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RECOVERY OF HEAVY OIL FROM OIL SANDS

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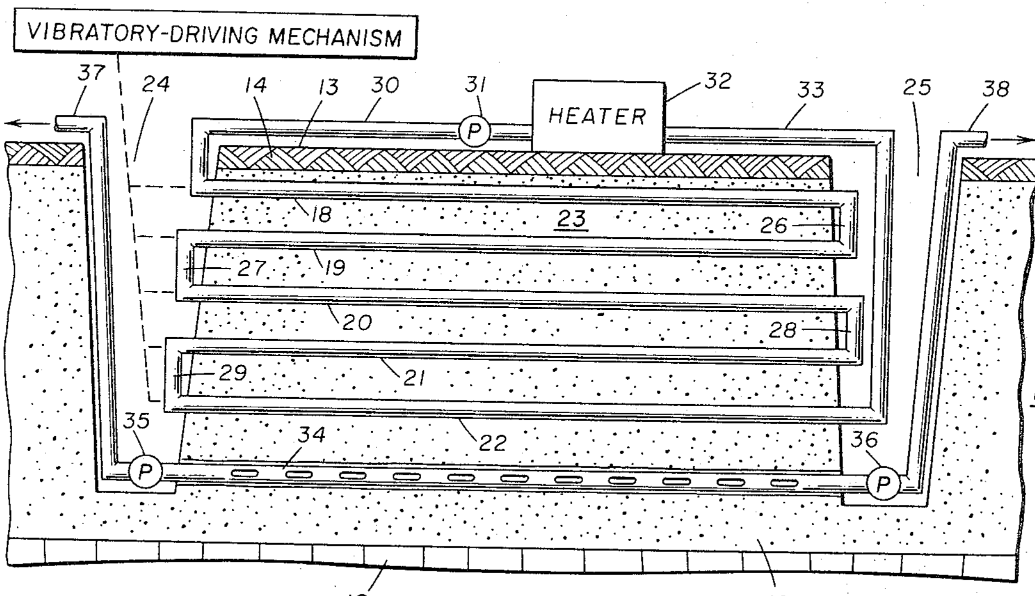

FIG. 1

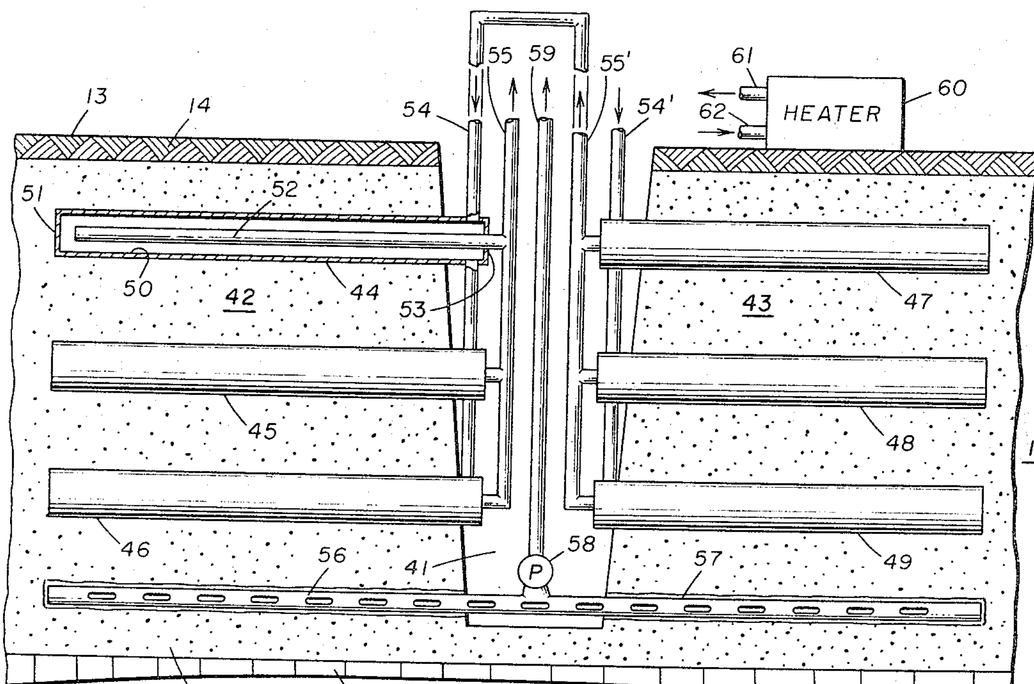

FIG. 2

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RECOVERY OF HEAVY OIL FROM OIL SANDS

