(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 January 2016 (21.01.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/010606 A1

(51) International Patent Classification:
E21B 36/04 (2006.01) *E21B 43/24* (2006.01)

(21) International Application Number:
PCT/US2015/028270

(22) International Filing Date:
29 April 2015 (29.04.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/024,360 14 July 2014 (14.07.2014) US

(71) Applicant: **EXXONMOBIL UPSTREAM RESEARCH COMPANY** [US/US]; CORP-URC-SW359, P.O. Box 2189, Houston, TX 77252-2189 (US).

(72) Inventors; and
(71) Applicants *(for US only)*: **HOPKO, Sandra, N.** [US/US]; 7843 Spruce Cover Dr., Houston, TX 77095 (US). **HOWELL, Shaquiiria, S.** [US/US]; 8038 Sands Point, Apt B, Houston, TX 77036 (US).

(74) Agents: **SULLIVAN, Jamie, L.** et al.; Exxonmobil Upstream Research Company, CORP-URC-SW359, P.O. Box 2189, Houston, TX 77252-2189 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

[Continued on next page]

(54) Title: SYSTEM AND METHOD FOR RECOVERING HYDROCARBONS FROM A SUBSURFACE FORMATION THAT MINIMIZES SURFACE DISTURBANCE

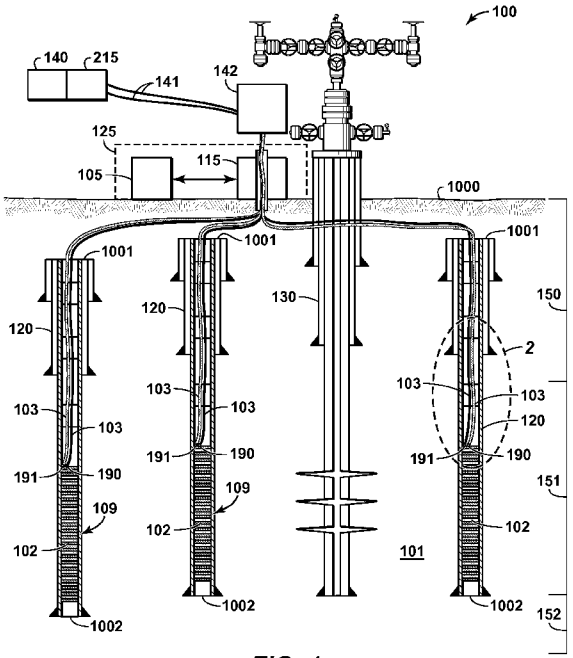


FIG. 1

(57) Abstract: The present disclosure provides a system and method for recovering hydrocarbons that minimize surface disturbance. The system includes an electrical heater within the subsurface formation that heats hydrocarbons within the subsurface formation and a heater wellbore within the subsurface formation that has been reclaimed for surface use.

WO 2016/010606 A1

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

SYSTEM AND METHOD FOR RECOVERING HYDROCARBONS FROM A SUBSURFACE FORMATION THAT MINIMIZES SURFACE DISTURBANCE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of U.S. Provisional Patent Application 62/024,360 filed 14 July 2014 entitled SYSTEM AND METHOD FOR RECOVERING HYDROCARBONS FROM A SUBSURFACE FORMATION THAT MINIMIZES SURFACE DISTURBANCE, the entirety of which is incorporated by reference herein.

BACKGROUND

Fields of Disclosure

[0002] The disclosure relates generally to the field of hydrocarbon recovery from subsurface formations and, more particularly, to systems and methods for recovering hydrocarbons, from a subsurface formation that minimizes surface disturbance.

Description of Related Art

[0003] This section is intended to introduce various aspects of the art, which may be associated with the present disclosure. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present disclosure. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0004] Modern society is greatly dependent on the use of hydrocarbons for fuels and chemical feedstocks. Subterranean formations that can be termed "reservoirs" may contain resources, such as hydrocarbons, that can be recovered. Removing hydrocarbons from the subterranean reservoirs depends on numerous physical properties of the subterranean rock formations, such as the permeability of the rock containing the hydrocarbons, the ability of the hydrocarbons to flow through the subterranean rock formations, and the proportion of hydrocarbons present, among other things.

[0005] Easily produced sources of hydrocarbons are dwindling, resulting in increased reliance on less conventional sources (i.e., unconventional resources) to satisfy future needs.

Examples of unconventional resources may include heavy oil, tar and oil shale. These unconventional sources may complicate production of the hydrocarbons from the subterranean formation. For example, a viscosity of the hydrocarbons may be sufficiently high to prevent production (or at least economical production) of the hydrocarbons from the subterranean formation and/or it may be desirable to change a chemical and/or physical composition (interchangeably referred to as chemical and/or physical property) of the hydrocarbons, such as by decreasing an average molecular weight of the hydrocarbons, prior to production of the hydrocarbons. To improve production, thermal processes may be used to recover unconventional resources.

[0006] One challenge with recovering hydrocarbons from unconventional resources relates to the tight well spacing required in some thermal processes. The development plan for unconventional resources may include a way to heat the subterranean reservoir *in situ* where the subterranean reservoir may, for example, contain the oil sand, the oil shale or the tar. Heating the subterranean reservoir *in situ* may reduce a viscosity of the hydrocarbon within the subterranean reservoir. Heating the subterranean reservoir *in situ* may induce *in situ* upgrading of the hydrocarbon source into products that can be efficiently produced from the subterranean reservoir. Heating the subterranean reservoir *in situ* may induce *in situ* conversion of the hydrocarbon source into products that can be efficiently produced from the subterranean reservoir.

[0007] Many of the thermal processes cause surface disturbance. The surface disturbance can take the form of extensions of tubing, wire connections, well heads, instrumentation and/or post installation maintenance hubs above the subsurface formation. The surface disturbance may make it difficult to produce unconventional resources. For example, regulators may not grant access to the unconventional resources if the unconventional resources are at locations with scenic value that are occupied, and/or meant for future development. Once initial development of thermal processes is completed and production facilities are installed, incremental operations activity, such as infill drilling, well work and maintenance, may be inhibited by the presence of surface equipment, which causes surface disturbance, in place at the surface location.

[0008] A need exists for improved technology, including technology that may address one or more of the above described disadvantages. For example, a need exists for systems and

methods for recovering hydrocarbons, from a subsurface formation that minimizes surface disturbance.

SUMMARY

[0009] The present disclosure provides systems and methods for recovering hydrocarbons, from a subsurface formation, that minimize surface disturbance.

[0010] A system for recovering hydrocarbons, from a subsurface formation, that minimizes surface disturbance may comprise an electrical heater within the subsurface formation that heats hydrocarbons within the subsurface formation; and a heater wellbore within the subsurface formation that has been reclaimed for surface use.A method for recovering hydrocarbons, from a subsurface formation below a surface of the earth, that minimizes surface disturbance may comprise forming a heater wellbore within the subsurface formation; placing an electrical heater within the heater wellbore; reclaiming at least a portion of the heater wellbore intersecting the surface of the subsurface formation; and creating thermally-inducing changes within the subsurface formation.

[0011] The foregoing has broadly outlined the features of the present disclosure so that the detailed description that follows may be better understood. Additional features will also be described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] These and other features, aspects and advantages of the present disclosure will become apparent from the following description and the accompanying drawings, which are described briefly below.

[0013] Figure 1 is a front view of a system that minimizes surface disturbance.

[0014] Figure 2 is a front view of section 2 of Figure 1.

[0015] Figure 3 is a flowchart of a method.

[0016] Figure 4 is a flowchart of a method.

[0017] It should be noted that the figures are merely examples and that no limitations on the scope of the present disclosure are intended hereby. Further, the figures are generally not

drawn to scale but are drafted for the purpose of convenience and clarity in illustrating various aspects of the disclosure.

DETAILED DESCRIPTION

[0018] For the purpose of promoting an understanding of the principles of the disclosure, reference will now be made to the features illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is thereby intended. Any alterations and further modifications, and any further applications of the principles of the disclosure as described herein are contemplated as would normally occur to one skilled in the art to which the disclosure relates. It will be apparent to those skilled in the relevant art that some features that are relevant to the present disclosure may not be shown in the drawings for the sake of clarity.

[0019] At the outset, for ease of reference, certain terms used in this application and their meaning as used in this context are set forth below. To the extent a term used herein is not defined below, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Further, the present processes are not limited by the usage of the terms shown below, as all equivalents, synonyms, new developments and terms or processes that serve the same or a similar purpose are considered to be within the scope of the present disclosure.

