hot Produced Oil
39	Downhole Heater
40	Power Cable to Heater
41	Annular steamed communications zone
42	Reamed out annular zone
43	Hydraulic P-Trap effect
44	Steam injection time.
45	Steam soak time
46	Oil production rate decline curve
47a	Oil production cycle period.
47b	Oil daily production rate
47c	Well Shut-in period, zero production rate
48	Wellbore heating period.
49	Oil flow rate increase trend
50	Oil flow rate decreasing trend.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT:

[0125] Referring now to the drawings wherein like reference numerals designate corresponding elements throughout all the figures and referring in particular to **FIG. 1**. an improved method for extracting hydrocarbons according to an example embodiment of the invention includes a wellbore **1** consisting of three primary sections. As shown in steps **100**, **101**, **102**, in **FIG. 13** and in **FIG. 1**, a downward section **6**, a lateral section **7** and an upward section **8** are drilled with conventional oilfield equipment. The downward section **6** has an entry wellhead **4** and is more or less vertically drilled depending on the nature of the recovery operations. Within the scope of this description a horizontal well or horizontal well section means a well or well section, which is substantially at or close to horizontal inclination. The horizontal or lateral section **7** is drilled in the producing oil formation **23**, which is a porous medium containing oil, gas and water in the pore spaces. The upward section **8** is a continuation of the lateral section **7** upward along a predetermined curve to the surface **9**. A steel casing **25** or steel liner **26** depending on the type of well and the location within the formation can line the wellbore **1**. In other embodiments an "open-hole" completion can be used in which there is no steel casing. This can be done in well consolidated rock formations. At the entry end of the well **1** there is an entry wellhead **4** and an exit wellhead **5** is on the distal end.

[0126] Perforations **27***b*, **27***a* are made in the casing to allow oil to be produced or in the case of injection operations to allow injected fluids to enter the oil zone **23**. The oil zone **23** is overlain by an overburden **3** and under-burden zone **2**. These zones are impermeable and trap the hydrocarbons in the oil zone **23** and from which oil production is possible when the well **1** drilled into the oil zone.

[0127] Referring to **FIG. 2**, a drilling assembly **11** is used to drill through the formations. This assembly is connected to the drill rig **28** at the surface by a drill pipe **16**. In some cases the bottom hole assembly consists of a downhole motor and a drill bit. In other cases coiled tubing can be used instead of drill pipe. All the drilling practices are well known in the industry and are not part of this invention. The point where the vertical hole section **6** changes to a horizontal section **7** is called the kickoff point **10**. Referring to **FIG. 3**, a small pilot hole **12** is that portion of wellbore **12**, which extends from the lateral section **7** to the surface **9** along a predetermined path **13**.

[0128] Referring to **FIG. 4**, the back reaming process shown in step **101** is implemented, using the back-reamer bit **14** which travels through the pilot hole **12**. The bit **14** is pulled backwards by pull back drill rig **17** at surface **9** using the drill pipe **16**. The enlarged hole **15** develops behind the reamer bit **14**. Referring to **FIG. 5**, a forward reaming process is subsequently implemented by using the forward reamer bit **20** is connected to the drill rig **18** at the exit end **5** by drill pipe **19**. The reamer bit **20** moves in a forward direction **22** as it moves down the pilot hole **12** while the rig **18** rotates the reamer bit **20**. In **FIG. 6**, the lateral section **7** can be extended **21** below the oil zone **23** and into the under-burden **2** in order to extend the range of the well and allow more gravity effect on production in the vertical direction. A downhole pump **24** is shown in this embodiment. The pump is used to lift the produced fluids to the surface as needed.

[0129] **FIG. 7** shows an embodiment of the invention for steam recovery of heavy oil. In a conventional steam recovery process, steam usually generated on the surface using combustion boilers or as a by product of a electric power cogeneration operation, is injected into the injector wellbore to heat the heavy oil, decrease its viscosity and drive it towards a producer well some distance away from the injector. Referring to **FIG. 11**, as indicated in steps **103** and **104***b* of **FIG. 13** in this embodiment, a downhole heater **39** is used to conductively preheat a near wellbore annular region **41** to a relatively high temperature of several hundred degrees Fahrenheit between 300 F and 700 F, in a short time. This temperature is sufficient to increase the rock permeability, lower the in-situ hydrocarbon viscosity significantly, raise the rock porosity and increase the oil saturation in the heated zone. After this preheat operation is implemented for a sufficient period of time, the downhole heater is removed. Referring to **FIG. 7**, in this embodiment, steam **30** is injected into the oil zone **23** through perforations **27***a* which are strategically placed in the well casing **25**. As indicated in step **105** the steam is prevented from traveling down the wellbore by a movable packer **29**, which separates the steam injector section from the oil production section. In an "open hole" completion, this packer **29** can be a retractable inflatable packer in those situations where the well is completed without a casing **25**. This blocking packer is retracted and moved along the axis of the lateral **1** as the steam zones are depleted and new oil production occurs as the processes are repeated.

