STEAM ENERGIZED HEAVY OIL PRODUCTION SYSTEM

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ABSTRACT

A method and apparatus for production of material from a subsurface earth formation being intersected by a wellbore that is lined with a well casing. After preparing the well casing by forming injection and production openings or removing a section of the casing to define a borehole interval, a plurality of lateral injection and production passages are formed that extend into the subsurface earth formation from the casing openings or borehole interval. Packers within the well casing define an injection zone that is in communication with the lateral injection passages and a production zone that is isolated from the injection zone. Steam or other injection fluid is injected into the formation via an injection conduit extending from the surface to the injection zone. Formation fluid migrating through the formation to the production passages is produced via a production conduit extending from the surface to the production zone. For stabilization of the formation at the lateral injection and production passages a perforate liner is washed into place within each of the passages.
STEAM ENERGIZED HEAVY OIL PRODUCTION SYSTEM

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates principally to the production of heavy oil from subsurface crude oil bearing formations. More particularly, the present invention concerns a heavy crude oil production system and method employing steam injection into a plurality of lateral or radial injection passages extending from a like plurality of holes formed in the casing of a primary wellbore or extending from an interval of the wellbore and into the formation after a section of well casing has been removed. The present invention also involves the production of formation fluid from a plurality of lateral or radial production passages that also extend from the wellbore and are in spaced relation with the injection passages. The scope of the present invention also concerns a method and apparatus for production of a wide variety of subsurface minerals from a subsurface earth formation, other than heavy crude oil, by means of chemical leaching, with or without steam injection.

[0003] 2. Description of the Prior Art

[0004] The term “bores”, as used herein, is employed to describe a plurality of lateral passages that extend from a wellbore into a subsurface earth formation of interest. It is not intended that this term be restricted solely to a rotary boring or drilling operation. Rather, it is intended that the terms “lateral or radial bores” and “lateral or radial passages” be considered synonymous. The term “bore” is intended to encompass any method of forming a passage in an earth formation extending laterally or radially from a wellbore. For example, lateral or radial passages are presently formed in subsurface earth formations by hydraulic jet blasting. The terms “lateral” or “radial” are intended to identify passages that extend from a wellbore into an earth formation whether they are oriented in normal relation with the wellbore or extend upwardly or downwardly into the formation in relation to their intersection with the wellbore.

[0005] For the production of fluid, such as crude oil or minerals from wells intersecting subsurface production formations, the formation of multilateral passages from a main or principal, typically vertical wellbore has been accomplished by rotary drilling or reaming as set forth in U.S. Pat. Nos. 4,880,067, 4,928,767 and RE. 33,660 of Jelsma, or by hydraulic jet blasting as set forth in U.S. Pat. Nos. 5,853,056 and 6,125,949 of Landers and U.S. Pat. Nos. 6,263,948 and 6,668,948 of Buckman et al.

SUMMARY OF THE INVENTION

[0006] It is a principal feature of the present invention to provide a novel method for producing heavy oil or minerals from a subsurface production formation of the earth by injecting a fluid material into the earth formation via a plurality of lateral injection passages extending laterally or radially from a wellbore and producing the subsurface production formation via a plurality of lateral production passages also extending laterally or radially from the wellbore and being in spaced relation with the array of injection passages;

[0007] It is also a feature of the present invention to provide a novel method and apparatus to define an injection zone and a production zone within a wellbore being isolated from one another and each being in respective communication with an array of lateral or radial injection passages and production passages that extend from the wellbore into the subsurface formation;

[0008] It is another feature of the present invention to provide a novel method for producing heavy oil from a subsurface oil bearing earth formation by injecting steam into the subsurface oil bearing earth formation from a source at the surface via an injection conduit extending to a production zone within the well which is in communication with a plurality of lateral injection passages extending laterally or radially from a wellbore and producing the heavy oil production formation by means of a plurality of lateral production passages extending radially from the wellbore to a production zone within the well casing that is isolated from the injection zone; and

[0009] It is also a feature of the present invention to provide a novel method for producing heavy oil or minerals from a subsurface oil bearing earth formation either employing lateral injection and production passages that extend into the earth formation from holes or windows that are formed in the casing of the well or which extend from a borehole interval resulting from removal of one or more sections of the well casing at or near the production formation.

