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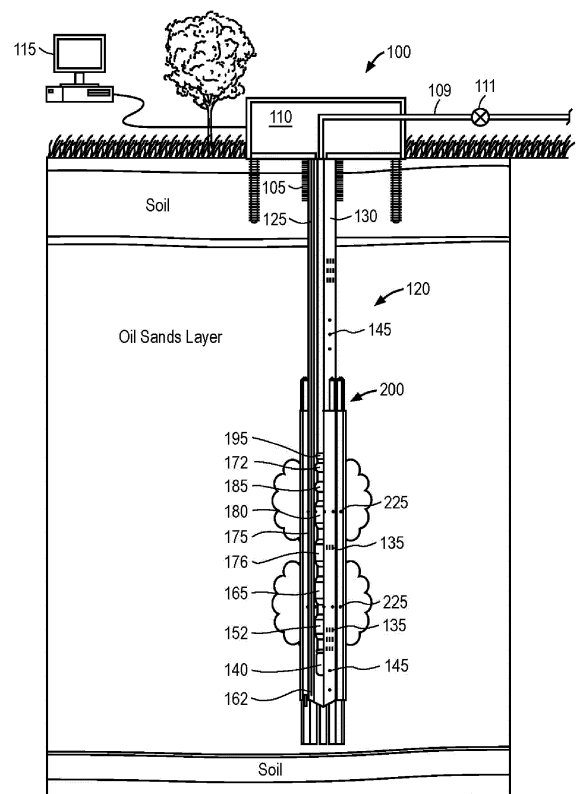
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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) **Apparatus and method for oil sand exploitation**

(57) Oil sand exploitation is enhanced, by using a downhole apparatus comprising a casing (130) for housing a water conduit for receiving water via a water pipe, at least one steam generation chamber mounted to the peripheral surface of the casing and being in fluid communication with said water conduit and having at least one steam outlet, at least one electrical heater, being thermally connected to said steam generation chamber, if the downhole apparatus further comprises at least one crude oil conduit (125) for recovering crude oil, which has been mobilized by said steam.

Fig. 1



Description

Field of the invention

[0001] The invention relates to a method and an apparatus for in situ mobilizing of heavy oil or crude oil by steam injection.

Description of the related art

[0002] Oil sand, as well referred to as tar sand, comprises sand grains coated with tar like petroleum crude oil, briefly referred to as crude oil. The crude oil in the oil sand has a high viscosity and must be heated or diluted to flow. In-situ exploitation of oil sands can be accomplished by "steam assisted gravity drainage", abbreviated as SAGD. SAGD uses a horizontally extending steam injection well forming a steam generation chamber for mobilizing the crude oil in the oil sand. The mobilized crude oil pours downward and is recovered by a second horizontally extending well, as so called production well, as disclosed in US2001/0278001A1.

[0003] The steam can be either produced by above ground facilities or downhole by an electrical heater as suggested by US-Patent 4,805,698. The water is supplied from above ground by a water supply line. The electrical steam generator heats the water to generate steam. The steam is injected into the sand and mobilizes the crude oil, which is collected by adjacent production wells.

Summary of the invention

[0004] The problem to be solved by the invention is to improve in-situ oil sand exploitation.

[0005] Solutions of the problem are provided by a downhole apparatus and a method for exploitation of an oil sand reservoir as described by the respective independent claims. The dependent claims relate to further improvements of the invention.

[0006] The downhole apparatus for oil sand exploitation, comprises at least a casing which houses a water conduit for receiving water via a water pipe and at least one steam generation chamber being in fluid communication with said water conduit and having at least one steam outlet. The steam generation chamber is thermally connected to an electrical heater. The downhole apparatus further comprises at least one crude oil conduit for recovering crude oil, which has been mobilized by said steam. Such downhole apparatus permits to inject steam for mobilization of the crude oil into the oil sand and to recover the crude oil by a single apparatus, and thus requires only a single bore.

[0007] The casing may preferably house the at least one crude oil conduit. The casing may for example be or include a multiple conduit tube, wherein the at least one water conduit and the at least one crude oil conduit are each at least one of the multiple conduits. This permits a stable design of the housing.

[0008] The at least one steam generation chamber is preferably supported by the peripheral surface of the casing. This position of the steam generation chamber permits a simple injection of the steam generated in said steam generation chamber into the oil sand.

[0009] Preferably there are multiple, e.g. five or nine, at least two steam generation chambers arranged around the peripheral surface of the casing defining a bundle of steam generation chambers. The downhole apparatus may have one or more bundles. In one embodiment, there is one bundle of steam generation chambers. In another embodiment, there are two or more bundles arranged at different positions along a distal length of the casing. The one or more bundles of steam generation chambers permit homogeneous injection of steam and thus an efficient exploitation of the oil sand. Because the one or more bundles of steam generation chambers are arranged around the casing, the one or more bundles also act to maintain or raise a temperature of the casing which aids in removal of crude oil from a reservoir (via the crude oil conduit in the casing).

