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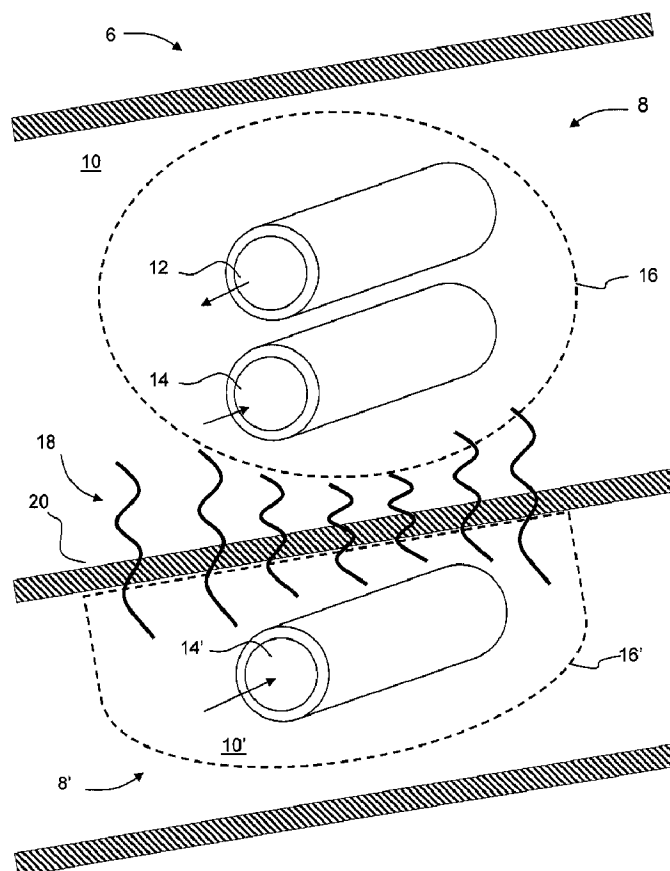
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(54) Titre : PROCÉDES DE RECUPERATION ASSISTÉE PAR CHAUFFAGE PASSIF

(54) Title: PASSIVE HEATING ASSISTED RECOVERY METHODS



(57) Abrégé/Abstract:

A method for producing hydrocarbons from a region having adjacent strata divided by an impermeable or partially permeable barrier and, wherein at least one of the strata contains hydrocarbons, comprises of sufficiently heating one of the stratum to allow

**(57) Abrégé(suite)/Abstract(continued):**

heat to be conducted to the hydrocarbon containing stratum and producing hydrocarbons therefrom. In one aspect, both strata contain hydrocarbons, such as bitumen, and heat is generated by a steam assisted gravity drainage process to the adjacent stratum. Heat may also be generated by in-situ combustion of hydrocarbons to preheat an adjacent stratum, or by electrical heating. Once pre-conditioned to a higher in-situ temperature, hydrocarbon production may be facilitated by diluting the target pre-heated hydrocarbon bearing stratum with solvent injection.

**ABSTRACT**

A method for producing hydrocarbons from a region having adjacent strata divided by an impermeable or partially permeable barrier and, wherein at least one of the strata contains hydrocarbons, comprises of sufficiently heating one of the stratum to allow heat to be conducted to the hydrocarbon containing stratum and producing hydrocarbons therefrom. In one aspect, both strata contain hydrocarbons, such as bitumen, and heat is generated by a steam assisted gravity drainage process to the adjacent stratum. Heat may also be generated by in-situ combustion of hydrocarbons to preheat an adjacent stratum, or by electrical heating. Once pre-conditioned to a higher in-situ temperature, hydrocarbon production may be facilitated by diluting the target pre-heated hydrocarbon bearing stratum with solvent injection.

## PASSIVE HEATING ASSISTED RECOVERY METHODS

### FIELD OF THE INVENTION

[0001] The present invention relates to the production of hydrocarbons from petroleum deposits by in-situ recovery techniques. More specifically, the invention relates to a process employing heat conduction from a first stratum to pre-condition a second stratum containing hydrocarbons such as heavy oil or bitumen, thereby permitting the enhanced recovery of such hydrocarbons.

### BACKGROUND OF THE INVENTION

[0002] Petroleum deposits of crude oil demonstrate significant variations across in-situ reservoir and fluid properties. Deposits of high viscosity or low API gravity oils (higher density oils) can grade from increasingly difficult to economically produce to being uneconomic to produce under initial reservoir conditions. The limiting physical properties of heavier oils controlling economic flow rates to producing wells, such as the oil viscosity, can be strongly improved by heating. At a higher initial in-situ temperature, a range of recovery techniques that would otherwise not be economically feasible can become effective.

[0003] Oil sand deposits are found predominantly in the Middle East, Venezuela, and Western Canada. The Canadian bitumen deposits, being the largest in the world, are estimated to contain between 1.6 and 2.5 trillion barrels of oil, so the potential economic benefit of this invention carries significance within this resource class. The term "oil sands" refers to large subterranean land forms composed of reservoir rock, water and bitumen. They comprise layers of bitumen-rich deposits, which may be internally continuous permitting vertical fluid flow, or otherwise segregated with flow barriers into discrete, adjacent layers. Bitumen is a heavy, black oil which, due to its high viscosity, cannot readily be pumped from the ground like other crude oils. Therefore, alternate processing techniques must be used to extract the bitumen deposits from the oil sands, which remain a subject of active development in the field of practice. The basic principle of known extraction processes is to lower the viscosity of the bitumen by applying heat, injecting chemical solvents, or a combination thereof, to a deposit layer, thereby promoting flow of the material throughout the treated reservoir area, in order to allow for recovery of bitumen from that layer.

[0004] Figure 1 illustrates the relationship between bitumen viscosity and temperature, for a range of oils identified according to API gravity, or oil density. Referring to the curve for an 8 API oil, commonly within the range of Canadian Athabasca bitumen, it can be seen that at in-

1 situ conditions of approximately 10°C, the bitumen viscosity is in the range of 6 - 7 million  
2 centipoise. However, for even a modest temperature increase of 40°C, the bitumen viscosity at  
3 50°C decreases dramatically to 20,000 cp, while in extending the formation temperature to  
4 100°C, the viscosity would fall to less than 1,000 cp. At these reduced viscosity values, the  
5 crude's ability to flow to a producing wellbore is markedly increased. More significantly,  
6 however, the effectiveness of alternate recovery techniques applied to such a preconditioned  
7 reservoir oil becomes greatly enhanced. The application of recovery strategies to an externally,  
8 or passively, pre-heated reservoir volume forms the basis of the present invention.

9 **[0005]** A variety of known extraction processes are commercially used to recover bitumen  
10 from oil deposits. For example, Steam-Assisted Gravity Drainage, commonly referred to as  
11 SAGD, involves the injection of steam into a bitumen-containing deposit in order to directly  
12 transfer heat to the oil. Steam is a preferred fluid as the latent heat of steam, defined as the  
13 heat released when a molecule condenses from vapour to liquid phase, is one of the highest per  
14 molecule among all known fluids. This allows the maximum heat transfer per volume of cycle  
15 fluid externally introduced into the reservoir. The heat from the injected steam reduces the  
16 viscosity of the bitumen and results in mobilization of same. As known in the art, a SAGD  
17 process results in condensation of the steam into liquid water, which is in effect introduced into  
18 the reservoir as a collateral contaminant to the heat transfer process through the physical phase  
19 change of the water. The mobilized bitumen must therefore flow with the introduced water,  
20 where the relative permeability of the water/oil mixture is reduced, leading to potentially poorer  
21 oil productivity and overall recovery. In addition, the mixture can form emulsions within the  
22 deposit, which block, or retard, bitumen flow. The water is also recovered with the bitumen,  
23 necessitating additional costs for pumping, separation and treating at surface, while also acting  
24 to remove heat within the produced fluid volumes. Consequently, while water is a pragmatic  
25 heat transfer medium, it also introduces a range of undesirable consequences for bitumen  
26 recovery.

27 **[0006]** Furthermore, the SAGD process is only an economically feasible option for larger  
28 deposits as measured by metrics of minimum formation thickness or bitumen volume. For  
29 example, it is common in the art to use SAGD processes only on deposits having a threshold  
30 thickness, commonly greater than 15 - 20 m, dependent on specific considerations such as ore  
31 grade or economic limitations subject to the evolving fiscal regime. The economics of a SAGD  
32 process are directly influenced by the costs of handling the water circulation through the  
33 reservoir. Consequently, an alternate technique to remove the need for water handling in

1 heating a formation would be of strong economic benefit. Such a process can be achieved by  
2 heating an oil deposit externally, where the complications developed in the art introducing heat  
3 into a reservoir directly, or from within a producing zone, are eliminated.