[0010] Briefly, the various objects and features of the present invention are realized through the provision of a method and system for production of subsurface constituents such as heavy oil or minerals that is energized for production by the injection of a fluid constituent into the subsurface formation under pressure. The injection fluid may be as steam for heating and energizing heavy viscous crude oil of the formation or a chemical leaching agent for leaching of desired minerals from the formation. A plurality of injection passages are formed in the production formation and extend from the wellbore and are arranged in substantially radial relation. The injection passages may extend from holes or windows that are milled or otherwise cut into the well casing or in the alternative may extend from the wellbore where a section of the well casing has been removed, such as by a casing milling operation. The injection passages are in communication with an injection zone within the well casing which is typically isolated by packers and an injection conduit extending from the surface through the well casing is also in communication with the injection zone.

[0011] A plurality of lateral production passages are formed in the subsurface formation from the wellbore and are spaced from the injection passages. The lateral production passages are in communication with a production zone within the well casing which is isolated from the injection zone, such as by means of one or more packers. A production conduit extends from the surface through the well casing to fluid handling equipment of the surface. The production conduit is also in communication with the production zone via holes or windows in the well casing or via a casing interval that exists due to the removal of one or more sections of the well casing.

[0012] When the production constituent is heavy oil, steam from a source as the surface is injected into the injection zone via the injection conduit and enters the production formation via the plurality of lateral injection passages. The steam is driven into the formation by steam.
pressure and causes heating of the heavy oil, thus reducing its viscosity and enabling it to migrate or be forced to flow through the formation by steam pressure. The radiating production passages are arranged to receive the heated heavy oil from the formation and conduct it to the production zone within the well casing. A production conduit extending from the production zone to the surface conducts the heated and less viscous heavy oil, any liberated natural gas and any water from the formation or condensed from the steam, to production fluid handling equipment that is located at the surface.

When the production constituent is a mineral that is capable of being released for the formation by chemical leaching a chemical leaching agent is pumped from a source at the surface and is conducted into the formation via the injection conduit, injection zone and the array of radiating injection passages.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features, advantages and objects of the present invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the preferred embodiment thereof which is illustrated in the appended drawings, which drawings are incorporated as a part hereof.

It is to be noted however, that the appended drawings illustrate only a typical embodiment of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

In the Drawings

FIG. 1 is a schematic illustration of the lower portion of a well, intersecting a production formation and having a system for injecting steam and/or chemical constituents into the formation via a plurality of radial passages extending from holes in the casing of a primary wellbore and producing the well via a production conduit of the well;

FIG. 2 is a schematic illustration similar to that of FIG. 1 and showing a well for steam or chemical injection via radial passages and another well having similar lateral or radial passages for production of the formation;

FIG. 3 is a schematic illustration in plan, showing an oil or other mineral production field having a plurality of well bores each having a plurality of lateral steam or chemical injection passages located in or near a production formation and collection bores extending laterally through a formation and having intersection with headers that collect the formation fluid and permit the formation fluid to be collected and produced;

FIG. 4 is a partial sectional view of a well showing holes or windows in the well casing and with lateral passages extending into an earth formation from the holes or windows that are formed in the casing;

FIG. 5 is a partial sectional view of a well showing a cased wellbore with a section of the well casing removed to expose an interval of an earth formation and showing lateral passages or passages provided with slotted post jetting liners and extending from the wellbore into the earth formation from the wellbore at the exposed interval;

FIG. 6 is a sectional view of a liner washing assembly for post jetting hole stabilization using a slotted liner that is preferably composed of polyvinyl chloride or a polymer material having similar characteristics;

FIG. 7 is a sectional view showing the liner washing assembly of FIG. 6 and illustrating an over-pull release assembly permitting separation of a washing flow-line from a jet head that is designed to wash the liner into a previously jet formed lateral passage and to remain within the lateral passage along with the slotted liner;

FIG. 9 is a sectional view of a heavy oil production system embodying the principles of the present invention having a downhole pump mechanism and representing the preferred embodiment of the invention; and

FIG. 10 is a sectional view of a heavy oil production system representing an alternative embodiment of this invention wherein a downhole pump is not employed and movement of production fluid from the formation and through the production conduit is responsive to the pressure of the injected fluid medium.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings and first to FIG. 1, a subsurface formation production system is shown generally at 10 and includes one or more primary wellbores 12 that are lined with a string of well casing 14. The primary wellbores 12 intersect a subsurface production formation 16 from which heavy viscous crude oil and natural gas are to be produced or which contains mineral constituents that can be produced by a chemical leaching process.

