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(54) Title: DOWNHOLE COMBUSTOR

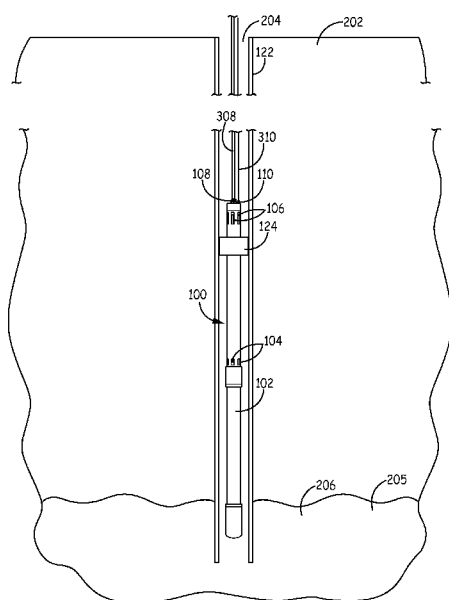


FIG. 1

(57) Abstract: A downhole combustor system (101) for a production well is provided. The downhole combustor includes a housing (102), a combustor (500) and an exhaust port (106). The housing is configured and arranged to be positioned down a production well. The housing further forms a combustion chamber (200). The combustor is received within the housing. The combustor is further configured and arranged to combust fuel in the combustion chamber. The exhaust port is positioned to deliver exhaust fumes from the combustion chamber into a flow of oil out of the production well.

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DOWNHOLE COMBUSTOR

BACKGROUND

[0001] Artificial lift techniques are used to increase the flow rate of oil out of a production well. One commercially available type of artificial lift is a gas lift. With a gas lift, compressed gas is injected into a well to increase the flow rate of the produced fluid by decreasing head losses associated with the weight of the column of fluids being produced. In particular, the injected gas reduces pressure on the bottom of the well by decreasing the bulk density of the fluid in the well. The decreased density allows the fluid to flow more easily out of the well. Gas lifts, however, do not work in all situations. For example, gas lifts do not work well with a reserve of high viscosity oil (heavy oil). Typically, thermal methods are used to recover heavy oil from a reservoir. In a typical thermal method, steam generated at the surface is pumped down a drive side well into a reservoir. As a result of the heat exchange between the steam pumped into the well and the downhole fluids, the viscosity of the oil is reduced by an order of magnitude that allows it to be pumped out of a separate producing bore. A gas lift would not be used with a thermal system because the relatively cool temperature of the gas would counter the benefits of the heat exchange between the steam and the heavy oil therein increasing the viscosity of the oil negating the desired effect of the thermal system.

[0002] Other examples where gas lifts are not suitable for use are production wells where there are high levels of paraffins or asphaltenes. The pressure drop associated with delivering the gas lift, changes the thermodynamic state and makes injection gases colder than the production fluid. The mixing of the cold gases with the production fluids act to deposit these constituents on the walls of the production piping. These deposits can reduce or stop the production of oil.

[0003] For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the present specification, there is a need in the art for an effective and efficient apparatus and method of extracting oil from a reservoir.

SUMMARY OF INVENTION

[0004] The above-mentioned problems of current systems are addressed by embodiments of the present invention and will be understood by reading and studying the following specification. The following summary is made by way of example and not by way of limitation. It is merely provided to aid the reader in understanding some of the aspects of the invention.

[0005] In one embodiment, a downhole combustor system is provided. The downhole combustor includes a housing, a combustor and an exhaust port. The housing is configured and arranged to be positioned down a production well. The housing further forms a combustion chamber. A combustor is received within the housing. The combustor is configured and arranged to combust fuel in the combustion chamber. The exhaust port is positioned to deliver exhaust fumes from the combustion chamber into a flow of oil out of the production well.