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ABSTRACT OF THE DISCLOSURE

This specification describes:

A method for the recovery of heavy oil in substantially its original state from a formation of unconsolidated oil sands. A plurality of vertically spaced, interconnected conduits provide an enclosed continuous fluid path through the formation. Heated fluid, from any source, is passed through these conduits for heating indirectly the oil to reduce its viscosity sufficiently that it flows downwardly into an oil-collection conduit from which it is recovered. The conduits are placed into tight sidewall engagement with the formation; and vibratory-driving means may be used for this purpose. The conduits may be driven into the formation from trenches. The conduits may be arranged to extract heat from heated areas and to apply this heat to cooler areas of the formation.

This invention relates to a method for recovering oil from unconsolidated oil sands within the earth, and more particularly, to such methods wherein indirect heating is employed for winning heavy oils from formations of oil sands.

There are vast deposits in the earth which contain large amounts of hydrocarbons and in which, at the present, the hydrocarbons may be classified as unrecoverable in their natural state through a well by conventional petroleum-producing methods. Among these deposits are oil sands which contain a highly viscous crude oil in an unconsolidated sand matrix. The oil sands, which are commonly known as the Athabasca Tar Sands, are a prime example of unconsolidated formations containing heavy oils unrecoverable by conventional petroleum-producing methods at the present time. The hydrocarbons in these oil sands have great viscosities at ambient formation temperatures but advantageously undergo a substantial reduction in viscosity when subject to elevated temperatures. For this reason, thermal recovery procedures practiced in situ appear to bear great promise as a practical and economical method for winning these heavy oils from oil sands.

Thermal recovery methods require the application of heat to the hydrocarbons so as to reduce their viscosity sufficiently to effect mobility. Thus, some means of heat transfer from a heat source to the heavy oils is required. The principal methods of heat transfer are by radiation, conduction, and convection. The transfer of heat by radiation is relatively inefficient, particularly when it is considered to be carried out within a subterranean formation for producing heavy oil. For the same reason, conduction, as a means for heat transfer through the formation matrix to the heavy oil, is somewhat more effective but requires a great lenth of time to pass through even one foot of formation. Production of the heavy oil from within the earth is much desired at as early a time as possible after applying the heat energy. Convection has economic efficiency in transferring heat energy underground from a source to the heavy oil to reduce its viscosity.

It has been a practice in the past to transfer heat through convection by a direct means. For example, a heated fluid passed into the formation directly heat exchanges with the heavy oil to reduce its viscosity. As a result of absorbed heat, the heavy oil may then flow read-

ily through the formation to a place from where it is recovered. These heated fluids may be obtained through in situ combustion, or injections of heated gases such as steam. Any direct heat exchange procedure employing heated fluids changes the character of the heavy oil. For example, the heavy oil produced by in situ combustion is thinned to a considerable degree by thermal degradation. The thinned heavy oil produced is also usually in tight emulsions formed with the water present in the formation.

In many instances, it is desired that the heavy oil be recovered in as near its original state as possible. For example, the recovery of heavy oils from tar sands permits their use directly in the manufacture of asphalt, in fluid-coking procedures to make industrial coke, and in the manufacture of construction materials, such as roofing, bricks, and the like. For this purpose, the direct heating of the heavy oil by a foreign heated fluid to obtain its recovery from subterranean formations obviously does not provide the best product for all uses.

One solution to the recovery of the heavy oil in its original form is by indirect heating. As mentioned previously, radiation and conduction type heat transfer, as from an indirect heat exchanger carrying a heated fluid in isolation from the formation, in the past required large amounts of heat and extended periods of time to obtain the production of heavy oil. Preferably, heat transfer is best obtained by convection to establish mobility of the heavy oil.