[0010] Each steam generation chamber preferably has a cladding compartment surrounding a heater tube. The heater tube may house at least one electrical heater cartridge. This permits on the one hand to efficiently heat the water and on the other hand a simple replacement of the electrical heater cartridge in case of failure. The heater tube preferably houses at least one spare electrical heater cartridge. This permits longer operating intervals between retracting the downhole apparatus.

[0011] The heater tube may be hollow and may have an interior containing a composition of inorganic compounds and possibly pure elemental species. Examples for such a composition are described in the patents US 6,132,823, US 6,911,231, US 6,916,430, US 6,811,720 and the application US2005/0056807, which are incorporated by reference as if fully disclosed herein. Such composition acts as a thermally conductive material or medium to provide at least an almost perfect homogeneous distribution by the heater tube of the heat provided by the heater cartridge. The heater tube may as well be evacuated as suggested in the above references.

[0012] The heater tube may extend over the steam generation chamber, e.g. extend axially. Thus, at least one section of the heater tube extends out of the steam generation chamber into the bore. The heater tube thus not only heats water inside the steam generation chamber to steam, but as well reheats steam or water that cooled in a reservoir after its injection. Thereby the efficiency of the exploitation is enhanced.

[0013] The method for exploitation of an oil sand reservoir comprises at least the steps of producing steam in a steam generation chamber of a downhole apparatus, injecting said steam via steam outlets into the oil sand reservoir for mobilizing crude oil of the oil sand reservoir. At least part of the mobilized crude oil is recovered by said downhole apparatus. This method reduces the minimum number of bores for in situ oil sand exploitation

compared to SAGD, and thus the costs.

Description of Drawings

[0014] In the following the invention will be described by way of example, without limitation of the general inventive concept, on examples of embodiment with reference to the drawings.

Figure 1 shows a schematic depiction of an oil sand exploitation system,

Figure 2 shows a perspective view of a section of downhole apparatus,

Figure 3 shows section of steam generation chamber.

Figure 4 shows a schematic depiction of a second embodiment of an oil sand exploitation system.

Detailed Description

[0015] The oil sand exploitation system 100 in Figure 1 has a ground station 110 for housing the above ground facilities, like for example a controlling station 115 for monitoring and controlling the oil sand exploitation. Ground station 110 may also include a power source to, for example, provide power to an extraction well. Ground station 110 may include a water source, such as a reservoir, to provide water (e.g., fresh water) to an extraction well. The ground station 110 is depicted as an onshore station, but can as well be a swimming station for exploitation of water covered oil sands.

[0016] The oil sand exploitation system 100 includes an extraction well 120 with a downhole apparatus inserted into bore 105. The downhole apparatus includes a multi conduit tube like casing 130, e.g. for a power cable 230 (see Figure 2) for supplying power to downhole equipment, for example a protector 165, and/or a motor 153 for driving a well head and a well monitor device 140, as schematically depicted in Figure 1. The extraction well 120 includes a steam generator 200 which may be mounted to the peripheral surface of the casing 130. The steam generator 200 is explained below in more detail with respect to Figures 2 and 3. The steam generator 200 is positioned in this embodiment around casing 130 at a bottom or distal portion of casing 130, being positioned in a first preferably vertical section of the extraction bore 105. The steam generator 200 injects steam preferably laterally into oil sand as shown in Figure 1. The steam mobilizes crude oil in the oil sand.

[0017] Extraction well 120 is configured to collect oil, in particular may the extraction well be configured to collect the mobilized crude oil in the oil sand. To this end casing 130 of the extraction well 120 includes one or more oil inlets 135 along its length that allow oil to infiltrate the casing. Disposed within casing 130 is at least one oil

conduit 125. The oil conduit 125 extends from the bottom or distal portion of casing 130 to the above ground station 110. Oil that infiltrates casing 130 may enter oil conduit 125 at the conduit's distal end, e.g. via one of the oil inlets 135 and may be pumped to the surface and fed to a production line 109 for example by a centrifugal pump 180 being preferably arranged in the bottom or distal portion of casing 130. Before pumping the crude oil to the above ground station 110, water may be separated from the crude oil by separator 176. Also, in the bottom or distal portion of casing 130 are an Electric Cable Clip 195, a Venting Valve 172, Single Flow Valve 185, a Power Cable 175, the Rotary Separator 176, a Protector 165, a Cable Head 162, a Motor 152 and Well Monitor Device 140. In between are a couple of water spray holes 145 and further oil inlets 135. The water spray holes 145 are preferably in fluid communication with steam generation means, for example with at least one of the steam generation chambers 375 (cf. Figure 3) and thus permit to inject steam into the oil sand for mobilizing crude oil.

