Fig. 1

Abstract: Deposits, such as coal, tar sand, heavy crude oil and/or minerals are excavated from an underground formation layer (4) by: - inserting a chain cutter string (11) into a 1st section (8, 9) and a control cable (12) into a 2nd section (10) of a T-V-U-or L-shaped channel assembly (8, 9, 10) traversing the layer (4); - connecting the control cable (12) to the chain cutter string (11) at a branchpoint (13) of said 1st & 2nd sections (8, 9 &10); and - pulling the chain cutter string (11) in a continuous or oscillating manner through the first section (8,9) while continuously pulling the control cable (12), such that the chain cutter string (11) carves deposits from the layer (4) and the control cable (12) optimizes the performance and reduces the risk of breakage of the chain cutter string (11).
EXCAVATING DEPOSITS FROM AN UNDERGROUND FORMATION LAYER

BACKGROUND OF THE INVENTION

The invention relates to a method for excavating deposits from an underground formation layer.

Such a method is known from US patents 2,796,129; 4,232,904; 4,442,896; 5,033,795 and 7,647,967.

In the methods known from these prior art references a chain cutter string is pulled through a channel in an underground formation layer, such as a coal seam, and the chain cutter is simultaneously moved such that the cutters scrape material from the wall of the channel.

In the method known from US patent 4,232,904 a U-shaped tunnel is bored into a substantially horizontal coal seam in a hill such that an both an entrance and an exit hole are laterally displaced along the front surface of the hill. A chain drive having rotating cutters spaced therealong is then drawn through the tunnel by a motor located outside the tunnel. The motor provides continuous outward pressure on the chain, causing the blades to rotate, thereby cutting the coal, thereby cutting the coal from the inside back wall of the tunnel. Buckets mounted along the chain remove the coal from the tunnel.

In the method known from US patent 4,442,896 a U-shaped channel is drilled in a substantially vertical plane, whereupon the chain cutter string is inserted into the U-shaped channel and induced to make an oscillating movement while a tension force is applied thereto, so that the chain cutter string scrapes material from the upper wall of the U-shaped channel and thereby cuts a substantially vertical cavity in the formation.

In the method known from US patent 5,033,795 a substantially horizontal U-shaped trench is digged in a
formation adjacent to a horizontal mineral deposit seam and a continuous chain saw string is rotated between guide wheels mounted on a pair caterpillar trucks that slowly move along the parallel legs of the U-shaped trench, such that the chain cutter string cuts a substantially horizontal cavity in the mineral deposit seam.

In the method known from US patent 7,647,967 hydrocarbon production from a subsurface oil reservoir is enhanced by inserting a flexible linear cutting device, such as a segmented diamond wire saw, into a pair of intersecting wellbores, to form a fissure beginning at the intersection of the wellbores and extending along the lower part of the length of the wellbores, which fissure intersects with natural or previously formed fractures to enhance the permeability and productivity of the subsurface oil reservoir.

In the method known from US patent 2,796,129 a chaincutter assembly is inserted into a V-shaped horizontal tunnel assembly arranged between three tri-angicularly spaced vertical wells and oil sand from a formation between these wells is mined by pulling the chaincutter assembly up and down through the V-shaped tunnel assembly until the chaincutter assembly forms a straight line between two of the three wells. In case the chaincutter assembly gets stuck in rocks or other blockages in the formation then the only option to retrieve the chaincutter assembly is to break it up and pull the broken pieces out of the wells.

A disadvantage of the known cutting methods is that there is no provision to control the lateral pressure of the chain cutter string against the formation or prevent it from sticking so there is a risk of damage and breaking of the cutter chain due to an overload.
Therefore there is a need to provide an improved method for mining deposits from an underground layer wherein the lateral pressure between the chain cutter string and the formation can be controlled and there is a provision to release the chain when it gets stuck.