[0020] As used herein, the term "hydrocarbon" refers to an organic compound that includes primarily, if not exclusively, the elements hydrogen and carbon. Hydrocarbons may also include other elements, such as, but not limited to, halogens, metallic elements, nitrogen, oxygen, and/or sulfur. Hydrocarbons generally fall into two classes: aliphatic, or straight chain hydrocarbons, and cyclic, or closed ring hydrocarbons, including cyclic terpenes. Examples of hydrocarbon-containing materials include any form of natural gas, oil, coal, heavy oil and kerogen that can be used as a fuel or upgraded into a fuel.

[0021] As used herein, the term "hydrocarbon-rich formation" refers to any formation that contains more than trace amounts of hydrocarbons. For example, a hydrocarbon-rich formation may include portions that contain hydrocarbons at a level of greater than 5 percent by volume. The hydrocarbons located in a hydrocarbon-rich formation may include, for example, oil, natural gas, heavy hydrocarbons, and solid hydrocarbons.

[0022] As used herein, the terms "produced fluids" and "production fluids" refer to liquids and/or gases removed from a subsurface formation, including, for example, an organic-rich rock formation. Produced fluids may include both hydrocarbon fluids and non-hydrocarbon fluids. Production fluids may include, but are not limited to, liquids and/or gases originating from pyrolysis of oil shale, natural gas, synthesis gas, a pyrolysis product of coal, carbon dioxide, hydrogen sulfide and water (including steam).

[0023] As used herein, the term "fluid" refers to gases, liquids, and combinations of gases and liquids, as well as to combinations of gases and solids, and combinations of liquids and solids.

[0024] As used herein, the term "formation hydrocarbons" refers to both light and/or heavy hydrocarbons and solid hydrocarbons that are contained in an organic-rich rock formation. Formation hydrocarbons may be, but are not limited to, natural gas, oil, kerogen, oil shale, coal, tar, natural mineral waxes, and asphaltenes.

[0025] As used herein, the term "gas" refers to a fluid that is in its vapor phase at 1 atmosphere (atm) and 15 degrees Celsius (° C).

[0026] As used herein, the term "kerogen" refers to a solid, insoluble hydrocarbon that may principally contain carbon, hydrogen, nitrogen, oxygen, and/or sulfur.

[0027] As used herein, the term "oil" refers to a hydrocarbon fluid containing primarily a mixture of condensable hydrocarbons.

[0028] As used herein, the term "oil shale" refers to any fine-grained, compact, sedimentary rock containing organic matter made up mostly of kerogen, a high-molecular weight solid or semi-solid substance that is insoluble in petroleum solvents and is essentially immobile in its rock matrix.

[0029] As used herein, the term "organic-rich rock" refers to any rock matrix holding solid hydrocarbons and/or heavy hydrocarbons. Rock matrices may include, but are not limited to, sedimentary rocks, shales, siltstones, sands, silicilytes, carbonates, and diatomites. Organic-rich rock may contain kerogen.

[0030] As used herein, the term "organic-rich rock formation" refers to any formation containing organic-rich rock. Organic-rich rock formations include, for example, oil shale formations, coal formations, tar sands formations or other formation hydrocarbons.

[0031] As used herein, "overburden" refers to the material overlying a subterranean reservoir. The overburden may include rock, soil, sandstone, shale, mudstone, carbonate and/or ecosystem above the subterranean reservoir. During surface mining the overburden is removed prior to the start of mining operations. The overburden may refer to formations above or below free water level. The overburden may include zones that are water saturated, such as fresh or saline aquifers. The overburden may include zones that are hydrocarbon bearing.

[0032] As used herein, "permeability" is the capacity of a rock to transmit fluids through the interconnected pore spaces of the structure. A customary unit of measurement for permeability is the milliDarcy (mD). The term "absolute permeability" is a measure for transport of a specific, single-phase fluid through a specific portion of a formation. The term "relative permeability" is defined for relative flow capacity when one or more fluids or one or more fluid phases may be present within the pore spaces, in which the interference between the different fluid types or phases competes for transport within the pore spaces within the formation. The different fluids present within the pore spaces of the rock may include water, oil and gases of various compositions. Fluid phases may be differentiated as immiscible fluids, partially miscible fluids and vapors. The term "low permeability" is defined, with respect to subsurface formations or portions of subsurface formations, as an average permeability of less than about 10 mD.

[0033] As used herein, the term "porosity," refers to the percent volume of pore space in a rock. Porosity is a measure of the rock's storage capacity for fluids. Porosity may be determined from cores, sonic logs, density logs, neutron logs or resistivity logs. Total or absolute porosity includes all the pore spaces, whereas effective porosity includes only the interconnected pores.

[0034] As used herein, the term "pyrolysis" refers to the breaking of chemical bonds through the application of heat. For example, pyrolysis may include transforming a compound into one or more other substances by heat alone or by heat in combination with an oxidant. Pyrolysis may include modifying the nature of the compound by addition of hydrogen atoms

which may be obtained from molecular hydrogen, water, carbon dioxide, or carbon monoxide. Heat may be transferred to a section of the formation to cause pyrolysis.

[0035] As used herein, "reservoir" or "subterranean reservoir" is a subsurface rock or sand formation from which a production fluid or resource can be harvested. The rock formation may include sand, granite, silica, carbonates, clays, and organic matter, such as oil shale, light or heavy oil, gas, or coal, among others. Reservoirs can vary in thickness from less than one foot (0.3048 meter (m)) to hundreds of feet (hundreds of meters).

[0036] As used herein, the term "solid hydrocarbons" refers to any hydrocarbon material that is found naturally in substantially solid form at formation conditions. Non-limiting examples include kerogen, coal, shungites, asphaltites, and natural mineral waxes.

[0037] As used herein "subsurface formation" refers to the material existing below the Earth's surface. The subsurface formation may interchangeably be referred to as a formation or a subterranean formation. The subsurface formation may comprise a range of components, e.g. minerals such as quartz, siliceous materials such as sand and clays, as well as the oil and/or gas that is extracted.

[0038] As used herein, "substantial" when used in reference to a quantity or amount of a material, or a specific characteristic of the material, refers to an amount that is sufficient to provide an effect that the material or characteristic was intended to provide. The exact degree of deviation allowable may in some cases depend on the specific context.

[0039] As used herein, the term "tar" refers to a viscous hydrocarbon that generally has a viscosity greater than about 10,000 centipoise (cP) at 15° C. The specific gravity of tar generally is greater than 1.000. Tar may have an American Petroleum Institute (API) gravity less than 10 degrees. "Tar sands" refers to a formation that has tar in it. In contrast, light oil may have a viscosity less than 10 cP; medium oil and heavy oil may have a viscosity of 10 cP and greater, up to or exceeding 10,000 cP.

[0040] As used herein, "underburden" refers to the material underlaying a subterranean reservoir. The underburden may include rock, soil, sandstone, shale, mudstone, wet/tight carbonate and/or ecosystem below the subterranean reservoir.

[0041] As used herein, "wellbore" is a hole in the subsurface formation made by drilling or inserting a conduit into the subsurface. A wellbore may have a substantially circular cross section or any other cross-section shape, such as an oval, a square, a rectangle, a triangle, or other regular or irregular shapes. The term "well," when referring to an opening in the formation, may be used interchangeably with the term "wellbore." Further, multiple pipes may be inserted into a single wellbore, for example, as a liner configured to allow flow from an outer chamber to an inner chamber.

[0042] As used herein, the term "coupled" means the joining of two members directly or indirectly to one another. Such joining may be stationary or moveable in nature. Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate members being attached to one another. Such joining may be permanent in nature or may be removable or releasable in nature.

[0043] As used herein, "electrical cable" is an assembly of electrical conductors and insulators that provide an electrical connection where the electrical cable includes the electrical conductors and insulators. The electrical cable permits the flow of electrical current in one or more directions.

[0044] As used herein, "conductor" is an object or type of material that permits the flow of electrical current in one or more directions. The conductor may be a positive conductor when it connects to a potential higher than zero, i.e., the voltage of a common ground. In this disclosure, positive conductors are said to have a positive charge. The conductor may be a negative conductor when it connects to a potential lower than zero. In this description, negative conductors are said to have a negative charge.