[0018] Figure 2 shows a section of an isometric view of casing 130 including a steam generator 200 of extraction well 120. The steam generator 200 comprises a bundle of heating members 300 (cf. Fig. 3.) The heating members 300 are arranged around the peripheral surface of the casing 130. The casing 130 is tube like. Casing 130 and has multiple compartments or conduits around an inner periphery which may serve as water conduit 250 (for water from ground station 110 to steam generator 200), oil conduit 125 (for oil infiltrating oil inlets 135 in casing 130) or as cable conduit (for providing power to components in the casing (e.g., centrifugal pump 180, motor 152) and to heat cartridges associated with the steam generator 200).

[0019] The steam generator 200 comprises a bundle of heating members 300 (cf. Figure 3). The heating members 300 are arranged around the peripheral surface of the casing 130 and are each connected to the casing 130 by, for example, one or more weld connections. Where it is desired to have more than one bundle associated with a well like extraction well 120, the bundles may be stacked one above the other along the casing 130. Referring to Figure 3, each heating member 300 includes a heater tube 310 and a steam generation chamber 375 respectively.

[0020] The front facing (upper) side of the heater tube 310 is closed by conical cap 330, which may be weld connected to the heater tube 310. The rear facing side of the heater tube 310 may be closed by an end cap 340, which may preferably be a water tight but releasable connection, e.g. a threaded connection. Heater tube 310, conical cap 330 and end cap 340 define a volume or chamber 335.

[0021] As shown in Figure 3, chamber 335 of heating member 300 is divided into a first portion and a second portion by cap 360 of a thermally conductive material such as a metal material (e.g., steel). In one embodiment, electrical heater cartridge 350 with positive and negative

terminals located at a single end (a proximal end as viewed) is positioned in a first portion of chamber 335 (proximal to cap 340). Cap 360 may divide chamber 335 at a distance from a first end to be sufficient to allow heater cartridge 350 to be disposed in a first portion of chamber 335 but minimizes any additional volume for the first portion. As shown in **Figure 3**, when heater cartridge 350 is disposed in a first portion of chamber 335 terminals 355 may extend into a volume of end cap 340. End cap 340 preferably includes lateral opening 365 that is, for example, a threaded opening for power connection to terminals 355. A conductor is fed through a peripheral conduit of casing 130 into lateral opening 365. Current can be supplied to the conductor from an above ground power source in ground station 110.

[0022] Each steam generation chamber 375 is defined by, for example, cylindrical shell 320 a front wall 380 and a rear wall 370 connected by, for example, weld connections. The front wall 380 and the rear wall 370 each have an opening through which a heater tube 310 is disposed. The heater tube 310 extends axially through the steam generation chamber 375. The connection of the heater tube 310 and the front wall 380 and/or the rear wall 370 may be a weld connection.

[0023] The electrical heater cartridge 350 is thermally connected to the heater tube 310 and electrically connected with a power line e.g. by power cable 230. The power (e.g., electrical current) is preferably controlled by the controlling station 115 and may be ducted via a lateral opening like lateral opening 365. A gasket may be used for sealing the cable feedthrough. Inside heater tube 310 is a thermally conductive material like it is described in the US-Patents 6,132,823; 6,911,231; 6,916,430; 7,220,365 and United States Patent Publication No. 2005/0056807.

[0024] Rear wall 370 of shell 320 includes inlet 395 for a water source to be connected thereto to provide water to steam generation chamber 375. Water is provided from a water source at, for example, ground station 110 to steam generation chamber 375 by a peripheral conduit of casing 130 that is in fluid communication with inlet 395. For heating the water to steam, power may be supplied to the electrical heater cartridge 350. The heater cartridge 350 thus produces heat, being transferred to the steam generation chamber 375 via the heater tube 310. Steam develops inside the steam generation chamber 375 and escapes through steam outlet 390 into the oil sand. A single flow pressure valve may be provided in the steam outlet 390. Thereby it can be avoided that foreign matter, like sand grains and the like enter the steam generation chamber 375. Further, the steam can be pressurized. As the heater tube 310 extends over the steam generation chamber a part of the heat provided by the electrical heater cartridge 350 is as well transferred directly to the oil sand. This heat reduces the condensation of the steam close to the extraction well 120 and thus permits the steam to heat a bigger area around the extraction well and thereby to better mobilize the crude oil. The mobilized

crude oil can be collected via oil inlets 135 (see Figures 1 and 2), separated from water by rotary separator 176 and pumped by centrifugal pump 180 into the production line 109 a schematically represented in Figure 1.

