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(54) **Title**: MODULAR ROLLER OVEN FOR SIMULATING BOREHOLE CONDITIONS AND ASSOCIATED METHODS

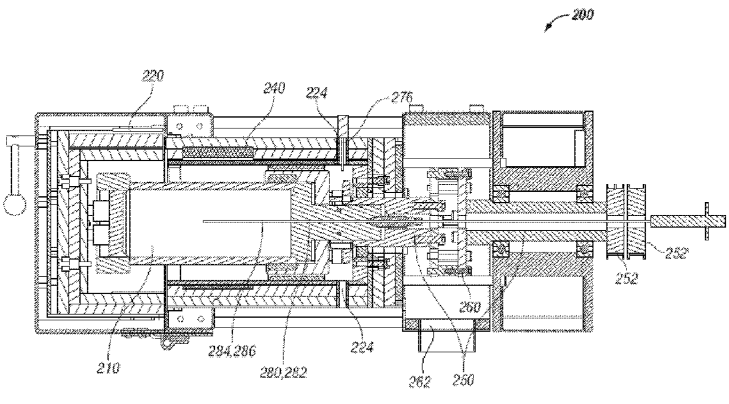

FIG. 3

(57) **Abstract**: A housing (220) may generally include a test cell (210) being enclosed and having at least one test cell wall (212) and one sealable opening and has a cell central axis (214) defined along the center line of the length of the test cell (210), a thermal element (240) in thermal communication with the test cell (210), and an insulation (222), at least a portion of the insulation (222) being disposed about the test cell (210) and the thermal element (240). An apparatus (200) may generally include a housing (20), a drive connection (252), and a shaft (250) operably connected to the test cell (210) and extending parallel to the cell central axis (214) from the test cell (210) through the insulation (222) to the drive connection (252) to which the shaft (250) is operably connected. A modular system (300) may include at least one apparatus (220) and a frame (230) that houses at least a portion of the housing (220), and a driving mechanism (270) operably connected to the drive connection (252). Using the driving mechanism (270) and an oven as housing (220), borehole conditions can be simulated and applied to the test cell (210) which can contain a test sample such as drilling fluids or cementous materials.

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MODULAR ROLLER OVEN FOR SIMULATING BOREHOLE CONDITIONS AND ASSOCIATED METHODS

BACKGROUND

[0001] The present invention relates to configurations of a modular roller oven and methods relating thereto.

[0002] Roller ovens are used for, *inter alia*, simulating dynamic-aging of fluids. Dynamic-aging is a test in which a fluid sample is mildly agitated by rolling (or tumbling) for the duration of the test, usually performed at a selected high temperature. Typically, the fluid sample is sealed in a fluid-aging cell, often under pressure, and placed in an oven that will roll (or tumble) the fluid-aging cell continually for a given period of time, *e.g.*, often 16 hours or overnight. The properties of the aged fluid sample are then measured. Dynamic-aging testing is especially important for fluids to be used in oilfield applications as the test simulates circulation of a fluid in a wellbore during pumping, which necessarily involves heat and pressure.

[0003] Generally, traditional roller ovens are large ovens with a series of rollers inside that can continuously roll a fluid-aging cell 360°. The volume of the roller oven may be large enough to accommodate four to six fluid-aging cells in a single horizontal plane, *e.g.*, greater than 2 feet in width, depth, and height. Referring to Figure 1, a nonlimiting example of a traditional roller oven, traditional roller oven **100** may generally be box **120** with rollers **130** parallel to box ceiling **124** that operably rotate about an axis perpendicular to box back wall **126**, heating elements **140** located at box sidewalls **122**, and fan **150** located at box ceiling **124**. Further, traditional roller oven **100** may also have a control box **160** with temperature controller **162** operably connected to heating elements **140** in order to maintain box **120** at a desired temperature. Dynamic-aging tests may include placing fluid-aging cell **110** on rollers **130**, rotating rollers **130**, heating box **120** to a desired temperature, and maintaining said temperature for a desired length of time after which box **120** is cooled for fluid-aging cell **110** retrieval. The heat distribution system of traditional roller oven **100** with fan **150** at box ceiling **124** and heating elements **140** at box sidewalls **122** provides uneven heating to individual fluid-aging cells **110**, *i.e.*, fluid-aging cells **110** closest to heating elements **140** may be at a different temperature than fluid-aging cells **110** under fan **150**. Further, a thermocouple (not shown) for monitoring the temperature in box **120** is often not near fluid-aging cells **110**, so the temperature of box **120** may not be the temperature of fluid-aging cells **110**. The thermal inconsistence between fluid-aging cells **110** and within box **120** are magnified at high temperatures, *e.g.*, above about 400 °F. Further, given the size of traditional roller oven **100** configured to hold four to six fluid-aging cells, heating to high temperatures, *e.g.*, above about 400 °F, takes a long time and is energy-intensive. Operating at the elevated temperatures is a further safety concern for workers using or in the vicinity of a large 400 °F oven.

[0004] This configuration also allows for only a single set of parameters to be tested at a given time. Given the plurality of subterranean formations and methods of drilling, often a variety of variables need to be tested, *e.g.*, temperature, time, and movement. In order to test several variables with a traditional roller oven, several experiments would need to be run consecutively or with several ovens, which can be time-consuming and/or costly. Further, traditional roller ovens only provide for investigating condition variables of temperature, fluid-aging cell internal pressure, and rolling speed. *In situ* monitoring capabilities are not available to help understand how a fluid is aging. Only beginning- and ending-points are available to a researcher. To fill-in the gaps, additional tests are required.

[0005] Given the plurality of variables that may need to be investigated to simulate the wide array of subterranean formations, a modular system for dynamic-aging of samples where the conditions of a single cell can be manipulated, even programmed and/or monitored, would be of value to one skilled in the art.

SUMMARY OF THE INVENTION

[0006] The present invention relates to configurations of a modular roller oven and methods relating thereto.

[0007] In some embodiments of the present invention, an apparatus may comprise: a housing that comprises a test cell being enclosed and having at least one test cell wall and one sealable opening and has a cell central axis defined along the center line of the length of the test cell, a thermal element in thermal communication with the test cell, and an insulation, at least a portion of the insulation being disposed about the test cell and the thermal element; a drive connection; and a shaft operably connected to the test cell and extending parallel to the cell central axis from the test cell through the insulation to the drive connection to which the shaft is operably connected.

[0008] In some embodiments of the present invention, a modular system may comprise: at least one apparatus that comprises a housing that comprises a test cell being enclosed and having at least one test cell wall and one sealable opening and has a cell central axis defined along the center line of the length of the test cell, a thermal element in thermal communication with the test cell, and an insulation, at least a portion of the insulation being disposed about the test cell and the thermal element; a drive connection; and a shaft operably connected to the test cell and extending parallel to the cell central axis from the test cell through the insulation to the drive connection to which the shaft is operably connected; and a frame that houses at least a portion of the housing; and a driving mechanism operably connected to the drive connection.

[0009] In some embodiments of the present invention, a method may comprise: providing an apparatus that comprises a housing that comprises a test cell being enclosed and having at least one test cell wall and one sealable opening and has a cell central axis defined along the center line of the length of the test cell, a thermal element in thermal communication with the test cell, and an insulation, at least a portion of the insulation being disposed about the test cell and the thermal element; a drive connection; and a shaft operably connected to the test cell and extending parallel to the cell central axis from the test cell through the insulation to the drive connection to which the shaft is operably connected; providing a driving mechanism operably connected to the drive connection; providing a sample in the test cell of the apparatus; manipulating the test cell; and analyzing the sample.

[0010] In some embodiments of the present invention, a method of testing the stability of deep-sea treatment fluids may comprise: providing an apparatus that comprises a housing that comprises a test cell being enclosed and having at least one test cell wall and one sealable opening and has a cell central axis defined along the center line of the length of the test cell, a thermal element in thermal communication with the test cell, and an insulation, at least a portion of the insulation being disposed about the test cell and the thermal element; a drive connection; and a shaft operably connected to the test cell and extending parallel to the cell central axis from the test cell through the insulation to the drive connection to which the shaft is operably connected; providing a driving mechanism operably connected to the drive connection; providing a sample in the test cell of the apparatus; manipulating the test cell; changing the sample temperature to a first temperature below room temperature; changing the sample temperature to a second temperature above room temperature; and analyzing the sample.

[0011] In some embodiments of the present invention, a method of testing a cement composition may comprise: providing an apparatus that comprises a housing that comprises a test cell being enclosed and having at least one test cell wall and one sealable opening and has a cell central axis defined along the center line of the length of the test cell, a thermal element in thermal communication with the test cell, and an insulation, at least a portion of the insulation being disposed about the test cell and the thermal element; a drive connection; and a shaft operably connected to the test cell and extending parallel to the cell central axis from the test cell through the insulation to the drive connection to which the shaft is operably connected; providing a driving mechanism operably connected to the drive connection; providing a cementitious sample in the test cell of the apparatus; manipulating the test cell; changing the sample temperature; and monitoring the temperature within the test cell.

[0012] The features and advantages of the present invention will be readily apparent to those skilled in the art upon a reading of the description of the preferred embodiments that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The following figures are included to illustrate certain aspects of the present invention, and should not be viewed as exclusive embodiments. The subject matter disclosed is capable of considerable modification, alteration, and equivalents in form and function, as will occur to those skilled in the art and having the benefit of this disclosure.

[0014] Figure 1 illustrates an example of a traditional roller oven.

[0015] Figure 2 illustrates a nonlimiting example of a cross-sectional view of a modular roller oven of the present invention.

[0016] Figure 3 illustrates a nonlimiting example of a cross-sectional view of a modular roller oven of the present invention.

[0017] Figure 4 illustrates a nonlimiting example of a side view of a modular roller oven of the present invention with a view window through the base.

[0018] Figure 5 illustrates a nonlimiting example of a side view of a modular roller oven of the present invention with extendable legs.

[0019] Figure 6 illustrates a nonlimiting example of a single modular roller oven of the present invention.

[0020] Figure 7 illustrates a nonlimiting example of a system with two modular roller ovens of the present invention.

[0021] Figure 8A illustrates a nonlimiting example of a system with four modular roller ovens of the present invention.