[0045] As used herein, "wire" is an electrical conductor surrounded by an insulator. Wires are typically used to transmit relatively low-voltage signals, such as electrical measurement signals. The wire may be installed within an electrical cable. Multiple wires may be installed within an electrical cable.

[0046] As used herein, "electrical pathway" refers to a path that permits the flow of electrical current in one or more directions. Consequently, the electrical pathways may transmit power. An electrical cable has an electrical pathway. A wire has an electrical pathway.

[0047] The articles "the", "a" and "an" are not necessarily limited to mean only one, but rather are inclusive and open ended so as to include, optionally, multiple such elements.

[0048] "At least one," in reference to a list of one or more entities should be understood to mean at least one entity selected from any one or more of the entity in the list of entities, but not necessarily including at least one of each and every entity specifically listed within the list of entities and not excluding any combinations of entities in the list of entities. This definition also allows that entities may optionally be present other than the entities specifically identified within the list of entities to which the phrase "at least one" refers, whether related or unrelated to those entities specifically identified. Thus, as a non-limiting example, "at least one of A and B" (or, equivalently, "at least one of A or B," or, equivalently "at least one of A and/or B") may refer, to at least one, optionally including more than one, A, with no B present (and optionally including entities other than B); to at least one, optionally including more than one, B, with no A present (and optionally including entities other than A); to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other entities). In other words, the phrases "at least one," "one or more," and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B and C," "at least one of A, B, or C," "one or more of A, B, and C," "one or more of A, B, or C" and "A, B, and/or C" may mean A alone, B alone, C alone, A and B together, A and C together, B and C together, A, B and C together, and optionally any of the above in combination with at least one other entity.

[0049] The disclosure relates to systems and methods (Figures 1-4) for recovering hydrocarbons, from a subsurface formation 101, that minimizes surface disturbance. Figures 1-4 of the disclosure display various aspects of the systems and methods.

[0050] The systems 100 and methods may include an electrical heater 102. The electrical heater 102 may be within the subsurface formation 101. The electrical heater 102 may heat hydrocarbons within the subsurface formation. The electrical heater 102 may heat hydrocarbons by generating heat 201 (Figure 3). The electrical heater 102 may generate heat when power transmitted to the electrical heater 102, 202 (Figure 3) reaches the electrical heater 102. The subsurface formation 101 may comprise an overburden 150, a subterranean reservoir 151, and an underburden 152. The hydrocarbons may be within the subterranean reservoir 151.

[0051] The electrical heater 102 may be any suitable electrical heater that requires electrical power. Examples of electrical heaters include, but are not limited to, a heating device 109 (Figure 1).

[0052] The electrical heater 102 may comprise electrical heaters. Each of the electrical heaters 102 requires electrical power to generate heat. The electrical heaters 102 may be controlled as a system or independently, based on the method described, including, but not limited to initiating, terminating or adjusting power transmission to one or more of the electrical heaters 102. The power transmitted may be defined as any component of energy, such as but not limited to magnitude or frequency. Power transmission adjustments can include either magnitude (typical units are Watts) or frequency (typical units are Hertz).

[0053] The systems 100 and methods may include a heater wellbore 120 within the subsurface formation 101. The heater wellbore 120 may be formed in the subsurface formation 101, 401 (Figure 4). At least a portion of the heater wellbore 120 may be reclaimed 403 (Figure 4). The at least the portion of the heater wellbore 120 may intersect a surface 1000 of the subsurface formation. The surface 1000 may be the Earth's surface. After the at least the portion of heater wellbore 120 has been reclaimed, the electrical heater 102 may heat the subsurface formation 101. The heater wellbore 120 may be a wellbore that has been reclaimed so that the heater wellbore 120 minimizes surface disturbance, 403 (Figure 4). The heater wellbore 120 may be reclaimed by shutting in the heater wellbore.

[0054] The heater wellbore 120 may not be flush with the surface 1000 (Figure 1) of the subsurface formation 101. The heater wellbore 120 may be completely within the subsurface formation 101. The heater wellbore 120 may comprise a heater wellbore topmost portion 1001 and a heater wellbore bottommost portion 1002. The heater wellbore topmost portion 1001 may be closer to the surface 1000 of the subsurface formation 101 than the heater wellbore bottommost portion 1002. The heater wellbore topmost portion 1001 and the heater wellbore bottommost portion 1002 may be completely within the subsurface formation 101.

[0055] The electrical heater 102 may be within the heater wellbore 120. The electrical heater 102 may be placed within the heater wellbore 120, 402 (Figure 4). The electrical heater 102 may be placed within the heater wellbore 120 before heating hydrocarbons. The hydrocarbons may be heated during and/or after the electrical heater 102 generates heat. All or

at least a first portion of the electrical heater 102 may be within the heater wellbore 120. If only the first portion of the electrical heater 102 is within the heater wellbore 120, a second portion of the electrical heater 102 may be outside of the electrical heater 102. The second portion of the electrical heater 102 may be within the subsurface formation 101. The electrical heater 102 within the heater wellbore 120 may comprise one or more electrical heaters so that, for example but not limited to, electrical heaters 102 may be within the heater wellbore 120.

[0056] The heater wellbore 120 may interchangeably be referred to as a first wellbore or a second wellbore, etc. The heater wellbore 120 may not be configured to produce the hydrocarbons. The heater wellbore 120 may be a caseless wellbore (i.e., uncased wellbore) or wellbore comprising a casing.

[0057] The systems 100 and methods may include heater sensors 212. The heater sensors 212 may help detect an electrical heater performance of an electrical heater 102. At least one of the heater sensors 212 may be coupled to a respective one of the electrical heaters 102. The amount of heater sensors 212 coupled to a respective one of the electrical heaters may include a number within and bounded by the preceding range of heater sensors 212.

[0058] Each of the heater sensors 212 may be configured to detect a heater characteristic of the one of the electrical heaters 102 to which it is coupled. If multiple heater sensors are coupled to an electrical heater, one or more of the heater sensors may determine a different heater characteristic than the rest of the heater sensors. The heater sensor 212 may be a sensor that can detect a heater characteristic. The heater characteristic may be any suitable heater characteristic. For example, the heater characteristic may comprise one of temperature, voltage, current, electrical resistance and impedance.

[0059] The systems 100 and methods may include a first local electrical room 125. The first local electrical room 125 may be configured to detect deviations in heater performance within each of the electrical heaters 102 based on a heater characteristic of the respective electrical heaters. The first local electrical room 125 may detect deviation in heater performance by determining whether each of the electrical heaters 102 is operating within a target operating heater range based on the heater characteristics of each of the electrical heaters 102. The target operating heater range is the range of suitable numerical values for the heater characteristic of an electrical heater that shows the electrical heater is operating within design limits. The target

operating heater range may be a range of heater characteristics from a desired operating heater characteristic of a given electrical heater 102.

[0060] The first local electrical room 125 may be configured to detect whether each of the heater characteristics for each of the electrical heaters 102 is within a target expected heater range. The target expected heater range may be the heater characteristic expected for the amount of power transmitted to the electrical heater. The target expected heater range differs from the target operating heater range in that the target expected heater range is intended to help determine whether the heater response to a given signal or power input is as expected while the target operating heater range is intended to define the operating constraints of the electrical heater by which the electrical heater does not fail. The target operating heater range and the target expected heater range can vary over time.

[0061] The first local electrical room 125 may compare the heater characteristic detected by a heater sensor 212 to the target operating heater range to determine whether the heater characteristic is within the target operating heater range. If the heater characteristic detected is within the target operating heater range, the first local electrical room 125 detects that the heater has not failed. If the heater characteristic detected is outside of the target operating heater range, the first local electrical room 125 detects that there may be a heater failure in one of the electrical heaters 102. If the heater failure is detected, the first local electrical room 125 may be configured to redistribute power transmitted from the failed electrical heater to another electrical heater, such as from a first electrical heater to a second electrical heater, etc. The another electrical heater is separate from the failed electrical heater.

[0062] The first local electrical room 125 may compare the heater characteristic detected by a heater sensor 212 to the target expected heater range to determine whether the heater characteristic is within the target expected heater range. If the heater characteristic is within the target expected heater range, the first local electrical room 125 detects that the heater characteristic is within the range of heater characteristics expected for the amount of power being transmitted to the electrical heater. If the heater characteristic detected is outside of the target expected heater range, the first local electrical room 125 detects that the amount of power being transmitted to the electrical heater is too much or insufficient. If the amount of power being transmitted to the electrical heater is too much or insufficient, the first local electrical room 125

is configured to correct the amount of power being transmitted to the electrical heater by decreasing the amount of power or by increasing the amount of power.

