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(54) EXTRACTION OF HEAT ENERGY FROM ACTIVE HYDROCARBON WELLS

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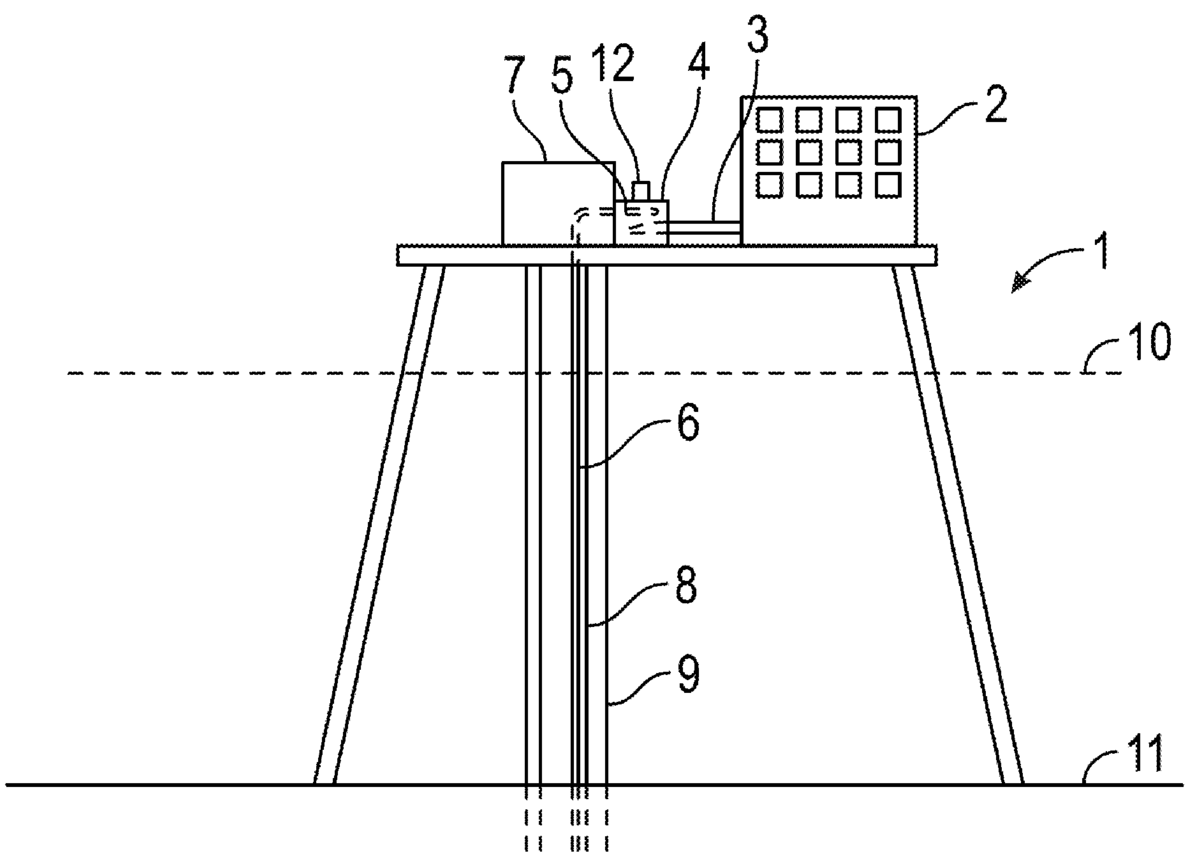
CPC *F24T 10/15* (2018.05); *E21B 41/0007* (2013.01); *F24T 2010/50* (2018.05)

(57) ABSTRACT

A method of extracting heat from hydrocarbon production or injection wells involves passing heat exchanger tubing (**6**) down an active production or injection well and securing it. Heat from the formation or from fluids in the production tubing or annulus is extracted and returned to the surface to be used in various ways on a platform, e.g. heating accommodation or water supplies. The heat exchanger tubing (**6**) may be delivered on coil tubing (**13**) into the production tubing (**8**) and anchored above the DHSV, in a retro-fit operation. Alternatively it may be installed in a sidetrack well (**126**) via a dedicated kick-off (**124**, **125**). If installed at the completion of the well, the heat exchanger tubing (**206**) may be located in the annulus, mounted on the outside of the production tubing (**208**); in this event, the heat exchanger tubing may extend further into the well (beyond the DHSV) to, or even beyond, the production packer (**231**).