[0130] During the recovery process, the steam forms a zone or steam bank **30** in which oil is heated creating a tremendous drop in viscosity allowing the oil to flow easier. A viscosity drop from 10,000 cp at reservoir conditions to 2 cp at steam conditions is possible. The annular region pre-heated in step **104***b* by the downhole heater provides a high conductivity communication path **41** and driven by gravity and other hydraulic forces, the hot low-viscosity oil **38** moves to the lower downstream perforations **27***b* as shown in step **108** of **FIG. 14**. As hot oil **38** accumulates in the lateral section **7** and fills the wellbore, it provides a hydraulic "P-trap" effect **43** shown in **FIG. 6**, which acts as a backpressure valve preventing the bypass of steam from the upper perforations **27***a* to the lower perforations **27***b*. In one embodiment, the wellbore segment liquid can be pressured from the surface with natural gas or some inert gas to help implement the "P-trap" effect pneumatically in addition to hydraulically. As indicated in step **109** of **FIG. 14**, by modulating production rates a process called "choking" in the industry, this backpressure can be used to minimize and prevent any steam bypass in step **110**. Oil is produced with a pump **24** if the pressure is insufficient to flow to the surface or it can flow to the surface if the driving pressure is sufficiently high. As can be seen from the physical implementation of this new embodiment the heated oil **38** travels only a few feet, a significantly shorter distance in the steam zone **31** to the producing perforations **27***b*. This compares to the very large inter-well distances of several hundred feet, through cold highly viscous oil zones with limited transmissibility that the hot oil has to travel in conventional steam floods as shown in Ref. 3. The new embodiment shown herein allows oil recovery to begin almost instantaneously via the highly communicative annular zone developed by the preheat process described above. This is in stark comparison to the long steam injection and steam soak times needed for the conventional steam flood to displace oil to the producer well.

[0131] Referring to **FIG. 8** which shows an embodiment of the invention in in-situ combustion recovery of heavy oils or tar sands also called a fireflood. In this embodiment, a downhole heater **39** is used to conductively preheat a near wellbore annular region **41**. After this preheat the downhole heater is removed. Air **33** is then injected down the downward section **6** of the uniwell™ through perforations **27***a* and into the oil zone **23**. Following the operations of a typical fireflood a combustion front **35** is initiated in step **107***a*. This burning front **35** creates a zone of vapors **36** and a zone of light hydrocarbons **37** ahead of the combustion front. In the conventional fireflood, the intent is to heat the oil to drop the viscosity and move the free flowing oil towards the producer wellbore several hundred feet distance away. In this embodiment as the combustion front moves forward through the reservoir, the heated oil **38** decreases in viscosity and it flows downwards under gravity and other physical forces to the wellbore **1** and through the highly permeable annular communication zone **41** and enters through the perforations **27***b*. As can be seen from the physical implementation of the embodiment the heated oil travels a significantly shorter distance from the combustion zone **35** to the producing perforations **27***b* and not needing to flow through a cold formation. This compares to the very large inter-well distances through cold highly viscous oil zones with limited transmissibility, that the front has to travel in conventional combustion floods as shown in Ref. 3. The new embodiment shown herein allows oil recovery to begin almost instantaneously compared to the long combustion times needed for the conventional fireflood to displace oil to the producer well. Oil recovery begins in days via the highly communicative annular zone developed by the early preheat process, rather than in months and years under conventional combustion processes and this time shortened time factor increases the economic viability and profitability of the overall process.