Conduits carrying heated fluids in isolation from the formation could provide a suitable answer. However, no matter what degree of care was employed in the past in placing these conduits in unconsolidated oil sands, as for example by boring, a slight space remained between the conduits and the formations. This space reduces heat transfer to principally radiation and thereby greatly reduces the effective transfer of heat between the conduit and the adjacent formation. The solution to this problem is greatly complicated by the nature of the oil sands formations. These formations are unconsolidated. More particularly, the oil sands such as in the Athabasca deposits have a plastic nature which results in a hybrid stress behavior resembling that of a liquid hydrocarbon and a solid substratum. Thus, the oil sands readily yield to redistribute partially the stresses prior to any initial failure, such as in fracturing. As a result, boring through the oil sands will result in their yielding outwardly very readily to provide an enlarged bore with a nonuniform gauge. Great difficulty is later experienced in inserting a conduit within such bore in tight sidewall engagement with the formation. Also, the oil sands usually are not pure matrices of unconsolidated material. Interspersed within these formations may be various thin beds of clay, silt, and shale sections, which shale sections include shaley sands, as well as lenses of barren siltstones and the like interbedded therein. Further, these interbeddings may be continuous or discontinuous in the horizontal, depending upon the locality of the deposit. Obviously, the nonuniform natural structure of the oil sands formation complicates the problem relating to indirect heating.

The method of this invention overcomes the aforementioned problems to produce more economically from unconsolidated formations of oil sands, heavy oils in near their original state. Broadly, initial mobility is established in the heavy oil by heat energy applied indirectly from conduits specially disposed in the oil sands, principally by conduction. After the heavy oils have sufficient mobility to gravitate, the gravitation of such oils heats further areas of the oil sands by heat energy applied from the conduits being principally transferred by convection. Thus, although heating is applied indirectly to the oil sands, initially conduction and lastly convection provide the principal means of heat transfer to the heavy oil to establish its mobility. The heavy oil, after being made mobile, is suitably recovered without contamination from a directly applied heated fluid.

It is the principal purpose and object of this invention to provide a thermal method for recovering heavy oil from subterranean oil sands without suffering the undesired aforestated results. Another object is to provide a method for the recovery of heavy oils from oil sands by heating the heavy oils through an indirect heat exchange means, by transferring heat initially through conduction and later by convection. Another object, as for indirectly heating the heavy oil in oil sands formations, is to dispose a conduit for carrying a fluid in tight sidewall engagement with the surrounding formation. Another object is to provide a method for recovering from oil sands heavy oils in substantially their original state and without contamination from nonresident fluids. These and other objects will be more apparent when considered in conjunction with the following detailed description of embodiments of the present invention, the appended claims, and the attached drawings in which like structures bear like reference numerals, and wherein:

FIGURE 1 is a vertical section taken through the earth illustrating an oil sands formation with the structures employed for carrying out indirect heating for recovering heavy oil according to the method of the present invention; and

FIGURE 2 is a view like FIGURE 1 showing additional structures which may be employed according to the method of this invention for the recovery of heavy oil.

Referring particularly to FIGURE 1 of the drawings, a description of a preferred embodiment of the method of this invention will be described as practiced in an unconsolidated oil sands formation. A subterranean formation **11** is shown which contains oil sands **12**, such as Athabasca Tar Sands, disposed below the earth's surface **13** beneath an overburden **14** which may be glacial drift. The oil sands **12** usually rest upon a bedding **16** which may be limestone.

As the first step of this embodiment, a plurality of conduits **18** through **22**, inclusively, are disposed with tight sidewall engagement into the oil sands **12** and with the conduits being vertically aligned in spaced relationship from one another. For this purpose, a block **23** of the oil sands **12** may be provided in nature with an exposed working surface by terrain breaks, or the like. Each conduit is positioned at a suitable angle of attack to the working surface and then driven into the oil sands **12**. However, where a working surface of the block **23** is not naturally exposed, it may be desirable first to provide one or more trenches **24** and **25** from the earth's surface **13** extending downwardly into the oil sands **12**. The trenches **24** and **25** are of suitable dimensions to facilitate driving the conduits **18** to **22** and they may be provided by any suitable means, such as by a dragline, a digging machine, or the like. Other means, of course, can be used to provide an exposed working surface.