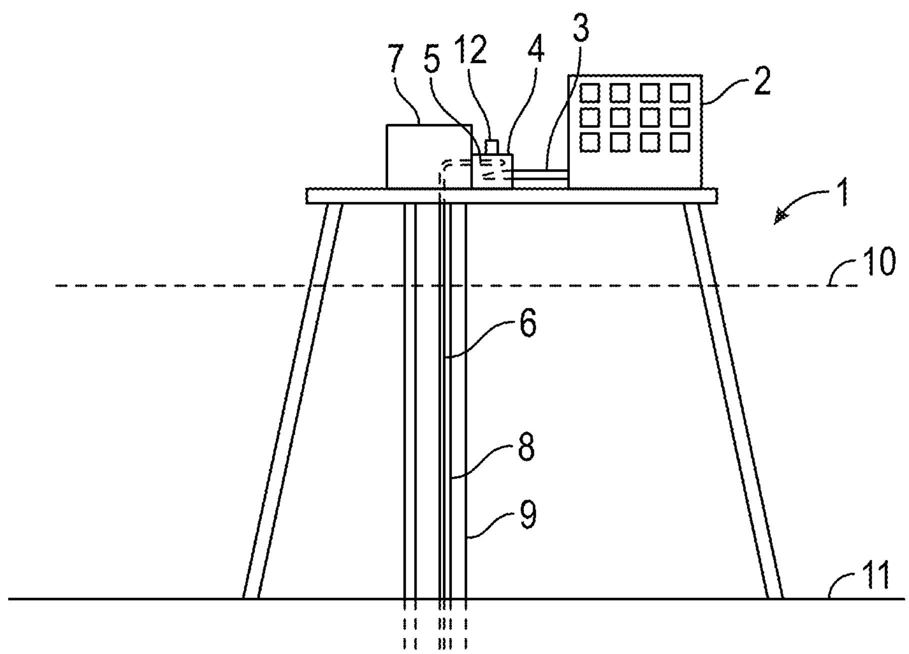


FIG. 1

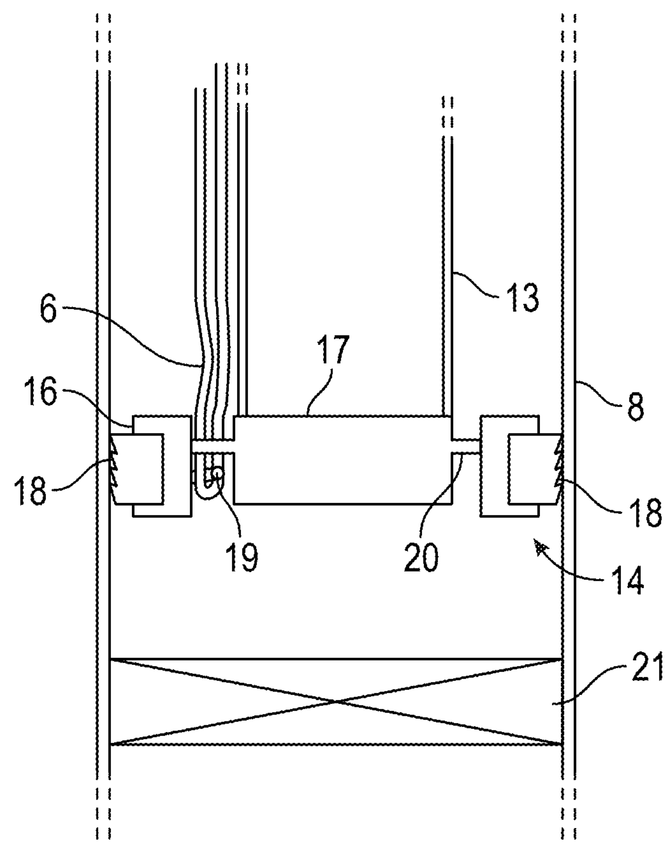


FIG. 2

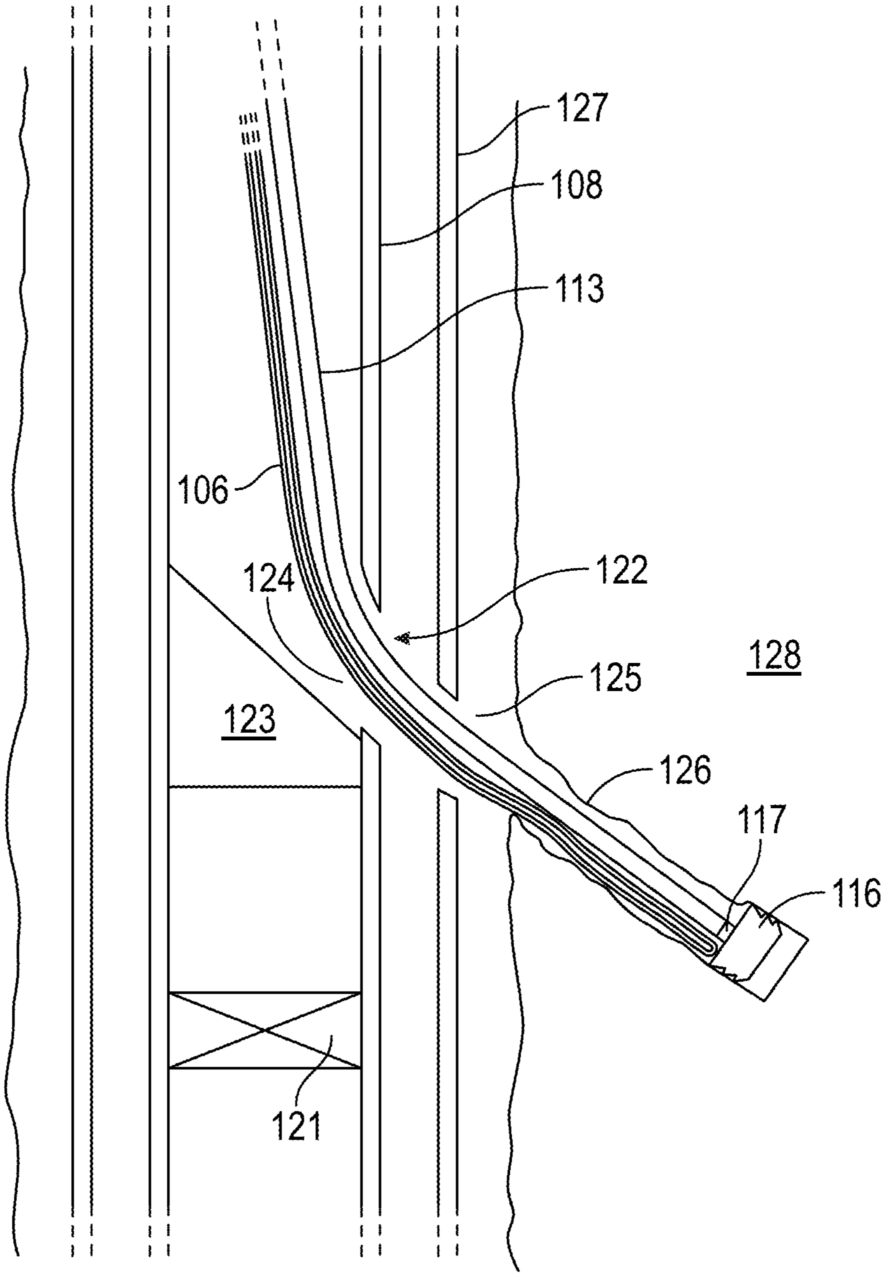


FIG. 3

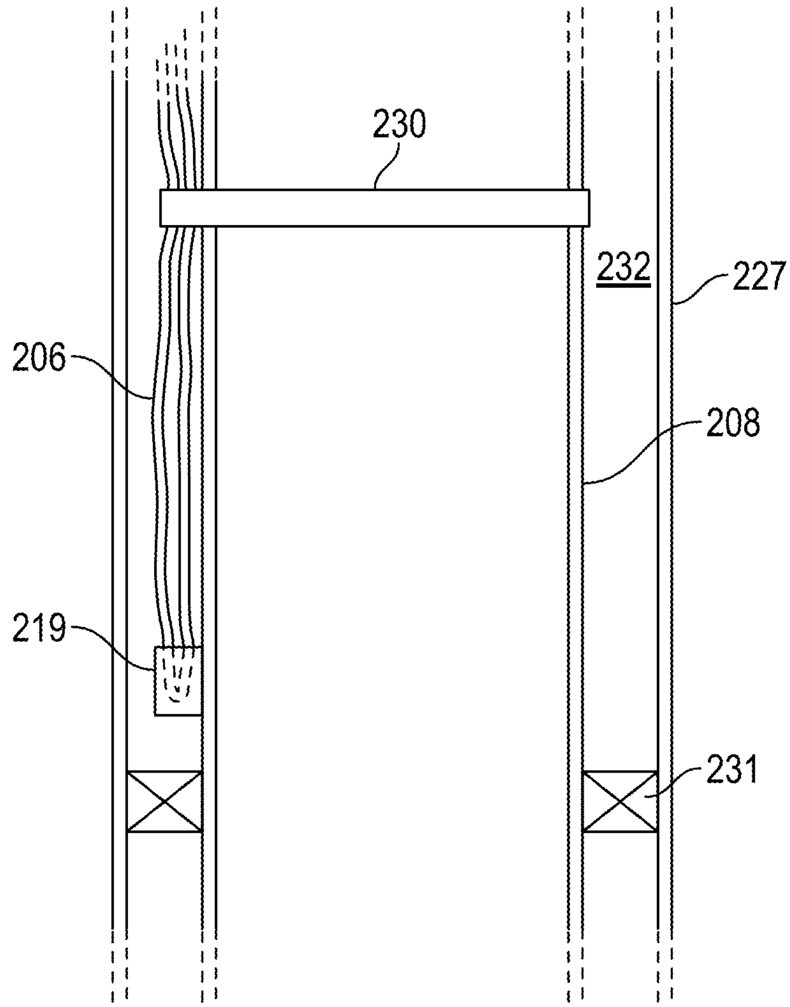


FIG. 4A

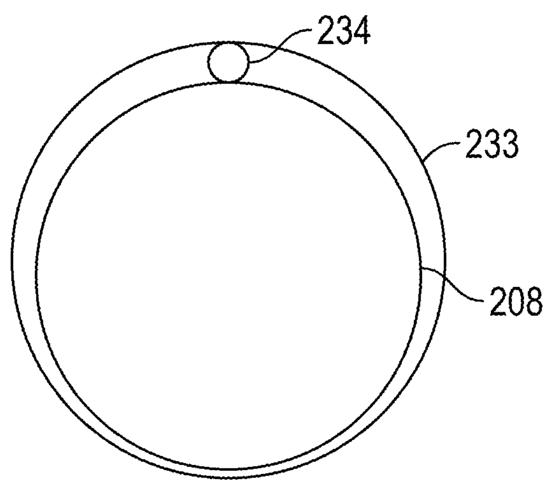


FIG. 4B

EXTRACTION OF HEAT ENERGY FROM ACTIVE HYDROCARBON WELLS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a non-provisional application which claims benefit under 35 USC § 119 (e) to U.S. Provisional Application Ser. No. 63/556,260 filed Feb. 21, 2024 entitled "EXTRACTION OF HEAT ENERGY FROM ACTIVE HYDROCARBON WELLS," which is incorporated herein in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

[0002] None.

FIELD OF THE INVENTION

[0003] This invention relates to the extraction of geothermal energy from an active hydrocarbon production or injection well.

BACKGROUND OF THE INVENTION

[0004] Systems exist for extracting geothermal energy from bore holes. A deep bore hole is drilled to access a region where the temperature is substantially greater than average surface temperature. A heat exchange fluid is passed down the bore hole where its temperature is raised before being circulated back to the surface where the high temperature fluid may be used, e.g. to heat a home.

[0005] It has been suggested that this method could be used to extract heat energy from abandoned hydrocarbon wells, which are very deep and therefore provide access to rock at a high temperature. A problem with this concept is that abandoned hydrocarbon wells are required to be plugged to avoid the possible escape into the environment of hydrocarbon fluids. Maintaining an un-plugged well, especially an offshore well, would