An injection tubing string 18 extends from the surface through the well casing 14 and is secured in place by packers 20 and 22 or by any other suitable means for support and orientation thereof within the wellbore. The lower open end 24 of the injection tubing string 18 is in communication with an injection zone 26 within the well casing which is isolated such as by packers 22 and 28 that establish sealing within the well casing.

From the isolated injection zone 26 extend an array of laterally oriented injection passages or passages 30 and 32 that are formed within the production formation 16 and extend from the wellbore wall or from a like plurality of openings or windows 34 and 36 that are formed in the well casing 14 by a suitable milling or cutting tool or by any other suitable means. In the case of heavy crude oil production from the subsurface production formation 16, steam from a suitable source “S” located at the surface as shown in FIG. 2 is typically injected through the injection tubing string 18 into the injection zone 26 of the well casing 14. From the injection zone 26 the steam enters the array of injection passages 30 and 32 and enters the subsurface production formation where it heats the heavy crude oil and reduces its viscosity and also pressurizes the production formation. The formation pressure induced by the pressure of the steam causes the heated and less viscous crude oil to migrate through the formation toward a lower pressure zone where it can be acquired and produced. In most cases a downhole pump is provided for pumping the collected production fluid to the surface; however in many cases production of the well is caused by injection pressure or steam pressure.
While only two radially or laterally oriented injection passages 30 and 32 are shown in FIG. 1, it will be apparent that any suitable number of the injection passages or bores may be formed, as is evident from the pattern of the subsurface production field of FIG. 3. Though the subsurface production field of FIG. 3 is designed particular for application of the principles of the present invention to mining operations by injected chemical leaching, a similar field pattern may also be utilized for the production of heavy crude oil by steam injection. Though the injection passages may be formed through the use of various commercially available processes, to minimize the cost of preparing a well for production according to the principles of the present invention it is desirable to form a desired number of lateral passages through the use of equipment permitting all of the lateral passages to be formed during a single run of an appropriate lateral bore tool into the well. A system for single run formation of multiple lateral passages for steam and/or chemical injection and for well production preferably employs the subject matter of U.S. patent application Ser. No. ______ of Henk H. Jelsma, filed on ______ and entitled ______, which Application is incorporated herein by reference for all purposes. In many applications, to minimize the potential for sloughing of formation material into previously jetted lateral passages it is desirable to conduct post jetting liner washing operations where a perforate i.e., slotted liner is washed into place to provide formation support and to also provide for flow of formation fluid to the wellbore for production.

For production of the well, a production tubing string 38 extends from the surface through the casing string 14 and is secured by the packer 20. The lower open end 40 of the production tubing string extends below the packer 20 and is open to a production zone 42 within the well casing 14 that is isolated by the packers 20 and 22. Typically, a pump will be located to pump collected formation fluid from the production zone to the surface; however in some cases the formation pressure, being enhanced by steam or injected fluid pressure will cause flow of the production fluid to the surface to fluid handling equipment at the surface. A plurality of lateral production passages or bores, two of which are shown at 44 and 46, extend into the production formation 16 from openings or windows 48 and 50 that are formed in the well casing. The production passages may be un-lined as shown in FIG. 4 or lined as shown in FIG. 5 depending on the characteristics of the production formation. The lateral production passages 44 and 46 may also be formed by single run operation of the lateral bore tool that is used to form the lateral injection passages 30 and 32. The lateral production passages 44 and 46 are open to the production zone 42 of the well casing. As mentioned above, for heavy oil production the heat and formation pressure induced by the pressure of the steam causes the heated and less viscous crude oil to migrate through the formation to the lateral production passages 44 and 46 which conduct the produced oil and gas through the openings or windows 48 and 50 into the production zone 42 of the well casing. When a pump is not employed, the crude oil and gas is then forced by the formation pressure into the production tubing 38 which conducts it to the surface where it is then received by surface equipment "P" for gas separation and for liquid storage, handling or transportation.