[0063] The first local electrical room 125 may be configured to detect and adjust power transmission to the electrical heater 102 during a transient period, such as initial startup of the electrical heater. During the transient period, the target operating heater range and the target expected heater range can be variable and either or both ranges may be used to actively control transmission of power to an electrical heater 102. In the example of initial startup, power may be transmitted to the electrical heater 102 until heater behavior is stabilized. Stabilization can occur when one or more heater characteristics reach a stable operating level for a given power transmitted to the electrical heater 102. The target operating heater range and target expected heater range can be adjusted continuously or in staged increments during heater transient periods. The heater operations can reach a target, steady-state level when heater characteristics and target expected heater range reach predetermined steady-state values.

[0064] The first local electrical room 125 may comprise a first local distribution circuit 115 and a first data acquisition system 105. The first local distribution circuit 115 and the first data acquisition system 105 may make it possible for the first local electrical room 125 to detect deviations in heater characteristics. The first local distribution circuit 115 and the first data acquisition system 105 may make it possible for the first local electrical room 125 to determine whether a heater characteristic is within the target expected heater range. The first local distribution circuit 115 may include power hardware of the first local electrical room 125. Examples of power hardware include, but are not limited to, a circuit breaker and a relay. The first data acquisition system 105 may include data acquisition hardware and power software of the first local electrical room 102. The data acquisition hardware and power software may make it possible for the first local electrical room 125 to detect the heater characteristics. The data acquisition hardware and power software may make it possible for the first local electrical room 125 to analyze the heater characteristics detected to determine whether there is deviation in a heater's performance. The data acquisition hardware and power software may make it possible for the first local electrical room 125 to analyze the heater characteristics detected to determine whether the heater characteristic detected is within the target operating heater range. The data acquisition hardware and power software may make it possible for the first local electrical room 125 to adjust power distribution to one or more heaters in response to detected deviations in

heater performance. The data acquisition hardware and power software may make it possible for the first local electrical room 125 to analyze a heater characteristic detected to determine whether the heater characteristic detected is within the target expected heater range.

[0065] If deviation in heater performance is detected in which a heater characteristic is outside of the target operating heater range, the first data acquisition system 105 may send a signal to the first local distribution circuit 115 to switch power transmitted from the failed electrical heater to another cable within the electrical heater or to another electrical heater. By switching power transmitted from the failed electrical heater to another electrical heater, the failed electrical heater no longer receives power. Instead, another electrical heater may receive power. The process of the first local electrical room 125 detecting a heater failure may continue for the other electrical cable 103 and the other electrical heater 102 and so on. If it is detected that the heater characteristic detected by the heater sensor 212 is within the target expected heater range, the first data acquisition system 105 may not send a signal to the first local distribution circuit 115 to switch power from the electrical heater being powered to the other electrical heater.

[0066] If it is detected that the heater characteristic is within the target expected heater range, the first data acquisition system 105 may not modify a signal sent to the first local distribution circuit 115. If it is detected that the heater characteristic is outside of the target expected heater range, the first data acquisition system 105 may modify the signal sent to the first local distribution circuit 115. The signal may be modified to increase the power sent or to decrease the power sent to the electrical heater if the heater characteristic is below the target expected heater range or above the target expected heater range, according to the control system design. The signal may be modified to increase or decrease other inputs to the heater, according to the control system design, such as the frequency or magnitude in which the power is transmitted.

[0067] At least a substantial portion of the first local electrical room 125 may be within the subsurface formation 101. The substantial portion may be within the subsurface formation 101 to help minimize surface disturbance. An access point to the first local electrical room 125 may be the portion of the first local electrical room 125 outside of the subsurface formation or within the subsurface formation 101 but close to the surface of the subsurface formation 101 such that

the first local electrical room 125 is easily accessible to an operator. All (i.e., an entirety of) of the first local electrical room 125 may be within the subsurface formation 101.

[0068] The electrical cable 103 may be substantially within the subsurface formation 101. The electrical cable 103 may be substantially within the subsurface formation such that a substantial portion of the electrical cables 103 is within the subsurface formation 101. The substantial portion may extend within the subsurface formation 101 from the electrical heater 102 such that a first end 190, 191 of the electrical cables 103 connects to the electrical heater 102. The substantial portion being within the subsurface formation 101 minimizes the surface disturbances that would otherwise be caused by the electrical cables 103 if the substantial portion was not within the subsurface formation 101. An entirety of the electrical cables 103 may be within the subsurface formation 101.

[0069] The electrical cable 103 may comprise greater than or equal to one electrical cable. The amount of electrical cables 103 may be any amount within and bounded by the preceding range. Each of the electrical cables 103 may be separate from the other electrical cables 103. Only one of the electrical cables 103 may transmit power to the electrical heater 102 at a time. In other words, if a first electrical cable 103 transmits power to the electrical heater 102, a second electrical cable 103 and so on may not transmit power to the electrical heater 102; if the second electrical cable 103 transmits power to the electrical heater 102, the first electrical cable 103 may not transmit power to the electrical heater 102.

[0070] The systems 100 and methods may include electrical pathways 103, 106, 116, 126 that are configured to transmit power to the electrical heaters 102. Each of the electrical cables 103 may comprise one of the electrical pathways. For example, a first electrical cable 103 may comprise a first cable electrical pathway 103 of the electrical pathways, a second electrical cable 103 may comprise a second cable electrical pathway 103 of the electrical pathways, etc.

[0071] The electrical pathways 103 may transmit power to the electrical heaters 102, 202 (Figure 3). The electrical pathways 103 may be substantially within the subsurface formation 101. The electrical pathways 103 may be substantially within the subsurface formation such that a substantial portion of the electrical pathways 103 is within the subsurface formation 101. The substantial portion being within the subsurface formation 101 minimizes the surface disturbances that would otherwise be caused by the electrical pathways 103 if the substantial portion was not

within the subsurface formation 101. An entirety of the electrical pathways 103 may be within the subsurface formation 101.

[0072] Pathway sensors may be coupled to the electrical cable 103. Specifically, at least one pathway sensor may be coupled to the electrical cable 103. The amount of pathway sensors coupled to a given electrical cable may include any number of pathway sensors within and bounded by the preceding range. For example, the pathway sensors may comprise a first cable sensor 121, that is coupled to the first electrical cable 103, and a second cable sensor 122, that is coupled to the second electrical cable 103. The pathway sensors detect pathway characteristics of the electrical cables 103, 203 (Figure 3). For example, the first cable sensor 121 may detect a first cable pathway characteristic of the first electrical cable 103; the second cable sensor 122 may detect a second cable pathway characteristic of the second electrical cable 103. If multiple pathway sensors are coupled to an electrical cable, one or more of the pathway sensors may determine a different pathway characteristic than the rest of the pathway sensors.

[0073] The pathway characteristics may comprise any suitable characteristics. For example, each of the pathway characteristics may comprise one of temperature, voltage, current electrical resistance, and impedance.

[0074] The first local electrical room 125 may be configured to (i) detect a pathway error within the electrical pathways 103 based on pathway characteristics of pathway sensors 121, 122 and (ii) correct the pathway error by switching power transmitted from a first one of the electrical pathways 103 to a second one of the electrical pathways 103 (Figures 1-2). The first local electrical room 125 may be configured to detect the pathway error of the power transmitted to the electrical heater 102, 204 (Figure 3). The first local electrical room 125 may detect the pathway error of the power transmitted to the electrical heater 102 by determining whether each of the pathway characteristics is operating within a target operating pathway characteristic range based on the pathway characteristics of each of the electrical pathways 103. More specifically, the first local electrical room 125 may detect the pathway error within a given electrical pathway based on that electrical pathway's pathway characteristic. For example, the first local electrical room 125 may be configured to detect the pathway error within at least one of a first electrical pathway of a first electrical cable based on the first cable pathway characteristic of the first electrical cable and a second electrical pathway of a second electrical cable based on a second

cable pathway characteristic of the second electrical cable. The target operating pathway characteristic range is the range of suitable numerical values for the pathway characteristic of an electrical pathway that shows the electrical pathway 103 of the electrical cable 103, 104 has not failed. The target operating pathway characteristic range may be a range of pathway characteristics from a desired operating pathway characteristic of a given electrical pathway of an electrical cable 103.

