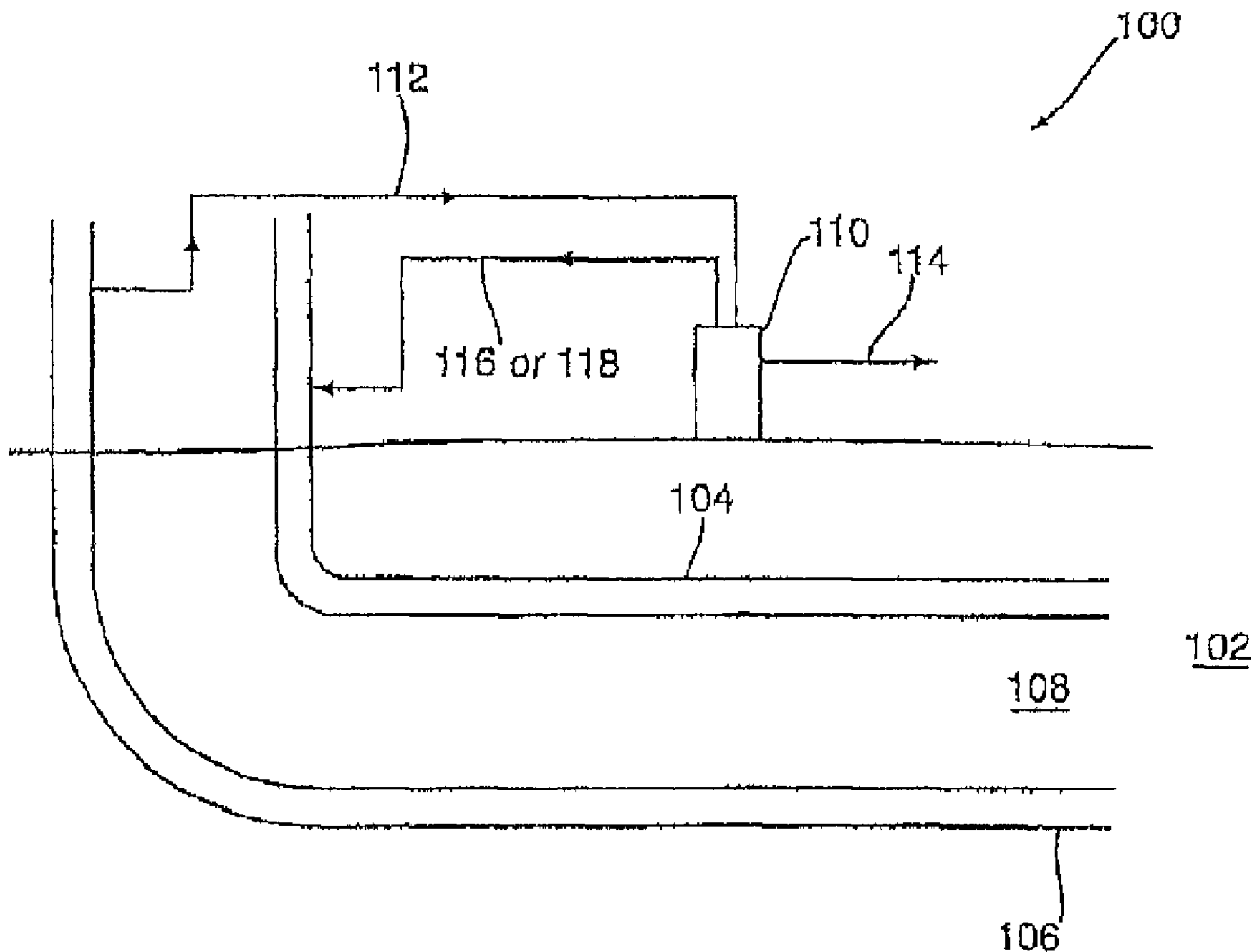




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(54) **Titre : PROCÉDES A BASCULE DE PRESSION DESTINES A LA PRODUCTION D'HYDROCARBURES LOURDS DANS UN RESERVOIR**
(54) **Title: PRESSURE SWING PROCESSES FOR PRODUCING HEAVY HYDROCARBONS FROM RESERVOIR**



(57) **Abrégé/Abstract:**

A process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising: maintaining



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

pressure within the communication zone above a predetermined high pressure during a high pressure production phase, and during at least a fraction of the high pressure production phase, supplying the first production-initiating fluid to the communication zone such that: mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone; effecting a reduction in pressure of the communication zone from above the predetermined high pressure to below a predetermined low pressure such that at least a fraction of the dissolved non- condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby at least contributes to driving the mobilized hydrocarbon material to the production well; after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase; effecting an increase in pressure of the communication zone from below the predetermined low pressure to above the predetermined low pressure; and repeating steps through, at least once.

ABSTRACT

A process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising: maintaining pressure within the communication zone above a predetermined high pressure during a high pressure production phase, and during at least a fraction of the high pressure production phase, supplying the first production-initiating fluid to the communication zone such that: mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone; effecting a reduction in pressure of the communication zone from above the predetermined high pressure to below a predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby at least contributes to driving the mobilized hydrocarbon material to the production well; after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase; effecting an increase in pressure of the communication zone from below the predetermined low pressure to above the predetermined low pressure; and repeating steps through, at least once.