[0025] Representatively, as described above with reference to **Figure 1**, one or more tube bundles 200 of extraction well 120 may be used to generate and discharge steam into a petroleum reserve to, in the case of oil sands, provide sufficient liquidity to the crude oil in oil sands to allow its extraction through casing 130 and pumping conduit 125, and secondarily to heat as well the casing 130. Preferably the temperature of the steam produced in the steam generation chamber 375 is monitored and/or controlled by controller 115. For example, a processing protocol delivered to control computer 115 may include instructions for receiving temperature measurements from at least one temperature sensor.

[0026] Based on these measurements, instructions are provided in a machine-readable form to be executed by controller 115. Accordingly, controller 115 executes the instructions to increase or decrease the power output to one or more heating rods 350 to achieve a target temperature in a range f (e.g., 250°C to 280°C). It is appreciated that controller 115 may be increasing power to some heating cartridges 350 while at the same time decreasing power to other heating cartridges 350. The controller 115 may alternatively or additionally control, i.e. enhance or reduce the water flow provided to the steam generation chamber(s) 375 to thereby control the steam temperature. Still further, controller 115 may be connected to pump 180 and other components in pumping conduit 125 and control the pump and/or other components based on program instructions to achieve a desired throughput from the well.

[0027] Figure 4 shows another embodiment of an oil sand exploitation system. In this embodiment, oil sand exploitation system 400 includes ground station 410 for housing the above ground facilities, like for example, a controller 415, a power source and a water source. Similar to Figure 1, the above ground station 410 is depicted as onshore station, but can as well be a swimming station for exploitation of water covered oil sands. The system 400 includes a bore 405 into which an extraction well 420 with a downhole apparatus is inserted. In Figure 1, the extraction well was inserted vertically or approximately vertically the entire length of the well. In Figure 4, the extraction well 420 extends vertically through bore 405 at a ground surface of the well, but then extends laterally into the well. Otherwise, the construction and operation of extraction well 420 and system 400 is similar to the construction and operation of extraction well 120 and system 100 described with reference to Figures 1-3. The downhole apparatus includes casing 430 which is, for example a multi-conduit casing configured similar to casing 130 in Figure 1, and one or more bundles of steam generators 500 configured similar to steam generators 200. Figure 4 shows a single bundle disposed about and connected to a distal portion of casing 430. Water pro-

vided to each steam generation chamber of steam generator 500 is converted to steam by heat provided to the chamber by a heater tube containing a heater cartridge and a thermally conductive material as described above with reference to Figures 1-3. The steam is dispensed from steam outlets 490 of a steam generation chamber into the oil sands reservoir to mobilize oil in the oil sand. Mobilized oil infiltrates casing 430 through oil inlets 435 and is pumped to the surface of the well.

List of reference numerals

[0028]

100 system

105 bore

108 well head

109 production line

111 valve

110 ground level station

115 controlling station

120 extraction well

125 oil conduit

130 extraction tube

135 oil inlet

140 well monitor device

150 motor

162 cable head

165 protector

170 rotary separator

172 venting valve

175 power cable

176 rotary separator

180 centrifugal pump

185 single flow valve

190 venting valve

195 electric cable clip

200 tube bundle/steam generator

5 230 electric cable

250 water conduit

300 heating member

10

310 heater tube

320 shell

15

330 conical cap

335 chamber

340 end cap

20

350 electrical heater cartridge

360 end cap of heater cartridge

25

365 lateral opening

370 rear wall (down facing)

375 steam generation chamber

30

380 front wall (up facing)

390 steam outlet

35

395 water inlet

400 system

405 bore

40

410 above ground station

415 controller

45

420 extraction well

430 casing

435 oil inlets

50

490 steam outlets

500 steam generator

55

Claims

1. Downhole apparatus for oil sand exploitation, com-

prising at least:

- a casing (130) for housing a water conduit (250) for receiving water via a water pipe,
- at least one steam generation chamber (375) being in fluid communication with said water conduit (250) and having at least one steam outlet (390),
- at least one electrical heater (350), being thermally connected to said steam generation chamber (375),

characterized in that

the downhole apparatus further comprises at least one crude oil conduit (135) for recovering crude oil, which has been mobilized by said steam.