Referring now to the schematic illustration of FIG. 2, and to the schematic production field illustration of FIG. 3 heavy oil or other mineral constituents may be produced from a production field by employing injection wells and production wells or wells that employ both injection and production equipment. At the right hand portion of FIG. 2 an injection and production well system is shown generally at 52 and comprises a primary wellbore 56 which intersects a subsurface production zone 54. The primary wellbore 56 is lined with a string of well casing 58. From a source "S" of steam or chemical injection fluid, an injection supply line 60 conducts steam or chemical constituents to a control valve 64 which is monitored by pressure and/or temperature gauge 68. An injection line 72 extends from the injection fluid control valve 64 through the casing string 58 and is secured and positioned within the casing string by packers 74 and 76 or by any other suitable means for anchoring and positioning the lower end thereof with respect to the well casing. When an anchoring and sealing packers 76 and 78 are employed the packers will effect a seal within the casing string and will establish a sealed injection zone 80 within the well casing. The injection line 72 is arranged to inject steam or chemical constituents into the sealed or isolated injection zone 80.

Lateral injection passages 82 and 84 extend into the production formation from openings or windows 86 and 88 that are formed in the well casing and serve to conduct injected steam or chemical constituents from the sealed or isolated injection zone 80 into the production formation for producing the formation for oil and gas or for recovery of other minerals, such as by means of chemical leaching. Lateral production passages 81 and 83 also extend from the wellbore into the production formation and are in spaced relation with the injection passages 82 and 84 as shown. The lateral production passages are in communication with a production zone 85 which is isolated within the wellbore by the packers 74 and 76. A production conduit 77 is open to the production zone 85 and serves to conduct produced fluid to production equipment "P" which is located at the surface. Especially when the production conduit system is provided with a pump to pump the produced fluid to the surface a control valve 79 and pressure gauge 81 may be employed for production control and monitoring.

One or more adjacent wells of the production field, such as shown generally at 90 in the left portion of FIG. 2, are likewise provided with lateral steam or chemical injection passages 92 and 94 and production passages 93 and 95 that extend from the well into a subsurface formation of interest. For production of heavy crude oil or minerals, the steam or chemical constituents injected into the formation via the injection well system 52 can be caused to migrate through the formation to an adjacent production well 90. The production components of well 90 will then incorporate one or more injection and production tubing strings that are sealed within the well casing by packers and, if needed, are secured and positioned within the well casing by anchor devices or packers that also serve the function of providing for anchoring and orientation of the injection and production tubing strings.

Referring now particularly to FIG. 3 the schematic illustration in plan presents a portion of a production field arrangement, shown generally at 100, that is particularly suited to the production or mining of mineral constituents by means of chemical leaching. It should be borne in mind, however, that a production field for heavy oil and natural gas may be of similar nature. The production field of FIG. 3...
incorporates a plurality of primary, typically vertical wells 102 that extend from the surface to one or more subsurface formations of interest and are typically at least partially lined with a string of well casing. Multiple lateral or radial passages 104, 106, 108 and 110 extend laterally into the production formation from openings or casing windows that are formed at one or more desired casing depths. Steam, in the case of heavy oil, or chemical constituents, in the case of chemical leaching, is caused to flow from one or more sources “S” to one or more of the wells 102 and is injected into the formation via the lateral or radial passages that extend into the formation from the wells in the manner discussed above in connection with FIGS. 1 and 2. Each of the wells may be provided with both injection and production equipment as shown in FIG. 1 or there may be injection wells and production wells as shown in FIG. 2.

[0035] For the production of minerals, lateral collector passages 107, 109 and 111 and typically formed in the subsurface mineral containing formation and are typically oriented laterally. The collector passages are in communication with collector receptacles 114, 115 and 116 that receive and collect the leached chemical materials together with the residual leaching fluid. The collected fluid is then recovered from the collector receptacles by means of pumps or any other suitable system for recovering the fluid and then transmitting it to suitable handling or processing equipment which is located at or near the earth surface.