require active steps to prevent leakage of hydrocarbons, e.g. maintaining the well under pressure. This is associated with a cost that may not be justified simply by the extraction of thermal energy. Examples of proposals for extraction of energy from abandoned wells are described in NO20210956A1 (Oktra AS), US2013300127A1 (DiNicolantonio) and US2015330670A1 (Wynn).

BRIEF DESCRIPTION OF THE DISCLOSURE

[0006] The invention more particularly includes a process for extracting thermal energy from an active hydrocarbon production or injection well, wherein the process comprises:

- **[0007]** a) running a loop of heat exchanger tubing into the active well, e.g. on coil tubing;
- **[0008]** b) securing the heat exchanger tubing;
- **[0009]** c) circulating heat exchange fluid through the heat exchanger tubing; and
- **[0010]** d) extracting thermal energy from the heat exchange fluid at the surface.

[0011] In this way it is believed that useful thermal energy may be extracted from an active hydrocarbon production well or injection well at relatively low installation cost and low ongoing running cost, whilst not substantially affecting the ongoing operation of the well either in producing hydrocarbons or injecting water to stimulate hydrocarbon production.

[0012] One way of achieving this may be for coil tubing to be run into production tubing of a production well, where the coil tubing also carries the loop of heat exchanger tubing. A packer or anchor device may be run into the well to secure the heat exchanger tubing in the production tubing, above the downhole safety valve (DHSV). The packer may be a flow-through packer.