[0132] Referring to **FIG. 9 a** plan view of an embodiment is shown in which two cycles of injection and production are superimposed. The first cycle show the stream flow lines **30** from steam injected into the wellbore perforations **27***a* and the oil produced from the wellbore perforations **27***b*. After a prescribed time interval, the downhole packer **29** is moved down from position 'a' to position 'b' in the wellbore between the next set of injection and production perforations. A new cycle of operations is initiated as shown in **FIG. 15**, steps **113**, **114**, **115***a*, **115***b* and **116**. The downhole heater **39** is re-installed and the new wellbore annular zone is heated to provide a high conductivity zone for hot fluid movement. Next the first production perforation is converted to steam injection and the oil is produced into the wellbore from the next perforation set along the axis of the lateral wellbore. The stream flow lines **31** are shown in the figure. Continued steam injection can still occur in the first set of steam perforations or they can be plugged off if needed to allow the steam front to advance more rapidly.

[0133] Referring to **FIG. 10 a** plurality of parallel wellbores **32** used in an embodiment is shown. This parallel approach allows a planar displacement of oil by the injected steam as injection continues into the reservoir.

[0134] Referring to **FIG. 11** the initiation of a flow channel **41** is shown. It is made by initially heating the area around the lateral wellbore **7** by using a removable downhole heater **39** which heats the rock to between 300 F and 700 F. This heating lowers the oil viscosity, increases the rock porosity and permeability and lowers the water saturation in the near wellbore region opposite the downhole heater. It is possible but not nearly as effective to form the communication zone by injecting steam for a few days through the first sets of injectors to allow the zone around the wellbore to be heated and to lower the viscosity of oil in place in this near wellbore region.

[0135] Referring to **FIG. 12** which shows another embodiment of the invention in which a section of the lateral wellbore **7** is reamed out in step **104***a* during the drilling process to make a large open-hole annular zone section **42**. This annular cylinder **42** around the wellbore forms the communication zone through which the produced fluids **38** move from the steam zone **30** to the production zone. The steam is injected down the wellbore **6**, the wellbore packer **29** diverts the steam into the cold formation **23** where a steam chamber **30** develops. The formation oil is heated by the steam and flows down the sides and periphery walls of the steam chamber under gravity towards the bottom of the steam chamber. The produced oil and condensed steam flow down the reamed out zone **42** towards the bottom of the wellbore. In this embodiment the produced fluids accumulate in the lateral wellbore **7** and fill the production string.

[0136] A novel aspect of this invention is the use of the heated oil in the wellbore sections to act as a hydraulic pressure control and a flow control device. By modulating the production of the fluid produced the process creates a back pressure and a fluid "P-trap" seal in the lateral section of the wellbore which prevents the injected steam from bypassing the cold formation and forcing the steam to remain in the steam bank zone and then to grow vertically.

[0137] Operationally the drilling operation is summarized as follows; the downward portion **6** is drilled in a conventional manner, at the kickoff point **10** the lateral portion **7** is drilled using the typical horizontal drilling operations found in the oilfield today. At the start of the upward portion **8**, the drilling assembly is changed to allow the process to continue less expensively with a slim hole assembly **11**, which employs a smaller bit to drill the pilot hole to the surface along a planned trajectory **12**. On reaching the exit end on the surface the pilot hole **12** is reamed out to a larger size by either a back reamer **14** or by using a forward reamer bit **20**. The extension **21** of the lateral below the oil zone **23** is a simple modification of the basic drilling process. In a similar manner the completion processes which include cementing of casings, perforating of casings, or setting of liners in the wellbore, installing of pumps and valves are basic processes in the oil drilling industry and are well known to all versed in the art.

[0138] In engineering the steam injection operation, a computer or simulation analysis is routinely used in the industry to calculate the optimal required injection time of steam into the hydrocarbon bearing formation for optimal oil recovery. This analysis incorporates steam flow rate, steam quality, steam pressure, formation rock properties, oil saturation and depth of formation from the surface.

[0139] In this invention, during the earliest steam injection time only, the production of hot oil is maintained at zero to allow the oil to accumulate in (a) the bottom of the steam bank, (b) in the vertical communication zone and (c) in the wellbore segment. This accumulated hot oil behaves as a hydraulic seal preventing steam from bypassing the formation and flowing into the wellbore. In alternative embodiments, the backpressure system described herein prevents the production of oil into the wellbore. These no-flow embodiments are essential and by preventing oil flow, they allow a steam bank to grow since the injected steam is forced to enter the formation directly heating the rock and in-situ hydrocarbons.