PRESSURE SWING PROCESSES FOR PRODUCING HEAVY HYDROCARBONS FROM RESERVOIR

FIELD

[0001] The present disclosure relates to improvements in production of hydrocarbon-comprising material from hydrocarbon-bearing reservoirs.

BACKGROUND

[0002] Steam-Assisted Gravity Drainage (SAGD) is an enhanced oil recovery technology for producing heavy crude oil and bitumen. However, in spite of its success in recovering highly viscous bitumen, SAGD remains an expensive technique that requires large energy input in the form of steam for each volume of produced oil. This entails consuming large quantities of water and natural gas, resulting in considerable greenhouse gas emissions and costly post-production water treatment procedures. Thus, methods to improve SAGD efficiency are sought after in the industry.

SUMMARY

[0003] In one aspect, there is provided a process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising: (a) maintaining pressure within the communication zone above a predetermined high pressure during a high pressure production phase, and during at least a fraction of the high pressure production phase, supplying the first production-initiating fluid to the communication zone such that: (i) mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and (ii) at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone; (b) effecting a reduction in pressure of the communication zone from above the predetermined high pressure to below a predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby at least contributes to driving the mobilized hydrocarbon material to the production well;

(c) after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase; (d) effecting an increase in pressure of the communication zone from below the predetermined low pressure to above the predetermined low pressure; and (e) repeating steps (a) through (d), at least once.

[0004] In another aspect, there is provided a process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising: (a) supplying a first production-initiating fluid, including steam and non-condensable gaseous material, to the communication zone of the oil sands reservoir via the injection well such that: (i) mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and (ii) the communication zone becomes disposed above a predetermined high pressure such that at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone; (b) effecting a reduction in pressure of the communication zone to below a predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby drives mobilized hydrocarbon material to the production well; and (c) after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase; wherein the difference, between: (a) the maximum pressure differential between the injection and production wells during the higher pressure production phase, and (b)) the maximum pressure differential between the injection and production wells during the lower pressure production phase, is less than 200 kPa, and includes zero difference or substantially no difference.

[0005] In another aspect, there is provided a process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising: (a) supplying a first production-initiating fluid, including steam and non-condensable gaseous material, to the communication zone of the oil sands reservoir via the

injection well such that: (i) mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and (ii) the communication zone becomes disposed above a predetermined high pressure such that at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone; (b) effecting a reduction in pressure of the communication zone to below a predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby drives mobilized hydrocarbon material to the production well; and (c) after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase; wherein the non-condensable gaseous material of the first production-initiating fluid includes at least 20 volume % of relatively soluble material, based on the total volume of non-condensable gaseous material, wherein the relatively soluble material is selected from the group consisting of CH₄, CO₂, and a composition of CH₄ and CO₂.

[0006] In another aspect, there is provided a process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising: (a) supplying a first production-initiating fluid, including steam and non-condensable gaseous material, to the Communication zone of the oil sands reservoir via the injection well such that: (i) mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and (ii) the communication zone becomes disposed above a predetermined high pressure such that at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone; (b) effecting a reduction in pressure of the communication zone to below a predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby drives mobilized hydrocarbon material to the production well; and (c) after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase; wherein,

during at least a fraction of the low pressure production phase, supplying of a second production-initiating fluid is effected to the communication zone. and wherein the concentration of non-condensable gaseous material of the second production-initiating fluid is less than the concentration of non-condensable gaseous material of the first production-initiating fluid, and includes zero concentration or substantially zero concentration

BRIEF DESCRIPTION OF DRAWINGS

[0007] In the drawings, embodiments of the invention are illustrated by way of example. It is to be expressly understood that the description and drawings are only for the purpose of illustration and as an aid to understanding, and are not intended as a definition of the limits of the invention.

[0008] Figure 1 is a schematic illustration of a system including an injection well and a production well within a hydrocarbon reservoir for initiating oil production by way of stimulating the reservoir with a production-initiating fluid including steam; and

[0009] Figure 2 is a schematic illustration of an end view of the system of Figure 1, taken from the “toe end” of the injection and production wells.

[0010] Embodiments will now be described, by way of example only, with reference to the attached figures, wherein:

DETAILED DESCRIPTION

[0011] The present disclosure relates to use of a production-initiating fluid including steam and non-condensable gaseous material for effecting production of hydrocarbon material from a hydrocarbon-containing reservoir.

[0012] As used herein, the following terms have the following meanings:

[0013] “Hydrocarbon” is an organic compound consisting primarily of hydrogen and carbon, and, in some instances, may also contain heteroatoms such as sulfur, nitrogen and oxygen.

[0014] “Hydrocarbon material” is material that consists of one or more hydrocarbons.

[0015] “Heavy hydrocarbon material” is material that consists of one or more heavy hydrocarbons. A heavy hydrocarbon is a hydrocarbon that, at conditions existing with the hydrocarbon-containing reservoir, has a an API gravity of less than 26 degrees and a viscosity of greater than 10,000 centipoise.

[0016] “Non-condensable gaseous material” is material that consists of one or more gases and is disposed in a gaseous phase under the operating conditions of the process of the present disclosure. Examples of non-condensable gaseous material include hydrogen, nitrogen, helium, oxygen, air, methane, ethane, propane, butane, carbon dioxide, carbon monoxide, combustion gases, flue gases, or any combination thereof.