The means for driving the conduits **18** to **22** may be of any suitable design which can obtain tight sidewall engagement with the surrounding oil sands **12**. Preferably, the conduits **18** to **22** are driven with vibrators into the oil sands **12** which cause longitudinal expansion and contraction of these conduits. For example, the vibratory-driving mechanisms illustrated in the United States Patents 2,972,380, 2,975,846, and 3,054,463, may be employed to great advantage. Other driving mechanisms which produce longitudinal vibrations of the conduits may be used if desired. Mechanical biasing means may be necessary to supplant the force of gravity on the vibratory-driving means, which means are illustrated schematically in FIGURE 1, where the conduits **18** to **22** are driven off vertical into the oil sands **12**. It is an advantage to drive the conduits **18** to **22** by their longitudinal vibrations into the oil sands **12** since the yielding-elastic nature

of the oil sands **12** insures that these conduits will be disposed in tight sidewall engagement with the immediate surrounding formation. Thus, no open spaces surrounding or interposed between these conduits and the oil sands **12** exist across which initial heat transfer must depend more nearly on radiation alone. Obviously, the conduits **18** to **22** may be made in short couplable sections to facilitate their being driven to the desired extent in the oil sands **12**. If desired, the forwardmost extremities of the conduits penetrating the oil sands **12** may be provided with suitable pointed extremities to reduce the magnitude of the driving forces. These structures are not shown, but are considered to be conventional in the pile-driving art.

As mentioned, the conduits **18** to **22** are vertically aligned from one another at equal or random spacings in the oil sands **12**. This arrangement insures the transfer of heat indirectly from the conduits **18** to **22** to the heavy oil in the immediate surrounding oil sands **12** initially by conduction until the oil is sufficiently made mobile to gravitate and then by convection with the downward flow of the heated heavy oils along the subtending conduits. More particularly, the heavy oil in the oil sands **12** immediately surrounding the conduit **18** will become more fluid by its being initially heated by conduction until the heated oil will gravitate downwardly toward the conduit **19**. The heavy oil about the conduit **19** is also heated sufficiently to gravitate, and will then gravitate downwardly with the other descending oil. Thus, there will be a continuous supply of gravitating heavy oil from around each of the conduits. This insures that each subtended conduit always receives a supply of the heated heavy oil gravitating downwardly from about each superimposed conduit. Thus, indirectly applied heat from the conduits **18** to **22** is transferred through convection, once initial mobility is obtained, by gravitation of the heated heavy oils to the unheated heavy oils throughout the vertical extent of the oil sands **12**.

The next step of this method is the passing of a heated fluid through the conduits **18** to **22** to heat indirectly the adjacent heavy oil to a temperature so that it gravitates downwardly in the block **23**. To effect this step, the conduits **18** through **22** are interconnected at their ends with conduit means to provide a continuous flow path therethrough. For example, the conduit **18** is connected to the conduit **19** through an elbow **26**. Similarly, the remainder of the conduits are interconnected through elbows **27, 28,** and **29**. The end of the conduit **18** not joined to the conduit **19** is connected through suitable piping **30** to a source of heated fluid which may include a pump **31** and then to a heater **32**. The end of the conduit **22** not connected to the conduit **21** is connected by suitable piping **33** to the heater **32**. The heater **32** may be of any suitable construction. For example, the heater **32** may be a gas-fired boiler, through which a fluid is circulated, via the piping **30** and **33**, to be heated to suitable temperatures for use in the oil sands **12**. Preferably, the heated fluid from the heater **32** is circulated through the piping **33** downwardly into the conduit **22**, and thence upwardly to exit the conduit **18** through the piping **30**, the pump **31**, and then is re-introduced into the heater **32**.

The fluid circulated through the conduits **18** to **22** may be of any type. For example, hot water, steam, or other heat-carrying fluid, gaseous or liquid, may be employed. One advantage of employing steam is that for a given pressure with an adequate supply of steam, the temperature of the fluid circulating through the conduits **18** to **22** will be uniform throughout its travel. Thus, the temperature of the fluid may be regulated sufficiently to heat indirectly the heavy oil about each conduit in the oil sands **12** initially by conduction to a temperature sufficient that it gravitates downwardly in the block **23** of oil sands **12** and thereafter to distribute heat energy by convection to further areas in the oil sands **12**.

The last step of this embodiment is the recovery of heavy oil which gravitates downwardly in the block **23** of the oil sands 12. The heavy oil may be recovered by any suitable means. For example, a perforated pipe 34 may be disposed through the lower levels of the oil sands 12 between the trenches 24 and 25. Preferably, the pipe 34 is not placed into tight sidewall engagement with the oil sands 12. It is more desirable that the perforated pipe 34 be disposed within a borehole formed by conventional drilling means. The greater the space about the pipe 34, the easier will be the collection of the gravitating heavy oil. The pipe 34 is connected through suitable means, such as pumps 35 and 36, and thence through suitable piping 37 and 38, to a suitable surface employment for the recovered heavy oil. It is obvious that the heavy oil also may be collected at the bottoms of the trenches 24 and 25 from which it is readily recovered by any suitable mechanism, if desired.