[0140] After the requisite injection time, which is nominally a matter of days, the production of hot oil and condensed water is initiated by permitting the removal of hot fluids from the wellbore via the production system or by lowering the backpressure on the fluid column in the wellbore. After the production of accumulated hot oil is complete as evidenced by the incipient flow of dry steam detectable at the surface, the fluid production is shut down and the accumulation of hot oil and condensed water at the bottom of the steam bank resumes. It should be noted that in this invention, except as noted later, steam injection is a continuous operation and the oil production phase is started and stopped at specific operational conditions during this thermal recovery process.

[0141] This invention differs significantly from the prior art in its implementation in the field. The ability of the well to be produced very soon after steam injection begins, allows oil revenue to begin almost immediately. Furthermore the volumetric flow rate of oil remains relatively constant while the steam bank is growing and can even increase as cumulative steam injection occurs. This is due to the larger volume of rock being contacted and heated thus lowering the oil viscosity and also by increasing the vertical extent of the steam bank, the gravity effect on the oil flow column is increased, both results contribute to increased oil flow rates.

[0142] A typical response of a steam heated heavy oil reservoir using the prior art of huff and puff operations is shown in **FIG. 16**. It should be noted that after the steam injection time **44**, steam injection is curtailed and after the soak time **45**, the well is put on production as shown in curve element **46**. There is an initial increase in oil production rate which immediately declines exponentially to the un-stimulated level after a number of days. This process is repeated several times to fully develop the steam operations and deplete the oil reservoir.

[0143] On the other hand, the invention described herein, provides for a very different set of operations. **FIG. 17** shows the steam injection period **44** followed by the period **48** in one embodiment in which the wellbore heater **39** is installed in the wellbore and is operated for a fixed time, and during which time the packer **29** is also moved along the wellbore. Note that the steam injection rate is essentially constant, however in practice it is usually necessary to increase the injection rate over time to offset the heat losses as the steam bank increases in size.

[0144] **FIG. 18** shows a more detailed set of operational data where the well production is intermittent. This occurs early in the steam operations since the steam zone or steam bank **30** is still small and growing and the accumulated oil **38** is insufficient to be produced continuously without compromising the hydraulic seal **43** and allowing steam breakthrough in the communication zone **41** and the wellbore **1**. This figure shows the oil production rate **47***b* and the oil shut-in period **47***c*.

[0145] As the steam bank **30** grows, there is more reservoir formation **23** volume available for oil production and there is a concurrent increase in the oil production rate as shown by the trend line **49** in **FIG. 19**. This trend continues to a maximum point after which there is an inevitable decline due to heat losses, oil depletion and other factors as shown by trend line **50**.

[0146] Given the increased oil flow rates which begin soon after steam injection, coupled with the growth of the steam bank by almost continuous steam injection, as opposed to the intermittent injection of the prior art huff and puff method; and the concurrent oil production increase, this invention provides for an improvement in the technology and prior art in a manner which allows significant rapid development of hydrocarbon reserves from heavy and viscous oil from subterranean formations with existing equipment and field operations applied in a manner that has been heretofore lacking.

[0147] Various modifications and alterations of this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention and it should be understood that this invention in not unduly limited to that set forth herein for illustrative purposes.

[0148] In this patent certain U.S. patents, patent applications, and other materials (e.g., articles) have been incorporated by reference. The text of such U.S. patents, U.S. patent applications, and other materials is, however, only incorporated by reference to the extent that no conflict exists between such text and the other statements and drawings set forth herein. In the event of such conflict, then any such conflicting text in such incorporated by reference U.S. patents, U.S. patent applications, and other materials is specifically not incorporated by reference in this patent

[0149] Further modifications and alternative embodiments of various aspects of the invention may be apparent to those skilled in the art in view of this description. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the general manner of carrying out the invention. It is to be understood that the forms of the invention shown and described herein are to be taken as the presently preferred embodiments. Elements and materials may be substituted for those illustrated and described herein, parts and processes may be reversed, and certain features of the invention may be utilized independently, all as would be apparent to one skilled in the art after having the benefit of this description of the invention. Changes may be made in the elements described herein without departing from the spirit and scope of the invention as described in the claims.