2. Downhole apparatus of claim 1
characterized in that
the casing (130) houses the at least one crude oil conduit (135).
3. Downhole apparatus of any one of the preceding claims **characterized in that**
the casing (130) is a multiple conduit tube wherein the at least one water conduit (250) and the at least one crude oil conduit (125) are each one of the multiple conduits.
4. Downhole apparatus of any one of the preceding claims **characterized in that**
the at least one steam generation chamber (375) is supported by the peripheral surface of the casing (130).
5. Downhole apparatus of any one of the preceding claims **characterized in that**
at least two steam generation chambers (375) are arranged in bundles arranged around the peripheral surface of the casing (130).
6. Downhole apparatus of any one of the preceding claims **characterized in that**
 - the steam generation chamber (130) has a cladding compartment surrounding a heater tube (310),
 - the heater tube (310) houses at least one electrical heating cartridge (350).
7. Downhole apparatus of claim 6
characterized in that the heater tube (310) is hollow and has an interior surface, the interior surface being coated with inorganic salts.
8. Downhole apparatus of claim 7
characterized in that the

heater tube (310) is evacuated.

9. Downhole apparatus of any one of claims 6 to 8 **characterized in that**
the heater tube (310) axially extends over the steam generation chamber (375).
10. A method for exploitation of an oil sand reservoir comprising at least the steps:
 - producing steam in a steam generation chamber (375) of a downhole apparatus,
 - injecting said steam via steam outlets (390) into the oil sand reservoir for mobilizing crude oil of the oil sand reservoir,

characterized in that

at least part of the mobilized crude oils is recovered by said downhole apparatus.

Amended claims in accordance with Rule 137(2) EPC.

1. Downhole apparatus for oil sand exploitation, comprising at least:
 - a casing (130) for housing a water conduit (250) for receiving water via a water pipe,
 - at least one steam generation chamber (375) being in fluid communication with said water conduit (250) and having at least one steam outlet (390),
 - at least one electrical heater (350), being thermally connected to said steam generation chamber (375),

characterized in that
the casing further comprises at least one crude oil conduit (135) for recovering crude oil, which has been mobilized by said steam.
2. Downhole apparatus of claim 1
characterized in that
the casing (130) houses the at least one crude oil conduit (135).
3. Downhole apparatus of any one of the preceding claims
characterized in that
the casing (130) is a multiple conduit tube wherein the at least one water conduit (250) and the at least one crude oil conduit (125) are each one of the multiple conduits.
4. Downhole apparatus of any one of the preceding claims
characterized in that

the at least one steam generation chamber (375) is supported by the peripheral surface of the casing (130).

5. Downhole apparatus of any one of the preceding claims 5

characterized in that

at least two steam generation chambers (375) are arranged in bundles arranged around the peripheral surface of the casing (130). 10

6. Downhole apparatus of any one of the preceding claims

characterized in that

- the steam generation chamber (130) has a cladding compartment surrounding a heater tube (310),
- the heater tube (310) houses at least one electrical heating cartridge (350). 15 20

7. Downhole apparatus of claim 6

characterized in that the

heater tube (310) is hollow and has an interior surface, the interior surface being coated with inorganic salts. 25

8. Downhole apparatus of claim 7

characterized in that the

heater tube (310) is evacuated. 30

9. Downhole apparatus of any one of claims 6 to 8

characterized in that

the heater tube (310) axially extends over the steam generation chamber (375). 35

10. A method for exploitation of an oil sand reservoir comprising at least the steps:

- producing steam in an steam generation chamber (375) of a downhole apparatus according to claim 1, 40
- injecting said steam via steam outlets (390) into the oil sand reservoir for mobilizing crude oil of the oil sand reservoir, 45

characterized in that

at least part of the mobilized crude oils is recovered by at least one crude oil conduit of said downhole apparatus. 50