[0075] The first electric room 125 may be configured to detect whether each of the pathway characteristics is within a target expected pathway characteristic range. The target expected pathway characteristic range is the pathway characteristic expected for the amount of power transmitted from a given electrical pathway to an electrical heater 102. The target expected pathway characteristic range differs from the target operating pathway characteristic range in that the target expected pathway characteristic range is intended to help determine whether a given signal is being transmitted by a given electrical pathway 103 of an electrical cable 103 while the target operating pathway characteristic range is intended to define the operating constraints of a given electrical pathway of an electrical cable 103 by which electrical cable 103 does not fail.

[0076] The first local electrical room 125 may compare the pathway characteristic detected by a pathway sensor 108, 118 to the target operating pathway characteristic range to determine whether the pathway characteristic is within the target operating pathway characteristic range. If the pathway characteristic detected is within the target operating pathway characteristic range, the first local electrical room 125 detects that there is no pathway error. If the pathway characteristic detected is outside of the target operating pathway characteristic range, the first local electrical room 125 detects that there is a pathway error. If the pathway error is detected, the first local electrical room 125 is configured to correct the pathway error by switching power transmitted from the electrical pathway with the pathway error to another electrical pathway that is separate from the electrical pathway with the pathway error. By switching power transmitted from the electrical pathway with the pathway error to the other electrical pathway, the power transmitted is switched from being transmitted via a first one of the electrical cables to a second one of the electrical cables, 205 (Figure 3). The first one of the electrical cables includes the electrical pathway with the error; the second one of the electrical cables includes the other of the electrical pathways.

[0077] The first local electrical room 125 may compare the pathway characteristic detected to the target expected pathway characteristic range to determine whether the pathway characteristic is within the target expected pathway characteristic range. If the pathway characteristic is within the target expected pathway characteristic range, the first local electrical room 125 detects that the pathway characteristic is the pathway characteristic expected for the amount of power being sent to the electrical heater via the given electrical pathway of an electrical cable. If the pathway characteristic detected is outside of the target expected pathway characteristic range, the first local electrical room 125 detects that the amount of power being sent to the electrical heater is too much or insufficient. If the amount of power being sent to the electrical heater is too much or insufficient, the first local electrical room 125 is configured to correct the amount of power being sent to the electrical heater by decreasing the amount of power or by increasing the amount of power sent.

[0078] As previously discussed, the first local electrical room 125 may comprise the first local distribution circuit 115 and the first data acquisition system 105. The first local distribution circuit 115 and the first data acquisition system 105 may make it possible for the first local electrical room 125 to detect the pathway error. The first local distribution circuit 115 and the first data acquisition system 105 may make it possible for the first local electrical room 125 to determine whether a pathway characteristic is within the target expected pathway characteristic range. The power software of the first data acquisition system 105 may make it possible for the first local electrical room 125 to analyze the pathway characteristics detected by the pathway sensors 121, 122 to determine whether there is a pathway error. The power software may make it possible for the first local electrical room 125 to analyze the pathway characteristics detected by the pathway sensors 121, 122 to determine whether the pathway characteristic detected by the pathway sensor 121, 122 is within the target operating pathway characteristic range. The power software may make it possible for the first local electrical room 125 to correct the pathway error. The power software may make it possible for the first local electrical room 125 to analyze a pathway characteristic detected by a pathway sensor 121, 122 to determine whether the pathway characteristic detected by the pathway sensor 121, 122 is within the target expected pathway characteristic range.

[0079] If the pathway error is detected, the first data acquisition system 105 may send a signal to the first local distribution circuit 115 to switch power from the electrical cable with the

pathway error to another electrical cable, such as for example but not limited to from a first electrical cable to a second electrical cable. By switching power from the electrical cable with the pathway error to the other electrical cable, the electrical cable with the pathway error no longer receives power. Instead, the other electrical cable may receive power. The process of the first local electrical room 125 detecting a pathway error may continue for the other electrical cable and so on. If it is detected that the pathway characteristic detected by the pathway sensor 121, 122 is within the target expected pathway characteristic range, the first data acquisition system 105 may not send a signal to the first local distribution circuit 115 to switch power from the electrical cable being powered to the other electrical cable.

[0080] If it is detected that the pathway characteristic is within the target expected pathway characteristic range, the first data acquisition system 105 may not modify a signal sent to the first local distribution circuit 115. If it is detected that the pathway characteristic is outside of the target expected pathway characteristic range, the first data acquisition system 105 may modify the signal sent to the first local distribution circuit 115. The signal may be modified to increase the power sent or to decrease the power via the electrical cable to the electrical heater if the pathway characteristic is below the target expected pathway characteristic range or above the target expected pathway characteristic range, respectively.

[0081] Each electrical cable 103 may comprise a first wire 106, a second wire 116 and a third wire 126. The first wire 106 may have a positive charge. The second wire 116 may have a negative charge. The third wire 126 may be a redundant wire that can have a positive charge or a negative charge. At any given time, two of the first wire 106, the second wire 116 and the third wire 126 may transmit power to the electrical heater 102 at a time. Two of the wires transmit power to the electrical heater 102 at a time because the electrical heater 102 needs to receive a positive charge and a negative charge to be powered.

[0082] The wires 106, 116, 126 may transmit the power via electrical pathways. Each of the wires 106, 116, 126 includes an electrical pathway. For example, the first wire 106 may include a first wire electrical pathway, the second wire 116 may include a second wire electrical pathway and the third wire 126 may include a third wire electrical pathway. The electrical pathways may transmit the positive or negative charge of the wire to the electrical heater 102. For example, the first wire 106 may transmit the positive charge to the electrical heater 102 via

the first wire electrical pathway and the second wire 116 may transmit the negative charge to the electrical heater 102 via the second wire electrical pathway.

[0083] Each of the wires 106, 116, 126 may be coupled to at least one pathway sensor 108, 118, 128. The amount of pathway sensors coupled to each of the wires 106, 116, 126 may include any number within or bounded by the preceding range. In some instances, the wires 106, 116, 126 may include more than one pathway sensor to help detect a pathway characteristic of a given wire. For example, the pathway sensors may comprise a first wire sensor and a second wire sensor coupled to the first wire 106, a third wire sensor and a fourth wire sensor coupled to the second wire 116, and a fifth wire sensor and a sixth wire sensor coupled to the third wire 126. If multiple sensors are coupled to a wire, the sensors may be located at different locations along the wire. For example, one of the sensors may be located at a first end of the wire and another of the sensors may be located at a second end of the wire that is diametrically opposed to the location of the one of the sensors. If multiple pathway sensors are coupled to a wire, one or more of the pathway sensors may determine a different pathway characteristic than the rest of the pathway sensors.

[0084] The pathway sensors detect the pathway characteristics of the wires within the electrical cables, 203 (Figure 3). For example, the first wire sensor 108 may detect a first wire pathway characteristic of the first wire 106, the second wire sensor 118 may detect a second wire pathway characteristic of the second wire 116 and the third wire sensor 128 may detect a third wire pathway characteristic of the third wire 126. The pathway characteristics may comprise any suitable characteristics. For example, each of the pathway characteristics may comprise one of temperature, voltage, current, electrical resistance and impedance.

[0085] The first local electrical room 125 may be configured to (i) detect a pathway error within the wires 106, 116, 126 based on pathway characteristics of pathway sensors 108, 118, 128 and (ii) correct the pathway error by switching power transmitted from a first one of the electrical pathways 106, 116, 126 to a second one of the electrical pathways 106, 116, 126 (Figures 1-2). The first local electrical room 125 may be configured to detect the pathway error by determining whether each of the pathway characteristics is operating within a target operating pathway characteristic range, 204 (Figure 3) based on the pathway characteristics of each of the electrical pathways 103, 104. More specifically, the first local electrical room 125 may be

configured to detect the pathway error within a given wire within an electrical cable based on that wire's pathway characteristic. For example, the first local electrical room 125 may be configured to detect the pathway error within a first wire based on the first wire pathway characteristic of the first wire, a second wire based on a second wire pathway characteristic of the second wire, and a third wire based on a third wire pathway characteristic of the third wire. The target operating pathway characteristic range is the range of suitable numerical values for the pathway characteristic of an electrical pathway that shows the wire 106, 116, 126 has not failed. The target operating pathway characteristic range may be a range of pathway characteristics from a desired operating pathway characteristic of a given wire 106, 116, 126.