[0036] Referring now to FIGS. 6 and 7, in cases where the subsurface production formation requires support to minimize the potential for sloughing of the formation material into the jetted lateral passages, the present invention also contemplates employment of equipment and processes for installing formation supporting liners which are preferably perforated or slotted to provide for flow of injected fluid from the lateral passages into the production formation or flow production fluid into the lateral passages for production. As shown in FIG. 6 a slotted tubular liner is shown generally at 120, which is preferably composed of polyvinyl chloride or any one of a number of polymer materials having similar characteristics. The tubular liner is provided with a multiplicity of flow slots or perforations 122 that are located along substantially the entirety of its length. The slotted formation support liner is of sufficient flexibility to be passed through the principal typically vertically oriented wellbore and to become bent as it is diverted into a lateral passage that extends from the wellbore into the formation.

[0037] After lateral passages have been formed in the formation such as by a jetting or hydroblasting operation a jet washing assembly 124 is connected to the leading end of the liner and a fluid supply conduit 126 is connected in fluid supplying relation with a jet washing head 128 by means of an over-pull release mechanism 130. The fluid supply conduit 126 is typically formed by flexible tubing that can be run into the well and bend to transition into the lateral passages that extend from the wellbore. The jet washing head 128 is provided with a plurality of hydraulic jet nozzles 132 that are arranged to direct jets of high velocity fluid, such as water, against the formation within the lateral passages. The jet nozzles 132 of the jet washing head 128 may be arranged to develop a reaction force which drives the jet washing head 128 and the liner 122 forwardly from the wellbore and into a lateral passage responsive to the jet reaction that occurs at the jet washing head. After sufficient jet washing has occurred to position the entirety of the formation supporting slotted liner 120 within a lateral passage, a pulling force is applied to the fluid supply conduit 126, causing the over-pull release mechanism to actuate, releasing the connection of the fluid supply conduit 126 with the jet washing head 128. When this occurs the fluid supply conduit 126 is simply withdrawn from the slotted liner and is retrieved from the well. This process is repeated until the desired lateral passages have been provided with a formation supporting liner. Thereafter, the liners will prevent sloughing of the formation material into the lateral passages and the slots or perforations of the liner will permit efficient flow of injection fluid into the formation and will permit the flow of production fluid from the formation and into the lateral passages.

[0038] Referring now to FIG. 8 which shows the a steam energized heavy oil production system preferred embodiment of the present invention generally at 140 a borehole is shown at 142 which is lined with a well casing 144 in typical fashion. Upper and lower sets of holes or windows 146 and 148 are provided in the well casing or in the alternative, portions of the casing may be milled or otherwise cut away to expose one or more desired intervals of the borehole. Arrays of lateral injection passages 150 and lateral production passages 152 are formed in vertically spaced relation within the surrounding production formation. Each of the vertically spaced arrays of lateral passages may have any desired number of lateral passages that extend into the formation to be produced. These lateral passages may also be lined by a slotted liner if desired.

[0039] A production assembly shown generally at 154 is installed within the well casing and may be supported by a casing head 156 which is mounted to the upper end of the casing at or above surface level. The production assembly 154 incorporates an injection conduit 156 receiving steam or other injection fluid from a source “S” and having an injection supply conduit 158 which extends downwardly within the well casing. The injection supply conduit is open by means of perforations 159 of a portion of the injection conduit to an injection chamber or zone 160 that is located between spaced packers 162 and 164. The injection conduit terminates at a baffle 166 that is located below the lower packer member 162. The lower end portion of the injection conduit is offset so that the tubular portion that is located between the packer members is substantially centralized within the well casing.

[0040] A production conduit 168 also extends from the casing head 156 through the well casing and it positioned with its lower terminus located above the upper packer member 164 and thus within a production chamber or zone 170. The upper array of lateral production passages 152 are located to deliver collected production fluid into the production chamber 170. A pump 172 is provided at the lower portion of the production conduit 168 and is provided with upper and lower valve members 174 and 176 which open and close responsive to differential pressure. The pump 172 is a piston pump that is actuated by a reciprocating string of pump actuating rods 178 that are energized by a pump jack or other power device. The uppermost one of the pump actuating rods extends through a packing and control valve assembly 180 so that a seal is maintained during pump actuation. A production discharge conduit 182 extends from the packing and control valve assembly 180 and serves to
conduct produced well fluid to the usual fluid receiving and handling equipment for gas/water separation and conducts the produced crude oil to a suitable facility for storage and handling.