[0013] Above the depth of the DHSV, the formation temperature may not be considerably higher than surface temperature, but fluids coming up from the reservoir are likely to be at much higher temperatures and heat from these fluids by be extracted via the het exchange tubing.

[0014] The installation may involve running the heat exchanger tubing loop into the well and running the packer or anchor device into the well may be achieved on the same coil tubing run as another operation related to hydrocarbon production, thereby further reducing the add-on cost of installing the heat exchange system.

[0015] If the active well is an injector well, a kickoff (that is to say, a window in the production tubing and casing) may be made in the well prior to delivery of heat exchanger tubing through the kickoff and then anchored in a sidetrack well. In this way, the heat of the formation may be directly accessed by the heat exchange tubing.

[0016] Alternatively, the heat exchanger tubing may be anchored outside production tubing and run into the well with the production tubing. In this event the heat exchanger tubing may be anchored much further down the well, below the DHSV, where reservoir and fluid temperatures may be higher. In this situation, the heat exchanger tubing would normally be run into the well during completion of the well.

[0017] At the surface, depending on the temperature of the returned heat exchange fluid, heat may be extracted using a conventional heat exchanger or by a heat pump.

[0018] It may be possible for differences in density of the heat exchange fluid as it is heated and cooled to create circulation or assist circulation of the heat exchange fluid.