**SUMMARY OF THE INVENTION**

In accordance with the invention there is provided a method of excavating deposits from an underground formation layer, comprising:

- drilling a first, second and third well, which penetrate the underground formation layer at three triangularly spaced locations;
- drilling from these locations a channel assembly that traverses the formation layer and interconnects each of the wells;
- inserting a chain cutter string into a first section of the channel assembly that is located between the first and second wells;
- inserting a chain cutter control cable from the third well into a second section of the channel assembly;
- connecting the chain cutter control cable to the chain cutter string at a branchpoint of the first and second sections of the channel assembly;
- pulling the chain cutter string through the first section of the channel assembly while exerting a lateral force to the chain cutter string by the chain cutter control cable such that the chain cutter string is pressed against the wall of the first section of the channel assembly and is thereby induced to carve deposits from of the underground formation layer; and
- flushing carved out deposits through the channel assembly and at least one of the wells.
Optionally, during an initial or subsequent moment of execution of the method:
- the first section of the channel assembly extends as a substantially straight line between the first well and the second well;
- the second section of the channel assembly extends from the third well to the branchpoint, which is formed by a midpoint of the first section of the channel assembly, so that the channel assembly substantially has a T-shape; and
- the chain cutter string is pulled through the first section while the chain cutter string is pressed against the sidewall of the first section by the chain cutter control cable and is pulled by the chain cutter control cable towards the third well.

Alternatively or subsequently, during an initial or subsequent moment of execution of the method:
- the first section of the channel assembly has a V-shape and has a first leg, which extends from the first well towards the third well and a second leg, which extends from the third well towards the second well and the chain cutter string extends through the first and second legs of the V-shaped first section of the channel assembly;
- the chain cutter control cable is connected to the chain cutter string at the location where the third well penetrates the formation layer, which location forms the branchpoint of the first and second sections of the channel assembly; and
- the chain cutter string is pulled through the first section.

In the latter case the chain cutter control cable is gradually slackened while the chain cutter string is pulled through the first section of the channel assembly, thereby
controlling the pressure between the chain cutter string and the sidewall of the first section.

The chain cutter string may be pulled sequentially from the first to the second well and from the second to the first well to mine deposits from the underground formation layer.

The chain cutter string is an endless chain, which carries a series of cutting elements and is moved in a continuous motion through the first section of the channel assembly and the first and second wells to mine deposits from the underground formation layer and the cutting elements may be selected from the group of mechanical cutters and/or hydraulic jets.

The method according to the invention may be used to create at least plane with a high permeability in a viscous crude oil containing formation in order to Enhance Oil Recovery (EOR) therefrom and/or to mine hydrocarbon deposits selected from the group of coal, oil shale, tar sand and heavy crude from the subsurface formation layer and/or for other purposes.

These and other features, embodiments and advantages of the method and according to the invention are described in the accompanying claims, abstract and the following detailed description of non-limiting embodiments depicted in the accompanying drawings, in which description reference numerals are used which refer to corresponding reference numerals that are depicted in the drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Fig.1 is a schematic three-dimensional view of a chain cutter assembly that is operated in accordance with the method according to the present invention;
Fig. 2 is a top view of a chain cutter assembly, which moves in a single direction through a first section of a subsurface channel assembly;

Fig. 3 is a top view of a chain cutter assembly, which makes an oscillating movement to excavate rock from the wall of a first section of a subsurface channel assembly;

Fig. 4 is a schematic vertical sectional view of an assembly of two wells, which define three triangularly spaced locations between which a triangularly shaped cavity is carved using the method according to the invention;

Fig. 5 is a schematic vertical sectional view of a multilateral well assembly, which defines three triangularly spaced locations between which a triangularly shaped cavity is carved using the method according to the invention;

Fig. 6 is a schematic vertical sectional view of another multilateral well assembly, which defines three triangularly spaced locations between which a triangularly shaped cavity is carved using the method according to the invention; and

Fig. 7 is a schematic vertical sectional view of a H-shaped multilateral well assembly, which defines four rectangularly spaced locations between which a rectangularly shaped cavity is carved using the method according to the invention.

DETAILED DESCRIPTION OF THE DEPICTED EMBODIMENTS

Fig. 1 shows a triangular well assembly comprising first, second and third well 1, 2 and 3, which penetrate a underground formation layer 4, such as a mineral, coal, tar sand or heavy oil containing seam, at three triangularly spaced locations 5, 6 and 7.