4 **[0007]** Dilution is another technique with potential application in the extraction of bitumen  
5 from oil sand or heavy oil deposits. A dilution process involves the injection of a physical  
6 solvent, such as light alkanes or other relatively light hydrocarbons, into a deposit, similar to the  
7 procedure used in steam injection, to dissolve heavy oil or bitumen in the solvent. This  
8 technique also reduces the viscosity of the bitumen, thereby allowing the recovery of the  
9 bitumen-solvent mixture that is mobilized throughout the reservoir. Condensing hydrocarbon  
10 solvents have also been proposed in the literature, where a reduced level of heat is introduced  
11 in the reservoir from the vapour to liquid phase change, in addition to the subsequent solvent  
12 dilution effect. See for example: Nenniger, J. E. and Dunn, S.G., "*How Fast is Solvent Based*  
13 *Gravity Drainage?*", CIPC 59<sup>th</sup> Annual Technical Meeting, Calgary, June 17 – 19, 2008, paper  
14 2008-139). However, the condensing hydrocarbon strategy is a further example where heat is  
15 introduced directly to the produced zone by means of the working fluid.

16 **[0008]** Solvents that can be used in effective dilution strategies include lower molecular  
17 weight alkanes (ethane through to dodecane), common transportation diluent mixtures,  
18 kerosene, naphta, flue gas and carbon dioxide. Carbon dioxide may be of particular interest as  
19 large quantities may otherwise be available from such processes as steam generation.  
20 Immiscible carbon dioxide injection is demonstrated to have a strong effect on bitumen viscosity  
21 reduction and can be re-circulated in a recovery process to permit a level of ultimate  
22 underground storage, or sequestration.

23 **[0009]** It is increasingly common to apply a combination of heat and dilution processes in  
24 order to recover an economically significant amount of bitumen from solvent-assisted steaming  
25 processes. Solvent aided or solvent assisted processes, SAP techniques, involve the addition  
26 of a hydrocarbon solvent to steam. Some modest success has been reported with SAP  
27 techniques, which are currently under active development. However an inherent difficulty with  
28 SAP techniques remains the introduction of liquid water into the reservoir. Water acts as an  
29 effective barrier to solvent, limiting the full efficiency of solvent in a SAP process. Thus, known  
30 SAP processes remain disadvantageous by introducing water into the reservoir.

31 **[0010]** Consequent to the net removal of bitumen and related fluids from a reservoir,  
32 pressure depletion would develop within the deposit. This could deter from bitumen production  
33 by impeding the reservoir energy for artificial lift of fluids to surface, or create a pressure sink for

1 fluid migration, such as in bounding water zones, to enter the treated zone. The above  
2 mentioned recovery processes use the injection of fluids, such as steam or solvents, to replace  
3 the volume occupied by the extracted bitumen within the deposit, thus preventing the  
4 development of reservoir pressure depletion.. The injection of a solvent, such as for example  
5 CO<sub>2</sub>, to replace reservoir voidage within a preheated working chamber can be used to  
6 advantage as both providing pressure maintenance and as a dilution agent as outlined in this  
7 invention.

8 **[0011]** Thermal processes for bitumen recovery within a deposit inherently involve heat  
9 losses to surrounding rock strata. Due to the physical nature of a petroleum deposit, heat  
10 introduced into a bitumen reservoir is dissipated throughout the target area and is conducted to  
11 surrounding structures including adjacent hydraulically isolated bitumen deposits. This results  
12 in higher process cost, as a portion of the energy supplied to heat the target bitumen area is  
13 transferred to other regions within the deposit, resulting in a loss of thermal efficiency.

14 **[0012]** The prior art methods of bitumen recovery have focused primarily on transferring  
15 heat directly to or generating heat directly within the targeted reservoir and extracting production  
16 directly from the same single hydraulically continuous stratum within an oil sand or heavy oil  
17 reservoir. This strategy is logically inherent to a steaming process, as the highest temperature  
18 with more favoured changes or improved bitumen characteristics (lowest viscosity) is achieved  
19 at the entry point of steam injection within a reservoir. Prior to further heat losses, heavy oil or  
20 bitumen removed at this point has the best physical flow properties for optimal productivity  
21 and/or recovery. Heated bitumen, initial formation waters, water condensed from injected steam  
22 and non-condensable gases are extracted from the formation to which heat was initially  
23 supplied. Heat losses to the bounding formation is accepted as a necessary physical  
24 consequence of the thermal process in a SAGD operation. Consequently, SAGD suffers from  
25 both thermal inefficiencies of heat losses outside of the producing formation and further heat  
26 losses from produced fluids within the formation.

27 **[0013]** Such prior art techniques have attempted to overcome some issues of heat loss due  
28 to lateral heat conduction to horizontally adjacent areas by incorporating a plurality of heaters,  
29 isolating the treatment area by frozen barriers, and by electrically heating an internal non-  
30 bitumen rock layer, such as an internal sequence of shale stringers, to allow heat to transfer  
31 internally directly to the desired bitumen-rich layer.

32 **[0014]** For example, U.S. Patent No. 6,991,032 and 7,225,866 disclose a modified thermal  
33 process for bitumen extraction using an arrangement of several heating wells and several

1 production wells dispersed throughout a single deposit layer. U.S. Patent No. 7,073,578  
2 describes a thermal process for heating two sections of a single deposit using two sets of  
3 heating sources, one for each section, and leaving a third, unheated section between them.

4 **[0015]** There are several patents describing recovery techniques for extracting kerogen  
5 from solid oil shale layers within an oil sand deposit. For example, U.S. Patents No. 4,886,118;  
6 6,722,431; and 7,040,400 refer specifically to the recovery of kerogen from an oil shale layer  
7 within a single deposit. They relate to a deposit having layers of varying permeability that are  
8 conductively heated from either a heat source applied to another portion of the deposit, or  
9 applied directly to the oil shale layer.

10 **[0016]** Other examples of known bitumen recovery processes are provided in the following:  
11 U.S. Patent No. 7,077,198; U.S. Patents No. 4,926,941; 5,042,579 ; 5,060,726; and  
12 WO/2008/048454

13 **[0017]** In general, the prior art methods have primarily focused on producing bitumen from  
14 within a single reservoir or stratum. However, in some cases, bitumen deposits are located in  
15 vertically adjacent reservoirs or stratum separated by a natural barrier. Such barriers  
16 hydraulically restrict the movement of fluids between layers, but do not restrict heat transfer  
17 between layers as the reservoir rock in such barriers does not provide an insulating capacity  
18 limiting heat conduction. Such barriers may be a geological formation, such as rock, shale, or  
19 mudstone. In such cases, it is common for a separate heating and production process to be  
20 carried out for both strata, where specific economic criteria permit (such as adequate pay  
21 thickness, hydrocarbon saturation and reservoir permeability). If the economic criteria for  
22 individual layer exploitation are not met, then either all or a subset of the layers may not be  
23 exploitable by SAGD. Further, in the case of SAGD, the injection of steam in both regions  
24 extends the problems associated with the mixing of water and bitumen and related thermal  
25 inefficiencies. Therefore, there exists a need for an improved bitumen recovery process.

26 **[0018]** Consequently, the essence of the invention is to provide a means to precondition a  
27 reservoir oil volume by indirect, or passive heat conduction from heat-generating operations in  
28 an adjacent, hydraulically isolated layer. Once heated, a range of techniques for production  
29 operations in the adjacent layer can then be optimally designed and applied.

## 1 SUMMARY OF THE INVENTION

2 **[0019]** The invention disclosed herein relates to an improved thermal process for oil sands  
3 and/or heavy oil recovery utilizing heat conduction losses from one stratum to recover bitumen  
4 in an adjacent stratum.

5 **[0020]** In one aspect, the invention provides a strategy being an improvement over the art  
6 herein discussed, overcoming the consequences of water contamination during steam heating  
7 and the need to actively preheat, or otherwise condition, a solvent prior to bitumen dilution.

8 **[0021]** In one aspect of the invention, a SAGD, steam-assisted gravity drainage thermal  
9 process for extracting bitumen from a primary target stratum is used and a secondary bitumen  
10 recovery system is placed in an adjacent stratum of the oil deposit. In one embodiment, the  
11 secondary stratum is above or below the primary target stratum. This secondary zone is  
12 separated from its adjacent stratum by a hydraulically impermeable formation. Thus, the  
13 conductive heat losses from the actively heated primary zone act to passively heat the deposit  
14 in the secondary zone. The oil in the secondary zone is heated and thus has a lowered initial  
15 viscosity. When the viscosity is sufficiently lowered to induce flow of the oil within the zone,  
16 production wells can directly recover mobilized hydrocarbons from the second stratum on a  
17 "primary" production basis.