It will be apparent that passing the heated fluid through the conduits 18 to 22 in the block 23 of oil sands 12 will result in the production of heavy oil by indirect heating effects through initially conduction and lastly through convection. The recovered heavy oil will be substantially the same as it was originally. Thus, the problems of visbreaking, stripping of the lighter portions or tight emulsions formed through the employment of in situ combustion, steam injection, or similar fluid injection procedures are avoided.

Turning now to FIGURE 2, suitable structure for practicing another embodiment of the present method will be described. In FIGURE 2, the geological structures are the same as described for FIGURE 1 and bear like referenec numerals. A working surface of the oil sands 12 is exposed by nature or, if desired, by a trench 41. The trench 41, of suitable dimension, forms blocks 42 and 53 in the oil sands 12.

As the next step, a plurality of paralleled conduits 44 to 49 are driven into the blocks 42 and 43 of the oil sands 12. Preferably, these conduits are driven substantially horizontallly into the oil sands 12 as from the trench 41. These conduits are vertically aligned in spaced relationship from one another in each of these blocks. For example, the conduits 44, 45, and 46 are driven substantially horizontally into the block 42 in vertical spaced alignment from one another; and the conduits 47, 48, and 49 are driven substantially horizontally into the block 43 in vertical spaced alignment from one another. Any suitable means for driving the conduits into the blocks 42 and 43 may be employed wherein tight sidewall engagement with the oil sands 12 is obtained. The means employed in the earlier described embodiment for driving the conduits with vibrators may be used to good advantage. The conduits 44 to 49 are of any suitable construction which permits indirect heating by a circulating heated fluid. The conduits 44 to 49 may take the form which is shown in partial section for the conduit 44. More particularly, the conduit 44 is comprised of an outer sheath 50 adapted to withstand driving into the oil sands 12 with a fluid-tight closure 51 at its end remote from the trench 41. Disposed coaxially within the sheath 50 is a pipe 52 open at its end adjacent the closure 51. The tube 52 at its other end extends exteriorly from the sheath 50 through a fluid-tight header 53. Inlet and outlet pipes 54 and 55 are connected to the sheath 50 in fluid communication with the annulus between the tube 52 and the sheath 50. Fluids introduced into either the sheath 50 or the tube 52 will exit through the other of these members. Preferably, all of the conduits 44 to 49 are of this construction with their respective inlet and outlet pipes connected together in parallel. The inlet and outlet pipes of conduits 47 to 49 are designated as 54′ and 55′. At a lower level in each of the blocks 42 and 43 are disposed perforated pipes 56 and 57, respectively. These perforated pipes 56 and 57 may be constructed and disposed within the oil sands 12 in the same manner as was pipe 34 in the previously described embodiment. The perforated pipes 56 and 57 are connected together with a pump 58 and otlet pipe 59. The heavy oil collecting in these perforated pipes is passed to the earth's surface 13 for suitable utilization.

A heater 60 is provided, which means may be disposed at the surface of the earth, for heating a fluid to a temperature suitable to effect a sufficient reduction in the viscosity of the heavy oil in the oil sands 12 that it will gravitate downwardly to a lower level in each of the blocks 42 and 43. For example, the heater 60 may take the form of a steam boiler where water is heated to form steam which is passed outwardly through outlet 61. Feed water, as a liquid or steam, is passed into the heater 60 through inlet 62.

In a particular preferred mode of operation, the heated fluid is passed by suitable piping from the outlet 61 to the inlet pipe 54 of the conduits 44 to 46 (in parallel) so as to transfer heat from the heater fluid indirectly to the heavy oil in the oil sands 12. The heated fluid returns, via the outlet 55 from the conduits 44 to 46 through suitable piping, to the inlet pipe 62 of the heater 60. The circulation of heated fluid through the conduits 44, 45, and 46 is continued with the fluid at a temperature sufficient to heat indirectly the heavy oil in the block 42 to a temperature so that it gravitates downwardly to a lower level from which it is collected within the perforated pipe 56 and recovered through employment of the pump 58 and conduit 59. The recovered heavy oil may be passed to storage or suitable utilization as desired. After the block 42 has received sufficient heat from the conduits 44 to 46 in excess of that required for a desired recovery of heavy oil, circulation of the heated fluid may be discontinued. At this time, there will be sufficient heat stored in the matrix of the oil sands 12 for the heavy oil to continue to gravitate downwardly to the perforated pipe 56 for ready recovery. At such time, the conduits 44, 45, and 46 may be removed from the block 42.