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Fig. 1

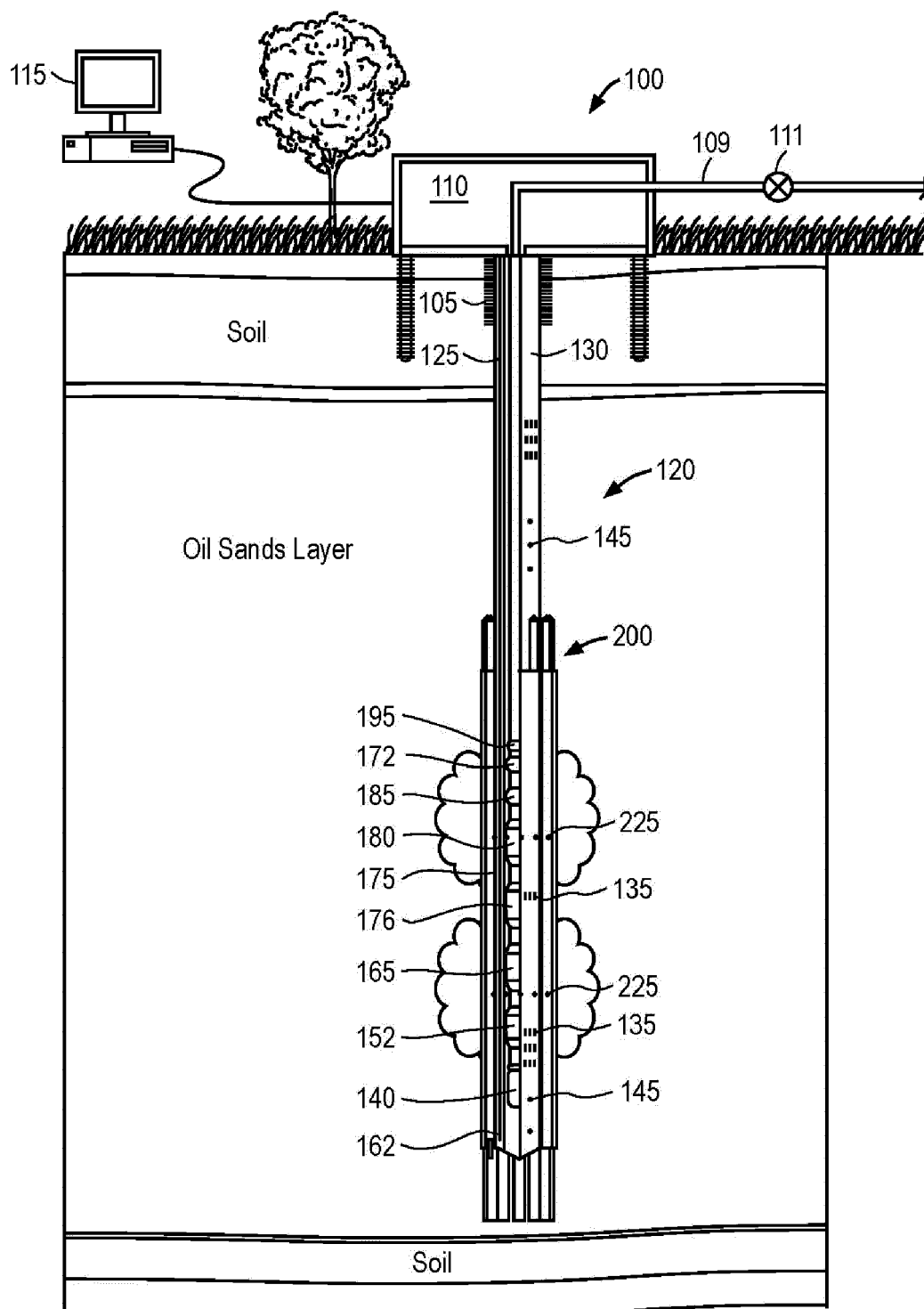


FIG. 1

Fig. 2