18 **[0022]** In another aspect of the invention, a secondary dilution process can be applied to the  
19 target oil in the second stratum in conjunction with the above mentioned passive heat transfer.  
20 In the case of a very heavy oil, or bitumen deposit, a dilution process applying a solvent may not  
21 be practical or effective at initial in-situ temperatures, therefore the pre-conditioning of the  
22 stratum by passive heat conduction may be a necessary condition to successfully apply a  
23 dilution process. Therefore, the bitumen that is not mobilized by passive conductive heating  
24 alone can be recovered using by the collateral process of solvent dilution.

25 **[0023]** In yet another aspect of the invention steam is applied to a non-bitumen containing  
26 primary zone, resulting in the conduction of heat to an adjacent, bitumen-containing secondary  
27 zone, from which production wells can recover subsequently mobilized bitumen.

28 **[0024]** In another aspect of the invention, a hydrocarbon bearing first stratum can be used  
29 as the heat source to passively heat an adjacent zone. For example, if a first hydrocarbon  
30 containing stratum is not exploitable by SAGD, or otherwise not economically producible, the  
31 hydrocarbon in the first stratum may be combusted in-situ, thereby generating heat energy that

1 is transferred via conduction to adjacent bitumen or heavy oil bearing zones. Oil can then be  
2 produced from the adjacent zone by the techniques previously outlined.

3 **[0025]** In general terms, an embodiment of the present invention provides a hydrocarbon  
4 production method utilizing passive heat transfer from thermal processes actively applied to one  
5 zone to pre-heat a heavy oil in a neighbouring zone, as opposed to most currently known  
6 methods in the art where heat is applied directly within the produced zone. This method  
7 provides an improvement over prior techniques as it does not introduce water to at least one of  
8 the hydrocarbon containing formation intervals. Furthermore, the present invention provides an  
9 energy efficient method for heavy oil recovery, as the heat losses from producing oil from one  
10 reservoir are employed to enhance or assist in the production of another reservoir, thereby  
11 increasing production yields and thermal efficiencies for subsurface heating processes.

12 **[0026]** Thus, according to one aspect, the invention provides a method of producing  
13 hydrocarbons from a subterranean formation comprising at least a first stratum and an adjacent,  
14 hydrocarbon containing second stratum, said first and second strata being separated by a  
15 barrier, the method comprising:

- 16 - heating the first strata;
- 17 - allowing heat from the first strata to be conducted into the second strata, said heat  
18 being sufficient to pre-condition the hydrocarbons in said second strata in reducing the oil  
19 viscosity, permitting the effective application of ancillary recovery strategies; and,
- 20 - producing said hydrocarbons from the second strata.

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

22 **[0027]** Exemplary embodiments of the invention will now be described by way of example  
23 only with reference to the accompanying drawings, in which:

24 **[0028]** Figure 1 is a graph illustrating the correlation between Canadian Athabasca heavy  
25 oil/bitumen viscosity and the temperature of the deposit.

26 **[0029]** Figure 2 is a graph illustrating the correlation between Athabasca bitumen viscosity  
27 and the volume of solvent added to the deposit.

28 **[0030]** Figure 3 shows the arrangement of a SAGD process in a first stratum containing  
29 bitumen and the recovery of bitumen from a second adjacent stratum.

30 **[0031]** Figure 4 shows the arrangement of a SAGD process in a first stratum containing  
31 bitumen and the recovery of bitumen in a second stratum, whereby the said second stratum is

1 smaller than said first stratum and may not be economically recoverable by SAGD on a stand  
2 alone basis.

3 **[0032]** Figure 5 shows the arrangement of a SAGD process in a first stratum containing  
4 bitumen and the recovery of bitumen in a second stratum, where the second stratum also  
5 incorporates a dilution process.

6 **[0033]** Figure 6 shows the arrangement of a steam injection process in a first stratum not  
7 containing bitumen and the recovery of bitumen in a second stratum.

8 **[0034]** Figure 7 shows the arrangement of an in-situ combustion process in a first stratum  
9 and the recovery of bitumen in a second stratum, whereby the recovery of bitumen from said  
10 first stratum is uneconomical.

## 11 **DETAILED DESCRIPTION OF THE INVENTION**

12 **[0035]** For clarity of understanding, the following terms used in the present description will  
13 have the definitions as stated below:

14 **[0036]** "Reservoir", "formation", "deposit", "stratum", and "zone" all are synonymous terms  
15 referring to a single area within a reservoir that can contain hydrocarbon layers, non-  
16 hydrocarbon layers, and any combination thereof;

17 **[0037]** "Stacked zones" refers to a type of geological configuration consisting more than one  
18 reservoir, or the like, disposed adjacent one another, where said zones are separated by a  
19 barrier.

20 **[0038]** As used herein, the term "barrier" will be understood to mean a physical formation  
21 that separates two or more heavy oil containing strata. A barrier according to the invention may  
22 be impermeable, thereby preventing hydraulic flow of the heavy oil present on opposite sides  
23 thereof. However, the invention may also be used in cases where the barrier is semi-  
24 permeable. That is, the barrier may be sufficiently permeable to allow some degree of reservoir  
25 fluids there-through. However, such flow would generally be insufficient to impair the  
26 commercial viability of the passive heating process. It is also known that a barrier within a  
27 formation may change characteristics over time from being impermeable to partially  
28 impermeable to flow of heavy oil. Such change may be related to the depletion of adjacent  
29 heavy oil deposits, thermally induced geomechanical effects, etc. Although the invention is  
30 particularly suited for use in formations having an impermeable barrier, it will be understood that

1 the invention may be equally applicable to formations with leaky barriers that allow a limited  
2 degree of heavy oil flow.

3 **[0039]** "Oil sands" will be used herein by way of example. However, as discussed herein,  
4 the invention is applicable for use with reservoirs of oil sands (as the term is known in the art),  
5 as well as other heavy oil hydrocarbon materials (i.e. heavy crude oil). However, for  
6 convenience, the term "heavy oil" is used for the purposes of the following description and will  
7 be understood to refer generally to any of the above mentioned hydrocarbon materials. The  
8 choice of such term serves to facilitate the description of the invention and is not intended to  
9 limit the invention in any way.

10 **[0040]** It will be understood that the terms "vertically" and "horizontally" and "vertical" and  
11 "horizontal", as may be used herein, are intended to describe in general terms the arrangement  
12 or orientation of wells and/or deposits etc. Unless otherwise indicated, these terms are not  
13 intended to limit the invention to any particular or specific orientation.

14 **[0041]** In the following description, reference will be made to the attached figures for  
15 facilitating understanding of the invention. It will be understood that the figures are intended  
16 merely to illustrate specific aspects or examples of the invention and are not intended to be  
17 limiting the scope of the invention. Further, various reference numerals are used in the figures.  
18 Elements that are depicted in the figures and which are common to two or more figures are  
19 identified with common reference numerals for convenience.

20 **[0042]** As discussed above, two of the known techniques to reduce in situ bitumen viscosity  
21 comprise heating the bitumen and dilution of the bitumen with an injected solvent.

22 **[0043]** As also discussed above, one common method to effectively raise the temperature  
23 of hydrocarbons within a reservoir involves a process known as Steam Assisted Gravity  
24 Drainage, or SAGD. In this process, steam is injected into a target reservoir through a  
25 horizontal injection well to heat heavy crude oil within a reservoir. The range of temperatures,  
26 and corresponding viscosities, required to achieve an economic flow rate is dependent on the  
27 specific reservoir permeability. SAGD, and most recovery strategies, are focused on increasing  
28 bitumen temperature within a limited region around a steam injection well. The reduced-  
29 viscosity oil is then allowed to flow by gravity drainage to an underlying point of the reservoir  
30 and to be collected by a horizontal production well. The heavy oil/bitumen is then brought to the  
31 surface for further processing. Various pumping equipment and/or systems may be used in  
32 association with the production well. Although effective, stand alone SAGD processes have

several associated inefficiencies. Firstly, the process is very energy intensive in that a great deal of energy is required to heat the volumes of water to generate the steam used for the heat transfer process, with many heat loss inefficiencies throughout the process. Further, upon condensation of the steam, the resulting water mixes with the mobilized bitumen and may lead to additional inefficiencies. For example, the water-bitumen mixture may have a reduced flow rate and may require more energy for the pumping operation. In addition, the subsequent separation of the bitumen and water requires further processing and costs associated with such procedures. Also, as common with other known active heating methods, the energy input to the deposit is often transferred to neighbouring geological structures and lost by way of conduction. Thus, the process becomes more energy intensive in order to achieve sufficient heating of the target formation fluid. Furthermore, SAGD processes are only commercially viable for reservoirs having a minimum volume, such as, for example, reservoirs less than an economic thickness. In the result, the SAGD process is often uneconomical for deposits having a size smaller than a minimum volume.