[0017] Referring to Figure 1, there is provided a system 100 for carrying out a process for producing a hydrocarbon from a hydrocarbon-containing reservoir 102. In some embodiments, for example, the hydrocarbon-containing reservoir includes an oil sands reservoir, and the hydrocarbons includes heavy oil, such as bitumen.

[0018] The system 100 includes a pair of wells 104, 106. An interwell region 108 is disposed between the wells 104, 106.

[0019] Each one of the wells 104, 106 includes a horizontal section, and the horizontal sections are vertically spaced from one another, such that the horizontal section of the well 104 is vertically higher than the horizontal section of the well 106. During the production phase, the well 104 (the “injection well”) functions to inject a production-initiating fluid 116 into the reservoir 102 to effect mobilization of the hydrocarbon material within the reservoir such that the hydrocarbon material is conducted to the well 106 for production through the well 106 (the “production well”). In some embodiments, for example, the production-initiating fluid includes steam. In some embodiments, for example, the process is similar to steam-assisted gravity drainage, with the exception that the production-initiating fluid includes non-condensable gaseous material, in addition to steam, and that the non-condensable gaseous material plays a role in assisting with production of the hydrocarbon material.

[0020] The production phase of the process occurs after interwell communication has been established within the interwell region 108 between the wells 104, 106. The interwell

communication is established when the injected production-initiating fluid is able to communicate heat to bitumen within the reservoir such that the bitumen is mobilized, and the mobilized bitumen is able to be conducted, by gravity, through the interwell region 108 to the production well 106.

[0021] In some embodiments, for example, initially, the reservoir 102 has relatively low fluid mobility. In order to enable the injected production-initiating fluid 116 (being injected through the injection well 104) to promote the conduction of the reservoir hydrocarbons, within the reservoir 102, to the production well 106, heat and mass transfer communication must be established between the wells 104, 106 through the interwell region 108. This communication may be established during a “start-up” phase. During the start-up phase, the interwell region 108 is heated. In some embodiments, for example, the heat is supplied to the interwell region 108 by circulating a start-up phase fluid 118 (such as steam, or a fluid including steam) through one or both of the wells 104, 106. The heat that is supplied to the interwell region 108 heats the reservoir hydrocarbons within the interwell region 108, thereby reducing the viscosity of the reservoir hydrocarbons. Eventually, the interwell region 108 becomes heated to a temperature such that the bitumen is sufficiently mobile (i.e. the bitumen has been “mobilized”) for displacement to the production well 106 by at least gravity drainage, thereby signalling completion of the start-up phase and the establishment of a communication zone 109 (see Figure 2), whereby production-initiating fluid 116, when injected through the injection well 104, is disposed to: (i) communicate heat to bitumen within the reservoir, and (ii) effect mass transfer communication between the non-condensable gaseous material and the bitumen within the reservoir, through the communication zone 109, such that (in no particular order) the non-condensable gaseous material becomes dissolved within the bitumen and the bitumen becomes heated, and, when mobilized, the bitumen is able to be conducted, by at least gravity drainage, through the communication zone 109, to the production well 106.

[0022] As the mobilized bitumen drains to the production well 106, space previously occupied by the bitumen within the reservoir becomes filled with the production-initiating fluid, thereby exposing a fresh bitumen surface for receiving heat from the production-initiating fluid 116 (typically, by conduction). This repeated cycle of heating, mobilization, drainage, and establishment of heat transfer communication with a freshly exposed bitumen source results in

the growth of the communication zone 109, with the freshly exposed bitumen being disposed along an edge of the communication zone 109. In some embodiments, for example, the communication zone 109 includes a “vapour chamber”. In some embodiments, for example, the vapour chamber may also be referred to as a “steam chamber”.

[0023] After the interwell communication has been established between the wells 104, 106, production of hydrocarbon material from the reservoir may be effected during the production phase. The production phase includes a higher pressure production phase and a lower pressure production phase.

[0024] During at least a fraction of the higher pressure production phase (such as, for example, during the entirety, or the substantial entirety, of the higher pressure production phase), the first production-initiating fluid is supplied into the communication zone 109 through the well 104 (when the supplying of the production-initiating fluid is effected during the entirety of the higher pressure production phase, the supplying is said to be “continuous”). The first production-initiating fluid includes steam and a non-condensable gas. The injection is with effect that the first production-initiating fluid is disposed within the communication zone at a relatively high pressure. In some embodiments, for example, the pressure is above a predetermined high pressure. In some embodiments, for example, the pressure is the maximum allowable operating pressure that will not result in failure of the cap rock. Failure of the cap rock means failure to hold pressure. This may be caused by a loss of mechanical strength of the cap rock due to exposure to high temperatures, or the creation of fractures, or the activation of faults caused by a combination of high pressure and high temperature. In this respect, failure of the cap rock may result from changes in in-situ stresses caused by the operating pressure and temperature conditions of the process.

[0025] The production-initiating fluid, disposed within the communication zone 109, effects heating of hydrocarbon material within the reservoir (for example, the hydrocarbon material, such as bitumen, disposed at an edge of the communication zone) thereby effecting a reduction in its viscosity such that the hydrocarbon material becomes mobilized. This phenomenon is particularly dramatic for heavy hydrocarbon material, such as bitumen. As well, the non-condensable gaseous material of the production-initiating fluid, disposed within the

communication zone, becomes dissolved within this hydrocarbon material disposed. The solubility of the non-condensable gaseous material increases with increasing partial pressure and, concomitantly, with an increase in total pressure of the production-initiating fluid. The dissolved non-condensable gaseous material contributes to production of the hydrocarbon material, when pressure within the communication zone is reduced during the subsequent lower pressure production phase, as is explained below.