A channel assembly 8, 9 and 10 traverses the formation layer 4 and interconnects each of the wells 1, 2 and 3 at these locations 5, 6 and 7.

A chain cutter string 11 is inserted via the first and
second wells 1 and 2 into a first section 8, 9 of the channel assembly that extends between the first and second wells 1 and 2.

A chain cutter control cable 12 extends from the third well 3 into a second section 10 of the channel assembly and is connected to the chain cutter string 11 at a branchpoint 13 of the first and second sections 8,9 and 10 of the channel assembly.

During normal use the chain cutter string 1 may be moved in a continuous or oscillating mode through the first section 8,9 of the channel assembly while exerting a lateral force to the chain cutter string 11 by the chain cutter control cable 12 such that the chain cutter string 11 is pressed against the wall of the first section 8,9 of the channel assembly and is thereby induced to carve deposits from the underground formation layer 4.

Carved out deposits may be flushed from the channel assembly 8,9, 10 by injecting water, steam and/or another fluid into the third well 3 and discharging a slurry comprising the stream of the injected fluid and cuttings of carved out deposits via one or both of the other wells 1,2. It may be advantageous to reverse or alternate the direction in which the fluid flows through the channel and well assembly 1,2,3,8,9,10.

Fig. 1 shows that during an initial moment of execution of the method the first section 8,9 of the channel assembly extends as a substantially straight line between the first well 1 and the second well 2. In this situation the second section 10 of the channel assembly extends from the third well 3 to the branchpoint 13, which is formed by a midpoint of the first section 8,9 of the channel assembly, so that the channel assembly 8,9,10 substantially has a T-shape. In the situation shown in Fig.1 the chain cutter string 11 is
pulled through the first section 8,9 while the chain cutter string 11 is pressed against the sidewall of the first section 8,9 by the chain cutter control cable 11 and is pulled by the chain cutter control cable towards the third well as shown by arrow 14.

Alternatively, during an initial or subsequent moment of execution of the method the first section of the channel assembly has a V-shape as illustrated by dotted lines 18, 19 and has a first leg 18, which extends from the first well 1 towards the third well 3 and a second leg 19, which extends from the third well 3 towards the second well 2 and the chain cutter string 11 extends through the first and second legs 18, 19 of the V-shaped first section of the channel assembly. After drilling of the V-shaped channel assembly the chain cutter control cable 12 is connected to the chain cutter string 11 at or near the location 7 where the third well 3 penetrates the formation layer 4, which location 7 then forms the branchpoint 13 of the first and second sections 12, 18, 19 of the channel assembly, whereupon the chain cutter string is pulled in a continuous or oscillating mode through the first section 18,19 to carve out deposits from the underground formation layer 4.

In that situation chain cutter control cable 12 is gradually slackened while the chain cutter string 11 is pulled through the first section of the channel assembly, thereby controlling the pressure between the chain cutter string and the sidewall of the first section 8,9.

It will be understood that the chain cutter assembly may be pulled up and down by the chain cutter control cable 12 such that subsequently triangularly shaped slices are carved from the formation layer 4, which slices are within the triangle formed by the first and second sections 8,9, 18 and 19 of the channel assembly shown in Fig.1.
After a substantial part of the deposits contained in the part of the formation layer 4 within the triangle within the sections 8, 9, 18 and 19 are removed a fourth well 15 may be drilled and be connected by a third channel section 16 to the existing channel section 19, whereupon the chain cutter string may be inserted into the section 19 and the chain cutter control cable may be inserted via the fourth well 15 into the third channel section 16, whereupon the chain cutter string 11 may be moved in a continuous or oscillating manner through the existing channel section 19 and moved towards the fourth well 15 by the chain cutter control cable 12 until a triangular section of the formation layer 4 between the channel section 19 and lines 20 and 21 is carved from the formation layer.

The process of drilling further wells and carving further triangular sections of the formation layer 4 adjacent to existing channel sections 8, 9, 19, 19, 20, 21 may be repeated in a similar manner as described with reference to the fourth well 15 in Fig.1.