[0041] The steam energized heavy oil production system 140 is positioned within the well casing 144 by means of one or more centralizers 184 thus positioning the lower end of the injection conduit in substantially centralized position within the injection zone 160 and also positioning the packers 162 and 164 in position for efficient sealing engagement with the inner surface of the well casing. If desired, the injection conduit and the production conduit may be connected in spaced relation by means of connecting devices along the length thereof so that the conduits will not have any tendency to become twisted between the surface and the production zone.

[0042] Another embodiment of the present invention is shown generally at 190 in FIG. 9 wherein a wellbore 192 is shown to have a well casing 194 that is provided with upper and lower arrays of openings or windows 196 from which arrays of injection and production passes are formed within the subsurface formation. In a typical shallow well the well casing may have an internal diameter of 4 ½ inches. The well production system 190 has a string of production tubing 198 which extends to the surface and may have an internal diameter of about 2 ½ inches. The injection tubing 200 extends from the surface through the production tubing 198 and is provided with a centralizer device 202 to engage the inner wall of the production tubing 198 and to maintain the production tubing centrally located therein. The production tubing 198 is perforated as shown at 204 to admit production fluid from the well casing. Upper and lower packers 206 and 208 are provided on the injection tubing 200 and engage the internal surface of the well casing 194 and define an injection zone 210 within the well casing. The injection zone is in communication with the lower array of injection passes 197 of the subsurface formation and thus provide for injection of steam or chemical injection fluid into the formation. A bullnose member 212 is located beneath the lower packer member 208. The injection tubing is open to the injection zone 210 by means of a multiplicity of injection perforations 212.

[0043] The present invention is practiced according to the following method: Lateral or radial passages are formed within a subsurface formation by drilling or by hydraulic jet blasting from openings or windows that are formed in the well casing at a desired depth and desired orientation. In the alternative, one or more sections of the well casing at the depth of the production formation may be removed such as by a milling operation. Preferably a “single-run” lateral passage forming tool is run into the well casing and is set at a desired orientation and anchored either at the bottom of the wellbore or at a desired depth within the wellbore, such as by means of packers and anchors. The single-run lateral passage forming tool may also be selectively moved to two or more vertically spaced locations within the well casing after the formation of a plurality of multiple lateral passages, without having to retrieve the tool from the well. This “single-run” feature significantly minimizes the labor and equipment operation time that is required to prepare a well for injection of steam or chemical constituents or for production of fluid from the formation that is intersected by the well.

[0044] Following multilateral passage or bore forming activity, for support of the formation to minimize the potential for blockage of the lateral injection and production passes in the formation, a slotted or perforated liner composed of flexible polyvinyl chloride or any one of a number of suitable polymer materials having similar characteristics is washed into place within each of the lateral passes. When the liner is properly positioned within the lateral passes a pulling force is applied to the flexible washing fluid supply conduit 126 to release the over-pull release mechanism of the jet head, thus leaving the liner and jet head in position within each of the lateral passes. After this has been done, an injection tubing string adapted for communication with a source of steam or leaching chemical constituents is positioned within the well with its lower open end in communication with an isolated injection zone within the well casing or wellbore with which radial injection passages of the formation are also in communication. The injection zone is isolated by packers or by any other suitable means. The steam pressure or injection pressure within the injection zone causes the steam or chemical constituents to be injected into the formation from the lateral or radial passes, thus treating and pressurizing the production fluid and causing migration of the treated fluid within the formation toward the lateral production passes. The lateral production passes are situated relative to the injection passes such that the migrating fluid of the formation is collected by the production passes and is then conducted to the production zone within the primary wellbore. From the production zone the fluid is conducted to fluid handling equipment at the surface via the production tubing either under the influence of a downhole pump or by the pressure of the injected fluid medium.

[0045] Referring specifically to FIG. 4, the sectional view illustrates a wellbore 120 being lined with a well casing 122. Openings shown at 124, 126 and 128 are formed in the well casing by any suitable means and radial passages or passes 130, 132 and 134 extend into an earth formation of interest from the openings or windows of the well casing.

[0046] As shown in FIG. 5, a wellbore is shown at 136 to be lined with a well casing 138 in conventional manner. A section or interval of the well casing is shown to have been removed such as by means of a milling operation, thus exposing the wellbore wall at or near the production formation. Lateral passages or bores 140, 142 and 144 are shown to extend from the wellbore 136 into the subsurface earth formation. A like set of lateral passages or bores, either for injection or production will be located above or below the lateral passages shown in FIGS. 4 and 5. The vertical spacing of the lateral injection and production passages will be determined by the thickness or other factors of the production formation.