The heated fluid from the outlet 61 of the heater 60 is passed by suitable piping via the inlet pipe 54′ through the conduits 47 to 49 (in parallel). The fluid will heat the surrounding oil sands of block 43 in the same manner as in the previous block 42. The heated fluid thereafter may be returned from the conduits 47 to 49, via the outlet pipe 55′, through suitable piping to the inlet 62 of the heater 60. However, it is preferred to employ the stored heat in the block 42 in heat exchange with the fluid employed for heating the block 43 of oil sands 12. For this purpose, the heated fluid from the outlet pipe 55′ is circulated via suitable piping to the inlet pipe 54 of the conduits 44 to 46. Thence, the heated fluid passes through the conduits 44 to 46 to scavenger heat from the block 42. Inasmuch as the temperature of the fluid at this time can easily be much greater than required to fluidize the heavy oil in the oil sands 12 when excess heat is available in the block 42, the heated fluid returning from outlet pipe 55 will have gained heat from its passage through the block 42. Now the heated fluid exiting the pipe 55 may be passed through suitable piping to the inlet 62 of the heater 60. In this manner, conservation of heat may be readily practiced in accordance with the present invention.

Obviously, the aforedescribed steps may be practiced successively and alternatively through adjacent and separated blocks in the oil sands 12. Thus, the steps of the present invention may be practiced throughout extended areas with relatively simple structures. Further, since indirect heat exchange is employed, the heavy oil recovered by this method is not contaminated through the injected fluids as in prior methods employing direct heat exchange. After the oil sands 12 has been gravity-drained of heavy oil, a waterflood or other secondary recovery procedure may be carried out for further production of the remaining heavy oil.

From the foregoing it will be apparent that a method is disclosed which accomplishes all of the stated objects of this invention. Various modifications of the disclosed method may be made by those skilled in the art without departing from the spirit of this invention. Similarly, the disclosed steps of this method, when employed both in combination and in subcombination, are of utility. As one example, conduits may be driven by vibratory means into a formation for monitoring the subsurface temperatures with greater accuracy. For this and other reasons, the present description is intended to be illustrative of this invention, and only the appended claims are to be considered as limitative of this invention.

What is claimed is:

1. A method for the recovery of heavy oil in substantially its original state, which oil undergoes a large viscosity reduction upon being heated, from a formation of unconsolidated oil sands, comprising:
   (a) driving a plurality of conduits into a formation of unconsolidated oil sands with the conduits in tight sidewall engagement therewith and the conduits being vertically spaced from one another,
   (b) interconnecting the conduits at their ends with conduit means to provide a continuous enclosed fluid path through said conduits and connecting to said conduit means a source of heated fluid,
   (c) passing a heated fluid from the source through the conduits at a temperature above the initial formation temperature sufficient to heat indirectly the heavy oil in the surrounding oil sands to such a temperature that it will gravitate downwardly past the conduits in such oil sands and by such gravitation heat further areas in such formation, and
   (d) recovering the gravitated heavy oil from the oil sands at a level lower than the lowermost conduit.

2. A method for the recovery of heavy oil in substantially its original state, which oil undergoes a large viscosity reduction upon being heated, from a formation of unconsolidated oil sands, comprising:
   (a) providing a trench in an unconsolidated oil sands formation to form a block with an exposed working surface,
   (b) driving a plurality of conduits with vibratory driving means substantially horizontally into the block of oil sands from the trench with the conduits being vertically aligned in spaced relationship from one another,
   (c) interconnecting the conduits at their ends with conduit means to provide a continuous enclosed fluid path through said conduits, and connecting to said conduit means a source of heated fluid,
   (d) passing a heated fluid from the source through the conduits at a temperature above the initial formation temperature sufficient to heat indirectly the heavy oil in the block of oil sands to such a temperature that it will gravitate downwardly past the conduits in such block of oil sands and by such gravitation heat further areas in such formation, and
   (e) recovering the gravitated heavy oil from such block at a level lower than the lowermost conduit.