It will be understood that the use of a chain cutter control cable 12 that controls the lateral pressure between the chain cutter string 11 and the wall of the channel assembly will optimize the cutting performance of the cutters mounted on the chain cutter string 11 and will reduce the risk of breaking of the chain cutter string 11 and provide a possibility to relieve it when stuck. It will further be understood that water, steam and or other fluid injection hoses may be connected to the chain cutter string 11 and/or chain cutter control cable 12 to flush carved out cuttings from the channel and well assembly, thereby reducing the risk of plugging of the channel and well assembly.
Furthermore fluid injection hoses may be used to inject a filler and/or tailings into the created cavity in order to inhibit subsidence of the overburden.

Fig. 2 depicts a top view of a detail of the cutting mechanism of a continuous chain cutter assembly 50, 51 that is moving in one direction.

The continuous chain cutter assembly 50, 51 traverses a first section 53 of a channel assembly that is located between a region of disturbed rock 61 and an undisturbed rock formation 60. The chain cutter assembly 50, 51 comprises cutting blades 51 that are mounted on chain sections 50, which chain sections 50 are pivotably interconnected by connector pins 52.

At a branchpoint 53a the first section 53 is connected to a second section 62 of the channel assembly 53, 62, at which branchpoint 53a the chain cutter string 50, 51 is connected to a control device 54.

The control device 54 comprises a connection assembly 40 to apply a controlled pulling force to the chain cutter string 50, 51. The control device 54 controls the pressure of clamp blades 41a, 41b to fixate the position of the control device 54 in the horizontal borehole 62 while cutting, like fixation devices known as 'friends' or 'camalots' in mountain climbing. The teeth on the clamp blades 41a, 41b penetrate into the undisturbed rock formation 60 when pulling on the chain 50, 51. The clamp blades 41a, 41b have a wide operating range with respect to width of the second section 62 of the channel assembly they are in.

The clamp blades 41a, 41b are mounted on a common shaft 41 and connected by strings 43 to a motor assembly 44 that can pull the strings 43 to relieve the clamp blades 41a, 41b from the wall of the horizontal borehole 62.
The connection assembly further comprises a spring 4 5 which is connected by a connecting rod 4 6 to a shaft 4 8 which rotatably carries a guide wheel 4 7 provided with cutter blades 4 9, which intermesh with the cutting blades 5 1 of the chain cutter string 5 0,5 1 to control the lateral pulling force exerted by the control device 5 4 on the chain cutter string 5 0,5 1.

The guide wheel 4 6 thereby accurately guides and presses the cutter blades 5 1 of the chain cutter string 5 0,5 1 against the undisturbed rock formation 6 0. It will be understood that the wheel 4 7 may have more teeth than four and may have a corresponding larger diameter.

Optionally hydraulic jets can be mounted on the control device 5 4 to facilitate movement in forward and/or backward direction.

Fig. 3 is a top view of a chain cutter assembly 8 0,8 1, which makes an oscillating movement to excavate soil from the wall of a first section 7 5 of a subsurface channel assembly 7 5,7 6.

FIG. 3 depicts how a control device 7 0,7 4 is connected to a chain cutter string 8 0,8 1 which cuts rock and/or hydrocarbon containing material in an oscillating manner from an undisturbed rock, shale oil, tar sand, viscous crude, tight gas and/or coal containing formation 7 7.

The control device 7 0,7 4 is arranged in a second section 7 6 of the subsurface channel assembly 7 5,7 6 and comprises a connection bar 7 0, which is connected by a pin 7 1 to a connection rod 7 4, which is slideably arranged within a cylindrical housing 8 3 in which a spring 8 4 is arranged and which housing 8 3 is connected to a chain cutting string control cable 9 4.

The control device 7 0,7 4 furthermore comprises a pin 7 1 to connect the connection bar 7 0 to the connection rod 7 4 in
a pivotable manner and optionally a cutting blade 72 which
is arranged at the end of the connection bar 70.
A pin 73 pivotably connects the cutting chain 80 to the
connection rod 70. In this case the cutting chain 80 is a
cable 80 of two parts with eyes at the end 82a and 82b and
connected to pin 73. Here four cutting blades 81 are mounted
over the complete circumference of the cable.