[0019] The invention also encompasses a system for extracting thermal energy from an active hydrocarbon production or injection well, wherein the system comprises:

- **[0020]** a) a coil tubing delivery system including a length of coil tubing;
- **[0021]** b) a length of heat exchanger tubing of smaller diameter than the coil tubing;
- **[0022]** c) an assembly mounted on the coil tubing, the assembly including a packer (e.g. a flow-though packer) and a fastener for securing the heat exchanger tubing to the packer;

whereby a loop of the heat exchanger tubing is capable of being run into a well on the coil tubing, the packer anchored in the well and the coil tubing then withdrawn.

[0023] Examples and various features and advantageous details thereof are explained more fully with reference to the exemplary, and therefore non-limiting, examples illustrated in the accompanying drawings and detailed in the following description. Descriptions of known starting materials and processes can be omitted so as not to unnecessarily obscure the disclosure in detail. It should be understood, however, that the detailed description and the specific examples, while indicating the preferred examples, are given by way of illustration only and not by way of limitation. Various substitutions, modifications, additions and/or rearrangements within the spirit and/or scope of the underlying inventive concept will become apparent to those skilled in the art from this disclosure.

[0024] As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, product, article, or apparatus that comprises a list of elements is not necessarily limited only those elements but can include other elements not expressly listed or inherent to such process, process, article, or apparatus. Further, unless expressly stated to the contrary, "or" refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

[0025] The term substantially, as used herein, is defined to be essentially conforming to the particular dimension, shape or other word that substantially modifies, such that the component need not be exact. For example, substantially cylindrical means that the object resembles a cylinder, but can have one or more deviations from a true cylinder.

[0026] Additionally, any examples or illustrations given herein are not to be regarded in any way as restrictions on, limits to, or express definitions of, any term or terms with which they are utilized. Instead these examples or illustrations are to be regarded as being described with respect to one particular example and as illustrative only. Those of ordinary skill in the art will appreciate that any term or terms with which these examples or illustrations are utilized encompass other examples as well as implementations and adaptations thereof which can or cannot be given therewith or elsewhere in the specification and all such examples are intended to be included within the scope of that term or terms. Language designating such non-limiting examples and illustrations includes, but is not limited to: "for example," "for instance," "e.g.," "In some examples," and the like.

[0027] Although the terms first, second, etc. can be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present inventive concept.

[0028] The term "active" in the context of a hydrocarbon production well is used herein to mean a well from which hydrocarbons are being produced or a well that has not been permanently abandoned for the purpose of extracting hydrocarbons. The term "active" in the context of an injection well is used herein to mean a well through which fluids are being introduced into a subterranean hydrocarbon reservoir either continuously or intermittently, or a well that has not been permanently abandoned for this purpose.

DETAILED DESCRIPTION OF THE DRAWINGS

[0029] A more complete understanding of the present invention and benefits thereof may be acquired by referring to the follow description taken in conjunction with the accompanying drawings in which:

[0030] FIG. **1** is a schematic view of an offshore hydrocarbon platform showing the invention in use;

[0031] FIG. **2** is a schematic view of a bottom hole assembly at the distal end of a length of coil tubing, showing a first embodiment of the invention;

[0032] FIG. **3** is a view similar to FIG. **2**, showing a second embodiment of the invention;

[0033] FIG. **4**A is a view similar to FIGS. **2** and **3**, showing a third embodiment of the invention; and

[0034] FIG. **4**B is a cross section through a production tubing joint for use in the third embodiment.

DETAILED DESCRIPTION

[0035] Turning now to the detailed description of the preferred arrangement or arrangements of the present invention, it should be understood that the inventive features and concepts may be manifested in other arrangements and that the scope of the invention is not limited to the embodiments described or illustrated. The scope of the invention is intended only to be limited by the scope of the claims that follow.

[0036] FIG. **1** shows in highly schematic form an offshore hydrocarbon producing platform **1**.

[0037] The platform includes an accommodation block **2**, which is heated by a conventional circulating hot water system (not shown). The hot water system is a closed loop system and one part **3** of the circuit passes through a heat exchanger **4** located on the platform. The heat exchanger **4** is designed to transfer thermal energy from a portion **5** of heat exchanger tubing **6**.

[0038] A loop of the heat exchanger tubing **6** passes from the heat exchanger **4** through a Xmas tree **7** on the platform **1** and down through production tubing **8** of a producing hydrocarbon well. The production tubing passes through a casing **9** (or riser) through the sea surface **10** and into the seabed. Details such as a seafloor template, wellhead and casing strings, etc., are conventional and are omitted from the drawings for clarity. The well could alternatively be an injector well.

[0039] The heat exchanger tubing **6** is anchored at a point in the production tubing. The heat exchanger tubing **6** could be run into this location and installed using coil tubing, according to techniques well known in this art. Alternatively, the heat exchanger tubing **6** could be installed at a point in the annulus A; in this case the heat exchanger tubing could be run in and installed during completing after traditional drilling.