[0047] In view of the foregoing it is evident that the present invention is one well adapted to attain all of the objects and features herein above set forth, together with other objects and features which are inherent in the apparatus disclosed herein.

[0048] As will be readily apparent to those skilled in the art, the present invention may easily be produced in other specific forms without departing from its spirit or essential characteristics. The present embodiment is, therefore, to be considered as merely illustrative and not restrictive, the
scope of the invention being indicated by the claims rather than the foregoing description, and all changes which come within the meaning and range of equivalence of the claims are therefore intended to be embraced therein.

1 claim:
1. A method for production of material from a subsurface earth formation being intersected by a wellbore, comprising:
   forming a plurality of lateral injection passages extending into the subsurface earth formation from the wellbore;
   forming a plurality of lateral production passages extending into the subsurface earth formation from the wellbore, said plurality of lateral production passages being substantially vertically spaced from said plurality of lateral injection passages;
   establishing an injection zone within the wellbore, said injection zone having communication with a source of injection fluid via an injection conduit;
   establishing a production zone within the wellbore being sealed from said injection zone, said production zone being in communication with fluid handling equipment at the surface via a production conduit;
   injecting fluid from a source of injection fluid into said injection zone and into the formation via said injection passages, the injection fluid migrating through the production formation to said plurality of lateral production passages; and
   producing material and injection fluid from the subsurface formation via said plurality of lateral production passages and said production zone and to the surface via said production conduit.
2. The method of claim 1, wherein said material of the subsurface formation being heavy oil and said injection fluid being steam, said method comprising:
   injecting steam into the subsurface formation from a source of steam via said injection conduit, injection zone and said plurality of lateral injection passages to render the heavy oil less viscous and to cause steam pressure induced migration of the heavy oil through the subsurface earth formation and to said plurality of lateral production passages; and
   producing the heavy oil from said production zone to said production fluid handling equipment via said production conduit.
3. The method of claim 1, comprising:
   after forming a plurality of lateral injection and production passages in the subsurface formation, placing perforate liners within each of said lateral injection and production passages and stabilizing the subsurface formation.
4. The method of claim 3, wherein said step of placing perforate liners comprising:
   for each of said lateral injection and production passages, attaching a jet washing head to a perforate liner and attaching a washing fluid supply conduit to said jet washing head with an over-pull release mechanism; and
   after washing the liner to a position substantially completely lining the lateral passage, stopping washing activity and applying sufficient pulling force to said washing fluid supply conduit to release said over-pull release mechanism; and
   retrieving said washing fluid supply conduit, leaving said perforate liner and said jet washing head within the lateral passage.
5. The method of claim 1, wherein said material of the subsurface formation being a mineral and said injection fluid being a leaching constituent for said mineral, said method comprising:
   injecting said leaching constituent into the subsurface formation from a source thereof via said injection conduit, said injection zone and said plurality of lateral injection passages to leach the mineral from the earth formation and to cause pressure induced migration of the mineral and leaching constituents through the subsurface earth formation to said plurality of lateral production passages and to said production zone; and
   producing the mineral and leaching constituent from said production zone to said production fluid handling equipment via said production conduit.
6. The method of claim 1, comprising:
   forming a plurality of openings in the well casing; and
   forming said plurality of lateral injection and production passages within the subsurface earth formation from said plurality of openings.
7. The method of claim 1, comprising:
   removing at least one section of said well casing to define one or more non-cased intervals; and
   forming said plurality of lateral injection and production passages within the subsurface earth formation from said one or more non-cased intervals.
8. The method of claim 1 wherein said method step of forming a plurality of lateral injection passages and forming said plurality of lateral production passages comprising:
   locating a single-run lateral passage forming tool within the wellbore; and
   running a hydro-blasting tool through said single-run lateral passage forming tool and into the subsurface earth formation; and
   relocating said single-run lateral bore forming tool within the well bore after completion of each of said plurality of lateral injection passages and said plurality of lateral production passages.
9. A method for production of heavy and normally viscous crude oil from a subsurface earth formation being intersected by a wellbore lined with a well casing, comprising:
   forming a plurality of injection and production openings in the well casing at predetermined locations for fluid injection and for heavy crude oil production;
   forming a plurality of lateral injection passages extending into the subsurface earth formation from the plurality of injection openings;
   forming a plurality of lateral production passages extending into the subsurface earth formation from the plurality of production openings, said plurality of lateral production passages being spaced from said plurality of lateral injection passages;
establishing an injection zone within the wellbore, said injection zone having communication with a source of steam via an injection conduit;