**[0044]** Figure 1 illustrates the effect of heat on bitumen viscosity. The curves for varying oil density, or API gravity, show a maximum slope at the lower temperatures, indicating that small initial in-situ formation temperature increases produce the largest reductions in oil viscosity per degree of temperature rise.

**[0045]** Figure 2 illustrates the effect of solvent injection on bitumen viscosity. The graph shows the correlation of the mole fraction of solvent 4, the solvent in this example being hexane, with the bitumen viscosity 1. The top dotted curve 4 for solvent at 10°C demonstrates that as the mole fraction of hexane 2 in a hexane/bitumen solution increases, the viscosity 1 of the mixture can be reduced from millions of centipoises a viscosity of less than 10 centipoise. However, in comparison with described SAGD processes, pure unheated solvent applications have proven much more difficult to execute in practice, with numerous uneconomic field trials attempted.

**[0046]** To improve the utility of dilution techniques, the prior art provides methods wherein the target area is preheated. It is a known fluid property relationship that as the viscosity of the bitumen is reduced, the value of its diffusion coefficient and the mass flux of bitumen mobilization increases. Consequently, by preheating a bitumen-rich deposit, to any degree, and thereby lowering the viscosity of the contained bitumen, the efficiency of subsequent dilution processes are greatly improved.

1 **[0047]** According to one aspect, the invention provides a preheating treatment to improve  
2 the efficiency of bitumen recovery from a subterranean heavy oil deposit. In one particular  
3 aspect, the invention is suited for recovery from two adjacent deposits separated by a geological  
4 barrier that is either impermeable or partially permeable to flow of heavy oil there-through. In  
5 another aspect, the adjacent deposits may comprise "stacked zones", which, as indicate above,  
6 is a term in the art denoting two adjacent but separated oil sand deposits or zones that are  
7 generally vertically segregated.

8 **[0048]** Figure 3 illustrates the general arrangement of one embodiment of the invention for  
9 extracting bitumen from a stacked zone deposit. As shown, a stacked-zone oil deposit 6  
10 contains a first stratum 8 which contains a bitumen or heavy oil rich area 10. To recover the  
11 bitumen from this first stratum 8, a heating process, such as a SAGD process, may be  
12 performed in order to reduce the viscosity of the bitumen in area 10 and to promote mobility. As  
13 discussed above, a SAGD process is well known in the art. In the case of a SAGD process, at  
14 least one steam injection well 12 is positioned within the first stratum 8 to inject steam into the  
15 bitumen-rich area 10. Generally, the injection well 12 is positioned in a lower portion of the  
16 stratum 8. Further, at least one production well 14 is provided in the stratum 8 and also located  
17 in a lower portion thereof and displaced generally vertically below the steam injection well 12. In  
18 the present description, all wells will generally be described in the singular form but, as will be  
19 known to persons skilled in the art, any number of wells may be used depending on various  
20 factors such as the size of the deposit, the amount of pumping equipment available etc. As  
21 described further below, the SAGD process influences the characteristics of material in an  
22 affected zone 16 within the first stratum 8. As with known SAGD processes, the steam injection  
23 well 12 releases steam through outlets (not shown), which may be disposed along its length,  
24 into the hydrocarbon-rich area 10 in the first stratum 8. The steam flows through to the bitumen-  
25 rich area 10 and releases heat energy therein and, in the result, the steam condenses into liquid  
26 water. This transfer of heat energy raises the temperature of the surrounding bitumen and  
27 reduces the bitumen viscosity within the stratum 8. The lower viscosity bitumen is then  
28 rendered mobile and the mobilized bitumen from the affected area 16 enters the production well  
29 14 through inlets (not shown), which may be disposed along its length. As known in the art,  
30 various types of pumping equipment and systems may be used for production processes.

31 **[0049]** As illustrated in Figure 3, and according to one aspect of the invention, heat,  
32 depicted by arrows 18, from the first stratum 8 is conducted through a barrier 20 separating the  
33 first stratum 8 from an adjacent second stratum 8'. In the example shown in Figure 3, the strata

1 8 and 8' are generally vertically separated, thereby forming a "stacked zone". The second  
2 stratum 8' contains a second bitumen-rich area 10' from which mobilized bitumen can be  
3 recovered according to the invention. That is, according to an aspect of the invention, heat 18  
4 transferred from the first stratum 8 serves to passively heat the bitumen in a second affected  
5 area 16' in the second stratum 8', thereby reducing its viscosity and promoting mobility without  
6 the aid of a direct heat source within the stratum 8'. For this purpose, a second production well  
7 (or wells) 14' is disposed in the second stratum 8' to collect the mobilized bitumen from the  
8 second bitumen-rich area 10'. It should be noted that the mobilized bitumen from the first  
9 stratum 8 is either unable to pass into the second stratum 8' due to impermeable properties of  
10 the barrier 20 or is able to pass to a limited degree in the case of a partially permeable barrier.  
11 However, barrier 20 does allow the transfer of heat via conduction to pass from the first stratum  
12 8 (wherein a typical SAGD process is used) to the second stratum 8'.

13 **[0050]** The method of the invention can be used in cases where one stratum is smaller in  
14 size or volume than another adjacent stratum, rendering the smaller stratum otherwise  
15 uneconomic for a SAGD process. That is, as known in the art, the deposit must contain a  
16 sufficient amount of heavy oil or must be of a sufficient thickness for a SAGD application to be  
17 economically or practically viable. For example, in some cases, a deposit must have a  
18 minimum thickness for a SAGD treatment to be worthwhile. In some cases, such economically  
19 unviable deposits may lie adjacent, but separated, from a more plentiful deposit where a SAGD  
20 operation is warranted. An example of such a case is shown in Figure 4, where a first stratum 8  
21 has a sufficient thickness  $t$  for a SAGD process lies adjacent to a second stratum 8' with an  
22 insufficient thickness  $t'$ . As shown, a typical SAGD operation may be conducted in the first  
23 stratum 8', wherein a steam injection well 12 is used along with a production well 14. In the  
24 second stratum, a production well 14' is inserted for producing bitumen that is heated by  
25 conduction from the process conducted in the first stratum 8. Thus, although a separate SAGD  
26 process would not be viable in the second stratum 8', heat can be introduced via conduction 18  
27 from the first stratum 8 into the second stratum 8' thereby allowing recovery of bitumen from an  
28 otherwise non-commercial stratum.

29 **[0051]** A further aspect of the invention is illustrated in Figure 5. In this case, in addition to  
30 the passive heating of a second stratum 8', the invention provides the use of a solvent injection  
31 process to further mobilize the heated bitumen in the second stratum 8' and thereby further  
32 increase production yield. As shown in Figure 4, heat 18 is transferred from the first stratum 8  
33 to the second stratum 8'. The heat may, for example, be the result of the SAGD process

1 conducted in the first stratum 8. Such heat may be used to preheat bitumen in the second  
2 stratum 8'. In some instances, as determined by the characteristics of the stacked-zone  
3 formation 6, the heat 18 transferred from the first stratum 8 may be insufficient to adequately  
4 reduce the viscosity of the bitumen in the second stratum 8' to the extent required to promote  
5 mobility through the stacked-zone oil sand 6. However, as described above, any degree of heat  
6 transfer would facilitate in raising the temperature of the bitumen in the second bitumen-rich  
7 area 10' such that the diffusion coefficient of the solvent within the oil is also raised. Therefore,  
8 in conjunction with the passive heating method of the invention, a dilution process may also be  
9 conducted using an injected solvent. Examples of suitable solvents are known in the art, but  
10 can include light alkanes, C<sub>2</sub> through C<sub>12</sub>, diluent, naptha, kerosene, CO<sub>2</sub> and combinations  
11 thereof. In this aspect of the invention, as illustrated in Figure 5, a solvent injection well 22 can  
12 be positioned within the second stratum 8' to inject a solvent, such as a hydrocarbon fluid, into  
13 the second bitumen-rich area 10'. This causes the oil (i.e. heavy oil) in the second stratum 8' to  
14 be diluted thereby becoming mobilized. The mobilized bitumen is then collected in the second  
15 production well 14'. Due to the preheating conditions, more bitumen is able to be diluted by the  
16 solvent thereby increasing the production yield of the recovery process in the second stratum 8',  
17 and avoiding the use of a heat transfer medium, such as steam, in the second stratum. Thus, in  
18 this aspect of the invention, the heat applied in a production process in one stratum is used in a  
19 neighbouring stratum, thereby avoiding the need for a further heating step, the costs associated  
20 therewith and (as discussed above) the associated impairments to recovery caused by the  
21 addition of a water phase to the reservoir. A solvent dilution process is then used to produce  
22 the pre-heated bitumen in the neighbouring stratum.