[0040] Above the downhole safety valve (DHSV) the temperature of the rock will be a little higher than at the surface but the produced oil flowing up the tubing will be at a considerably higher temperature because it will have come from a much deeper part of the well. This temperature could be in the region of 80 to 100° C. since temperature down a well may increase by approximately 30 degrees C. per thousand feet of depth.

[0041] Heat exchange fluid is pumped by means of pump **12** located on the platform down one branch of the loop of heat exchanger tubing to the point where the tubing **6** is anchored, and the fluid then returns to the surface via the other branch of the loop and passes again through the heat exchanger **4** and pump **12**. The heat exchange fluid may be brine, water, ethanol, an ethanol solution in water, e.g. 35% ethanol in water, or any other suitable fluid. The fluid may contain a biocide and/or an anti-freeze additive.

[0042] The heat exchange fluid is heated by thermal conduction from the oil in the production tubing when fastened inside production tubing. In an alternative arrangement, the heat exchanger tubing may be installed in the annulus during completion after traditional drilling. In this arrangement, the heat exchanger tubing may extend further into the well since it does not have to pass through the DHSV since it is in the annulus. At greater depth, the fluid in the annulus is likely to be at relatively high temperature and so may also transfer heat to the heat exchanger tubing **6** in the annulus.

[0043] In either of the above scenarios, direct heat exchange may be possible between the heat exchange fluid and the water in the tubing **3** of the accommodation block's heating system. If the temperature of the heat exchange fluid is lower for some reason, then a heat pump system may be used to extract thermal energy from the heat exchange fluid. A heat pump is not shown in the drawings but is in itself conventional and would replace the heat exchanger **4** in FIG. **1**.

[0044] Of course, the heated water of the heating system may, as is conventional, also be used to heat a hot water supply for washing, etc., by transferring heat via a further heat exchanger to the hot water supply or to any other systems on the platform that require heat.

[0045] FIG. **2** illustrates, again in highly schematic form, the delivery and anchoring of the heat exchanger tubing **6** in the production tubing above the DHSV. A primary barrier element need not be added because the system is above the DHSV and the heat exchanger tubing will come to the platform through the X-mas tree (that is the secondary barrier).

[0046] Coil tubing **13** is run into the production tubing **8** by conventional means, e.g. using a specialist coil tubing vessel or an arrangement on the platform. At the distal end of the coil tubing is an assembly **14**.

[0047] The assembly **14** comprises a specially designed flow through packer **16** on a running tool **17**. The packer **17** comprises a ring with grips **18** spaced around it on the outer side of the ring. On the inner side of the ring is a fastener **19** that secures a loop of heat exchanger tubing **6** to the packer **16**.

[0048] When a workover or drilling operation using coil tubing is to be performed in a well, a specialist vessel or arrangement on the platform is brought in to perform the operation. In addition to performing the required operation, a relatively short coil tubing trip can be made to install the packer **16** at a point in the production tubing above the downhole safety valve (DHSV) **21**. Heat exchanger tubing **6** is run into the well alongside the coil tubing. In an alternative embodiment, the heat exchanger tubing is delivered inside the coil tubing to protect it from damage; however, the principles are essentially the same.

[0049] Once the assembly **14** has been delivered to the required depth above the DHSV **21**, the packer **16** is set by causing spring loaded grip elements **18** to bear outwardly against the inner surface of the tubing **8**. This could be achieved, e.g. by passing a signal to the packer via pulses in drilling fluid. Once the packer **16** is set, the running tool **17** is disengaged with the packer **16** via detachable mountings **20**; again, this step can be activated, e.g., in response to a pulsed signal in drilling fluid.

[0050] Once the packer **16** is set, the coil tubing **13** is withdrawn leaving the loop of heat exchanger tubing **6** secured to the packer **16**. Because of the design of the packer **16**, the tubing is still open and production is substantially unimpaired. The heat exchanger tubing **6** has very small diameter compared to the production tubing and so does not materially affect production rates. The heat exchanger tubing may have a diameter of between 0.25 and 0.75 inches, for example.

[0051] In an alternative embodiment, shown in FIG. **3**, heat exchanger tubing may be installed in a water injector well. A kickoff shown generally at **122** is created at a point above the DHSV **121** by known means which will not be described in detail here. A dissolvable whipstock **123** is installed as part of the process of creating the kickoff; windows **124**, **125** are created in the tubing **108** and casing **127**, respectively, and a short, open hole, sidetrack well **126** bored into the rock **128**.

[0052] Coil tubing **113** is then run into the well and diverted by the whipstock **123** into the sidetrack **128**. At the distal end of the coil tubing is a packer **116** mounted to a running tool **117**. Heat exchanger tubing **106**, fastened to the packer **116**, is run into the well with the coil tubing **113**. The coil tubing and running tool **117** is then withdrawn, leaving the packer **116** and heat exchange tubing **106** in place.