The control device 70, 74 shown in Figure 3 may have the
same fixation device 41a, 41b and motor assembly 44 as shown
in Figure 2.

Optionally, the width of the cutters 81 of the
oscillating cutter assembly shown in Figure 3 may vary over
the length of the chain leaving pillar like supported
structures in the formation 61.

It will further be understood that the wells 1,2 and 3 shown
in Figure 1 may have a tilted, non-vertical, orientation and
that the triangular area to be cut away in the plane defined
by the channel assemblies 8-10,53,62,75 and 76 shown in
Figures 1-3 may be adapted to foreseen subsidence.

It will also be understood that the channel assemblies 8-
10,53,62,75 and 76 shown in Figures 1,2 and 3 may define a
dipped, non-horizontal, plane to facilitate flushing of the
cutting deposits to the bottom of one of the wells 1,2 or 3
in which a slurry pump may be arrange to remove the cutting
deposits to the earth surface.

It will further be understood that the three wells 1,2,3 and
channel assembly 8,9,10 may be drilled by known deviated and
or river-crossing drilling technologies, wherein the first
and second wells 1,2 and the first and second sections 8,9
of the channel assembly are drilled as a single U-shaped
well having two entrances at the earth surface and the third
well 3 and third section of the channel assembly 10 are
drilled as a single J-shaped well, which is drilled towards
the branchpoint 13 by known navigation and homing-in techniques.

Finally, it will be understood that the first or second well 1 or 2 may be located above the branchpoint 13 so that the first and second sections of the channel assembly 8-10 have a L-shaped configuration instead of the T-shaped configuration shown in Figure 1. This alternative L-shaped configuration may be attractive if the control cable 12,62,94 also has cutting capabilities provided by jets and/or cutting elements (not shown) mounted on the control cable 12,62,94.

Fracking is widely used in the oil and gas industry to generate vertical fluid conduit planes to improve hydrocarbon production. But, there are circumstances that it cannot be done or is less effective. Examples are high permeable, vuggy reservoirs and subsurface formations where the risk is high that the fracture penetrates into a sedimentary layer causing problems.

Also, it can be advantageous to make a fracture with a relative large fracture aperture to fill the fracture with a gel, cement or other material to create a baffle for fluid flow of substantial areal dimensions. One application is the control of water ingress from an active aquifer, with or without pollutants, another is a sufficient wide fracture for viscous oil production or tight or shale gas production.

The chain cutter as described with reference to Figures 1-3 could in these cases be an alternative enabling technology. In the case that the planes to be cut out are predominantly vertical, simpler well configurations can be applied as illustrated in the following figures.
Figure 4 shows a configuration with two wells 400 and 405 which start vertical from the surface 420 and deviate from vertical further downwards.

The oscillating chain cutter 401 is anchored in the bottom by anchor 403 of well 400 via spring 404. The spring can freely rotate in the plane of cutting. The chain cutter control device 407 which controls the lateral force of the chain cutter on the rock is connected to the chain cutter via a guide wheel 408. This wheel can be provided with cutter blades. The chain cutter control device can be similar as the one shown in Fig. 2 of the original patent application. The chain cutter control device 407 is pulled upwards by the control cable 406. The control cable is guided in bends in the well at locations as 415 by appropriate mechanical means, such as guiding wheels (not drawn) to avoid unnecessary friction and deterioration of well and control cable. Guiding wheel 402 for the chain cutter is mounted in well 400 for similar reasons.

After drilling wells 400 and 405 with well intervention at location 413, the chain cutter is along line 410 and connected to the control device at this location. While pulling on the control cable, the oscillating chain cutter progresses from dashed dotted line 410 to dashed dotted line 411 to dashed dotted line 412.

It is obvious from Figure 4 that there is little to no lateral control on the chain cutter when the chain cutter operates in the accentuated area 414. Pending on rock properties and other factors, operation in this area requires consideration and, if needed, the size of this area should be limited by choosing a proper location of guiding wheel 402.
Alternatively, spring 404 is a pneumatic or electrically driven actuator, or is replaced by a guiding wheel. In the latter case the chain cutter string returns through well 400 to the surface allowing for a continuous (non-oscillating) movement of the chain cutter.