establishing a production zone within the wellbore being sealed from said injection zone, said production zone being in communication with fluid handling equipment at the surface via a production conduit;

injecting steam from a source into said injection zone and into the production formation via said injection conduit, injection zone and said plurality of lateral injection passages, the steam heating the heavy viscous crude oil of the subsurface formation and reducing the viscosity of the heavy crude oil and causing migration of the heavy crude oil through the production formation to said plurality of lateral production passages and into said production zone; and

producing the heavy crude oil from the subsurface formation via said plurality of lateral production passages, said production zone and said production conduit.

10. The method of claim 9, comprising:

setting at least one packer within said well casing and establishing said injection zone, said injection conduit extending through said at least one packer and being open to said injection zone; and

setting at least one packer within said well casing and establishing said production zone, said at least one packer isolating said production zone from said injection zone, said production conduit extending through said at least one packer and being open to said production zone.

11. The method of claim 9, comprising:

forming a plurality of openings in the well casing; and

forming said plurality of lateral injection and production passages within the subsurface earth formation from said plurality of openings.

12. The method of claim 9, comprising:

removing at least one section of said well casing to define one or more non-cased intervals; and

forming said plurality of lateral injection and production passages within the subsurface earth formation from said one or more non-cased intervals.

13. The method of claim 9, wherein said material of the subsurface formation being heavy oil and said injection fluid being steam, said method comprising:

injecting steam into the subsurface formation from a source of steam via said injection conduit, injection zone and said plurality of lateral injection passages to render the heavy oil less viscous and to cause steam pressure induced migration of the heavy oil through the subsurface earth formation and to said plurality of lateral production passages; and

producing the heavy oil from said production zone to said production fluid handling equipment via said production conduit.

14. The method of claim 9, wherein said material of the subsurface formation being a mineral and said injection fluid being a leaching constituent for said mineral, said method comprising:

injecting said leaching agent into the subsurface formation from a source thereof via said injection conduit, said injection zone and said plurality of lateral injection passages to leach the mineral from the earth formation and to cause pressure induced migration of the mineral

and leaching agent through the subsurface earth formation to said plurality of lateral production passages and to said production zone; and

producing the mineral and leaching agent from said production zone to said production fluid handling equipment via said production conduit.

15. A system for production of a material from a subsurface earth formation being intersected by a wellbore, comprising:

an array of lateral injection passages extending into the subsurface earth formation from the wellbore;

an array of lateral production passages extending into the subsurface earth formation from the wellbore, said array of lateral production passages being spaced from said array of lateral injection passages;

an injection zone within the wellbore;

a production zone within the wellbore being isolated from said injection zone, and being in communication with fluid handling equipment at the surface;

an injection passage within the wellbore being in communication with said injection zone; and

a production passage within the wellbore being isolated from said injection passage and being in communication with said production zone.

16. The system of claim 15 wherein the wellbore is lined with a well casing, said system comprising:

a plurality of injection openings and a plurality of production openings being defined at spaced locations within the well casing; and

said array of plurality of lateral injection passages and said array of production passages extending within the subsurface earth formation respectively from said plurality of injection openings and said plurality of production openings.

17. The system of claim 15 wherein the wellbore is lined with a well casing, said system comprising:

at least one section of the well casing being removed to define at least one non-cased interval; and

said plurality of lateral injection and production passages within the subsurface earth formation extending from said at least one non-cased interval.

18. The system of claim 15, comprising:

perforate liners being positioned within each of said lateral injection and production passages;

each of said perforate liners having a washing head being coupled with said perforate liner and having a plurality of washing jets and being hydraulically energized with flowing washing fluid to move said perforate liner to a position substantially completely lining a lateral injection or production passage; and

during installation of each of said perforate liners a washing fluid supply conduit connected with a supply of washing fluid extending through said perforate liner and having releasable connection with said washing head.