[0053] This way of installing heat exchanger tubing could in fact be used for an injector well or a production well, in each case to get the heat from outside the casing. This system will require a primary barrier element and a secondary barrier element because the completion will go through the production liner and conductor/casing. These barriers are not shown in FIG. **3**, but it is well-known how to achieve these barriers.

[0054] As with the first embodiment, an option may be to run the heat exchanger tubing inside the coil tubing to protect it whilst running into the well.

[0055] Once the kickoff has been created and the heat exchanger tubing installed, the whipstock **123** may be dissolved by conventional methods, e.g. by delivering acid into the well, and then the injector well may continue to function normally.

[0056] Since the kickoff is created above (proximal of) the DHSV **121**, which is normally located a few hundred feet into the well, the temperature of the rock may not be dramatically higher than the ground temperature at the surface. It may be, perhaps 15° C. higher. However, the use of a heat pump at the surface instead of a conventional heat exchanger would still allow this heat energy to be extracted and used.

[0057] FIG. **4**A shows a third embodiment, in which heat exchanger tubing **206** is located in the annulus **232** between the production tubing **208** and casing **227**. The heat exchanger tubing **206** is retained by a heat exchanger tubing anchor **219** mounted on the outside of the production tubing **208** during completion of the well.

[0058] This installation will be part of the completion of a traditional drilled well. The completion will provide a secondary barrier element in annulus A, but does not need to provide a primary barrier element if it's in the reservoir.

[0059] In this embodiment, there is no need for the heat exchanger tubing to terminate above the DHSV since the heat exchanger tubing is outside the production tubing. In FIG. **4**A, the heat exchanger tubing is shown extending to a point just above the production packer **231**. The hydrocarbon stream in the production tubing **208** and also the fluid in the annulus **232** will be at a considerably higher temperature than the surface, e.g. 100° C., so transfer of heat to the heat exchange fluid is likely to be more efficient than in the other embodiments. Alternatively, in this embodiment, the heat exchanger tubing can also go through the production packer and down into the reservoir.

[0060] In the third embodiment, the heat exchanger tubing **206** is run into the well with the production tubing **208**, the end of the tubing **206** being secured by the anchor **219** as the production tubing **208** is run in. The heat exchanger tubing may also secured by fastening bands to the production tubing at intervals along its length, although this may not be necessary.

[0061] The anchor **219** may be provided as part of a dedicated production tubing joint that comprises an outer tube **233** that encloses the production tube **208** itself and also a smaller diameter heat exchanger tube **234**. This arrangement is shown in FIG. **4**B. The heat exchanger tubing anchor (not shown in FIG. **4**B) is also located for protection between the outer tube **223** and the production tube **208**. This arrangement is similar to a known arrangement for a chemical injector valve. The tubing can also be attached to the production tube with specially made clamps.

[0062] In the third embodiment, the heat exchange system is installed at the start of the life of the well, in the completion stage. By installing the heat exchange system in the annulus of the well rather than inside the casing, it is protected from production equipment, logging tools and other treatments inside the casing. Unfortunately access to the annulus may be hindered by completion and the heat exchange system may be cemented in place. In contrast, in the first and second embodiments the heat exchanger tubing may be installed as a retro-fit at any time in the life of the well.

[0063] In any of the embodiments described above, especially the first and third since the temperatures are higher, it may be possible to use the effect of heat on the density and/or phase of the heat exchange fluid to cause it to flow round the loop. For example, the heat exchanger tubing may be formed from concentric tubes with the inner tubing feeding down into the well and the outer tube leading out of the well. Since the fluid in the outer tube will have more thermal energy transferred to it, its density will be less than that of the incoming fluid in the central tube. Depending on the fluid and the temperature, it may be that the fluid in the outer tube is vaporized at least for part of its journey back to the surface. This may promote circulation of the fluid and may assist or even replace the pump **12**.

[0064] The above embodiments have been described with reference to an offshore well, but there is no reason why a slightly modified system could not be used to extract thermal energy from an onshore well since the principles are the same.

[0065] It is envisaged that heat energy extracted from an active hydrocarbon well on one platform or in one location may be transferred for use on other platforms or installations, e.g. offshore wind farms, or even to onshore installations.

[0066] The techniques described in the embodiments above for installing heat exchanger tubing in a well either in production tubing or an annulus, could equally be applied to wells where the wellhead is installed on the seafloor in a subsea template, rather than on a platform. Produced hydrocarbons from such subsea wells are piped to the surface at another location, e.g. a platform or an onshore location. If the length of the pipeline is relatively short, then the temperature of the hydrocarbons may be substantially maintained. If the pipeline runs for a long distance and/or if it is running though deep/cold water then the pipeline may be heated, for example using direct electrical heating, to maintain efficient flow. In either case, the heat exchanger tubing from the subsea well template could be attached to the pipeline and run to the same platform or onshore location as the pipeline, where the thermal energy from the heat exchange fluid in the tubing could be employed in the same way as discussed above in connection with embodiments one to three,

[0067] In closing, it should be noted that the discussion of any reference is not an admission that it is prior art to the present invention, especially any reference that may have a publication date after the priority date of this application. At the same time, each and every claim below is hereby incorporated into this detailed description or specification as a additional embodiments of the present invention.