Figure 5 shows a single vertical well 500 with a side track 505. Two anchors 503 and 509 fixate two guiding wheel 504 and spring 510 for the oscillating chain cutter 501. The chain cutter control device 507 which controls the lateral force of the chain cutter on the rock is connected to control cable 506 and to the chain cutter via a guide wheel 508. Optionally, this wheel can be provided with cutter blades. The chain cutter control device can be similar as the one shown in Fig. 2 of the original patent application. Guiding wheels at location 502 or equivalent mechanical means reduce friction and avoid unlimited deterioration of the well and control cable 508. The cutting starts at the top of the intersection as denoted by the dashed dotted line 511 and the chain cutter and the chain cutter control gradually move downwards until dashed dotted line 512 is reached. Alternatively, spring can be replaced by an oscillating electric or pneumatic actuator or a guiding wheel. In the latter case the chain cutter string returns through the side track 505 and well 500 to the surface allowing for a continuous (non-oscillating) movement of the chain cutter.

Figure 6 shows a configuration somewhat similar to the one shown in Figure 5 but with two springs 604 and 610. The oscillating chain cutter has now two chains 601A and 601B that are connected to these springs via two small guiding wheels at the exit of the anchors. It is an option to house the springs in the anchors to minimize
negative impact of debris. Two integrated guiding wheels 608 with cutting blades are connected to the chain cutting control device 607 that is gently lowered during cutting using control cable 606 and/or the weight of this device and/or actuators shown in Figure 2 of the original patent application. The cutting starts at the top of the intersection as denoted by the dashed dotted line 611 and the chain cutter and the chain cutter control gradually move downwards until dashed dotted line 612 is reached.

Optionally, control cable 606 is left out and the lowering of the control device is activated and controlled by changing the operating mode of the cutting chains 601A and 601B since they can be operated in phase and out of phase. A mechanical device in the control unit act on frictional differences between the control device and the chain cutters in this case. Optionally, the springs 604 and 610 can be replaced by an oscillating electric or pneumatic actuator as in the examples given before.

Figure 7 shows a configuration with one vertical wells 700 and a vertical well 705 with side track 711. This may be advantageous if the distance between the two wells is large compared to the depth. The two anchors 703 and 709 fixate two wheels 704 and 710 to guide control cables 706 and 707. The end of these control cables are connected to guiding wheels 708 and 709 for the chain cutter 701. The chain cutter can oscillate or move continuously. By putting tension on the control cables the lateral force of the cutter on the rock can be increased while cutting. The cutting chain starts along the original side track 711 until it reaches the dashed dotted line 712. The guiding wheels 708 and 709 can move somewhat to each other as a result from the force
balance. Optionally, sliding cases in the well bore below these guiding wheels can maintain the center of these wheels in the well bore. These sliding cases are not drawn in Figure 7.

It will be understood that when the cutting operations start the side track 711 form a first section of the channel assembly and the lower parts of the vertical wells 700 and 705 form a second and third part of the channel assembly and that each of the control cables 706 and 707 forms a chain cutter control cable which controls the lateral force between the chain cutter assembly 712 and the bottom of the side track 711 from which formation particles are carved out by the oscillating or continuously rotating chain cutter assembly 712.

There is no limitation to tilt the cutting plane in Figures 4, 5, 6 and 7 from pure vertical to a plane outside the plane of the drawing.
1. A method of excavating deposits from an underground formation layer, comprising:
   - drilling a well assembly, which penetrates the underground formation layer at a first, a second and a third location, which locations are triangularly spaced;
   - drilling from these locations a channel assembly that traverses the formation layer and interconnects the locations;
   - inserting a chain cutter string into a first section of the channel assembly that is located between the first and second locations;
   - inserting a chain cutter control cable from the third location into a second section of the channel assembly;
   - connecting the chain cutter control cable to the chain cutter string at a branchpoint of the first and second sections of the channel assembly;
   - pulling the chain cutter string through the first section of the channel assembly while exerting a lateral force to the chain cutter control cable such that the chain cutter string is pressed against the wall of the first section of the channel assembly and is thereby induced to carve deposits from the underground formation layer; and
   - flushing carved out deposits through the channel assembly and the well assembly.