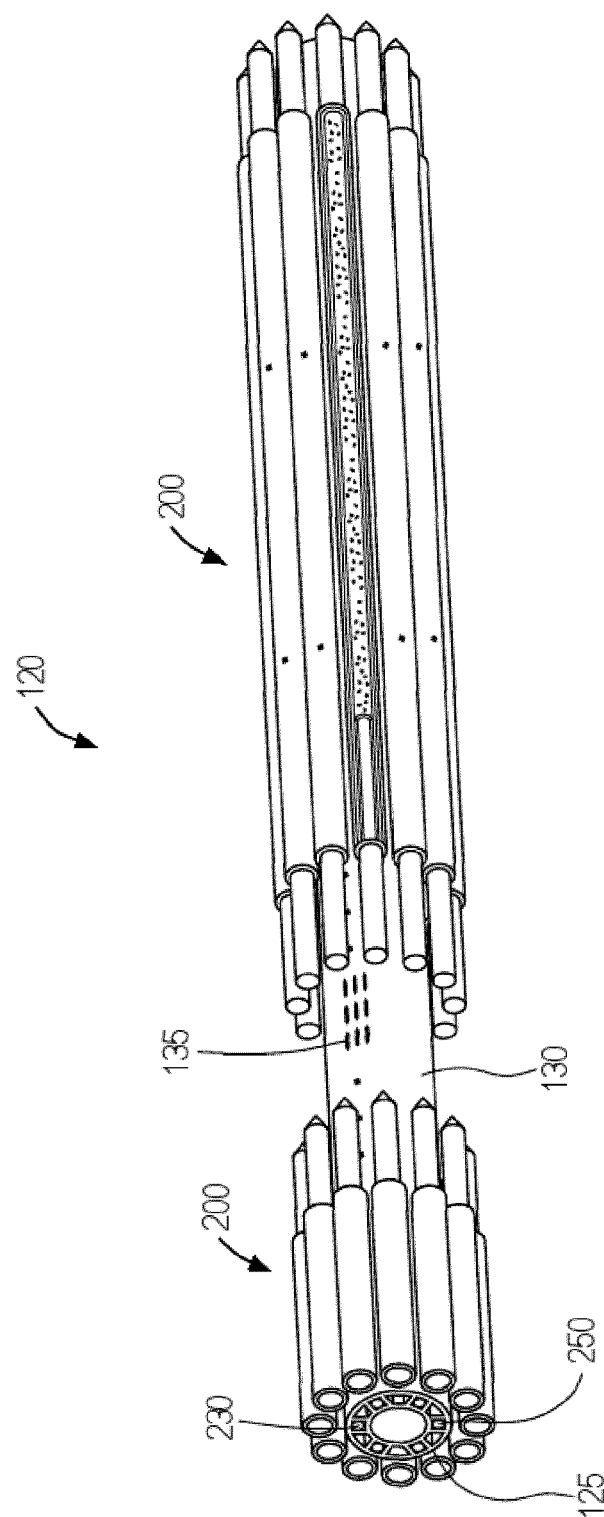


Fig. 3

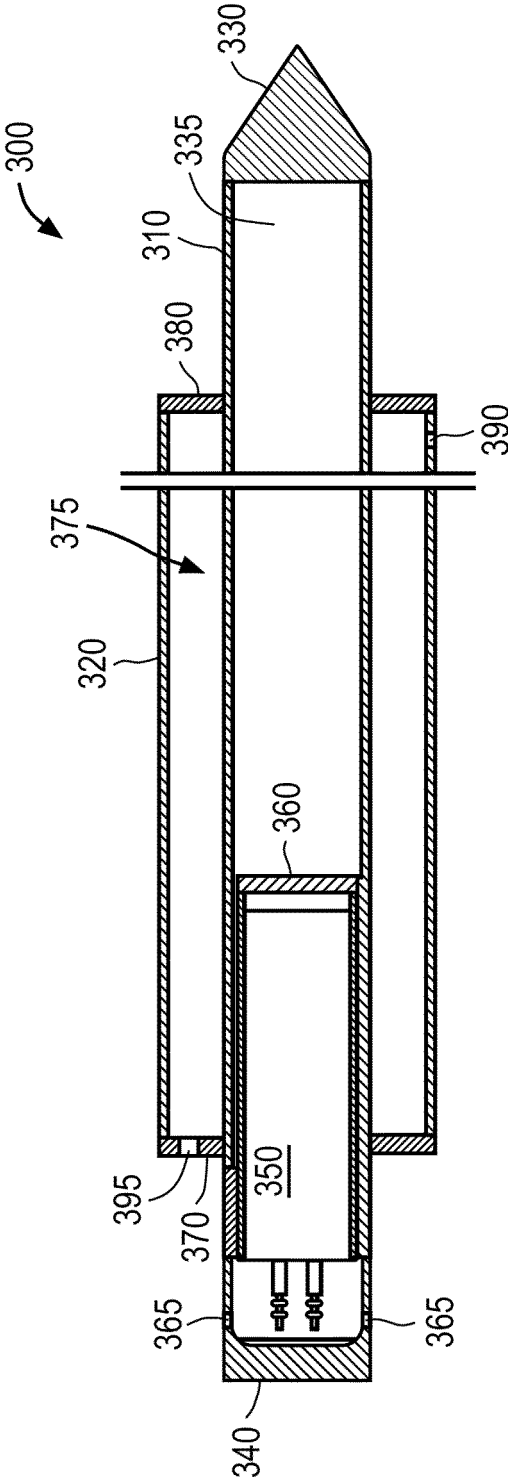
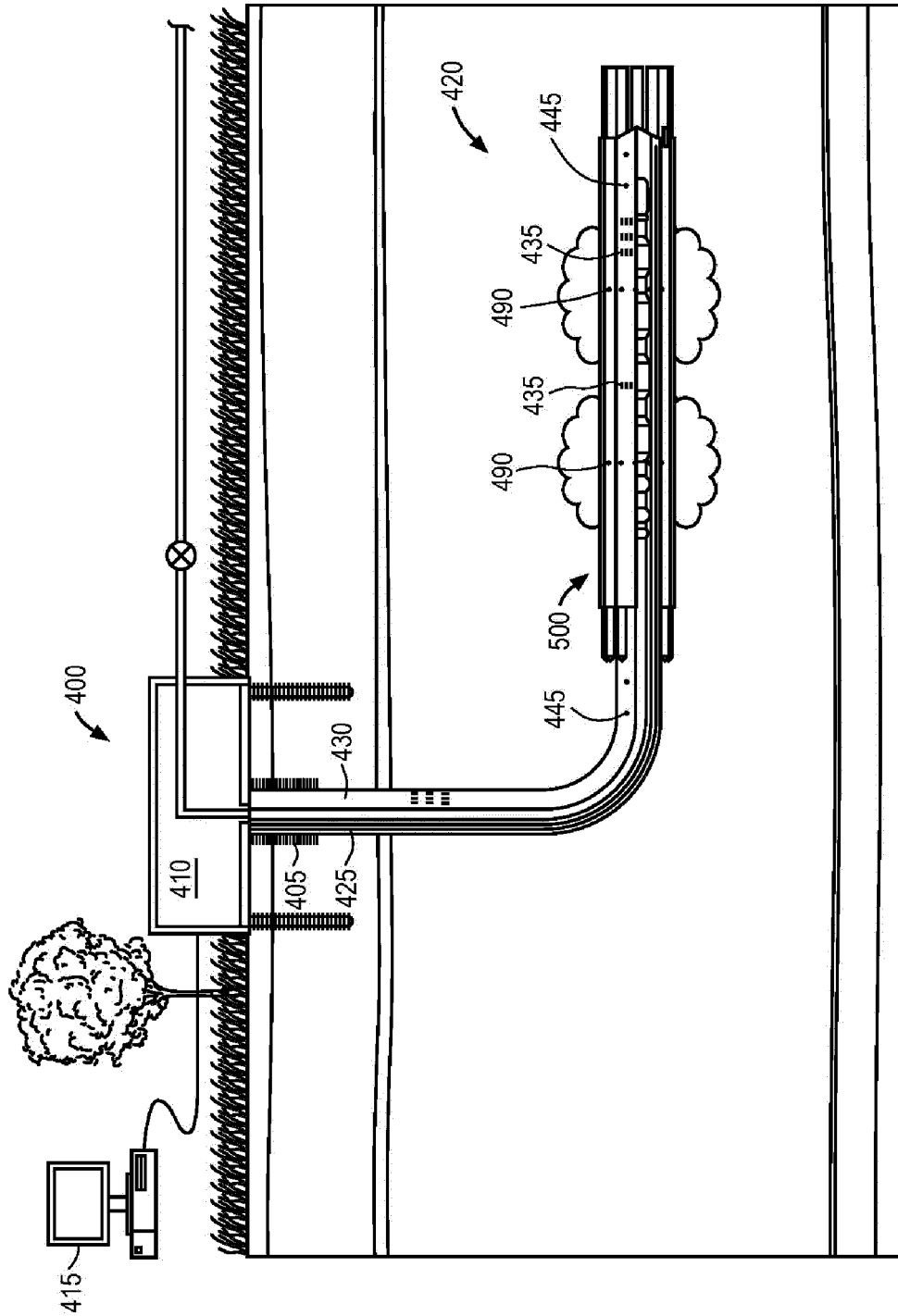