3. A method for the recovery of heavy oil in substantially its original state, which oil undergoes a large viscosity reduction upon being heated, from a formation of unconsolidated oil stands, comprising:
   (a) driving a plurality of conduits with vibratory driving means into an unconsolidated oil sands formation with the conduits being vertically spaced from one another,
   (b) interconnecting the conduits at their ends with conduit means to provide a continuous enclosed fluid path through said conduits, and connecting to said conduit means a source of heated fluid,
   (c) passing a heated fluid from the source through the conduits at a temperature above the initial formation temperature sufficient to heat indirectly the heavy oil in the surrounding oil sands to such a temperature that it will gravitate downwardly past the conduits in such oil sands and by such gravitation heat further areas in such formation, and

   (d) recovering the gravitated heavy oil from the oil sands at a level lower than the lowermost conduit.

4. A method for the recovery of heavy oil in substantially its original state, which oil undergoes a large viscosity reduction upon being heated, from a formation of unconsolidated oil sands, comprising:
   (a) providing a trench in an unconsolidated oil sands formation to form a block with an exposed working surface,
   (b) driving a plurality of conduits substantially horizontally into the block of oil sands from the trench with the conduits being vertically aligned in spaced relationship from one another and in tight sidewall engagement with the surrounding oil sands,
   (c) interconnecting the conduits at their ends with conduit means to provide a continuous enclosed fluid path through said conduits, and connecting to said conduit means a source of heated fluid,
   (d) passing a heated fluid from the source through the conduits at a temperature above the initial formation temperature sufficient to heat indirectly the heavy oil in the block of oil sands to such a temperature that it will gravitate downwardly past the conduits in such block of oil sands and by such gravitation heat further areas in such formation, and
   (e) recovering the gravitated heavy oil from such block at a level lower than the lowermost conduit.

5. A method for the recovery of heavy oil in substantially its original state, which oil undergoes a large viscosity reduction upon being heated, from a formation of unconsolidated oil sands, comprising:
   (a) providing a trench in an unconsolidated oil sands formation to divide it into first and second blocks presenting exposed working surfaces,
   (b) driving a plurality of conduits with vibratory driving means substantially horizontally into each block of the oil sands from the trench with the conduits in each block being vertically aligned in spaced relationship from one another,
   (c) interconnecting the conduits at their ends with conduit means to provide a continuous enclosed fluid path through said conduits, and connecting to said conduit means a source of heated fluid,
   (d) passing a heated fluid from the source through the conduits in the first block at a temperature above the initial formation temperature sufficient to heat indirectly the heavy oil in this block to such a temperature that it will gravitate downwardly past the conduits in such block of oil sands and by such gravitation heat further areas in such formation,
   (e) thereafter terminating the flow of heated fluid in such one block after an excess amount of heat is present therein,
   (f) passing a heated fluid through the conduits in the second block at a temperature above intial formation temperature sufficient to heat indirectly the heavy oil in this block to such a temperature that it will gravitate downwardly past the conduits in such block of oil sand and by such gravitation heat further areas in such formation,
   (g) returning the heated fluid from the conduits in the second block through the conduits in the first block to scavenge excess heat therefrom,
   (h) reheating the heated fluid from the conduits in the first block in the source to the first mentioned temperature and then recirculating such heated fluid through the conduits in the second block, and
   (i) recovering the gravitated hydrocarbons, after beginning the circulation of heated fluid, from both blocks at a level lower than the lowermost conduit.

6. A method for the recovery of heavy oil in substantially its original state, which oil undergoes a large viscosity reduction upon being heated, from a formation of unconsolidated oil sands, comprising:
   (a) providing a pair of spaced trenches in an uncon-

solidated oil sands formation to form a block with exposed working surfaces,

(b) driving a plurality of conduits with vibratory driving means substantially horizontally through the block of the oil sands from one trench to the other trench with the conduits being vertically aligned in spaced relationship from one another.

(c) interconnecting in series the conduits and with a source of heated fluid to provide a continuous enclosed fluid path through said conduits from said source,

(d) passing a heated fluid from the source through the conduits in the block at a temperature above the initial formation temperature sufficient to heat indirectly the heavy oil in the block to such a temperature that it will gravitate downwardly past the conduits in such block of oil sands and by such gravitation heat further areas in such formation, and

(e) recovering the gravitated heavy oil from such block at a level lower than the lowermost conduit.

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