2. The method of claim 1, wherein during an initial or subsequent moment of execution of the method:
   - the first section of the channel assembly extends as a substantially straight line between the first and the second locations;
   - the second section of the channel assembly extends from the third location to the branchpoint, which is formed by
a midpoint of the first section of the channel assembly, so that the channel assembly substantially has a T-shape; and
- the chain cutter string is pulled through the first section while the chain cutter string is pressed against the sidewall of the first section by the chain cutter control cable and is pulled by the chain cutter control cable towards the third location.

3. The method of claim 1, wherein during an initial or subsequent moment of execution of the method:
- the first section of the channel assembly has a V-shape and has a first leg, which extends from the first location towards the third location and a second leg, which extends from the third location towards the second location and the chain cutter string extends through the first and second legs of the V-shaped first section of the channel assembly;
- the chain cutter control cable is connected to the chain cutter string at the third location, which location forms the branchpoint of the first and second sections of the channel assembly; and
- the chain cutter string is pulled through the first section.

4. The method of claim 3, wherein the chain cutter control cable is gradually slackened while the chain cutter string is pulled through the first section of the channel assembly, thereby controlling the pressure between the chain cutter string and the sidewall of the first section.

5. The method of any one of claims 1-4, wherein the chain cutter string is pulled sequentially from the first to the second location and from the second to the first location to mine deposits from the underground formation layer.
6. The method of any one of claims 1-4, wherein the chain cutter string is an endless chain, which carries a series of cutting elements and is moved in a continuous motion through the first section of the channel assembly to mine deposits from the underground formation layer.

7. The method of claim 6, wherein the cutting elements are selected from the group of mechanical cutters and/or hydraulic jets.

8. The method of any one of claims 1-7, wherein the method is used to create at least one high permeability plane in a viscous crude oil or tight gas containing formation and/or in a formation comprising a flow barrier, such as a shale layer with a low permeability.

9. The method of any one of claims 1-7, wherein the method is used to mine hydrocarbon deposits selected from the group of coal, oil shale, tar sand and heavy crude from the subsurface formation layer.

10. The method of claim 9, wherein after mining a deposit from a first triangular section of the subsurface formation layer between the first, second and third locations an additional wellbore or well section is drilled such that it penetrates the underground formation layer at a triangularly spaced fourth location relative to a pair of the first, second and third locations, and deposits are mined from a second triangular section between the fourth location and said pair of the first, second and third locations.

11. The method of claim 10, wherein after mining a deposit from the second triangular section of the subsurface formation layer a fifth wellbore or section is drilled such that it penetrates the underground formation layer at a fifth triangularly spaced location relative to the third and fourth locations, and deposits are mined
from a third triangular section between the third, fourth and fifth locations.

12. The method of claim 11, wherein after mining a deposit from an n-th triangular section of the subsurface formation layer, wherein n is a number that is larger than five, a further wellbore or section is drilled such that it penetrates the underground formation layer at another triangularly spaced location relative to a pair of locations located at the outer periphery of the array of n existing triangular sections, and deposits are mined from said another triangular section between the n-th and said pair of locations located at the outer periphery of the array of n existing triangular sections.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. E21B43/30 E21C25/56 E21C29/14 E21C41/16

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

E21B E21C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of database and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<tr>
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<td>US 2 796 129 A (BRANDON CLARENCE W) cited in the application on column 3, line 25 - column 5, line 58; figures 1, 3</td>
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<td>US 2002/030398 AI (DRAKE RONALD D [US] ET AL) 14 March 2002 (2002-03-14) abstract; figure 1</td>
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**Further documents are listed in the continuation of Box C.**

**See patent family annex.**

*S* Special categories of cited documents:

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**Date of the actual completion of the international search**

15 November 2011

**Date of mailing of the international search report**

28/11/2011

Name and mailing address of the ISA:

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### DOCUMENTS CONSIDERED TO BE RELEVANT

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