[0026] The mobilized hydrocarbon material, as well as condensed steam, drains by gravity through the communication zone 109 to the horizontal section of the production well 106, such that a production fluid 112, including the gravity-drained hydrocarbon material and the condensed steam, is collected within the production well 106.

[0027] The production fluid may subsequently be conducted to a processing facility 110. At the processing facility 110, various processing operations can occur but generally, the water and the reservoir hydrocarbons can be separated, with the reservoir hydrocarbons 114 sent on for further refining. Water from the separation may be recycled to a steam generation unit within the facility 110, with or without further treatment, and used to generate the steam used for supply to the well 104. Also, any non-condensable gaseous material that is entrained within the production fluid may be separated from the production fluid (such as, for example, by flashing), recompressed, and recycled as part of the production-initiating fluid.

[0028] During the higher pressure production phase, the pressure within the communication zone 109 is maintained above the predetermined high pressure. In some embodiments, for example, the pressure within the communication zone 109 is maintained above the predetermined high pressure by co-operatively controlling the rate at which production-initiating fluid is supplied to the communication zone 109 via the injection well co-operatively with the rate at which production fluid is produced from the communication zone 109 via the production well 106.

[0029] Pressure within the communication zone 109 is then reduced. In response to the reduction in pressure within the communication zone 109, at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material. Upon the liberation, the non-condensable gaseous material expands and thereby drives

mobilized hydrocarbon material to the production well 106 (in accordance with a solution gas drive mechanism). In some embodiments, for example, the reduction in pressure is such that the pressure within the communication zone is disposed below a predetermined low pressure. The combination, of (a) bitumen mobilization effected by heating by the production-initiation fluid and (b) solution gas drive, effects more rapid growth of the steam chamber, and thereby effects a higher rate of production of bitumen from the reservoir.

[0030] Additionally, the non-condensable gaseous material may be able to better penetrate the immobile bitumen zone than steam condensate, thereby providing for increased rate of expansion of the vapour chamber. Synergistically, because the immobile bitumen zone is relatively colder, and because the solubility of non-condensable gaseous material within bitumen increases with decreasing temperature, higher amounts of non-condensable gaseous material is able to dissolve within the bitumen, and thereby rendering the solution gas drive effect to be more dramatic.

[0031] In some embodiments, for example, the reduction in pressure is effected by suspending supplying of the production-initiating fluid into the communication zone 109. In some embodiments, for example, the reduction in pressure is effected by increasing the molar rate of production of production fluid from the communication zone 109 via the production well 106, while continuing supplying of the production-initiating fluid to the communication zone 109 via injection well 104 at the same or substantially the same molar rate. In some embodiments, for example, the decrease in pressure is effected by continuing production of production fluid from the communication zone 109 via the production well 106 at the same or substantially the same rate, while decreasing the molar rate at which the production-initiating fluid is supplied to the communication zone 109 via injection well 104. In this respect, the pressure within the communication zone 109 is decreased by co-operatively modulating the rate at which production-initiating fluid is supplied to the communication zone 109 via the injection well 104 with modulating of the rate at which production fluid is produced from the communication zone via the production well 106.

[0032] In some embodiments, for example, the difference, between: (a) the maximum pressure differential between the wells 104, 106 during the higher pressure production phase, and

(b) the maximum pressure differential between the wells 104, 106 during the lower pressure production phase, is less than 200 kPa, such as, for example less than 100 kPa, and includes no difference or substantially no difference. In some embodiments, for example, there is no difference or substantially no difference. Varying the pressure differential, as between the higher pressure production phase and the lower pressure production phase, increases the risk of steam breakthrough. Generally speaking, during both of the higher pressure and lower pressure production phases, the pressure differential will be controlled so as to limit short circuiting of fluid from the injection well 104 to the production well 106, and to encourage the injected production-initiating fluid to enter the vapour chamber above the injection well 104.

[0033] In some embodiments, for example, such as during the start-up phase, it may be advantageous to define a higher pressure differential between the wells 104, 106 to accelerate the establishment of the interwell communication between the wells 104, 106, thereby enabling initiation of production and the development of the vapour chamber above the wells 104, 106.

[0034] In some embodiments, for example, the first production-initiating fluid includes from about 0.1 mole % to about 20 mole % of non-condensable gaseous material, based on the total number of moles of production-initiating fluid. In some of these embodiments, for example, the first production-initiating fluid includes from about 1 mole % to about 2 mole % of non-condensable gaseous material, based on the total number of moles of production-initiating fluid.

[0035] In some embodiments, for example, the non-condensable gaseous material of the first production-initiating fluid is material that is highly soluble within the hydrocarbon material of the reservoir. In some embodiments, for example, the non-condensable gaseous material includes at least 20 volume% of CH₄, based on the total volume of non-condensable gaseous material. In some embodiments, for example, the non-condensable gaseous material includes at least 20 volume% of CO₂, based on the total volume of non-condensable gaseous material. In some embodiments, for example, the non-condensable gaseous material includes at least 20 vol.% of a combination of CH₄ and CO₂, based on the total volume of non-condensable gaseous material.