[0022] Figure 8B illustrates a nonlimiting example of a front view of a system with four modular roller ovens of the present invention.

DETAILED DESCRIPTION

[0023] The present invention relates to configurations of a modular roller oven and methods relating thereto.

[0024] In some embodiments, the present invention provides a modular roller oven as an apparatus and as part of a system. The configurations the modular roller oven provided herein function for similar purposes of traditional roller ovens. However, because of the design and size that minimizes the volume of air to heat, the modular roller oven advantageously can ramp to operating temperatures faster, can cool to manageable temperatures faster, and requires less energy to do so. Additionally, the motor used to manipulate the smaller modular roller oven may be smaller and consequently quieter.

[0025] Further, the unique integration of elements and components allows for increased flexibility and capabilities over traditional roller ovens, *e.g.*, monitoring and manipulating samples *in situ*. Such elements and component described herein includes sensor that provide real-time analysis of the sample during a test. Further, traditional roller elements have been integrated in ways to increase the available capabilities including, but not limited to, variable movement of the fluid-aging cell (both speed and type), angular rolling, remote monitoring and/or manipulation, and data logging.

[0026] The modular nature of the roller oven allows for systems with more than one modular roller oven that can be operated (independently or cooperatively) at different conditions. To achieve this with traditional roller ovens would be an expensive proposition to acquire another roller oven, not to mention the floor space required. The modular roller oven configurations also provide for arranging the modular roller ovens in various configurations that can be adapted to a site (laboratory or in the field) based on, *inter alia*, available space and proximity to power. Further, the modular roller ovens may be designed to operate with a test cell of desired size. By way of nonlimiting example, a test cell may be a cylinder 3 inches in diameter and 10 inches in length. By way of nonlimiting example, a test cell may be a cylinder configured to test about 350 mL of sample. This size may be scalable to a desired size, and configuration as described below, with an appropriately scale modular roller oven.

[0027] The modular nature of the roller oven also allows for enhanced reliability. Operational reliability may manifest in repeatable, stable temperature of the sample in test cell. Other operation reliability may be realized if a module should become inoperable or require maintenance, only one roller oven of the system will be effected.

[0028] Referring now to Figure 2, a nonlimiting embodiment of the present invention, apparatus **200** is designed to overcome many of the drawbacks and/or limitations of traditional roller oven **100**. Apparatus **200** may comprise housing **220** that contains insulation **222**, test cell **210**, and thermal element **240** in thermal communication with test cell **210**. At least a portion of insulation **222** may be disposed between housing **220** and thermal element **240**. At least a portion of insulation **222** may be disposed between housing **220** and test cell **210**. Test cell **210** may be enclosed with at least one cell wall **212** and may have cell central axis **214** defined along the centerline of the length of test cell **210**. It should be noted that defining the centerline along the length of test cell **210** does not preclude test cells with other configurations where length may be ambiguous, *e.g.*, spherical. One skilled in the art, with the benefit of this disclosure, should understand how to define a cell central axis for other test cell configurations.

[0029] Referring again to Figure 2, in some embodiments, housing **220** may further comprise at least one housing port **224** that extends from outside housing **220** to inside housing **220**. In some embodiments, housing port **224** may extend from outside housing **220** to inside housing **220** near test cell **210**. Housing port **224** may be used for several purposes including, but not limited to, a path for an air flow to assist in cooling after a test and/or a path for a sensor (described further below).

[0030] Housing **220** may be made of any known material that is compatible with the operational requirements of apparatus **200** including temperature and movement (discussed below). Suitable materials for housing **220** include, but are not limited to, metals and metal alloys like aluminum and stainless steel; plastics and polymers like polyether ether ketone (PEEK) and polyurethane; composites including those with additives like carbon fibers, glass fibers, and nanomaterials; fiberglass; and any combination thereof. In some embodiments, housing **220** may be coated. Further, housing **220** may have a layered structure where at least some of the layers provide both structural support and insulation for apparatus **200**. One skilled in the art with the benefit of this disclosure should understand the plurality of materials and configurations with which housing **220** may be designed.

[0031] Insulation **222** may be made of any known material that can serve to maintain the desired temperature of elements encompassed by insulation **222** and to minimize thermal communication between thermal element **240** and the environment external to apparatus **200**. Suitable materials for insulation **222** may include, but not be limited to, glass and fiberglass; graphite; ceramics and ceramic fibers including calcium silicate; brick and cement; plastics and polymers including polyisocyanurate, polyurethane, polystyrene, and elastomers; natural materials including perlite, vermiculite, mineral wool, cork, sawdust, and woodshavings; and any combination thereof. Suitable structures of insulation **222** may include, but not be limited to, beads; honeycomb; porous or nanoporous; aerogel; foam including premade or foamed in place; fibers; fabric; wool; sheet; rigid board; and any combination thereof. In some embodiments, insulation **222** or a component thereof may comprise a reflective surface, *e.g.*, foil-faced, and/or an absorbative surface. One skilled in the art, with the benefit of this disclosure should understand the plurality of insulation materials and configurations within apparatus **200** including layering available to achieve the desired function of insulating given the operational requirements like temperature and size.

[0032] Test cell **210** is generally an enclosure comprising at least one wall and at least one sealable opening. In some embodiments, test cell **210** may be removable from apparatus **200**. The general configuration of test cell

210 may be any configuration suitable for a desired experiment. Suitable shapes include, but are not limited to, cylindrical, spherical, ellipsoidal, polyagonal, and the like, and any hybrid thereof. Generally, but not always, the length of test cell **210** is longer than its width. Test cell **210** should be configured to accept a sample, typically through a sealable opening. Such configurations may incorporate, by way of nonlimiting examples, a door, a hatch, a port, and the like, and any combination thereof. One skilled in the art would understand that the sealable opening should be configured to be compatible with operational conditions like temperature, pressure, and sample composition. Further, one skilled in the art should understand that the physical configuration of test cell **210** should allow for the operation of test cell **210** in apparatus **200** under selected operation parameters including, but not limited to, those outlined herein of removability, movement, operability with other elements of apparatus **200**, operability with external elements to apparatus **200**, and any combination thereof.

[0033] It should be noted that when "about" is provided at the beginning of a numerical list, "about" modifies each number of the numerical list. It should be noted that in some numerical listings of ranges, some lower limits listed may be greater than some upper limits listed. One skilled in the art will recognize that the selected subset will require the selection of an upper limit in excess of the selected lower limit.

[0034] Test cell **210** may be designed to contain elevated or reduced pressures therein. Test cell **210** may be designed to hold pressures ranging from a lower limit of about 1 psi, 10 psi, 100 psi, 500 psi, or 1000 psi to an upper limit of about 10,000 psi, 7500 psi, 5000 psi, 2500 psi, or 1000 psi, and wherein the pressure may range from any lower limit to any upper limit and encompass any subset therebetween.

[0035] Test cell **210** may be made of any known material that is compatible with the sample, compatible with any operational condition like temperature and pressure, and provide the necessary thermal transmission to change the temperature of the sample at a desired rate. Suitable materials for test cell **210** may include, but not be limited to, metals and metal alloys like aluminum, copper, brass, chrome, and stainless steel; plastics and polymers; glass; composites including those with additives like carbon fibers and nanomaterials; and any combination thereof. In some embodiments, test cell

210 may comprise a coating on at least a portion of the internal wall(s). In some embodiments, said coating may assist in sample compatibility. It should be noted that "a coating," as used herein, is a general term that includes a liner, a film, a skin, a cover, a crust, a glaze, a laminate, a paint, a membrane, and the like. Further, "a coating" may be permanent, semi-permanent, removable, disposable, and/or degradable. Moreover, "a coating" may be solid like polymer or metal or liquid like grease.

[0036] In some embodiments, test cell **210** may be of a configuration already in use by one skilled in the art, *i.e.*, apparatus **200** may be designed to accept known configurations of test cell **210**.

[0037] Thermal element **240** may be any known heating and/or cooling element including, but not limited to, an electric heater, an infrared heater, a thermoelectric cooler, and any combination thereof. Suitable configuration for thermal element **240** may include, but not be limited to, coils, plates, strips, finned strips, and the like, and any combination thereof. Having thermal element **240** and test cell **210** close to each other, especially if test cell **210** is rotating, may advantageously allow for more efficient thermal conduction therebetween. In some embodiments, thermal element **240** and test cell **210** may be relationally configured to be separated by a distance of about 5 mm or less. In some embodiments, thermal element **240** and test cell **210** may be relationally configured to be in physical contact in at least one point. In some embodiments, thermal element **240** and test cell **210** may be relationally configured to be separated by a distance ranging from a lower limit of physical contact, about 1 mm, about 2 mm, about 5 mm, or about 10 mm to an upper limit of about 10 cm, 5 cm, 25 mm, 20 mm, 15 mm, or 10 mm, and wherein the distance may range from any lower limit to any upper limit and encompass any subset therebetween. It should be noted, that the upper limit of the distance between thermal element **240** and test cell **210** is when thermal element **240** is no longer in thermal communication with test cell **210**, which may be in excess of 10 cm.

[0038] One skilled in the art, with the benefit of this disclosure, should understand how to make thermal element **240** operable to heat and/or cool test cell **210**. The range of temperatures apparatus **200** may be operated at may depend on the type and configuration of thermal element **240**, and therefore is limited only by hardware and hardware configuration. In some embodiments, thermal element **240** may be capable of causing test cell **210** to reach and/or maintain temperatures ranging from a lower limit of about -150 °F, -100 °F, 0 °F, 50 °F, 100 °F, 200 °F, 300 °F, or 400 °F to an upper limit of about 900 °F, 800 °F, 700 °F, 600 °F, 500 °F, or 400 °F, and wherein the temperature may range from any lower limit to any upper limit and encompass any subset therebetween.

[0039] Further, one skilled in the art, with the benefit of this disclosure, should understand the plurality of thermal element **240** options both in type and configuration. Further, one skilled in the art should understand the plurality of physical configuration applicable to operably integrating thermal element **240** into apparatus **200** including, but not limited to, about test cell **210**, near test cell **210**, proximal to test cell **210**, in contact with test cell **210**, integrated as part of about test cell **210**, and any combination thereof.