23 **[0052]** In another aspect, the invention provides a method involving the active heating of a  
24 first stratum containing a non-bitumen containing area to passively heat an adjacent second  
25 stratum. This aspect is illustrated by way of example in Figure 6 wherein a steam injection well  
26 12 is horizontally disposed within a non-bitumen containing area 24 of a first stratum 8. The  
27 well 12 introduces steam into the first stratum 8 thereby heating the stratum 8 in a manner  
28 similar to that shown in Figures 4 and 5. However, as the area 24 does not contain any  
29 bitumen, there is no need for any production wells in the first stratum 8. Therefore, the heat 18  
30 applied to the first stratum 8 serves only to heat, via conduction, the adjacent second stratum 8'.  
31 The first stratum 8 can also potentially be heated by other techniques, inclusive of resistive  
32 electrical or electromagnetic means. Similar to the method described above and as illustrated in  
33 Figure 3, the second stratum 8' contains a bitumen-rich area 10' and the transferred heat 18  
34 serves to mobilize the bitumen therein, which is then collected in production well 14'. It is noted

1 that the embodiment shown in Figure 6 can also be modified to incorporate the use of a solvent  
2 injection well 22, as illustrated in Figure 5, if needed and depending on the reservoir conditions.  
3 It will be understood that in the aspect shown in Figure 6, typical SAGD equipment can be used  
4 but wherein the injection and production wells are placed in separate deposits. Thus, rather  
5 than directly heating a deposit with steam, the deposit (i.e. in stratum 18') is passively heated.  
6 In this aspect, it will be understood that the problems associated with the mixing of water and oil  
7 are avoided without the need for additional equipment. It will also be understood that, as  
8 described above, a solvent injection system as illustrated in Figure 5 may also be incorporated  
9 into the stratum 8' to further enhance recovery.

10 **[0053]** In another aspect of the invention, Figure 7 illustrates the use of an in-situ  
11 combustion (ISC) process as the active heat source to be applied in the first stratum 8. For  
12 example, if the first stratum 8 contains hydrocarbons but is not of a sufficient size or volume to  
13 warrant a SAGD or appropriate recovery process, then the hydrocarbon therein may be  
14 subjected to combustion, as known in the art. The same situation may occur in cases where the  
15 hydrocarbon material contained in the first stratum 8 is of poor quality and, therefore, has a low  
16 economic return on recovered yield. In these instances, as shown in Figure 7, an ISC process  
17 can be applied to burn the bitumen in the first stratum 8. In such case, an oxygen injection well  
18 26 is provided within the bitumen-rich area 10 of the first stratum 8. The well 26 serves to inject  
19 air, enriched air or oxygen into the surrounding area 10 to promote combustion, or burning, of  
20 the hydrocarbon fuel. The combustion process of the bitumen creates what is known in the field  
21 as a "fire flood", or a combustion zone that moves through the reservoir. The fire flood releases  
22 heat to the surrounding area 10 and transfers heat 18 via conduction through the barrier 20 to  
23 the adjacent second stratum 8'. It should be noted that due to the impermeable or partially  
24 permeable nature of the barrier 20, the combustion reaction is contained within first stratum 8  
25 and does not directly affect the bitumen in an adjacent second stratum 8'. In a manner similar  
26 to that described previously with respect to other embodiments, the passive heat transfer 18  
27 causes heating of the bitumen in the second bitumen-rich area 10', thereby preconditioning  
28 such bitumen, which is then collected by the second production well 14' contained in the second  
29 stratum 8'. It is again noted that the use of a solvent injection process, as shown in Figure 5,  
30 may optionally be used with the embodiment illustrated in Figure 7, as determined by the  
31 characteristics of the reservoir.

32 **[0054]** In the foregoing discussion, various embodiments have been described wherein  
33 bitumen is produced from one or more reservoirs or strata. As will be understood and known to

1 persons skilled in the art, such removal of oil, and/or other related materials, results in the  
2 formation of a depleted pressure in the region of production. In such case, it will be understood  
3 that a pressure imbalance may develop, which may lead to the impairment of bitumen flow  
4 through the production system. To counteract this issue, it is common to inject some form of  
5 replacement component to counteract depletion voidage. In the case of a SAGD process, the  
6 injected steam may serve this purpose. Similarly, in a dilution process, the injected solvent fluid  
7 may serve this purpose. However, it will be understood that in cases where neither a SAGD nor  
8 a dilution process is used, some form of replacement fluid would generally be needed. Various  
9 types of pressure maintenance fluids are known in the art, such as diluents and solvents  
10 previously outlined, non-condensable gases (such as methane, CO<sub>2</sub>, N<sub>2</sub>), flue gas, etc. In a case  
11 where the oil in a preconditioned stratum is mobilized and produced solely by heating, a vertical  
12 injection well may be required for voidage replacement, particularly where the oil column may  
13 be associated with an underlying or adjacent aquifer. In the latter case, pressure maintenance  
14 would be desirable in order to retard the flow of formation water into the depleted zone.

15 **[0055]** The invention disclosed herein provides a method of bitumen recovery via thermal  
16 processing in which conductive heat losses are conserved and utilized to heat adjacent bitumen  
17 containing strata. Therefore, the invention utilizes a portion of the energy input to one reservoir  
18 to enable additional recovery of bitumen in an adjacent secondary zone. Furthermore, the  
19 thermal processing method of the invention does not require the continuous injection of steam  
20 into the secondary zone, thereby avoiding the issue of protracted mixing of water and bitumen in  
21 the secondary recovery zone. This improves production quality and efficiency as the flow rate  
22 of bitumen is not impeded and less secondary processing is required.

23 **[0056]** As may be held of benefit, start-up operations within the secondary zone may make  
24 use of an initial steaming process. For example, a limited start up number of cyclic steam  
25 stimulation cycles may prove of benefit in establishing a more rapid communication of a  
26 depletion chamber from a producer to an adjacent, directly heated zone. Once vertical  
27 communication through to the flow barrier between the two strata is achieved, such initial  
28 steaming would be terminated as the process continues through the pattern life by passive heat  
29 conduction as outlined. The objective of such start-up procedures would be to initiate and  
30 accelerate the initial development of a depletion chamber permitting a more rapid deployment of  
31 alternate recovery techniques, such as solvent processes, outlined.

32 **[0057]** Although the invention has been described with reference to certain specific  
33 embodiments, various modifications thereof will be apparent to those skilled in the art without

1 departing from the purpose and scope of the invention as outlined in the claims appended  
2 hereto. The drawings provided herein are solely for the purpose of illustrating various aspects  
3 of the invention and are not intended to be drawn to scale or to limit the invention in any way.  
4 The disclosures of all prior art recited herein are incorporated herein by reference in their  
5 entirety.

6

1. A method of producing hydrocarbons from a subterranean formation comprising at least a first stratum and an adjacent, hydrocarbon containing second stratum, said first and second strata being separated by a barrier, the method comprising:

- heating the first stratum;
- 5 • allowing heat from the first stratum to be conducted into the second stratum, said heat being sufficient to heat and reduce the viscosity of the hydrocarbons in said second stratum; and,
- producing said reduced viscosity hydrocarbons from the second stratum by gravity drainage of the hydrocarbons through at least one production well provided in the second
- 10 stratum;

wherein the heat conducted from the first stratum to the second stratum is the only source of man-made indirect heat supplied to the second stratum.

2. The method of claim 1, wherein said hydrocarbons comprise heavy oil or bitumen.

3. The method of claim 2, wherein said first stratum further contains hydrocarbons.

15 4. The method of claim 1, wherein said first stratum is heated by a steam assisted gravity drainage, SAGD, process.

5. The method of claim 4, wherein hydrocarbons are produced from the first stratum.

6. The method of claim 3, wherein hydrocarbons in the first stratum are combusted in-situ to produce heat.

20 7. The method of claim 6, wherein air, enriched air or oxygen is injected into said first stratum to facilitate said combustion.

8. The method of claim 2, wherein said first stratum contains no or a minimal amount of hydrocarbons.

9. The method of claim 8, wherein said first stratum is heated with a heat transfer fluid, with

25 steam injection, or by electrical or electromagnetic heating.