[0036] In some embodiments, for example, the reduction in pressure within the communication zone is effected relatively gradually. In this respect, in some embodiments, for example, the reduction is at a rate that is less than 3000 kPa per month. In some embodiments, for example, the reduction is at a rate that is between 500 kPa per month and 3000 kPa per month.

[0037] After the reduction in pressure within the communication zone 109, the pressure of the communication zone 109 is maintained below the predetermined low pressure during a lower pressure production phase. In this respect, operation of the process in the lower pressure production phase is effected after suspension of the higher pressure production phase. In some embodiments, for example, the pressure within the communication zone 109 is maintained below the predetermined maximum pressure by co-operatively controlling the rate at which production-initiating fluid is supplied to the communication zone 109 via the injection well co-operatively with the rate at which production fluid is produced from the communication zone via the production well 106.

[0038] In some embodiments, for example, during at least a fraction of the lower pressure production phase (such as, for example, during the entirety, or the substantial entirety, of the lower pressure production phase), a second production-initiating fluid is supplied into the communication zone 109 through the injection well 104 (when the supplying of the production-initiating fluid is effected during the entirety of the lower pressure production phase, the supplying is said to be “continuous”). The second production-initiating fluid includes steam, and may, in some embodiments, for example, include a non-condensable gaseous material. In some embodiments, for example, the concentration of non-condensable gaseous material of the second production-initiating fluid, if any, is less than the concentration of non-condensable gaseous material of the first production-initiating fluid. In some embodiments, for example, the concentration of non-condensable gaseous material of the second production-initiating fluid is less than 50% of the concentration of non-condensable gaseous material of the first production-initiating fluid, and includes zero concentration or substantially zero concentration.

[0039] The supplying of the second production-initiating fluid is with effect that the second production-initiating fluid becomes disposed within the communication zone at below the

predetermined low pressure. In this respect, heavy hydrocarbon material continues to be heated and mobilized, or maintained in a mobilized state, while the non-condensable gaseous material is being liberated from solution within the hydrocarbon material, and thereby contributing to production of hydrocarbon material via the production well 106.

[0040] The pressure within the communication zone 109 is then increased to above the predetermined low pressure, such as, for example, to above the predetermined high pressure. In some embodiments, for example, the increase in pressure is effected by suspending production of the production fluid via the production well. In some embodiments, for example, the increase in pressure is effected by decreasing the molar rate of production of production fluid from the communication zone 109 via the production well 106, while continuing supplying of the production-initiating fluid to the communication zone 109 via injection well 104 at the same or substantially the same molar rate. In some embodiments, for example, the increase in pressure is effected by continuing production of production fluid from the communication zone 109 via the production well 106 at the same or substantially the same rate, while increasing the molar rate at which the production-initiating fluid is supplied to the communication zone 109 via injection well 104. In this respect, the pressure within the communication zone 109 is increased by co-operatively modulating the rate at which production-initiating fluid is supplied to the communication zone 109 via the injection well with modulating of the rate at which production fluid is produced from the communication zone via the production well 106.

[0041] In some embodiments, for example, the increase in pressure within the communication zone is effected relatively gradually. In this respect, in some embodiments, for example, the increase is at a rate that is less than 3000 kPa per month. In some embodiments, for example, the increase is at a rate that is between 500 kPa per month and 3000 kPa per month.

[0042] In some embodiments, for example, the duration of the higher pressure production phase is at least 30 days, such as between 30 days and 180 days. In some embodiments, for example, the duration of the lower pressure production phase is at least 30 days, such as between 30 days and 180 days. In some embodiments, for example, the ratio of the duration of the higher pressure production phase to the duration of the lower pressure production phase is between 1:6 to 6:1.

[0043] In some embodiments, the process is a process including:

(a) maintaining pressure within the communication zone 109 above a predetermined high pressure during the high pressure production phase, and during at least a fraction of the high pressure production phase, supplying the first production-initiating fluid to the communication zone 109 (including the vapour chamber) such that:

(i) mobilization of producible bitumen within the communication zone 109 is effected, and such that the mobilized bitumen is conducted to the production well 106 and produced via the production well 106 ; and

(ii) at least a fraction of the supplied non-condensable gaseous material becomes dissolved within bitumen disposed within the communication zone 109;

(b) effecting a reduction in pressure of the communication zone from above the predetermined high pressure to below the predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the bitumen and, upon the liberation, expands and thereby at least contributes to driving the mobilized hydrocarbon material (such as, for example, the mobilized hydrocarbon material at the edge of the vapour chamber), to the production well 106; and

(c) after the effected reduction in pressure, maintaining pressure within the communication zone 109 below the predetermined low pressure during the lower pressure production phase;

(d) effecting an increase in pressure of the communication zone 109 from below the predetermined low pressure to above the predetermined low pressure such that solubility of non-condensable gaseous material, of any production-initiating fluid that is supplied to the communication zone, is increased; and

(e) repeating steps (a) through (d), in sequence, at least once.

[0044] In some embodiments, for example, steps (a) through (d) are repeated at least twice, such as, for example, at least three (3) times, and such as, for example, at least five (5) times.

[0045] The predetermined high pressure of the communication zone 109 during the high pressure production phase may be the same for some or all of the cycles, or, for each one of the cycles, may be different.

[0046] The predetermined low pressure of the communication zone 109 during the high pressure production phase may be the same for some or all of the cycles, or, for each one of the cycles, may be different.

[0047] The composition of the first production-initiating fluid may be the same for some or all of the cycles, or, for each one of the cycles, may be different.