[0086] The first electric room 125 may be configured to detect whether each of the pathway characteristics is within a target expected pathway characteristic range. The target expected pathway characteristic range is the pathway characteristic expected for the amount of power transmitted from a given electrical pathway of a wire 106, 116, 126 to an electrical heater 102. The target expected pathway characteristic range differs from the target operating pathway characteristic range in that the target expected pathway characteristic range is intended to help determine whether a given signal is being transmitted by a given wire 106, 116, 126 while the target operating pathway characteristic range is intended to outline what the operating constraints are of a given wire 106, 116, 126 without that wire 106, 116, 126 failing.

[0087] As previously discussed, the first local electrical room 125 may compare the pathway characteristic detected to the target operating pathway characteristic range to determine whether the pathway characteristic is within the target operating pathway characteristic range. If the pathway characteristic detected is within the target operating pathway characteristic range, the first local electrical room 125 detects that there is no pathway error within a wire. If the pathway characteristic detected is outside of the target operating pathway characteristic range, the first local electrical room 125 detects that there is a pathway error within the wire. If the pathway error is detected, the first local electrical room 125 is configured to correct the pathway error by switching power transmitted from the electrical pathway with the pathway error to another electrical pathway that is separate from the electrical pathway with the pathway error. In other words, if the pathway error is detected in a first wire 106 and not a second wire 116, the first local electrical room 125 is configured to correct the pathway error by switching power transmitted via the first wire 106 to the third wire 126 so that the second wire 116 and the third

wire 126 can transmit power to the electrical heater 102. If the first wire 106 has a positive charge and the second wire 116 has a negative charge, the third wire will transmit a positive charge after the transmission of power is switched from the first wire to the third wire.

[0088] As previously discussed, the first local electrical room 125 may compare the pathway characteristic detected to the target expected pathway characteristic range to determine whether the pathway characteristic is within the target expected pathway characteristic range. If the pathway characteristic is within the target expected pathway characteristic range, the first local electrical room 125 detects that the pathway characteristic is the pathway characteristic expected for the amount of power being sent to the electrical heater via the given wire. If the pathway characteristic detected is outside of the target expected pathway characteristic range, the first local electrical room 125 detects that the amount of power being sent to the electrical heater via the given wire is too much or insufficient. If the amount of power being sent to the electrical heater is too much or insufficient, the first local electrical room 125 is configured to correct the amount of power being sent to the electrical heater by decreasing the amount of power or by increasing the amount of power.

[0089] As previously discussed, the first local electrical room 125 may comprise the first local distribution circuit 115 and the first data acquisition system 105. The first local electrical room 125 and first local distribution circuit 115 may operate and include those components as previously discussed to detect and correct a pathway error. The first local electrical room 125 and first local distribution circuit 115 may operate and include those components as previously discussed to detect whether the pathway characteristic detected is within the target expected pathway characteristic range and to make a correction if the pathway characteristic is not within the target expected pathway characteristic range.

[0090] If the wires includes multiple pathway sensors, such as two pathway sensors, all of the pathway sensors for a given wire may be used to detect and correct a pathway error. If the wires include multiple pathway sensors, such as two pathway sensors, all of the pathway sensors for a given wire may be used to detect whether a pathway characteristic of the combined sensors is within the target expected pathway characteristic range and to make a correction if the pathway characteristic is not within the target expected pathway characteristic range. For example, if the first wire 106 includes a first pathway sensor and a second pathway sensor, the

first pathway sensor may detect voltage and the second pathway sensor may detect current. The voltage detected and the current detected may be used to determine impedance and the impedance may be compared to the target expected pathway characteristic range and/or the target operating pathway characteristic range. The impedance may be considered the pathway characteristic of the wire in this instance.

[0091] The electrical pathways 103, 104, 106, 116, 126 may receive power from a power source 215 having a power cable 141. The power source 215 may comprise any suitable power source, such as but not limited to a power source transmission and an output circuit. The power source 215 may be external to the subsurface formation 101 (i.e., not within the subsurface formation 101).

[0092] The power cable 141 may be external to the subsurface formation 101 (i.e., not within the subsurface formation 101). A substantial portion of the power cable 141 may be external to the subsurface formation 101. A portion of the power cable 141 may be within the subsurface formation.

[0093] The power cable 141 may comprise power cables. The power cables may comprise two or more power cables. The amount of power sensors may include a number within and bounded by the preceding range. When the power cable 141 comprises power cables, the power cables may operate similar to the electrical cable 103 and/or the wires 106, 116, 126. One of the power cables may transmit power at a time. Two of three wires within an electrical cable may transmit power at a time. The detection and correction of errors may operate similarly to the electrical cable 103 and/or the wires 106, 116, 126. The detection and correction of whether a pathway characteristic of a given power cable or wire of the power cable is within a target expected pathway characteristic range may operate similarly to the electrical cable 103 and/or the wires 106, 116, 126. A second local electrical room 140 instead of the first local electrical room 125 may be what makes the corrections and detections for the power cables 141 and/or wires of the power cables.

[0094] The power cable 141 connects to a power input feeder circuit 142. The power input feeder circuit 142 may comprise any suitable elements, such as but not limited to a transformer and a circuit breaker. The power input feeder circuit 142 may be configured to communicate with the power source 215 by virtue of the power cable 141 connecting the power input feeder

circuit 142 to the power source 215. The power input feeder circuit 142 may be configured to feed power from the power source 215 to the electrical pathways 103, 106, 116, 126. The power input feeder circuit 142 may be so configured because the power input feeder circuit 142 may connect to the first local electrical room 125.

[0095] The hydrocarbons may be produced from the subsurface formation 101, via a production wellbore 130, 405 (Figure 4). The production wellbore 130 may interchangeably be referred to as a second wellbore. The production wellbore 130 may be a different wellbore from the heater wellbore. The production wellbore 130 may be the same wellbore as the heater wellbore.

[0096] During a heater operation, power may be transmitted, as previously discussed, via at least one electrical pathway 103, 106, 116, 126 to the electrical heater 102, 202. As previously discussed, pathway characteristics and pathway errors may be detected, 203 and 204 with a pathway characteristic corrected if there is a pathway error 205. As previously discussed, heater characteristics may be detected and corrected if there is a heater failure. When there is no pathway error or heater failure, as previously discussed the electrical heater 102 may generate heat and transmit the heat to the subsurface formation resulting in an increase in temperature of the reservoir 151 within the subsurface formation 101 and hydrocarbons contained within. Detecting the pathway characteristic 203, detecting the pathway error 204 and correcting the pathway characteristic 205 may occur between transmitting power to the electrical heater 102, 202 and generating heat within the electrical heater 102, 201 (Figure 3). In other words, detecting the pathway characteristic 203, detecting the pathway error 204 and correcting the pathway characteristic 205 may occur after transmitting power to the electrical heater 102, 202 and before generating heat within the electrical heater 102, 201. Detecting the pathway characteristic 203, detecting the pathway error 204 and correcting the pathway characteristic 205 may occur while transmitting power to the electrical heater 102, 202 and before generating heat within the electrical heater 201, 202 (Figure 3).

[0097] An increase in formation temperature can result in thermally-induced changes occurring within the subsurface formation 404 (Figure 4). The thermally-induced changes may include changes in at least one of a physical property and a chemical property of the rock within the subsurface formation and hydrocarbon. The at least one physical property and chemical

property may include but is not limited to decrease in viscosity of fluids contained in the pore spaces of the rock, breaking of chemical bonds within hydrocarbon molecules, thermal fracturing of rock matrix and decomposition and absorption of constituents from the rock matrix into formation fluids. Many of the thermally-induced changes may result in increased reservoir porosity, increased permeability and improved fluid mobility. The thermally-induced changes may yield higher production rates from the production wellbore 130 than if there were no thermally-induced changes. The thermally-induced changes may yield greater ultimate hydrocarbon recovery from the reservoir than if there were no thermally-induced changes.

[0098] It is important to note that the elements and steps depicted in Figures 1-4 are provided for illustrative purposes only and a particular step may not be required to perform the inventive methodologies. The claims, and only the claims, define the inventive system and methodologies.