[0068] Although the systems and processes described herein have been described in detail, it should be understood that various changes, substitutions, and alterations can be made without departing from the spirit and scope of the invention as defined by the following claims. Those skilled in the art may be able to study the preferred embodiments and identify other ways to practice the invention that are not exactly as described herein. It is the intent of the inventors that variations and equivalents of the invention are within the scope of the claims while the description, abstract and drawings are not to be used to limit the scope of the invention. The invention is specifically intended to be as broad as the claims below and their equivalents.

REFERENCES

[0069] All of the references cited herein are expressly incorporated by reference. The discussion of any reference is not an admission that it is prior art to the present invention, especially any reference that may have a publication data after the priority date of this application. Incorporated references are listed again here for convenience:

[0070] NO20210956A1 (Oktra AS), "System and method for geothermal power production."

[0071] US2013300127A1 (DiNicolantonio), "Geothermal energy recovery from abandoned oil wells."

[0072] US2015330670A1 (Wynn), "System and Method for Utilizing Oil and Gas Wells for Geothermal Power Generation."

1. A process for extracting thermal energy from an active hydrocarbon production or injection well, wherein the process comprises:

a) running a loop of heat exchanger tubing into the active well;

b) securing the heat exchanger tubing;

c) circulating heat exchange fluid through the heat exchanger tubing; and

d) extracting thermal energy from the heat exchange fluid at the surface.

2. The process according to claim **1**, wherein the heat exchanger tubing is run into the well using coil tubing.

3. The process according to claim **2**, wherein the coil tubing is run into production tubing of a production well, and the coil tubing also carries the loop of heat exchanger tubing.

4. The process according to claim **1**, wherein a packer or anchor device is run into the well to secure the heat exchanger tubing in the production tubing, above a downhole safety valve.

5. The process according to claim **4**, wherein the packer is a flow through packer.

6. The process according to claim **4**, wherein running the heat exchanger tubing loop into the well, running the packer or anchor device into the well and the operation related to hydrocarbon production are all performed on the same run of coil tubing.

7. The process according to claim **1**, wherein the active well is an injector well and wherein a kickoff is made in the well prior to delivery of heat exchanger tubing through the kickoff and then anchored in a sidetrack well.

8. The process according to claim **1**, wherein the heat exchanger tubing is anchored outside production tubing and is run into the well with the production tubing.

9. The process according to claim **8**, wherein the heat exchanger tubing is run to a point in the well deeper than a downhole safety valve in the production tubing.

10. The process according to claim **8**, wherein the heat exchanger tubing is run into the well during completion of the well.

11. The process according to claim **1**, wherein a heat pump is used to transfer thermal energy from the heat exchange fluid at the surface.

12. The process according to claim **1**, wherein differences in density of the heat exchange fluid as it is heated and cooled create circulation or assist circulation of the heat exchange fluid.

13. The process according to claim **1**, wherein the active well is a subsea well having a wellhead located on the seafloor, and wherein the heat exchanger tubing is brought to the surface at a location remote from the subsea well.

14. The process according to claim **13**, wherein the remote location is a marine installation such as a marine platform or an onshore location, and wherein produced hydrocarbons are transported by pipeline to the location and the heat exchanger tubing is run along the pipeline.

15. The process according to claim **14**, wherein the pipeline is a heated pipeline.

16. A system for extracting thermal energy from an active hydrocarbon production or injection well, wherein the system comprises:

a) a coil tubing delivery system including a length of coil tubing;

b) a length of heat exchanger tubing of smaller diameter than the coil tubing;

c) an assembly mounted on the coil tubing, the assembly including a packer and a fastener for securing the heat exchanger tubing to the packer;

whereby a loop of the heat exchanger tubing is capable of being run into a well on the coil tubing, the packer anchored in the well and the coil tubing then withdrawn.

17. The system according to claim **16**, wherein the packer is a flow-through packer.

18. The system according to claim **16**, wherein the loop of the heat exchanger tubing is mounted in the coiled tubing, adjacent the coiled tubing, or in the annulus of the casing.

19. The system according to claim **16**, wherein the active well is a subsea well having a wellhead located on the seafloor, and wherein the heat exchange tubing is brought to the surface at a location remote from the subsea well.

20. The system according to claim **19**, wherein the remote location is a marine installation such as a marine platform or an onshore location, and wherein produced hydrocarbons are transported by pipeline to the location and the heat exchange tubing is run along the pipeline, optionally wherein the pipeline is a heated pipeline.

* * * * *