[0150] References:

[0151] 1 Robbins Horizontal Drilling, 29100 Hall St, Solon, Ohio 44139. www.robbinstbm.com

[0152] 2. The Crossing Company Inc.,1807-8th Street, Nisku, Alberta, Canada T9E 7S8, www.thecrossingcompany.com

[0153] 3. Improved Oil Recovery—Exxon Background Series (1982), NY. NY 10020.

[0154] 4. The Society of Petroleum Engineers 222 Palisades Creek Dr., Richardson, Tex. 75080, U.S.A. www.spe.org.

[0155] 5. "A Comparison of Mass Rate and Steam Quality Reductions to Optimize Steamflood Performance", Topical Report 108, Gregory L. Messner, July 1998, Stanford University, Stanford, Calif.

What we claim is:

1. A method for recovering hydrocarbons from a subterranean formation containing viscous oil or other heavy hydrocarbons; the method comprising the steps of:

(a) drilling at least one wellbore comprising a vertically drilled downward section, a lateral section and an upward section, in the hydrocarbon bearing formation by penetrating the formation with conventional drilling equipment;

(b) providing a wellhead at the entrance or proximal end of the wellbore and another wellhead at the exit or distal end of the wellbore;

(c) providing a plurality of perforations in the wellbore at pre-selected intervals;

(d) installing a downhole wellbore packer between upper and lower perforations;

(e) forming an annular hot zone of increased fluid conductivity near the said wellbore in the said formation to facilitate vertical flow of heated low viscosity oil and hot water produced from condensed steam, towards lower production perforations;

(f) heating the said formation by injecting a displacing fluid into the formation;

(g) lifting the produced oil and displaced fluids to the surface.

2. The method of claim 1, wherein the said formation is heated by injecting steam through upper perforations as a displacing fluid.

3. The method of claim 2, wherein the injected steam heats the wellbore and surrounding formation for sufficient time and at a calculated temperature.

4. The method of claim 1, wherein the said hot annular zone is formed by installing and initiating a downhole heater for a predetermined time greater than 24 hours, and at a predetermined temperature.

5. The method of claim 1, wherein the said formation is heated by transmitting heat energy to the said formation by using a combustion front.

6. The method of claim 1, wherein the said formation is heated by transmitting heat energy to the said formation by using a steam chamber or steam bank.

7. The method of claim 1, wherein the driving pressure of produced oil and displaced fluids is sufficiently high to push the produced oil and displaced fluids to the surface.

8. The method of claim 1, further comprising the steps of:

installing a fluid recovery system to lift the produced oil and displaced fluids to the surface, wherein the produced oil and displaced fluids are lifted to the surface by using the said fluid recovery system.

9. The method of claim 8, wherein the said fluid recovery system comprises a production pump.

10. The method of claim 1, wherein the step of drilling the upward section of the wellbore comprises the steps of:

drilling a small pilot hole upwards to the exit end of the wellbore with a small drilling assembly and bit; and

enlarging the upward section of the said wellbore.

11. The method of claim 10, wherein the step of enlarging the upward section comprises the steps of:

installing a back-reamer bit, connected to the pull back drill rig at the entrance of the wellbore by a drill pipe; and

pulling the said back-reamer bit to travel from the exit end of the wellbore through the small pilot hole to the entrance, to enlarge the upward section of the said wellbore.

12. The method of claim 10, wherein the step of enlarging the upward section comprises the steps of:

installing a forward-reamer bit, connected to the drill rig at the exit end of the wellbore by a drill pipe; and

rotating the said forward-reamer bit and pushing it forward to travel from the exit end of the wellbore through the small pilot hole to the entrance, to enlarge the upward section of the said wellbore

13. The method of claim 1, further comprising the step of cementing a steel casing in the wellbore in the said formation.

14. The method of claim 1, wherein the wellhead at the proximal end of the wellbore is an injection wellhead.

15. The method of claim 1, wherein the wellhead at the distal end of the wellbore is a production wellhead.

16. The method of claim 1, wherein the perforation zones in the wellbore are positioned as paired groups or couplets.

17. The method of claim 16, wherein the proximal perforations in the pair group form an injector set of perforations.

18. The method of claim 16, wherein the next or distal set of perforations in the pair group forms a producer set of perforations.

19. The method of claim 1, wherein the downhole packer in the wellbore is placed between the injector and producer pair of perforations separating the injection and production zones.

20. The method of claim 1, wherein the downhole packer forces the injection fluid to be to exit the wellbore and be injected into the hydrocarbon bearing formation.