[0040] Referring again to Figure 2, in some embodiments, apparatus **200** may comprise shaft **250** operably connected to test cell **210** and extending parallel to cell central axis **214** from test cell **210** to drive connection **252**, *e.g.*, a cog, which itself is operably connected to shaft **250**. As used herein, the term "cog" includes similarly operating elements that may be toothed and/or lipped including, but not limited to, a pulley, a gear, a gear wheel, a geared wheel, a cogwheel, and a sprocket. In some embodiments, shaft **250** may be more than one piece wherein said pieces are operably connected into shaft **250**. In some embodiments, shaft **250** may comprise bearings **254** disposed about shaft **250** between test cell **210** and drive connection **252**. It should be noted that, as used herein, disposed may include completely around, on opposing sides, space around, equally spaced around, randomly space around, and the like.

[0041] Suitable drive connections may include direct connections to a driving mechanism and/or a component, *e.g.*, a cog, capable of operably connecting to a drive mechanism. Suitable drive mechanisms may include, but not be limited to, motors, direct drive motors, pancake motors, stepper motors, bushed DC motors, bushless DC motors, permanent magnetic synchronous motors, AC induction motors, switched reluctance motors, electrostatic motors, hydraulic motors, pneumatic motors, heat engines, and the like. As used herein, the term "motor" means a machine or system designed to convert energy into useful motions and includes engines.

[0042] In some embodiments, driving mechanism **270** (not shown in Figure 2) may be operably connected to drive connection **252**. In some embodiments, driving mechanism **270** may be an element of apparatus **200**. In some embodiments, driving mechanism **270** may be a separate element that may be operably connected to drive connection **252** of apparatus **200**. In some embodiments, driving mechanism **270** may be external to housing **220**.

[0043] In some embodiments, driving mechanism **270** may cause drive connection **252**, shaft **250**, and test cell **210** to be manipulated. Manipulations of test cell **210** may include, but not be limited to, 360° rotation about cell central axis **214**; rocking about cell central axis **214**, *i.e.*, rotating in one direction about cell central axis **214** for less than about 360° then rotating in the other direction about cell central axis **214** for less than 360° and repeating; moving back and forth along cell central axis **214**; and any combination thereof.

[0044] One skilled in the art would recognize the plurality of ways to operably connect drive connection **252** and driving mechanism **270**. In some embodiments, drive connection **252** and driving mechanism **270** may be operably connected by connection element **256**. Suitable connection elements may include, but not be limited to, a belt (as shown in Figure 7), a rubber band, a chain, a cog belt, a sprocket, a shaft, a bar, and any combination thereof. By way of nonlimiting example shown in Figure 7, driving mechanism **270** may be operably connected to drive connection **272** which itself is operably connected to drive connection **252** by a belt connection element **256**. It should be noted that drive connection **272** and drive connection **252** need not be the same size. One skilled in the art should understand that the size and shape of drive connection **252** may effect the movement parameters, including speed, of shaft **250** and ultimately test cell **210**.

[0045] Drive connection **252** may be made of any known material capable of withstanding operations stresses. Suitable materials include, but are not limited to, metals and metal alloys like aluminum, copper, brass, chrome, chrome steel, carbon alloy steel, and stainless steel; ceramics including silicon nitride; plastics and polymers like polyether ether ketone (PEEK), polyurethane, and polytetrafluoroethylene (PTFE); composites including those with additives like carbon fibers, glass fibers, and nanomaterials; fiberglass; and any combination thereof. Drive connection **252** may be of any known configuration suitable for at least the operations described herein including, but not limited to, circular (shown in Figures 5-8) and substantially spherical.

[0046] Bearings **254** may be any known bearing type including, but not limited to, ball bearings, roller bearings, roller thrust bearings, tapered roller bearing, and any combination thereof. Bearings **254** may be made of any known material capable of withstanding the operations stress. Suitable materials include, but are not limited to, metals and metal alloys like aluminum, copper, brass, chrome, chrome steel, carbon alloy steel, and stainless steel; ceramics including silicon nitride; plastics and polymers like polyether ether ketone (PEEK), polyurethane, and polytetrafluoroethylene (PTFE); composites including those with additives like carbon fibers, glass fibers, and nanomaterials; fiberglass; graphite; any hybrid thereof; any mixture thereof; and any combination thereof. One skilled in the art, with the benefit of this disclosure, should understand other mechanical elements that may replace bearings **254** to achieve the same operability, including, but not limited to, bushings.

[0047] Suitable materials for shaft **250** may include any known material that can endure the mechanical stresses of operation disclosed herein. Suitable materials include, but are not limited to, metals and metal alloys like aluminum, copper, brass, chrome, chrome steel, carbon alloy steel, and stainless steel; ceramics including silicon nitride; plastics and polymers like polyether ether ketone (PEEK); composites including those with additives like carbon fibers, glass fibers, and nanomaterials; fiberglass; ceramics; and any combination thereof. One skilled in the art should understand, given the configuration of shaft **250** operably connecting test cell **210** and drive connection **252**, that opposing ends of shaft **250** may need to be at very different temperatures depending on the operating temperature of test cell **210** and material of drive connection **252**. Therefore, the material of shaft **250** should be chosen accordingly.

[0048] Referring again to Figure 2, in some embodiments, apparatus **200** may comprise thermal dam **260** disposed between test cell **210** and drive connection **252**. In some embodiments, thermal dam **260** may be connected to shaft **250**. In some embodiments, shaft **250** may be configured to comprise thermal dam **260**. By way of nonlimiting example, shaft **250** may be three pieces including a first piece operably connecting the cell to the second piece being the thermal dam, the second piece operably connecting the first piece to the third piece, and the third piece operably connecting the second piece to drive connection **252**. In some embodiments, thermal dam **260** may be proximal to shaft **250**. In some embodiment, thermal dam **260** may be disposed about shaft **250**. In some embodiments where shaft **250** comprises bearings **254**, bearings **254** may be disposed between thermal dam **260** and drive connection **252** and/or disposed between test cell **210** and thermal dam **260**, whether thermal dam **260** is part of the shaft or otherwise. In some embodiments where shaft **250** comprises bearings **254** disposed between thermal dam **260** and drive connection **252**, thermal dam **260** may advantageously extend the lifetime of bearings **254** by reducing the temperature to which bearings **254** are exposed.

[0049] Thermal dam **260** may be designed to interrupt the flow of heat along shaft **250** from test cell **210** toward drive connection **252**. In some embodiments, apparatus **200** may comprise at least one fan **262** in fluid communication with thermal dam **260**. Fan **262** may operate to reduce thermal transfer via the air around shaft **250** and/or thermal dam **260** by transporting gas toward or away from thermal dam **260**. Further, one skilled in the art, with the benefit of this disclosure, would understand that thermal dam **260** may be structurally designed to provide a longer path for heat to traverse by comprising two plate with diameters larger than shaft **250** and connected at, or close to the edges.

[0050] Suitable materials for thermal dam **260** include all materials with adequate thermal conductivity to interrupt heat transfer along shaft **250** from test cell **210** toward drive connection **252**. It should be noted that in some embodiments, thermal dam **260** may be a vessel for holding beads, fluids, dusts, particles, and the like of any of the above materials. One skilled in the art, with the benefit of this disclosure, would understand that the material should be compatible with the temperatures in which apparatus **200** will operate, *e.g.*, at operating temperatures in excess of about 400 °F a thermal dam comprising woods may not be appropriate. Examples of suitable materials that may be at least a portion of thermal dam **260** include, but are not limited to, aluminum; aluminum alloys including 1050A, 6061, and 6063; brass; lead; stainless steel; sandstone; concrete; rock; volcanic minerals; pozzolans; epoxy; cement; rubber; mineral oil; polyethylene; polypropylene; polyurethanes; polystyrenes; polyvinyl chlorides; polytetrafluoroethylene; hollow fiber insulation; woods; sawdust; aerogels; bitumen; graphite; carbon fiber composites; ceramics; silicas; aluminas; cork; fiberglass; glass; pyrex; quartz;

granite; gypsum; marble; mica; plaster; foamed plastics; materials with thermal conductivity coefficients less than about 150 W/(m*K) at 25 °C; any mixture thereof; and any combination thereof.

[0051] Referring again to Figure 2, in some embodiments, apparatus **200** may comprise cell bushings **216** disposed inline with or radially from cell central axis **214** such that test cell **210** is disposed between bushings **216** and shaft **250** and bushings **216** are disposed between insulation **222** and test cell **210**. Bushing **216** may operably work within apparatus **200** to stabilize test cell **210** while being manipulated, especially while rotating or rocking. Suitable materials for said bushing may be any known material suitable for bushings including, but not limited to, metals and metal alloys like brass; plastics and polymers like polyether ether ketone (PEEK), polyurethane, and polytetrafluoroethylene (PTFE); composites including those with additives like carbon fibers, glass fibers, and nanomaterials; carbon nanotube carpets; and any combination thereof. Bushing **216** may operably work within apparatus **200** in conjunction with a sensor, *e.g.*, a thermocouple, when electrically isolated from test cell **210**.

[0052] Referring now to Figure 3, in some situations, it my be desirable to monitor various properties and/or parameters of apparatus **200**. In some embodiments, apparatus **200** may comprise at least one sensor **276**. Suitable properties and parameters of apparatus **200** to sense and/or measure include, but are not limited to, thermal element **240** temperature; test cell **210** temperature; housing **220** temperature; shaft **250** temperature; thermal dam **260** temperature; fan **262** speed; test cell **210** movement direction and/or speed; shaft **250** movement direction and/or speed; and any combination thereof. In some embodiments, sensor **276** may operate wirelessly. In some embodiments, housing port **224** may be used to house at least part of sensor **276** and/or its corresponding connections. By way of nonlimiting example as shown in Figure 3, housing port **224** may contain at least a portion of sensor **276**, which may be a thermocouple, that extends from outside housing **220** to inside housing **220** to a point near test cell **210**.