10. The method of any one of claims 1 to 9, further comprising injecting a solvent into the second stratum during or after the heating of the second stratum to facilitate production of said hydrocarbons in the second stratum.
11. The method of claim any one of claims 1 to 10, wherein the barrier is impermeable or  
5 partially permeable to flow of hydrocarbon there-through.
12. The method of any one of claims 1 to 11, wherein the at least one production well is a generally horizontal well.
13. The method of any one of claims 1 to 12, wherein the first stratum is vertically above the second stratum.
- 10 14. The method of any one of claims 1 to 12, wherein the first stratum is vertically below the second stratum.
15. The method of any one of claims 1 to 14, wherein, prior to heating the first stratum, the second stratum is pre-treated by steam injection.
16. The method of claim 15, wherein said steam injection comprises one or more cyclic  
15 steam stimulation processes.

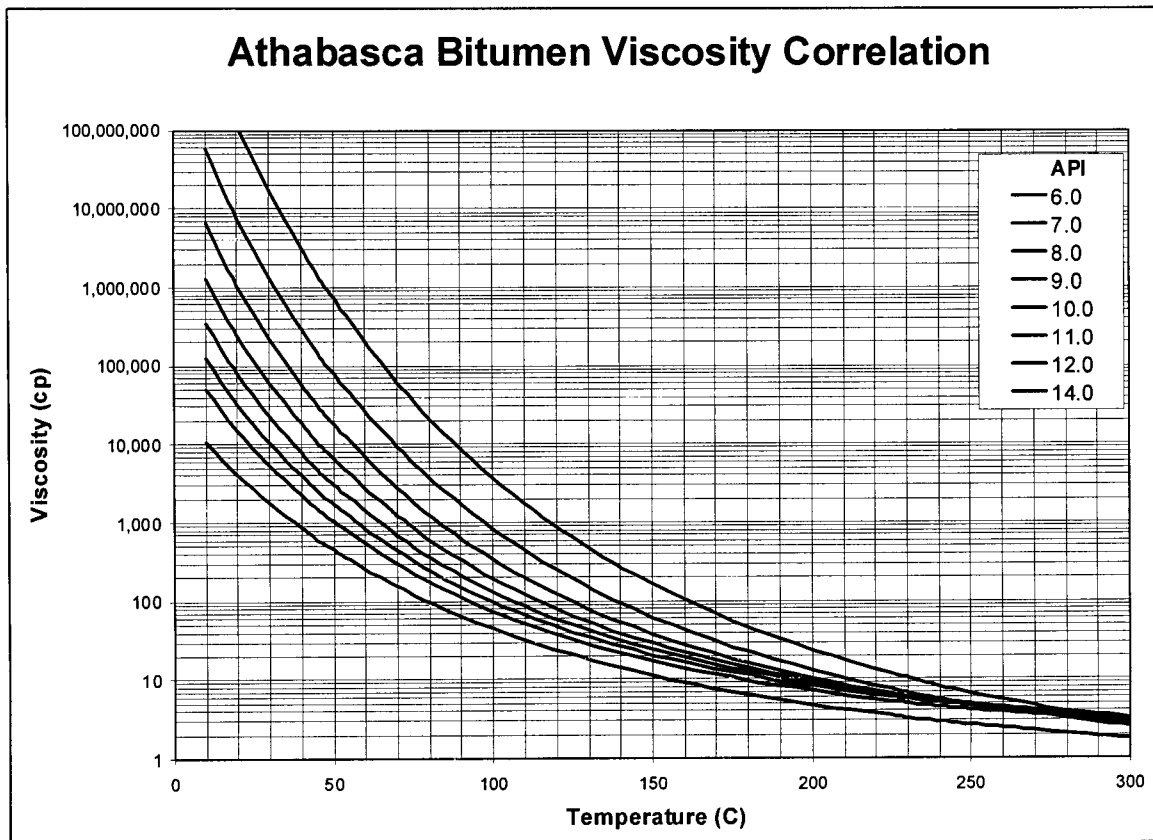


FIGURE 1

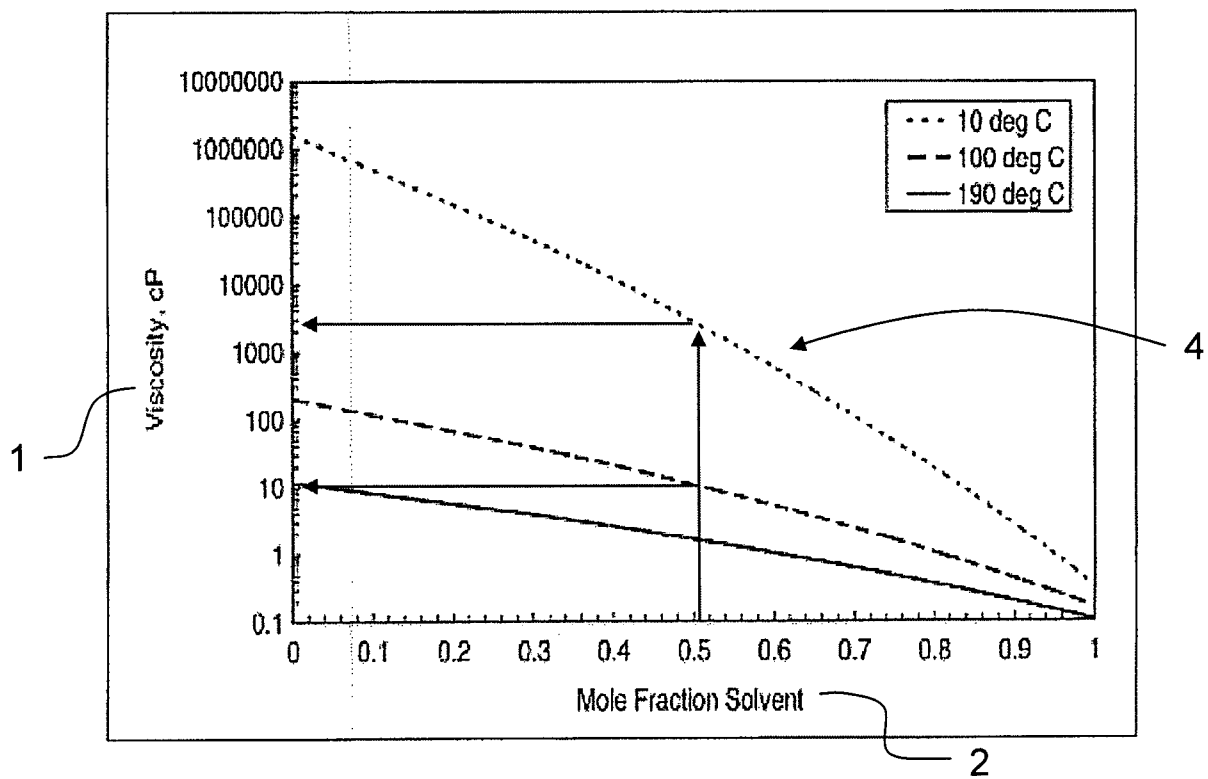


FIGURE 2

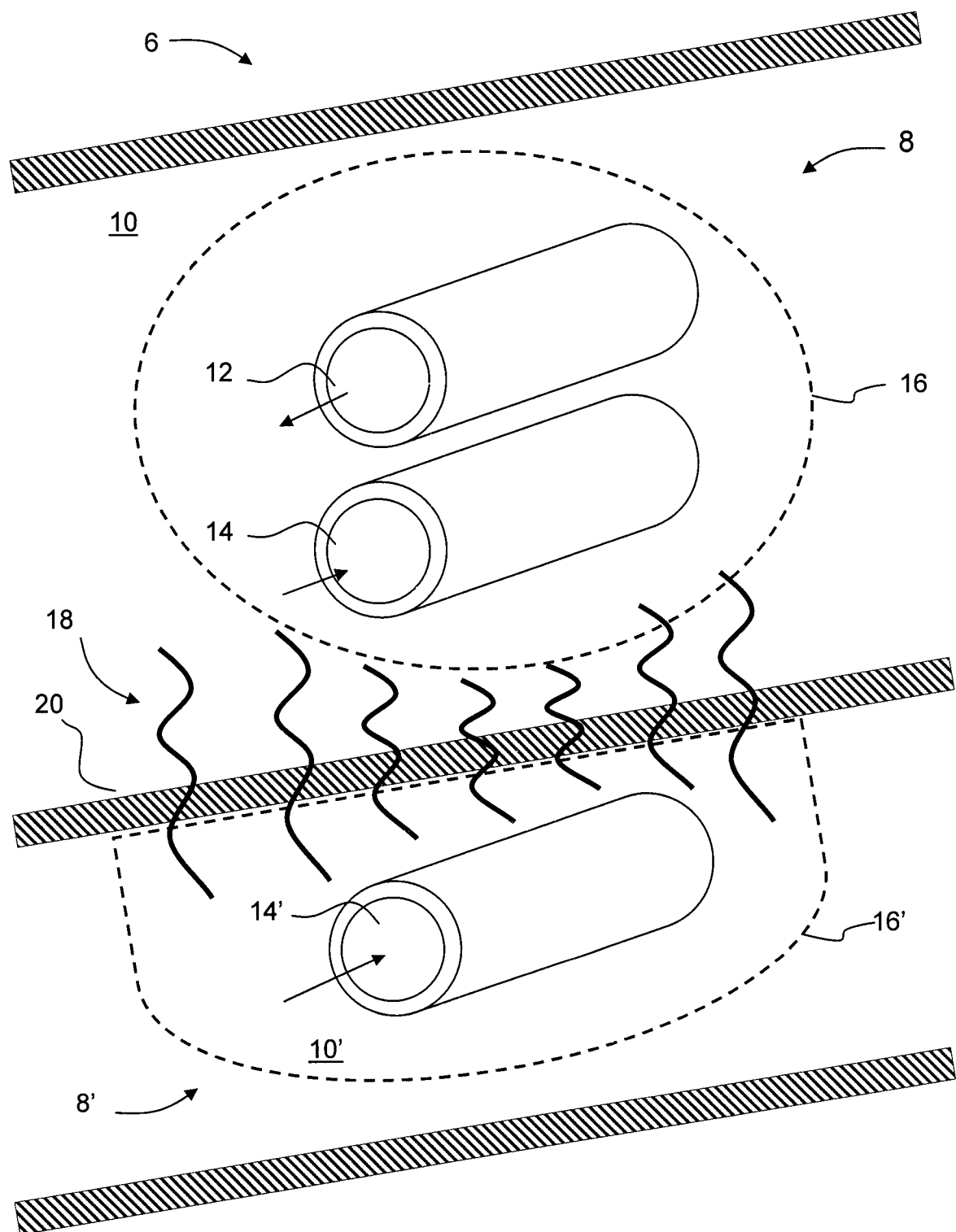


FIGURE 3

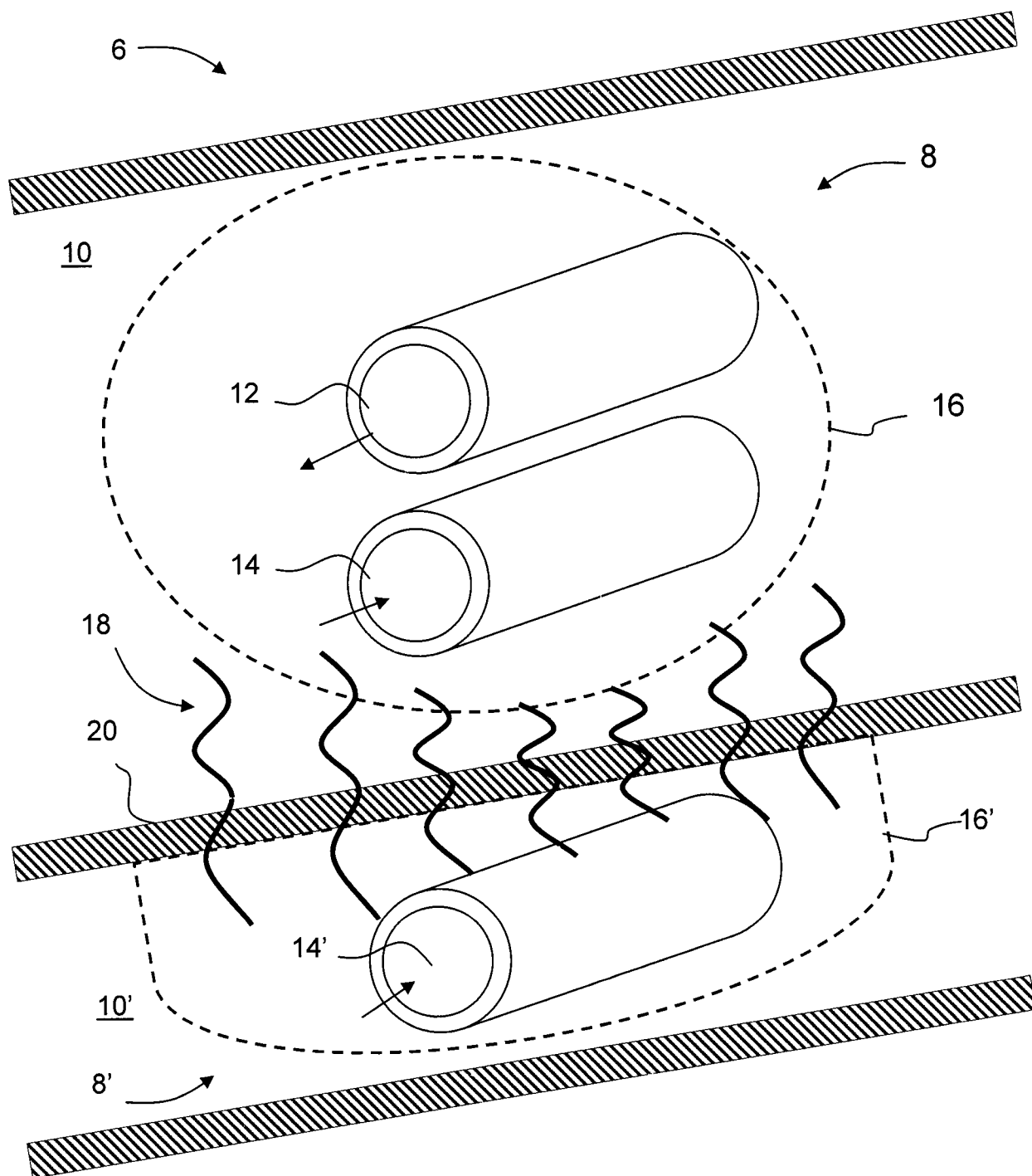


FIGURE 4

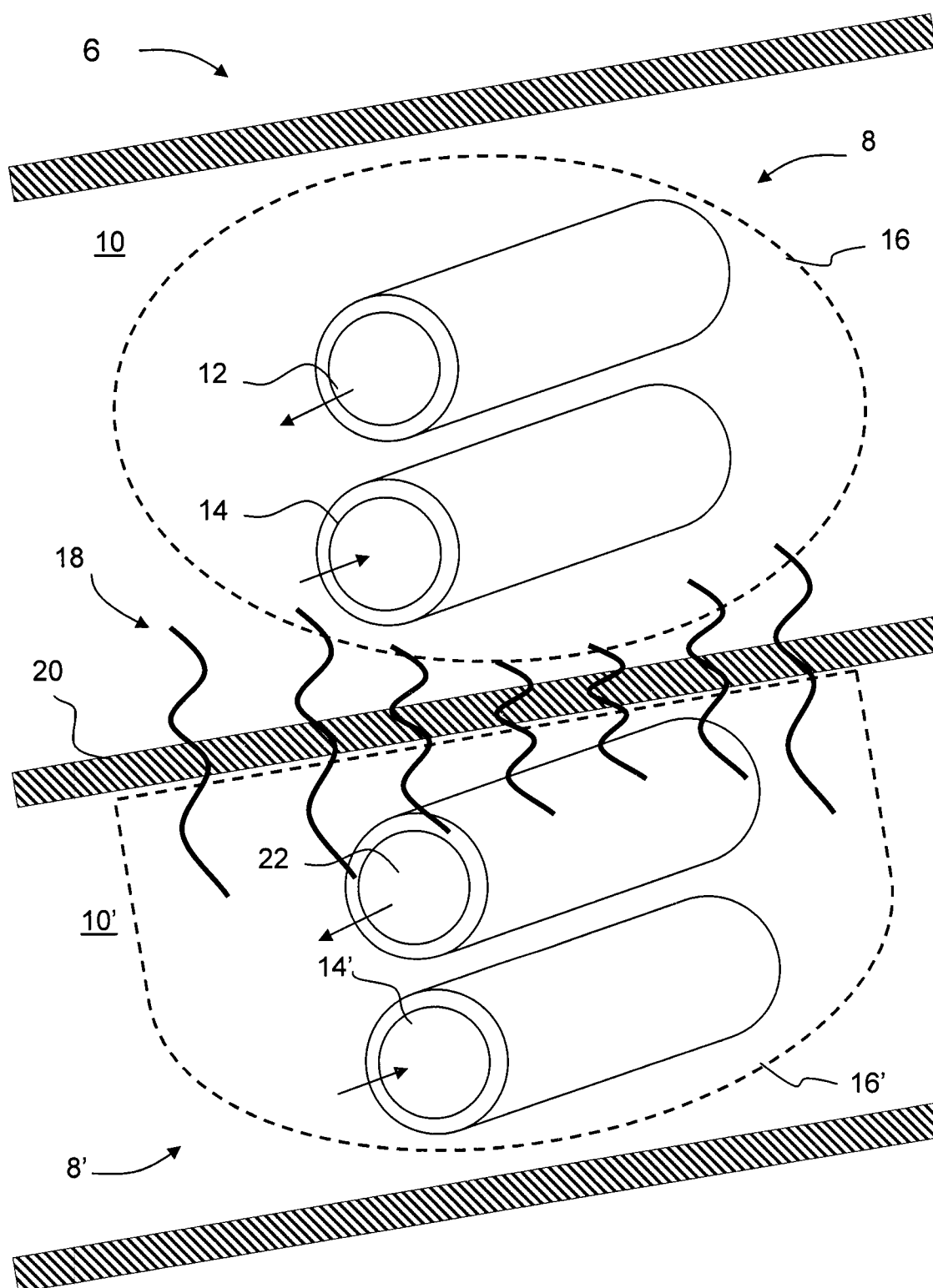


FIGURE 5

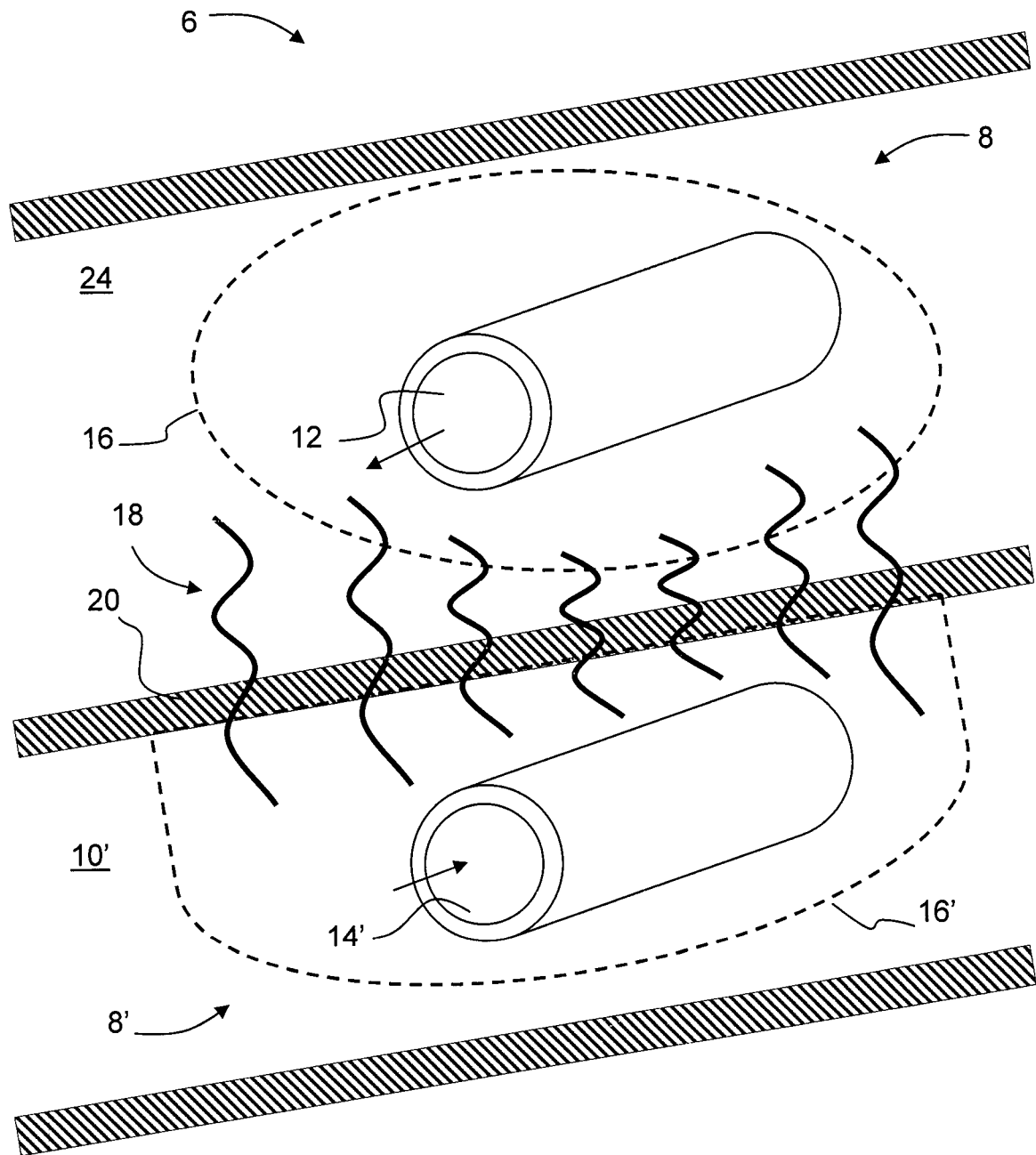


FIGURE 6

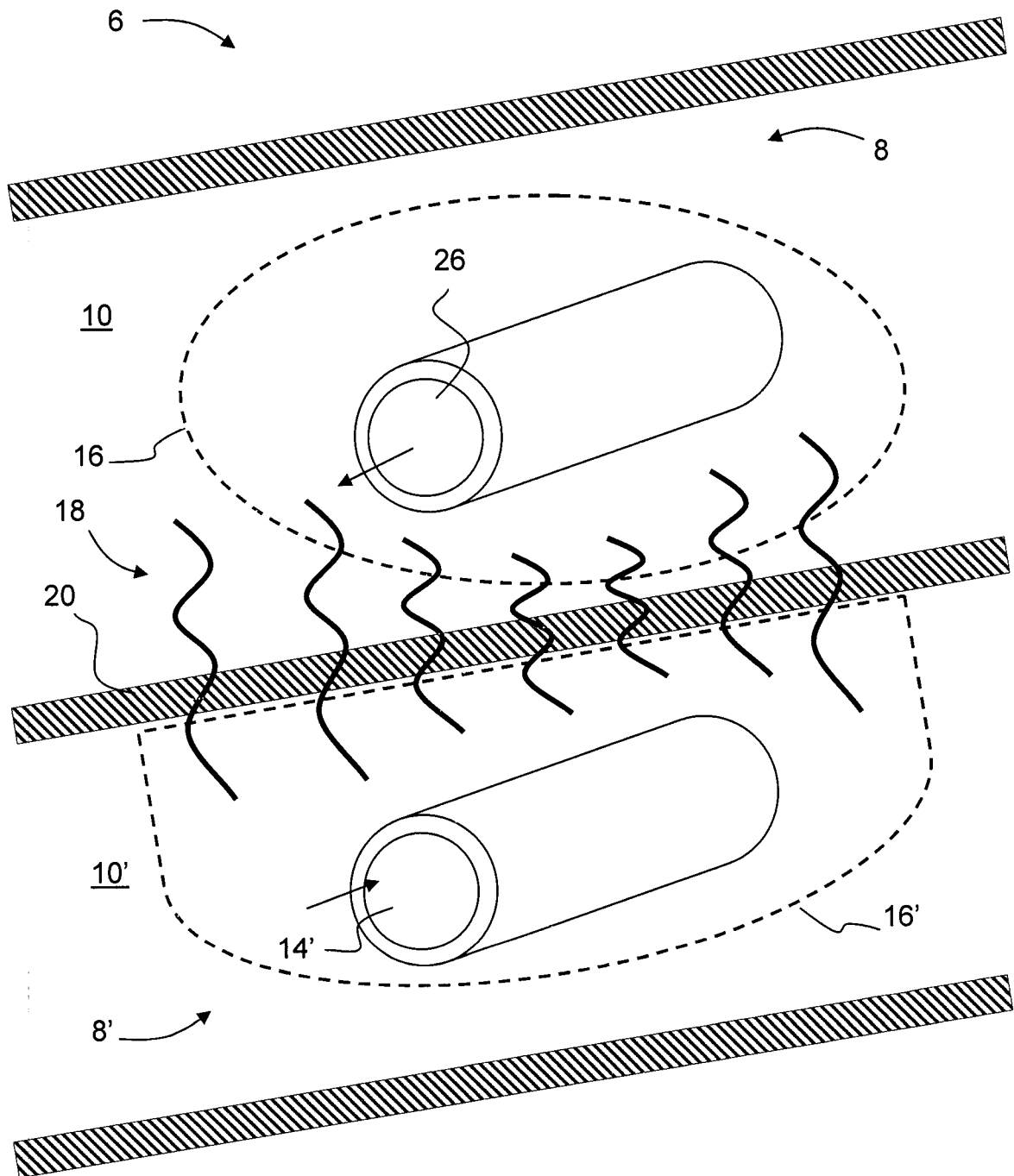


FIGURE 7