[0006] In another embodiment, another downhole combustor system for a production well is provided. The downhole combustor system includes a housing, at least one delivery connector, a combustor and a combustion chamber exhaust port. The housing has an oil and exhaust gas mixture chamber and a combustor chamber. The housing has at least one oil input port that passes through an outer shell of the housing allowing passage into the oil and exhaust gas mixture chamber for oil from a production well. The housing further has at least one oil and exhaust gas output port that passes through the outer shell of the housing and is spaced a select distance from the at least one oil input port. The at least one oil and exhaust gas output port is configured and arranged to pass oil and exhaust gas out of the housing. The housing further has at least one delivery passage that passes within the outer shell of the housing. The at least one delivery connector is coupled to the housing. Each delivery connector is in fluid communication with at least one associated delivery passage. The combustor is configured and arranged to combust fuel in the combustion chamber. The combustor is further configured and arranged to receive fuel and air passed in the at least one delivery passage. The combustion chamber exhaust port is positioned to pass exhaust gases from the combustion chamber to the oil and exhaust gas mixture chamber.

[0007] In still another embodiment, a method of extracting oil from an oil reservoir is provided. The method includes: positioning a downhole combustor in a production wellbore to the oil reservoir; delivering fuel to the combustor through passages in a housing containing

the combustor; initiating an ignition system of the combustor; combusting the fuel in a combustion chamber in the housing; and venting exhaust gases into the wellbore.

[0007a] According to another aspect of the present invention, there is provided a downhole combustor system comprising: a longitudinally extending housing configured and arranged to be positioned down a wellbore of a production well, the housing including: a first housing portion having an oil and gas mixing chamber, the first housing portion having at least one inlet port to the oil and gas mixing chamber to allow passage of oil from an oil reservoir in communication with the wellbore into the oil and gas mixture chamber, the first housing portion further having at least one outlet port out of the oil and gas mixing chamber to allow passage of mixed oil from the oil reserve and exhaust gas out of the oil and gas mixing chamber into the wellbore, the at least one outlet port spaced a longitudinal distance above the at least one inlet port; and a second housing portion comprising a combustion chamber below the first housing portion, the second housing portion coupled to the first housing portion; a combustor below the combustion chamber configured and arranged to combust fuel in the combustion chamber; a plurality of heat exchange tubes received within the first portion of the housing proximate the oil and gas mixing chamber and laterally adjacent to the at least one inlet port, the heat exchange tubes coupled to transfer heat of exhaust gases generated in the combustion chamber and passing through the plurality of heat exchange tubes to oil entering the first portion of the housing through the at least one inlet port; and at least one exhaust port positioned to deliver exhaust gases from at least some of the plurality of heat exchange tubes into the oil and gas mixing chamber.

[0007b] According to another aspect of the present invention, there is provided a downhole combustor system for a production well, the downhole combustor system comprising: a housing configured for disposition in a wellbore and comprising an oil and exhaust gas mixing chamber and a combustion chamber, the housing having at least one oil input port passing through an outer shell of the housing allowing passage into the housing of oil from an oil reservoir in communication with the wellbore, the housing further having at least one oil and exhaust gas output port passing through the outer shell of the housing at a

longitudinally spaced distance from the at least one oil input port, the at least one oil and exhaust gas output port configured and arranged to pass oil and exhaust gas out of the housing, the housing further having at least one delivery passage within the outer shell of the housing; at least one delivery connector coupled to the housing, the at least one delivery connector in fluid communication with at least one associated delivery passage; a combustor configured and arranged to combust fuel in a combustion chamber, the combustor configured and arranged to receive fuel and air passed through the at least one delivery passage; a plurality of heat exchange tubes received within the housing proximate the oil and exhaust mixing chamber, each heat exchange tube coupled to receive exhaust gases generated in the combustion chamber, to transfer heat from the exhaust gases to oil in the housing; and exhaust ports positioned to pass exhaust gases from at least some heat exchange tubes of the plurality to the oil and exhaust gas mixing chamber.

[0007b] According to another aspect of the present invention, there is provided a method of extracting oil from an oil reservoir, the method comprising: positioning a downhole combustor in a wellbore in communication with the oil reservoir; sealing the wellbore between a casing structure lining the wellbore and an exterior of a housing containing an oil and gas mixing chamber, a combustor and a combustion chamber of the combustor system with a packing seal; delivering fuel to the combustor through passages in the housing; initiating an ignition system of the combustor to combust the fuel in the combustion chamber; heating oil passing into the housing from the oil reservoir below the packing seal with a plurality of heat exchange tubes positioned within the oil and gas mixing chamber that are in communication with exhaust gases from the combustion chamber; mixing the oil passed into the housing with exhaust gases exiting at least some of the plurality of heat exchange tubes into the oil and gas mixing chamber; and venting exhaust gases mixed with oil from the housing into the wellbore above the packing seal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present invention can be more easily understood and further advantages and uses thereof will be more readily apparent, when considered in view of the detailed description and the following figures in which:

3a

[0009] Figure 1 is a side view of a thermal gas lift including a downhole combustor of one embodiment of the present invention;

[0010] Figure 2 is a side view of the thermal gas lift of Figure 1;

[0011] Figure 3 is a top view of the thermal gas lift of Figure 1;

[0012] Figure 4A is a cross-sectional side view of the thermal gas lift along line 4A-4A of Figure 2;

[0013] Figure 4B is a cross-sectional side view of the thermal gas lift along line 4B-4B of Figure 3;

[0014] Figure 4C is a cross-sectional side view of the thermal gas lift along line 4C-4C of Figure 3;

[0015] Figure 5 A is a cross-sectional top view of the thermal gas lift along line 5A-5A of Figure 2;

[0016] Figure 5B is a cross-sectional top view of the thermal gas lift along line 5B-5B of Figure 2;

[0017] Figure 5C is a cross-sectional top view of the thermal gas lift along line 5C-5C of Figure 2;

[0018] Figure 5D is a cross-sectional top view of the thermal gas lift along line 5D-5D of Figure 2;

[0019] Figure 5E is a cross-sectional top view of the thermal gas lift along line 5E-5E of Figure 2;

[0020] Figure 6A is a partial close up cross-sectional view of the thermal gas lift of Figure 4B;

[0021] Figure 6B is another partial close up cross-sectional view of the thermal gas lift of Figure 4B;

[0022] Figure 6C is a partial close up cross-sectional view of the thermal gas lift of Figure 4C;

[0023] Figure 6D is another partial close up cross-sectional view of the thermal gas lift of Figure 4C;

[0024] Figure 7 is a cross-sectional side view of a power generator including a downhole combustor of one embodiment of the present application; and

[0025] Figure 8 is a cross-sectional side view of a reforming system including a downhole combustor of one embodiment of the present application.

[0026] In accordance with common practice, the various described features are not drawn to scale but are drawn to emphasize specific features relevant to the present invention. Reference characters denote like elements throughout Figures and text.

DETAILED DESCRIPTION

[0027] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the inventions may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that changes may be made without departing from the spirit and scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the claims and equivalents thereof.

[0028] Embodiments of the present invention provide a downhole combustor system for use in a production well. In some embodiments, the downhole combustor system is part of a thermal gas lift 100. Embodiments of the combustion thermal gas lift provide advantages over traditional thermal methods that direct steam down a drive side well (dry well). For example, since very little water is generated in the downhole combustor system (i.e. merely in the form of water vapor in the combustion process), limited clean up of water is required. Moreover, embodiments are relatively portable which allows for ease of use in remote locations such as offshore reservoirs. The downhole combustor system has many other

applications that go beyond just heating oil, such as, but not limited to, gasification, electricity generation and reforming as discussed briefly below.

[0029] Referring to Figure 1, a thermal gas lift 100 of an embodiment with a downhole combustor system is illustrated. Figure 1 illustrates, a casing 122 positioned in a well bore drilled through the ground 202 to an oil reserve 205 containing oil 206. Down the well bore in the casing 122 is positioned a thermal gas lift 100. A packing seal 124 is positioned between a housing 102 of the thermal gas lift 100 and the casing 122 to form a seal. The packing seal prevents oil 206 from passing up around the outside of the housing 102 of the thermal gas lift 100. The housing 102 of the thermal gas lift 100 in Figure 1 is shown having a plurality of oil intake ports 104. Oil 206 from the oil reservoir 205 enters the oil intake ports 104 in the housing 102. The oil 206 is then heated up in the housing 102, as discussed below, and is then passed out of oil and exhaust gas outlet ports 106 in the housing 102. As illustrated, the oil and exhaust gas outlet ports 106 (or oil and gas outlet ports 106) of the housing are positioned above packing seal 124. The oil above the packing seal 124 can then be pumped out using traditional pumping methods known in the art. Since the viscosity of the oil will have been reduced by the thermal gas lift 100, the traditional pumping methods will be effective even for high viscosity oil (heavy oil) production. Also illustrated in Figure 1, is a first delivery intake connector 108 and a second delivery intake connector 110. The first delivery intake connector 108 is designed to couple a first delivery conduit 308 to the thermal gas lift 100 and the second delivery intake connector 110 is designed to couple a second delivery conduit 310 to the thermal gas lift 100. In an embodiment, first and second delivery conduits deliver select gases, fluids and the like, to the thermal gas lift 100 for combustion such as, but not limited to, air and methane. Although, only two intake connectors 108 and 110 are shown, it will be understood that more or even less connectors can be used depending on what is needed for the function of the thermal gas lift 100. Moreover, in one embodiment, a connector 108 or 110 provides a connection for electricity to power an igniter system for the combustor 500 as discussed below.