[0053] Referring again to Figure 3, in some situations, it may be desirable to monitor and/or affect various properties of a sample in test cell **210** while apparatus **200** is in operation. In some embodiments, test cell **210** may comprise at least one cell sensor port **280** that extends from outside test cell

210 to inside test cell **210**. One skilled in the art would understand the plurality of ways to design cell sensor port **280**. Suitable configurations may include those that allow for cell sensor port **280** to contain at least a portion of at least one cell sensor **284** and/or corresponding connections. In some embodiments, test cell **210** may comprise cell sensor port **280** for multiple sensors, cell sensor port **280** for single sensors, and any combination thereof. One skilled in the art, with the benefit of this disclosure, should understand that such cell sensor port **280** should be configured such that materials do not undesirably pass therethrough, *e.g.*, leak sample or loose pressure.

[0054] Suitable sample properties to monitor, sense, measure, affect, actuate, and/or stimulate may include, but not be limited to, sample temperature, pressure within test cell **210**, sample conductivity, sample composition, sample turbidity, sample density, sample rheology, particle size distribution, emulsion stability, and any combination thereof. Suitable sensors for measuring, monitoring, and/or sensing sample properties may include, but not be limited to, thermal sensors like thermocouples; conductivity sensors; spectroscopic sensors including those for measuring fluorescence, absorbance, FT-IR, and Raman; pressure sensors; optical computing devices like an integrated computational element (ICE), which separates electromagnetic radiation related to the characteristic or analyte of interest from electromagnetic radiation related to other components of a sample; multimodal sensors; and any combination thereof. Further details regarding how the optical computing devices can separate and process electromagnetic radiation related to the characteristic or analyte of interest are described in United States Patent 7,920,258, the entire disclosure of which is incorporated herein by reference. By way of nonlimiting example shown in Figure 6, cell sensor port **280** with a thermocouple as cell sensor **284** configured such that test cell **210** can rotate and/or rock about cell central axis **214**. One skilled in the art, with the benefit of this disclosure, should understand that additional configuration adjustments may be required for cell sensor **284** and/or corresponding connections to accommodate movement of test cell **210**. Further, one skilled in the art should understand that cell sensor **284** should be compatible with the sample and operational requirements like temperature and pressure.

[0055] In some embodiments, it may be desirable to affect, actuate, and/or stimulate the sample with a stimuli. Examples of stimuli may include, but not be limited to, structures within test cell **210** to change the movement of the sample, introduction of materials to change the composition of the sample, introduction of materials to challenge the composition of a sample (*e.g.*, testing the pH limitations of a foamed treatment fluid at elevated temperatures), introduction of an electrical stimuli, introduction of an acoustic stimuli, introduction of a vibration stimuli, change of the pressure (increase or decrease) in test cell **210**, or any combination thereof.

[0056] In some embodiments, test cell **210** may be designed to include a structure to affect the sample movement therein. Affecting sample movement within test cell **210** may be to change the fluid mixing dynamics and/or to measure a fluid property like viscosity. In some embodiments, a structure (not shown) within test cell **210** may be used in conjunction with cell sensor **284** including, but not limited to, for the purposes of measuring viscosity and/or turbidity. Suitable structures that may be included within test cell **210** include, but are not limited to, a vane; a plate oriented with its thickness along cell central axis **214**; a web of intertwined rods that may or may not be curved; unconnected spokes, fins, or blades attached internally to test cell wall **212**; a cylinder oriented concentrically within test cell **210** that may or may not be attached to test cell wall **212**; and any combination thereof. In some embodiments, a structure for affecting sample movement may be stationary, or substantially stationary, while test cell **210** moves. By way of nonlimiting example, a plurality of fins may be pneumatically controlled to change orientation within test cell **210**. Further, by way of nonlimiting example, a cylinder oriented concentrically within test cell **210** may comprise magnets that correspond to magnets outside test cell **210** within housing **220** proximal to test cell **210** and bearings to allow for test cell **210** to move relative to the cylinder. Further the bearings may provide a defined spacing between the cylinder and test cell **210**. One skilled in the art would understand that structures to be included within test cell **210** should be made of materials that do not significantly react with a sample and can withstand the operation requirements like temperature.

[0057] Referring again to Figure 3, in some situations, it may be desirable to add or remove materials from the sample in test cell **210** while apparatus **200** is in operation. Suitable materials to be transported include, but are not limited to, fluids (gas and/or liquid), solids, or any combination thereof.

In some embodiments, transport of a gas may yield or may be to effect a pressure increase or decrease within test cell **210**. In some embodiments, test cell **210** may comprise at least one cell material port **282** that extends from outside test cell **210** to inside test cell **210**. One skilled in the art would understand the plurality of ways to design cell material port **282**. Suitable configurations may include those that allow for transporting of materials into and/or out of test cell **210** through material transport element **286**. By way of nonlimiting example shown in Figure 6, cell material port **282** with a fluid injector as material transport element **286** is configured such that test cell **210** can rotate and/or rock about cell central axis **214**. One skilled in the art with the benefit of this disclosure, should understand that additional configuration adjustments may be required for material transport element **286** and/or corresponding connections to accommodate movement of test cell **210**. Further, one skilled in the art, with the benefit of this disclosure, should understand that material transport element **286** should be configured and be made of appropriate materials to effectively operate within the temperature and pressure ranges desired.

[0058] In some embodiments, cell sensor port **280** and cell material port **282** may be one in the same, *i.e.*, a single port may be configured to accommodate both at least cell sensor **284** and at least one material transport element **286** and/or a single port may be configured to accommodate at least cell sensor **284** or at least one material transport element **286**. One skilled in the art should understand that cell sensor port **280** and cell material port **282** should be appropriately configured such that if capable of being empty they may be plugged so as to maintain the necessary enclosure of test cell **210** within the operation requirements like temperature and pressure.

[0059] It should be noted that cell sensor port **280** and/or cell material port **282** may be configured to monitor, sense, measure, affect, actuate, and/or stimulate the sample in the ways described herein. The descriptive terms of cell sensor port **280** and/or cell material port **282** should not be considered limiting as to the function and/or capabilities of the ports. Further it should be noted that one skilled in the art, with the benefit of this disclosure, should understand how to configure cell sensor port **280** and/or cell material port **282** to accommodate an element necessary to achieve the desired monitoring, sensing, measurement, affect, actuation, and/or stimulation. One skilled in the art should further understand the element may be limited by the physical limitations of some embodiments of configurations of apparatus **200** and/or the desired operational conditions of apparatus **200**.

[0060] In some embodiments, apparatus **200** may comprise control mechanism **290**, a nonlimiting configuration of which is shown in Figure 4 as a computer. As used herein, the term "control system" refers to a system that can operate to receive and send electronic signals and may include functions of interfacing with a user, providing data readouts, collecting data, storing data, changing variable setpoints, maintaining setpoints, programming experimental parameters, providing notifications of failures and/or test interruptions, and any combination thereof. In some embodiments, control mechanism **290** may be an element of apparatus **200**. In some embodiments, control mechanism **290** may be a separate element that may be operably connected to elements of apparatus **200** including, but not limited to, sensor **276**, thermal element **240**, fan **262**, driving mechanism **270**, cell sensor **284**, material transport element **286**, and any combination thereof. In some embodiments, control mechanism **290** may be external to housing **220**. In some embodiments, cell sensor **284** and/or material transport element **286** may be operably connected to a control mechanism. Suitable control mechanisms **290** include, but are not limited to, variable transformers, ohmmeters, programmable logic controllers, digital logic circuits, electrical relays, computers, and any combination thereof. In some embodiments, control mechanisms **290** may be further capable of storing information from the functions listed above, both inputs and outputs.

[0061] Referring now to Figure 4, in some embodiments, apparatus **200** may comprise base **232**. In some embodiments, base **232** may house elements of apparatus **200** including, but not limited to, control mechanism **290**, driving mechanism **270**, a pressurization system (not shown), and any combination thereof.

[0062] Referring now to Figure 5, in some embodiments, base **232** may comprise at least one leg **234** including, but not limited to one, two, three, four, five, six, and so on. One skilled in the art would understand that leg **234** may have a plurality of configurations and not all legs **234** must be of the same configurations. In some embodiments, base **232** may comprise at least one leg **234** capable of extending. In some embodiments, some or all legs **234** may extend so as to level apparatus **200**. In some embodiments, extending and/or retracting some or all legs **234** may cause angle **236** between cell central axis **214** and the ground to change, as shown in Figure 8. Angle **236** may vary from any angle ranging from 0° to about 90°. One skilled in the art would understand that the configuration of apparatus **200** should be taken into consideration if wishing to accommodate larger angles. One skilled in the art would understand the plurality of mechanisms by which leg **234** may be extended. In some embodiments, leg **234** may be extended hydraulically. In some embodiments, leg **234** may be extended or retracted from a signal from control mechanism **290**. In some embodiments, leg **234** operably connected to control mechanism **290** may be programmed to extend and retract in a cyclical manner.

[0063] Referring now to Figure 6, in some embodiments, apparatus **200** may comprise frame **230** that houses at least a portion of housing **220**. In some embodiments, frame **230** may be a separate element that may be operable to house at least a portion of housing **220** of apparatus **200**. In some embodiments, frame **230** may be configured to connect to base **232**. In some embodiments, frame **230** may be configured to comprise legs **234**, which at least one may optionally be extendable as described above.

[0064] Referring now to Figure 5, in some embodiments, frame **230** may be configured such that multiple apparatuses **200** may be stacked vertically, horizontally, or any combination thereof. One skilled in the art, with the benefit of this disclosure, should understand the plurality of dimensional configurations in which the various elements and components of apparatus **200** can be configured and that any dimensions provided in the figures are nonlimiting embodiments. Further, one skilled in the art should recognize the scalability of apparatus **200**.

[0065] Referring now to Figures 7 and 8, in some embodiments, apparatus **200** may be part of modular system **300**. In some embodiments, modular system **300** may comprise at least one apparatus **200**, including, but not limited to, one, two (Figure 7), three, four (Figure 8), five, six, seven, and so on. In some embodiments, apparatus **200** of modular system **300** may be according to any embodiments disclosed herein. In modular system **300** embodiments with at least two apparatuses **200**, apparatuses **200** may be of the same configuration, of different configurations, or any combination thereof. In some embodiments, modular system **300** comprising at least two apparatuses **200** may be controlled, monitored, manipulated, operably connected to, etc. in any combination with any combination of components including, but not limited to, base **232**, legs **234**, connection element **256**, fan **262**, driving mechanism **270**, drive connection **272**, sensor **276**, cell sensor **284**, cell material transport **282**, control mechanism **290**, control box **292**, and any combination thereof.