21. The method of claim 1, wherein the downhole packer is retractable and be either solid or inflatable.

22. The method of claim 1, wherein the injected fluid is steam.

23. The method of claim 1, wherein the injected fluid forms a steam bank or chamber in the hydrocarbon reservoir.

24. The method of claim 1, wherein the said hot annular zone is formed by installing a reaming device and reaming out a portion of the said formation, thereby enlarging the said wellbore substantially.

25. The method of claim 24, wherein the reamed zone is concentric to the wellbore.

26. The method of claim 24, wherein the reamed zone forms an axial communication zone for fluid flow from the steam bank to the production zone perforations.

27. The method of claim 1, wherein the downhole packer is moved axially along the wellbore to new hydrocarbon rich formations to carry out the said method, after each steam displacing zone is depleted of hydrocarbons.

28. The method of claim 1, further comprising the step of:

installing a downhole backpressure valve in the said wellbore to create a backpressure to prevent the injected steam from bypassing downwards into the production perforations.

29. The method of claim 1, wherein the accumulation of produced hot oil in the lateral section is controlled by controlling the fluid production rate at the distal end of the wellbore, to provide a hydraulic "P-trap" effect, which acts as a backpressure valve preventing the bypass of steam from the upper perforations to the lower perforations.

30. The method of claim 29, wherein the said wellbore is pressured from the surface with natural gas or some inert gas to implement the "P-trap" effect pneumatically in addition to hydraulically.

31. The method of claim 1, wherein the injected fluid is air.

32. The method of claim 1, wherein the injected fluid is a combination of steam and heated water.

33. The method of claim 31, wherein the injected air provides the oxygen needed for combustion front of the in-situ hydrocarbon.

34. The method of claim 1, wherein the angle of the lateral section of the wellbore in the formation ranges between zero (0) degrees to 90 degrees from the horizontal.

35. The method of claim 4, wherein the downhole heater remains in place substantially long enough to heat radially, a preferred annular distance of at least two feet around the wellbore.

36. The method of claim 4, wherein the downhole heater is retractable and moveable.

37. The method of claim 1, wherein the heating of the annular communication zone increases the porosity of the reservoir formation in the annular region.

38. The method of claim 1, wherein the selective heating of the annular communication region increases the permeability of the reservoir formation in the communication zone.

39. The method of claim 1, wherein the selective heating of the annular communication region decreases the water saturation of the reservoir formation in the communication zone.

40. The method of claim 37, wherein the increased reservoir rock formation porosity increases the fluid transmissibility of the rock to oil flow in the annular communication zone.

41. The method of claim 38, wherein the increased reservoir rock formation permeability increases the fluid transmissibility of the rock to oil flow in the annular communication zone.

42. The method of claim 39, wherein the decreased reservoir rock formation water saturation increases the fluid transmissibility of the rock to oil flow in the annular communication zone.

43. The method of claim 1, wherein the lateral wellbore section extends substantially below the hydrocarbon formation.

44. The method of claim 29, wherein the P-trap is used for controlling the flow of produced oil in the wellbore.

45. The method of claim 1, wherein the displacing fluid is injected intermittently.

46. The method of claim 1, wherein the displacing fluid is injected continuously.

47. The method of claim 1, wherein the produced fluids are recovered intermittently.

48. The method of claim 1, wherein the produced fluids are recovered continuously.

49. The method of claim 19, wherein the downhole retractable packer completely separates the injection perforations from the production perforation in the wellbore.

50. The method of claim 1, wherein the heated annular zone extends substantially from below the base of the injection perforations to the top of the production perforations

51. The method of claim 1, wherein maintaining a prescribed oil level in the wellbore controls the vertical steam flow.

52. The method of claim 51, wherein maintaining a prescribed oil level in the wellbore prevents the flow of steam bypassing the cold formation and flowing to the production perforations.

53. The method of claim 1, comprising a plurality of parallel wellbores simultaneously over a large areal extent to maximize oil recovery by minimizing the heat losses attributed to each wellbore.

54. The method of claim 4, wherein the said temperature ranges between 300 deg. F and 600 deg. F.

55. The method of claim 3, wherein steam is injected until the formation is depleted of movable oil.

56. The method of claim 3, wherein the injected steam heats the formation to a temperature above 212 deg. F.

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