[0048] As mentioned above, during at least a fraction of the lower pressure production phase, a second production-initiating fluid may be supplied to the communication zone 109. In this respect, the second production-initiating fluid may be supplied for some, none or all of the cycles. For those cycles where the second production-initiating fluid is being supplied, the composition of the second production-initiating fluid may be the same for some or all of these cycles, or, for each one of these cycles, may be different.

[0049] In some embodiments, for example, the concentration of the non-condensable gaseous material within the first production-initiating fluid during step (a) of a later cycle is greater relative to the concentration of the non-condensable gaseous material within the first production-initiating fluid during step (a) of an earlier cycle. In some embodiments, for example, the concentration of the non-condensable gaseous material within the first production-initiating fluid during step (a) of a later cycle is greater relative to the concentration of the non-condensable gaseous material within the first production-initiating fluid during step (a) of an earlier cycle by a factor of at least two (2), such as, for example, a factor of at least five (5).

[0050] In the above description, for purposes of explanation, numerous details are set forth in order to provide a thorough understanding of the present disclosure. However, it will be apparent to one skilled in the art that these specific details are not required in order to practice

the present disclosure. Although certain dimensions and materials are described for implementing the disclosed example embodiments, other suitable dimensions and/or materials may be used within the scope of this disclosure. All such modifications and variations, including all suitable current and future changes in technology, are believed to be within the sphere and scope of the present disclosure.

CLAIMS

1. A process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising:

(a) maintaining pressure within the communication zone above a predetermined high pressure during a high pressure production phase, and during at least a fraction of the high pressure production phase, supplying a first production-initiating fluid, including steam and non-condensable gaseous material, to the communication zone such that:

(i) mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and

(ii) at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone;

(b) effecting a reduction in pressure of the communication zone from above the predetermined high pressure to below a predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby at least contributes to driving the mobilized hydrocarbon material to the production well;

(c) after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase;

(d) effecting an increase in pressure of the communication zone from below the predetermined low pressure to above the predetermined low pressure; and

(e) repeating steps (a) through (d), at least once.

2. The process as claimed in claim 1;

wherein the supplying of the first production initiating fluid to the communication zone is effected during the entirety, or the substantial entirety, of the high pressure production phase.

3. The process as claimed in claim 1 or 2;

wherein the concentration of the non-condensable gaseous material within the first production-initiating fluid is greater than 0.1 mol %.

4. The process as claimed in any one of claims 1 to 3;

wherein the concentration of the non-condensable gaseous material within the first production-initiating fluid is between 0.1 mol % and 20 mol %.

5. The process as claimed in any one of claims 1 to 4;

wherein the concentration of the non-condensable gaseous material within the first production-initiating fluid is between 1.0 mol % and 2.0 mol %.

6. The process as claimed in any one of claims 1 to 5;

wherein the duration of the high pressure production phase is greater than 30 days;

and wherein the duration of the low pressure production phase is greater than 30 days.

7. The process as claimed in any one of claims 1 to 6;

wherein the duration of the high pressure production phase is between 30 days and 180 days;

and wherein the duration of the low pressure production phase is between 30 days and 180 days.

8. The process as claimed in any one of claims 1 to 7;

wherein steps (a) through (d) are repeated at least twice.

9. The process as claimed in any one of claims 1 to 8;

wherein steps (a) through (d) are repeated at least three times.

10. The process as claimed in any one of claims 1 to 9;

wherein the concentration of the non-condensable gaseous material within the first production-initiating fluid during step (a) of a later cycle is greater relative to the concentration of the non-

condensable gaseous material within the first production-initiating fluid during step (a) of an earlier cycle.

11. The process as claimed in any one of claims 1 to 10;

wherein the difference, between: (a) the maximum pressure differential between the injection and production wells during the higher pressure production phase, and (b)) the maximum pressure differential between the injection and production wells during the lower pressure production phase, is less than 200 kPA, and includes zero difference or substantially no difference.

12. The process as claimed in any one of claims 1 to 11;

wherein the non-condensable gaseous material of the first production-initiating fluid includes at least 50 volume % of relatively soluble material, based on the total volume of non-condensable gaseous material, wherein the relatively soluble material is selected from the group consisting of CH₄, CO₂, and a composition of CH₄ and CO₂.

13. The process as claimed in any one of claims 1 to 12;

wherein, during at least a fraction of the low pressure production phase, supplying of a second production-initiating fluid is effected to the communication zone.

14. The process as claimed in claim 13;

wherein the second production-initiating fluid includes steam.

15. The process as claimed in claim 13 or 14;

wherein the supplying of the second production initiating fluid to the communication zone is effected during the entirety, or the substantial entirety, of the low pressure production phase.

16. The process as claimed in any one of claims 13 to 15;

wherein the concentration of non-condensable gaseous material of the second production-initiating fluid, if any, is less than the concentration of non-condensable gaseous material of the first production-initiating fluid.

17. The process as claimed in claim 16

wherein the concentration of non-condensable gaseous material of the second production-initiating fluid is less than 50% of the concentration of non-condensable gaseous material of the first production-initiating fluid, and includes zero concentration or substantially zero concentration.