[0066] In modular system **300** embodiments with at least two apparatuses **200'**, **200''**, and so on, apparatuses **200'**, **200''**, and so on may be operably connected to a single driving mechanism **270** through their respective cogs **252'**, **252''**, and so on (not shown). By way of nonlimiting example, first apparatus **200'** may comprise two cogs **252'** in series and second apparatus **200''** may comprise a single drive connection **252''**. One drive connection **252'** of apparatus **200'** may be operably connected to driving mechanism **270** while the other drive connection **252'** of apparatus **200'** may be operably connected to the single drive connection **252''** of second apparatus **252''**. This may allow for driving mechanism **270** to operate both apparatuses **200'**, **200''** of modular system **300** simultaneously. Further, one skilled in the art would understand that the speed of movement imparted on each drive connection may be different by changing the size of each drive connection appropriately. One skilled in the art would recognized that the orientation of apparatus **200'** and apparatus **200''** may be any configuration such that they can be operably connected including, but not limited to, stacked, arranged horizontally, arranged back-to-back, arranged diagonally, and the like.

[0067] Operable connections between two or more drive connections **252** may be achieved by any known connection element **256** including, but not limited to, those disclosed herein for an operably connect of driving mechanism **270** to drive connection **252**. In some embodiments, the operable connection between driving mechanism **270** and drive connection **252** may be different than that between tow drive connections **252** within modular system **300**. In some embodiments, connection element **256** may include a bar, or the like, operably connected to driving mechanism **270** with said bar being operably connected to drive connection **252** of each apparatus **200**.

[0068] In some embodiments, elements and components described above may be a part of modular system **300** as opposed to apparatus **200** including, but not limited to, frame **230**, base **232**, legs **234**, connection element **256**, fan **262**, driving mechanism **270**, drive connection **272**, sensor

276, control mechanism **290**, control box **292**, and any combination thereof. That is to say, the minimum elements and components of apparatus **200** may include test cell **210**, housing **220**, insulation **222**, thermal element **240**, shaft **250**, and drive connection **252**. Optional elements and components that may be of apparatus **200** without overlap with system **300** elements and components include cell bushings **216**, housing port **224**, bearings **254**, thermal dam **260**, cell sensor port **280**, and cell material port **282**. Further, some elements and components may be separate from both modular system **300** and apparatus **200** and may be appropriately operable connected to modular system **300** and/or apparatus **200**, including, but not limited to, base **232**, legs **234**, connection element **256**, fan **262**, driving mechanism **270**, drive connection **272**, sensor **276**, cell sensor **284**, cell material port **282**, control mechanism **290**, control box **292**, and any combination thereof.

[0069] The present invention provides for apparatus **200** and/or system **300** to be used in a variety of methods, only some of which are included herein. The methods may advantageously simulate conditions that cannot be otherwise simulated with traditional roller ovens. Apparatus **200** and/or system **300** also provide for methods that allow real-time monitoring and manipulation of a sample which they are testing. Further, apparatus **200** and/or system **300** allow for integration into quality control methods that may be practiced in a laboratory setting and/or in the field.

[0070] In some embodiments, apparatus **200** or system **300** according to a disclosed embodiment may be used to test a sample in test cell **210**. In some embodiments, samples may be a fluid including, but not limited to, gases, liquids, fluids comprising solids, fluids that harden, gelled fluids, foamed fluids, or any combination thereof. In some embodiments, a sample may be a fluid or portion of a fluid provided, produced in a laboratory, produced by a manufacturing process, produced at a wellbore site, or provided at a wellbore site. Examples of fluids may include, but not be limited to, treatment fluids, drilling fluids, drill-in fluids, completion fluids, workover fluids, lost circulation fluids, fracturing fluids, acidizing fluids, wellbore strengthening fluids, packer fluids, spacer fluids, cementitious slurries, insulation fluids, and the like.

[0071] In some embodiments, methods of testing a sample may include, but not be limited to, manipulating the cell, changing the sample temperature, introducing materials, changing the pressure within the cell, changing the manipulation of the cell, or any combination thereof. It should be noted that manipulating the cell is not required, *i.e.*, apparatus **200** and/or system **300** may be used for static testing of a sample. Further, apparatus **200** and/or system **300** may be used with both the static and dynamic movement in a single test.

[0072] In some embodiments, the sample may be analyzed before a test, during a test, after a test, or any combination thereof. Analysis may include, but not be limited to, chemical analysis, physical analysis, thermal analysis, electrical analysis, turbidity analysis, rheological analysis, density (including density gradient) analysis, particle size distribution analysis, and any combination thereof. The physical and/or chemical properties tested may include, but not be limited to, chemical composition including production of byproducts and/or degradation of the sample; physical make up like settling of particulates or breaking of foams or gels; thermal profile of the sample including points of endothermic or exothermic reactions; electrical conductivity of a sample; viscosity of a sample; or any combination thereof.

[0073] In some embodiments, analysis may be done on-line, off-line, or a combination thereof relative to the test. In some embodiments, off-line analysis may be performed during a test when a portion of the sample is taken during the test. In some embodiments, on-line analysis may be performed by sensor **276** and/or cell sensor **284**. In some embodiments, on-line analysis may be performed by extracting a portion of the sample during the test through cell sensor port **280** wherein cell sensor port **280** is operably connected to another instrument like a gas chromatograph, mass spectrometer, a UV-visible spectrometer, a fluorometer, the like, or any combination thereof. In some embodiments, on-line analysis may be conducted in conjunction with a computer operably connected to apparatus **200** and/or system **300**.

[0074] In some embodiments, operational conditions may be adjusted during a test. In some embodiments, operation conditions may be adjusted in response to analysis during a test. In some embodiments, operational conditions that may be changed include, but are not limited to, temperature of the sample; manipulation of test cell **210**, including speed of manipulation and/or type of manipulation; pressure within test cell **210**; composition of the sample; or any combination thereof.

[0075] In some embodiments, control mechanism **290** may be used in conjunction with monitoring and/or changing operation conditions. In some embodiments, control mechanism **290** may be a computer that may allow for remote operation and/or monitoring (*e.g.*, via the internet), for programmed operation, for logging of test parameters and results, for logging of apparatus history and/or errors, for programmed calibration procedures, or any combination thereof.

[0076] In some embodiments, a sample may comprise a liquid, a gas, a solid, or any combination thereof. Suitable samples may include, but not be limited to, any composition that may be placed in a subterranean formation. Nonlimiting examples of suitable sample may include treatment fluids, foamed treatment fluids, treatment fluids comprising particulates, components of a treatment fluid, solid particulates and/or beads, the solids of a cementitious compositions, slurried cementitious compositions, components of a downhole tool, and the like.

[0077] In some embodiments, based on the analysis of a sample, a fluid composition may be changed including, but not limited to, the fluid from which the sample was taken, a second fluid, or any combination thereof. In some embodiments, the second fluid may be a fluid to be produced and/or an existing fluid. In some embodiments, changing a second fluid may include changing a fluid-additive composition that may be used to produce the second fluid. The fluid-additive composition may be a fluid itself, a solid, a mixture of solids, or a combination thereof. In some embodiments, the fluid to which the composition has been changed may be introduced into a wellbore penetrating a subterranean formation.

[0078] In some embodiments, based on the analysis of a sample, a composition of solids may be changed including, but not limited to, the solids from which the sample was produced, a second composition of solids, or any combination thereof. In some embodiments, the second composition of solids may be solid to be produced and/or existing solids. In some embodiments, changing a second composition of solids may include changing an additive composition that may be used to produce the second composition of solids. In some embodiments, changing a second composition of solids may include changing the ratios of the solids that make up the second composition of solids. In some embodiments, the second composition of solids of which the composition has been changed may be introduced into a wellbore penetrating a subterranean formation in solid form, as part of a fluid, or any combination thereof.

[0079] Of the many advantages of the present invention, portability of apparatus **200** and/or system **300** provides for use at a wellbore site or a laboratory near a wellbore site.

[0080] Further, advantageously apparatus **200** and/or system **300** may be used to simulate conditions a fluid may experience not only within a subterranean formation, but also during transport. By way of nonlimiting example, a fluid may be tested under conditions that simulate transport to an offshore well site. Conditions a fluid may see in such transport includes rocking motions and temperature fluctuations.

[0081] In another advantage of apparatus **200** and/or system **300** over traditional roller ovens may be the applicability to test samples like cements in new ways. By way of nonlimiting example, a cementitious sample, like a cement slurry, may be analyzed *in situ* for the exothermic reaction at the point of setting while increasing temperature and manipulating test cell **210** continuously in 360°. Such an analysis may provide insight into the behavior of cementitious fluid while being pumped in a wellbore.

[0082] In some embodiments, a housing may include a test cell being enclosed and having at least one test cell wall and one sealable opening and has a cell central axis defined along the center line of the length of the test cell, a thermal element in thermal communication with the test cell, and an insulation, at least a portion of the insulation being disposed about the test cell and the thermal element. In some embodiments, an apparatus may generally include a housing, a drive connection, and a shaft operably connected to the test cell and extending parallel to the cell central axis from the test cell through the insulation to the drive connection to which the shaft is operably connected. In some embodiments of the present invention, a modular system may include at least one apparatus and a frame that houses at least a portion of the housing, and a driving mechanism operably connected to the drive connection.

[0083] Some embodiments may involve testing a sample in the test cell of an apparatus operably connected to a driving mechanism by at least manipulating the test cell and analyzing the sample.

[0084] Some embodiments may involve testing the stability of deep-sea treatment fluids by testing a sample in the test cell of an apparatus operably connected to a driving mechanism by at least manipulating the test cell, changing the sample temperature to a first temperature below room temperature, changing the sample temperature to a second temperature above room temperature, and analyzing the sample.

[0085] Some embodiments may involve testing a cement composition by testing a cementitious sample in the test cell of an apparatus operably connected to a driving mechanism by at least manipulating the test cell; changing the sample temperature; and monitoring the temperature within the test cell.

[0086] While the disclosure herein is drawn toward the subterranean operation industry, one skilled in the art, with the benefit of this disclosure, should recognize the parallel applications like food and beverage, automotive and motor fluids, and lubricants.