Fig. 4





EUROPEAN SEARCH REPORT

Application Number
EP 12 15 0055

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 5 085 275 A (GONDOUIN) 4 February 1992 (1992-02-04) * column 5, line 12 - line 32 * * column 6, line 41 - line 42 * -----	1-3,10	INV. E21B43/24
Y	US 4 116 275 A (BUTLER ET AL.) 26 September 1978 (1978-09-26) * column 4, line 48 - column 5, line 11 * -----	1-3,10	
Y,D	US 4 805 698 A (BAUGH ET AL.) 21 February 1989 (1989-02-21) * the whole document * -----	1-3,10	
Y	US 4 127 169 A (TUBIN ET AL.) 28 November 1978 (1978-11-28) * column 4, line 48 - column 5, line 45 * -----	1-3,10	
			TECHNICAL FIELDS SEARCHED (IPC)
			E21B F22B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 7 June 2012	Examiner Rampelmann, Klaus
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 12 15 0055

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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07-06-2012

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5085275	A	04-02-1992	CA 2038648 A1	24-10-1991
			US 5085275 A	04-02-1992
US 4116275	A	26-09-1978	CA 1070611 A1	29-01-1980
			US 4116275 A	26-09-1978
US 4805698	A	21-02-1989	NONE	
US 4127169	A	28-11-1978	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20010278001 A1 [0002]
- US 4805698 A [0003]
- US 6132823 A [0011] [0023]
- US 6911231 B [0011]
- US 6916430 B [0011]
- US 6811720 B [0011]
- US 20050056807 A [0011] [0023]
- US 6911231 A [0023]
- US 6916430 A [0023]
- US 7220365 A [0023]