[0099] The method and system may include a mechanism for performing the operations herein. The mechanism may be specially constructed for the required purposes, or it may comprise a general-purpose computer selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer readable medium. A computer-readable medium includes any mechanism for storing or transmitting information in a form readable by a machine (e.g., a computer). For example, but not limited to, a computer-readable (e.g., machine-readable) medium includes a machine (e.g., a computer) readable storage medium (e.g., read only memory ("ROM"), random access memory ("RAM"), magnetic disk storage media, optical storage media, flash memory devices, etc.), and a machine (e.g., computer) readable transmission medium (electrical, optical, acoustical or other form of propagated signals (e.g., carrier waves, infrared signals, digital signals, etc.)). The computer-readable medium may non-transitory.

[0100] Furthermore, as will be apparent to one of ordinary skill in the relevant art, the modules, features, attributes, methodologies, and other aspects of the present disclosure can be implemented as software, hardware, firmware or any combination of the three. Of course, wherever a component of the present disclosure is implemented as software, the component can be implemented as a standalone program, as part of a larger program, as a plurality of separate programs, as a statically or dynamically linked library, as a kernel loadable module, as a device

driver, and/or in every and any other way known now or in the future to those of skill in the art of computer programming. Additionally, the present disclosure is in no way limited to implementation in any specific operating system or environment.

[0101] Disclosed aspects may be used in hydrocarbon management activities. As used herein, "hydrocarbon management" or "managing hydrocarbons" includes hydrocarbon extraction, hydrocarbon production, hydrocarbon exploration, identifying potential hydrocarbon resources, identifying well locations, determining well injection and/or extraction rates, identifying reservoir connectivity, acquiring, disposing of and/ or abandoning hydrocarbon resources, reviewing prior hydrocarbon management decisions, and any other hydrocarbon-related acts or activities. The term "hydrocarbon management" is also used for the injection or storage of hydrocarbons or CO_2 (carbon dioxide), for example the sequestration of CO_2, such as reservoir evaluation, development planning, and reservoir management. The disclosed methodologies and techniques may be used to extract hydrocarbons from a subsurface region. Hydrocarbon extraction may be conducted to remove hydrocarbons from the subsurface region, which may be accomplished by drilling a well using oil drilling equipment. The equipment and techniques used to drill a well and/or extract the hydrocarbons are well known by those skilled in the relevant art. Other hydrocarbon extraction activities and, more generally, other hydrocarbon management activities, may be performed according to known principles.

[0102] It should be noted that the orientation of various elements may differ, and that such variations are intended to be encompassed by the present disclosure. It is recognized that features of the disclosure may be incorporated into other examples.

[0103] It should be understood that the preceding is merely a detailed description of this disclosure and that numerous changes, modifications, and alternatives can be made in accordance with the disclosure here without departing from the scope of the disclosure. The preceding description, therefore, is not meant to limit the scope of the disclosure. Rather, the scope of the disclosure is to be determined only by the appended claims and their equivalents. It is also contemplated that structures and features embodied in the present examples can be altered, rearranged, substituted, deleted, duplicated, combined, or added to each other.

CLAIMS

What is claimed is:

1. A system for recovering hydrocarbons, from a subsurface formation, that minimizes surface disturbance, comprising:

an electrical heater within the subsurface formation that heats hydrocarbons within the subsurface formation; and

a heater wellbore within the subsurface formation that has been reclaimed for surface use.

2. The system of claim 1, wherein the electrical heater is within the heater wellbore.

3. The system of any one of claims 1-2, wherein the electrical heater comprises electrical heaters.

4. The system of claim 3, wherein the electrical heaters are within the heater wellbore.

5. The system of any one of claims 1-2, wherein the heater wellbore comprises a heater wellbore topmost portion and a heater wellbore bottommost portion, wherein the heater wellbore topmost portion is closer to a surface of the subsurface formation than the heater wellbore bottommost portion.

6. The system of claim 5, wherein the heater wellbore topmost portion and the heater wellbore bottommost portion are completely within the subsurface formation.

7. The system of any one of claims 1-6, wherein the heater wellbore is not flush with a surface of the subsurface formation.

8. The system of any one of claims 1-7, further comprising a production wellbore that is configured to produce hydrocarbons heated by the electrical heater.

9. A method for recovering hydrocarbons, from a subsurface formation below a surface of the earth, that minimizes surface disturbance, comprising:

forming a heater wellbore within the subsurface formation;

placing an electrical heater within the heater wellbore;

reclaiming at least a portion of the heater wellbore intersecting the surface of the subsurface formation;

creating thermally-inducing changes within the subsurface formation.

10. The method of claim 9, wherein creating the thermally-inducing changes comprises generating heat within the subsurface formation using the electrical heater.

11. The method of any one of claims 9-10, wherein creating the thermally-inducing changes comprises altering at least one of a physical property and a chemical property of the hydrocarbons within the subsurface formation.

12. The method of any one of claims 9-11, further comprising producing the hydrocarbons after creating the thermally-inducing changes.

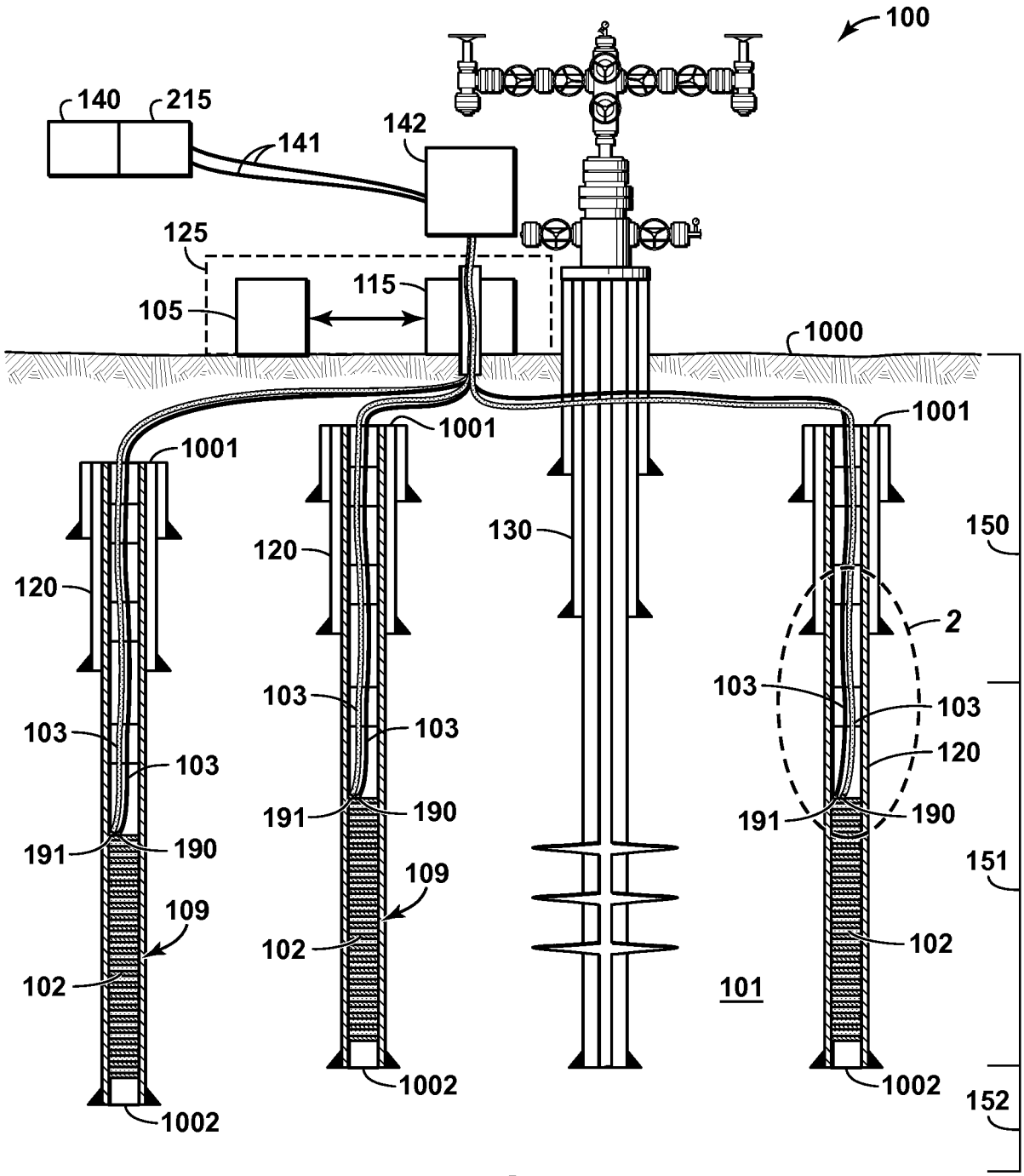

100
140
215
141
142
125
115
105
1000
1001
1001
1001
120
120
130
150
2
103
103
103
103
103
120
191
190
191
190
191
190
109
109
102
102
102
101
1002
1002
1002
151
152