[0087] Therefore, the present invention is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered, combined, or modified and all such variations are considered within the scope and spirit of the present invention. The invention illustratively disclosed herein suitably may be practiced in the absence of any element that is not specifically disclosed herein and/or any optional element disclosed herein. While compositions and methods are described in terms of "comprising," "containing," or "including" various components or steps, the compositions and methods can also "consist essentially of" or "consist of" the various components and steps. All numbers and ranges disclosed above may vary by some amount. Whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range is specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the element that it introduces. If there is any conflict in the usages of a word or term in this specification and one or more patent or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

CLAIMS

The invention claimed is:

1. A method comprising:

providing an apparatus that comprises:

a housing that comprises

a test cell being enclosed and having at least one test cell wall and one sealable opening and has a cell central axis defined along the center line of the length of the test cell,

a thermal element in thermal communication with the test cell, and

an insulation, at least a portion of the insulation being disposed about the test cell and the thermal element;

a drive connection; and

a shaft operably connected to the test cell and extending parallel to the cell central axis from the test cell through the insulation to the drive connection to which the shaft is operably connected;

providing a driving mechanism operably connected to the drive connection;

providing a sample in the test cell of the apparatus;

manipulating the test cell; and

analyzing the sample.

2. The method of claim 1 further comprising:

changing the pressure within the test cell.

3. The method of claim 1, wherein manipulating the test cell involves an action selected from the group consisting of 360° rotation about cell central axis; rocking about cell central axis; moving back and forth along cell central axis; and any combination thereof.

4. The method of claim 1, wherein manipulating the test cell involves changing the sample temperature.

5. The method of claim 1 further comprising:

allowing at least one control mechanism connected to an attachment of the apparatus to function in a way selected from the group consisting of collecting data from the attachment, sending a signal to the attachment, and any combination thereof, wherein the attachment selected from the group consisting of a housing thermal sensor in a housing sensor port that extends from outside the housing to inside the housing near the test cell; a test cell sensor in a test cell sensor port; a fluid transfer device operably connected to a test cell fluid port; and any combination thereof.

6. The method of claim 5, wherein the control mechanism is a computer.

7. The method of claim 1, wherein the thermal element and the driving mechanism are operably connected to at least one control mechanism.

8. The method of claim 7, wherein the control mechanism is a computer capable of running an automated procedure for changing the temperature and moving the test cell.

9. The method of claim 1, wherein the apparatus is located at a well site.

10. The method of claim 1 further comprising:

changing the fluid composition based on the analysis.

11. The method of claim 1 further comprising:

changing a fluid-additive composition used to produce a second fluid based on the analysis.

12. The method of claim 1 further comprising:

changing a second fluid composition based on the analysis.

13. The method of claim 1 further comprising:

changing a treatment fluid composition based on the analysis; and

introducing the treatment fluid into a wellbore penetrating a subterranean formation.

14. A method of testing the stability of deep-sea treatment fluids, the method comprising:

providing an apparatus that comprises:

a housing that comprises

a test cell being enclosed and having at least one test cell wall and one sealable opening and has a cell central axis defined along the center line of the length of the test cell,

a thermal element in thermal communication with the test cell, and

an insulation, at least a portion of the insulation being disposed about the test cell and the thermal element;

a drive connection; and

a shaft operably connected to the test cell and extending parallel to the cell central axis from the test cell through the insulation to the drive connection to which the shaft is operably connected;

providing a driving mechanism operably connected to the drive connection;

providing a sample in the test cell of the apparatus;

manipulating the test cell;

changing the sample temperature to a first temperature below room temperature;

changing the sample temperature to a second temperature above room temperature; and

analyzing the sample.

15. The method of claim 14 further comprising:

adjusting a treatment fluid composition based on the analysis; and

using the treatment fluid at a wellbore site.

16. The method of claim 14, wherein manipulating the test cell involves an action selected from the group consisting of 360° rotation about cell central axis; rocking about cell central axis; moving back and forth along cell central axis; and any combination thereof.

17. A method of testing a cement composition, the method comprising:

providing an apparatus that comprises:

a housing that comprises

a test cell being enclosed and having at least one test cell wall and one sealable opening and has a cell central axis defined along the center line of the length of the test cell,

a thermal element in thermal communication with the test cell, and

an insulation, at least a portion of the insulation being disposed about the test cell and the thermal element;

a drive connection; and

a shaft operably connected to the test cell and extending parallel to the cell central axis from the test cell through the insulation to the drive connection to which the shaft is operably connected;

providing a driving mechanism operably connected to the drive connection;

providing a cementitious sample in the test cell of the apparatus;

manipulating the test cell;

changing the sample temperature; and

monitoring the temperature within the test cell.

18. The method of claim 17, wherein the test cell comprises a coating on at least a portion of an internal cell wall.

19. The method of claim 17 further comprising:

changing a composition of solids based on the analysis.

20. The method of claim 19 further comprising:

placing the composition in a wellbore as a solid and/or as an additive in a fluid.