18. A process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising:

(a) supplying a first production-initiating fluid, including steam and non-condensable gaseous material, to the communication zone of the oil sands reservoir via the injection well such that:

(i) mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and

(ii) the communication zone becomes disposed above a predetermined high pressure such that at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone;

(b) effecting a reduction in pressure of the communication zone to below a predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby drives mobilized hydrocarbon material to the production well; and

(c) after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase;

wherein the difference, between: (a) the maximum pressure differential between the injection and production wells during the higher pressure production phase, and (b)) the maximum pressure differential between the injection and production wells during the lower pressure production phase, is less than 200 kPa, and includes zero difference or substantially no difference.

19. A process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising:

(a) supplying a first production-initiating fluid, including steam and non-condensable gaseous material, to the communication zone of the oil sands reservoir via the injection well such that:

(i) mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and

(ii) the communication zone becomes disposed above a predetermined high pressure such that at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone;

(b) effecting a reduction in pressure of the communication zone to below a predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby drives mobilized hydrocarbon material to the production well; and

(c) after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase;

wherein the non-condensable gaseous material of the first production-initiating fluid includes at least 20 volume % of relatively soluble material, based on the total volume of non-condensable gaseous material, wherein the relatively soluble material is selected from the group consisting of CH₄, CO₂, and a composition of CH₄ and CO₂.

20. A process for producing hydrocarbon material from a hydrocarbon reservoir through a production well that is disposed in fluid communication with an injection well via an interwell region disposed within a communication zone, comprising:

(a) supplying a first production-initiating fluid, including steam and non-condensable gaseous material, to the Communication zone of the oil sands reservoir via the injection well such that:

(i) mobilization of producible hydrocarbon material within the communication zone is effected, and such that the mobilized hydrocarbon material is conducted to the production well and produced via the production well; and

(ii) the communication zone becomes disposed above a predetermined high pressure such that at least a fraction of the supplied non-condensable gaseous material becomes dissolved within hydrocarbon material disposed within the communication zone;

(b) effecting a reduction in pressure of the communication zone to below a predetermined low pressure such that at least a fraction of the dissolved non-condensable gaseous material becomes liberated from solution within the hydrocarbon material and, upon the liberation, expands and thereby drives mobilized hydrocarbon material to the production well; and

(c) after the effected reduction in pressure, maintaining pressure within the communication zone below the predetermined low pressure during a lower pressure production phase;

wherein, during at least a fraction of the low pressure production phase, supplying of a second production-initiating fluid is effected to the communication zone.

and wherein the concentration of non-condensable gaseous material of the second production-initiating fluid is less than the concentration of non-condensable gaseous material of the first production-initiating fluid, and includes zero concentration or substantially zero concentration.

21. The process as claimed in claim 20;

wherein the second production-initiating fluid includes steam.

22. The process as claimed in claim 20 or 21;

wherein the supplying of the second production initiating fluid to the communication zone is effected during the entirety, or the substantial entirety, of the low pressure production phase.

23. The process as claimed in any one of claims 20 to 22;

wherein the concentration of non-condensable gaseous material of the second production-initiating fluid is less than 50% of the concentration of non-condensable gaseous material of the first production-initiating fluid, and includes zero concentration or substantially zero concentration.

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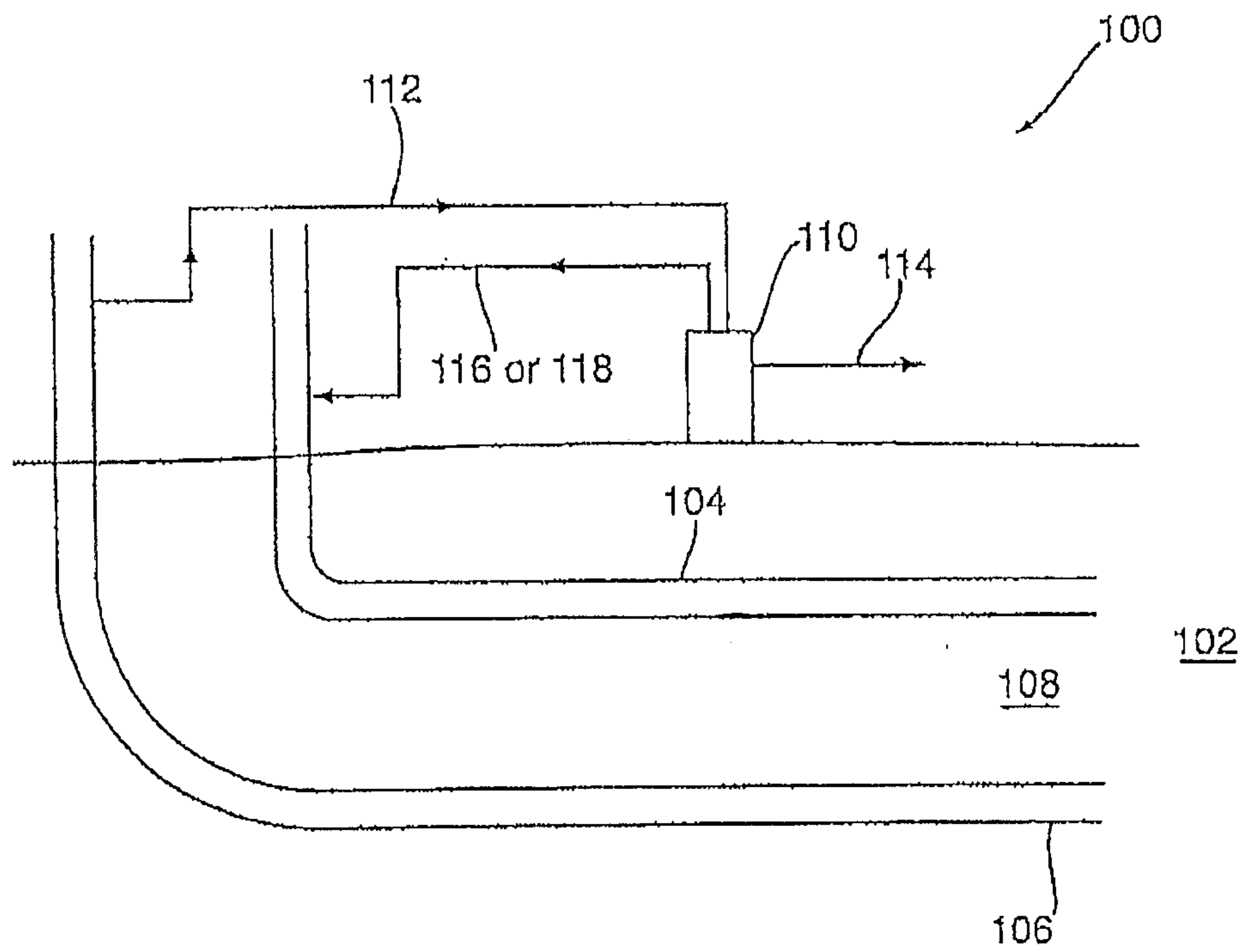