FIG. 1

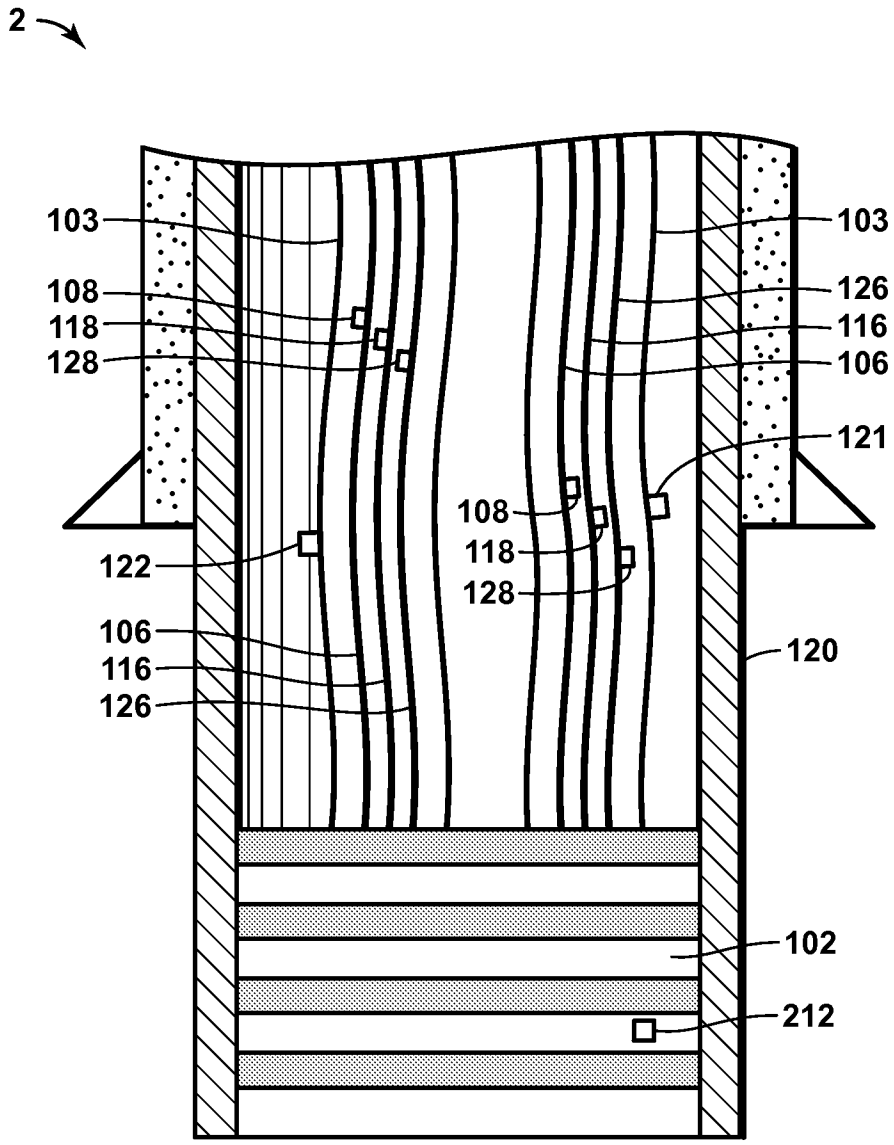

2
103
108
118
128
122
106
116
126
103
126
116
106
121
108
118
128
120
102
212

FIG. 2

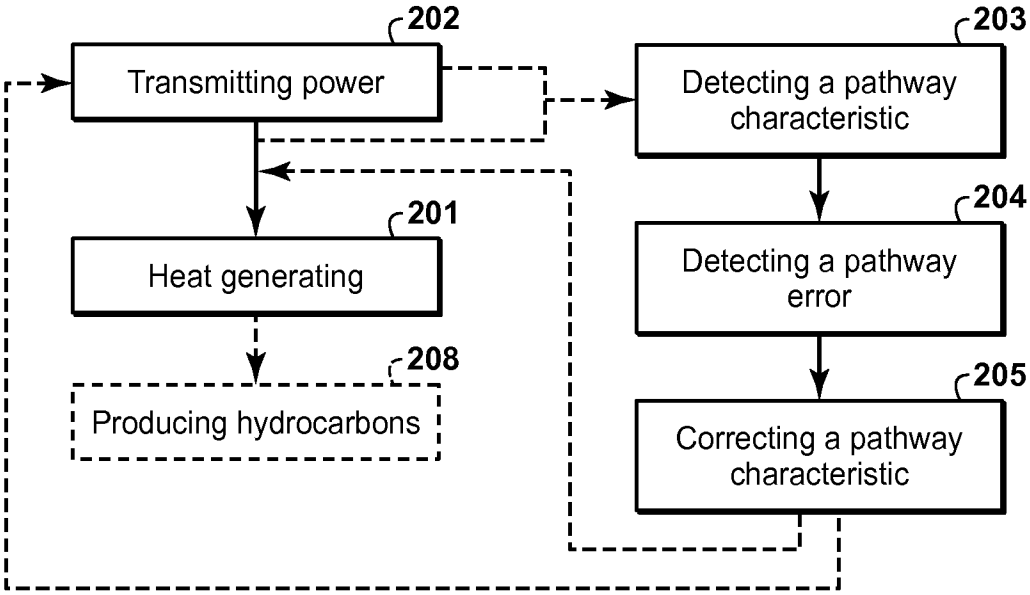

202
Transmitting power
203
Detecting a pathway characteristic
201
Heat generating
204
Detecting a pathway error
208
Producing hydrocarbons
205
Correcting a pathway characteristic

FIG. 3

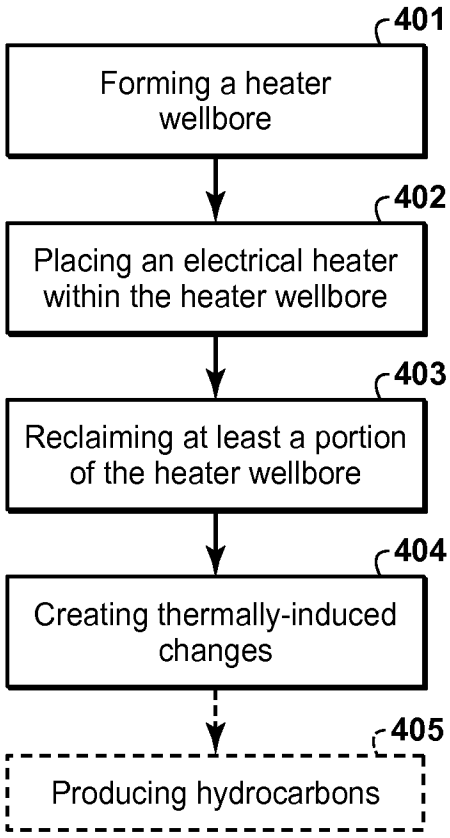

401
Forming a heater wellbore
402
Placing an electrical heater within the heater wellbore
403
Reclaiming at least a portion of the heater wellbore
404
Creating thermally-induced changes
405
Producing hydrocarbons

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/028270

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B36/04 E21B43/24
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 data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 670 802 A (ACKLEY CHARLES S) 2 March 1954 (1954-03-02) figures 1, 3 column 1, lines 1-5 column 2, lines 20-25 column 3, lines 42-64	1-12
A	US 6 540 018 B1 (VINEGAR HAROLD J [US] ET AL) 1 April 2003 (2003-04-01) the whole document	1-12
A	US 5 586 213 A (BRIDGES JACK E [US] ET AL) 17 December 1996 (1996-12-17) the whole document	1-12

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 October 2015	22/10/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Posavec, Daniel

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/028270

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2670802 A	02-03-1954	NONE	
US 6540018 B1	01-04-2003	NONE	
US 5586213 A	17-12-1996	NONE	