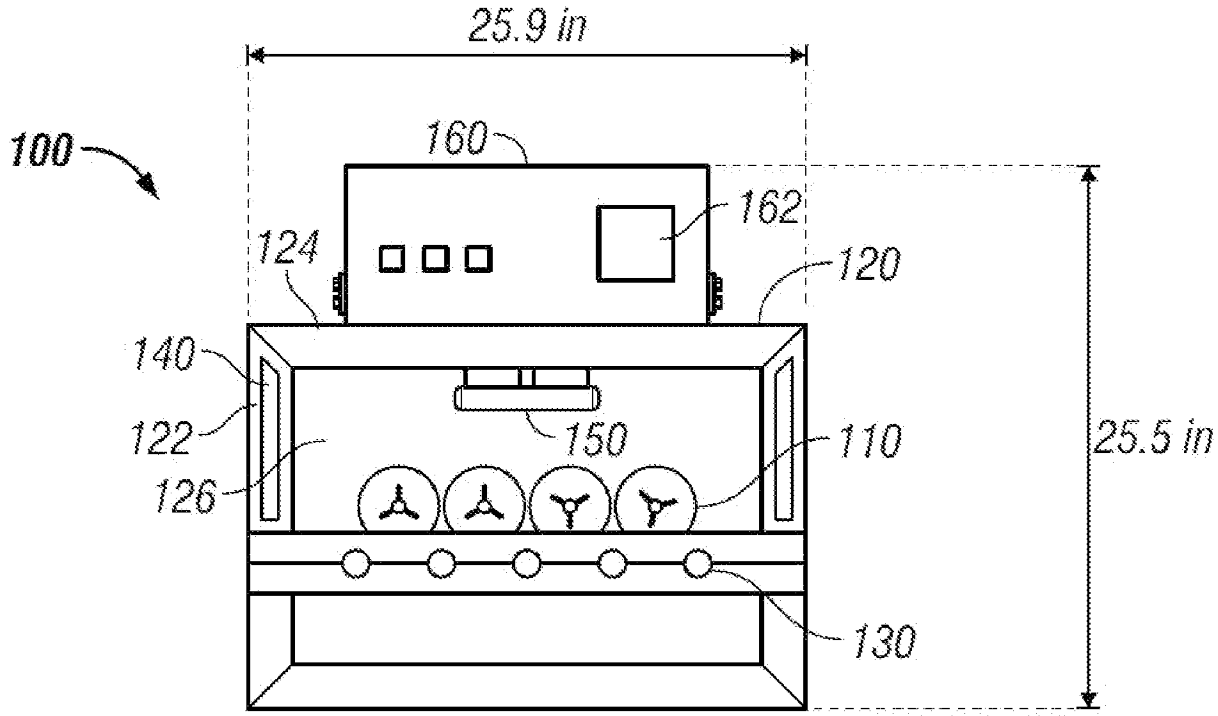

FIG. 1

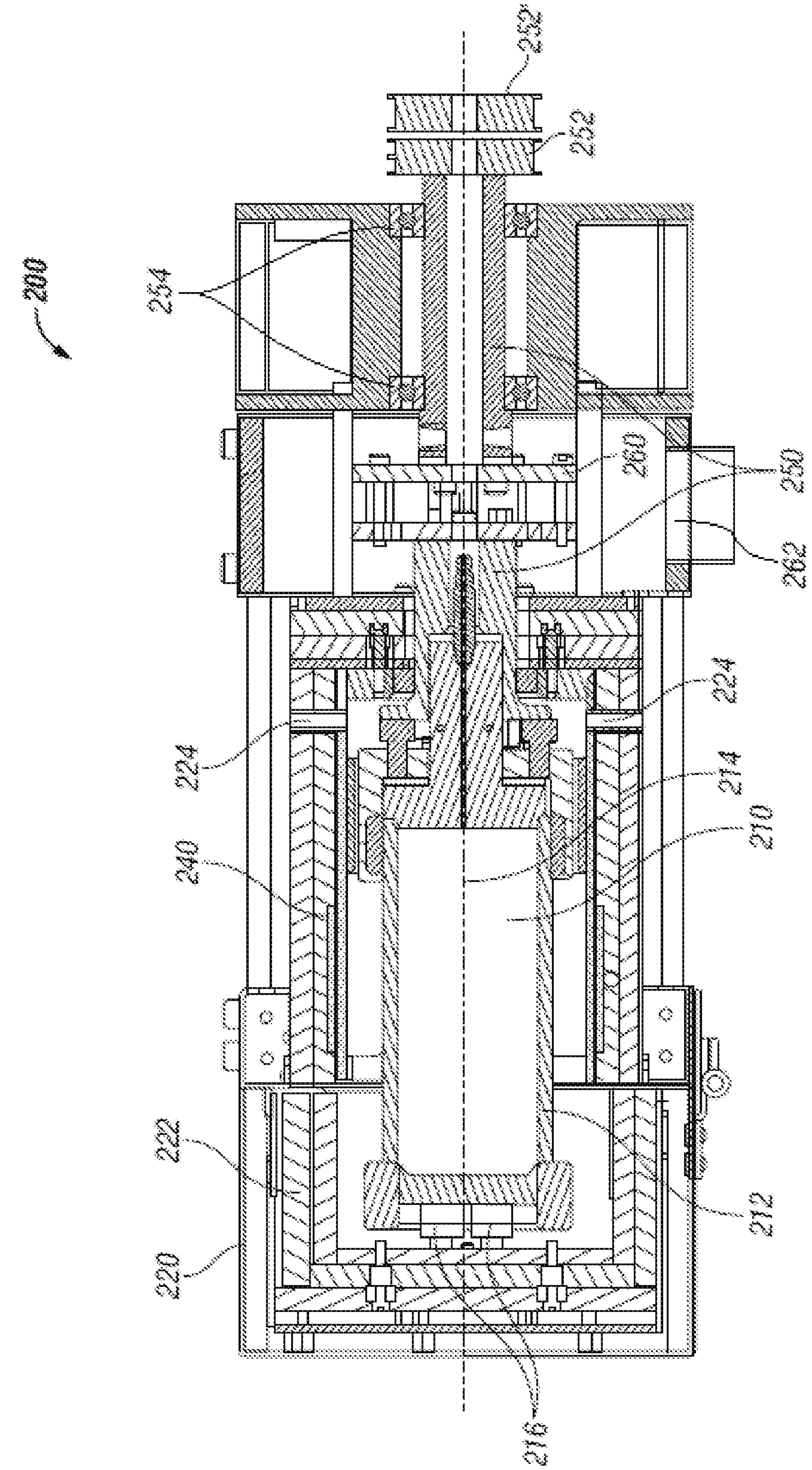

FIG. 2

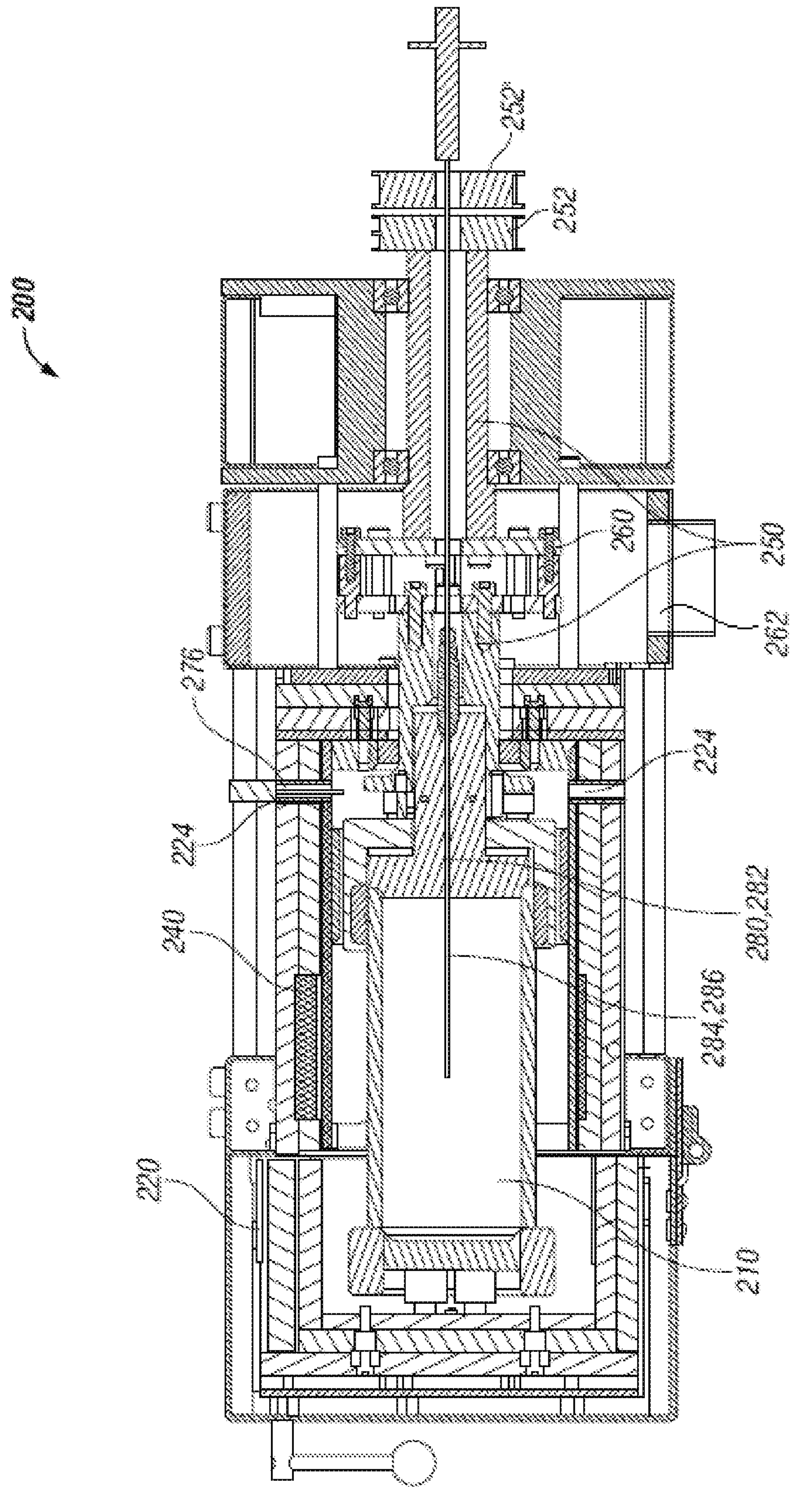

FIG. 3

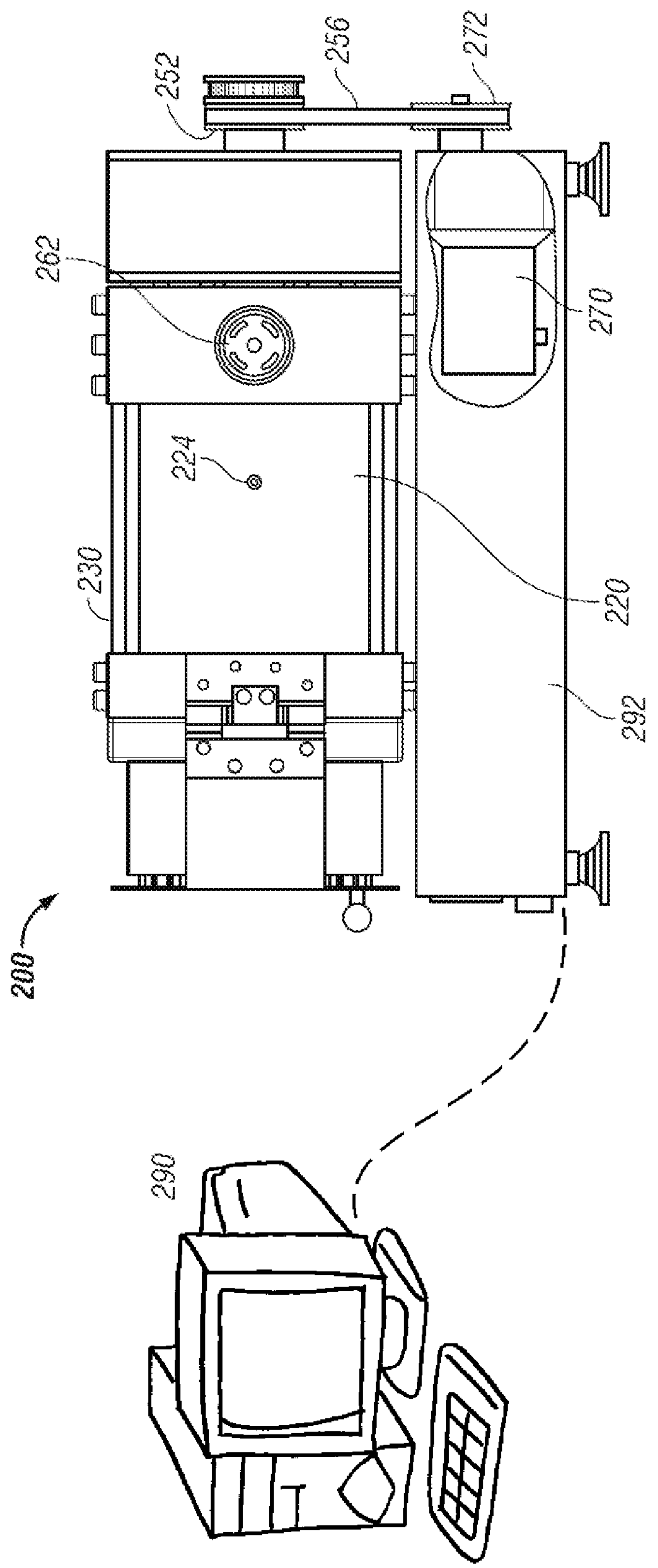

FIG. 4

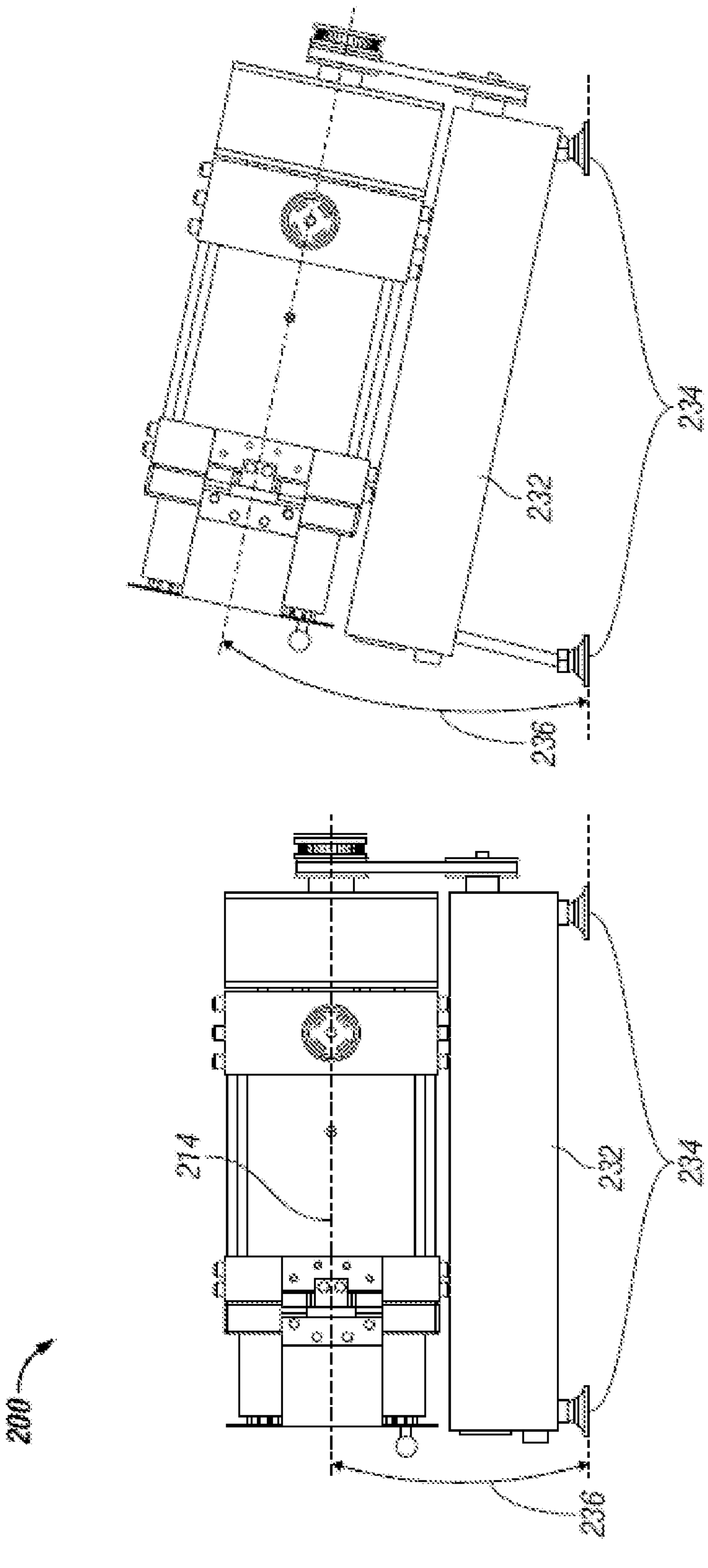

FIG. 5

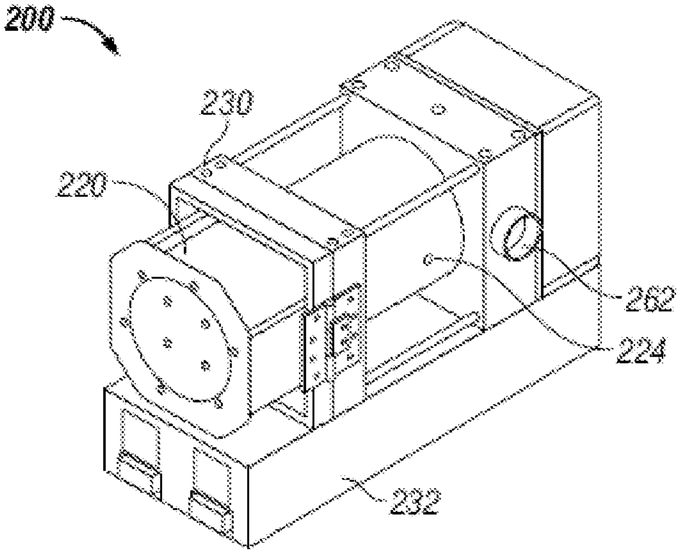

FIG. 6

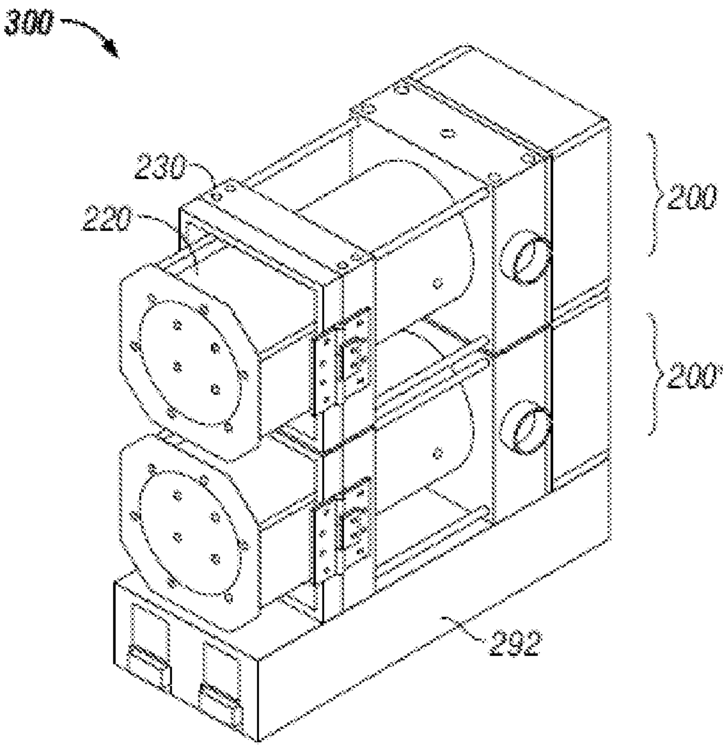

FIG. 7

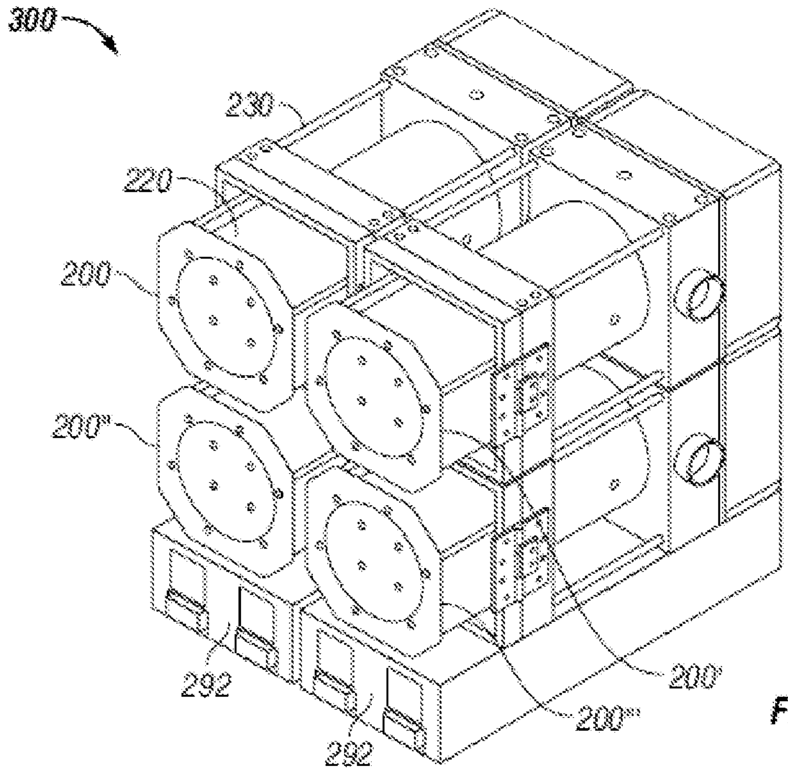
300
230
220
200
200''
292
292
200'
200'''

FIG. 8A

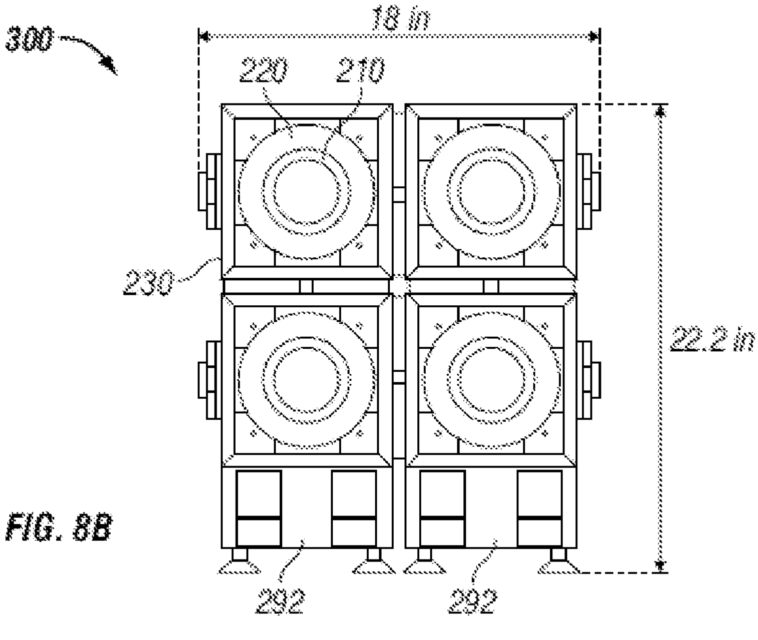
300
18 in
220
210
230
22.2 in
292
292

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/047837

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N25/00 G01N33/24 G01N33/38
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)
G01N F24C

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 Y	US 4 677 843 A (SCHROEDER ROYCE E [US]) 7 July 1987 (1987-07-07) abstract column 3, line 1 - column 5, line 2 figures 1-3	1,3,4, 7-16 2,5,6, 17-20
X	CAENN R ET AL: "Equipment and Procedures for Evaluating Drilling Fluid Performance"; "Chapter 3" In: "Composition and properties of drilling and completion fluids", 29 July 2011 (2011-07-29), Gulf Professional Publishing, Kidlington, Oxford, UK, XP008156496, ISBN: 978-0-12-383858-2 pages 91-135, page 106 - page 108 figures 3.15,3.16	1,3,4,7, 14-16

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 September 2012	02/10/2012

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	Couteau, Olivier

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/047837

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008/178683 A1 (HEATHMAN JAMES [US] ET AL) 31 July 2008 (2008-07-31) paragraphs [0001], [0006], [0018] - [0024], [0031] - [0033] figures 1,2 -----	2,5,6, 17-20
Y	US 5 152 184 A (SCHROEDER ROYCE E [US]) 6 October 1992 (1992-10-06) abstract figures 1,4,5 -----	18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/047837

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4677843	A	07-07-1987	NONE	
US 2008178683	A1	31-07-2008	NONE	
US 5152184	A	06-10-1992	NONE	