FIGURE 1

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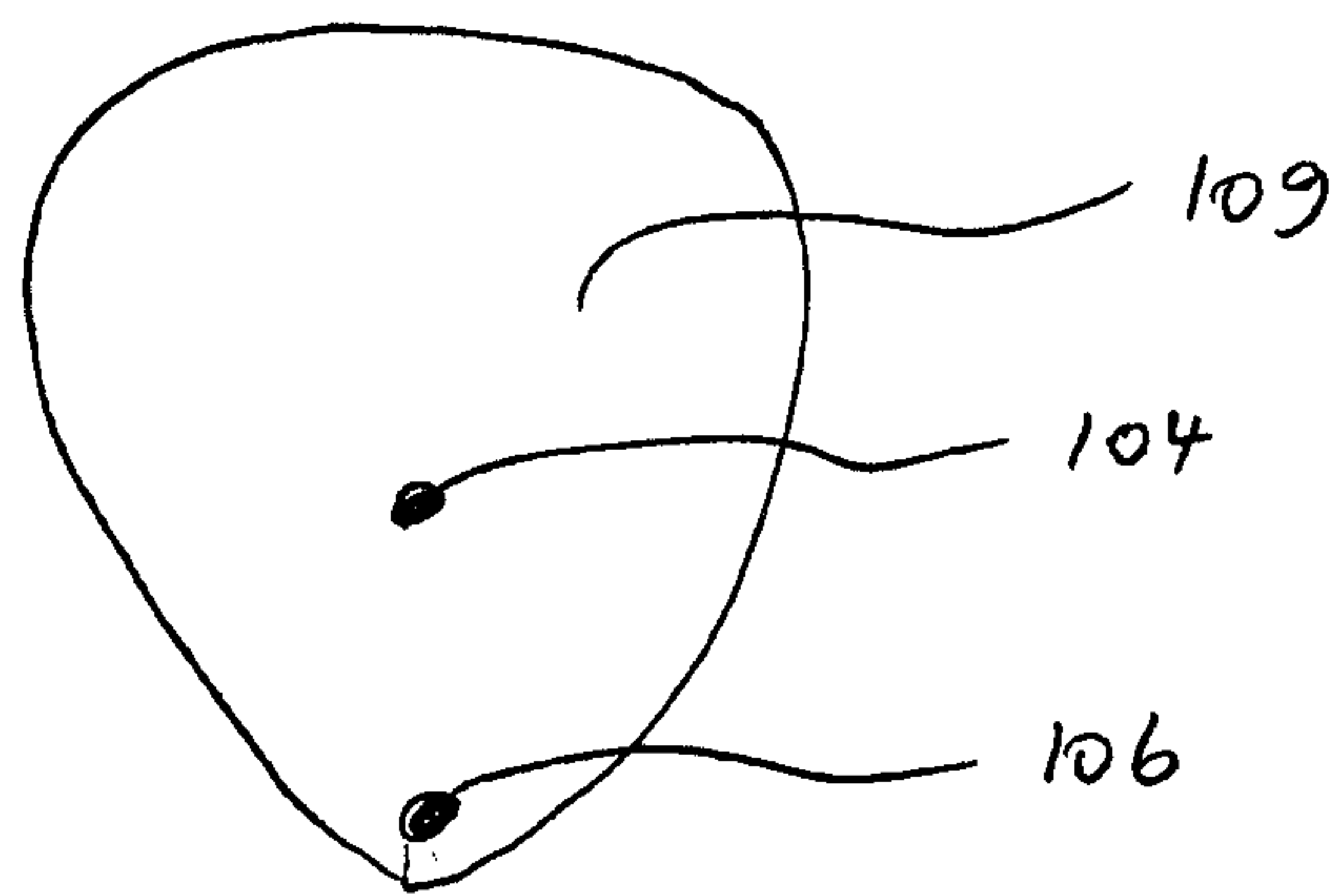


FIGURE 2