[0030] Figure 2 illustrates a side view of the thermal gas lift 100 and packing seal 124. The housing 100 includes a first housing portion 102a that includes the oil inlet ports 104 and the oil and gas outlet ports 106, a second housing portion 102b and a third housing portion 102c. Figure 3 illustrates a top view of the thermal gas lift 100 within the casing 122. This top view illustrates the first delivery input connector 108 and the second delivery input connector 110. Referring to cross-sectional side views in Figures 4A-4C, the components of

an embodiment of the thermal gas lift 100 is provided. In particular, Figure 4A is a cross-sectional view of the thermal gas lift along line 4A-4A of Figure 2, Figure 4B is a cross-sectional view of the thermal gas lift along line 4B-4B of Figure 3 and Figure 4C is a cross-sectional view of the thermal gas lift along line 4C-4C of Figure 3. The thermal gas lift 100 of this embodiment includes a combustor system 101 that includes a combustor 500 that is received in the third housing portion 102c and a combustion chamber 200 that is formed within the second housing portion 102b. The thermal gas lift 100 further includes a thermal exchange system 300 and a mix chamber 207 (oil and exhaust gas mixing chamber). The combustor 500 of the combustor system 101 ignites gases pumped into the thermal gas lift 100 via the first and second intake connectors 108 and 110. In particular, passages in the housing 102 deliver the gases to the combustor 500. For example, referring to close up section view 402 of the thermal gas lift 100 illustrated in Figure 6A, an illustration of the first delivery input connector 108 is shown. As illustrated, the first housing portion 102a includes passages 302a that are aligned with a passage in the first delivery input connector 108 in which a gas flows through. Passages 302a are within an outer shell 103 of the housing 102 and extend through the length of the first housing portion 102a as illustrated in Figure 4B. Referring to the close up section view 404 illustrated in Figure 6B, passages 302a extend to passage 302b that extends radially around a second end of the first housing portion 102a. The close up section view 406 of Figure 6C further illustrates the connection of passage 302b to passages 302c in the second housing portion 102b. Passages 302b extend in the second housing portion 102b to the combustor 500 as illustrated in the close up section view 408 illustrated in Figure 6D. Hence, one method of providing passages for fluids such as fuel and air to the combustor 500 has been provided. Passages 302a, 302b and 302c not only provide a delivery means, they also provide a way of cooling the jacket (housing 102). That is, the flow of relatively cool air and fuel passing through the passages 302a, 302b and 302c, helps cool the housing portions 102a and 102b when the combustor 400 is operating.

[0031] Close up section views 404 and 406 in Figures 6B and 6C show a connection sleeve 420 used to couple the first housing portion 102a to the second housing portion 102b. As illustrated, the connection sleeve 420 includes internal threads 422 that threadably engage external threads 130 on the second housing portion 102b. The external threads 130 of the second housing portion 102b are proximate a first end 132 of the second housing portion 102b. The connection sleeve 420 further includes an internal retaining shelf portion 424 proximate a first end 420a of the sleeve 420 that is configured to abut a lip 140 that extends

from a surface of the first housing portion 102a to couple first housing portion 102a to the second housing portion 102b. The lip 140 extends from the first housing portion 102a proximate a second end 142 of the first housing portion. External threads 130 that extend from the first end 132 of the second housing portion 102b terminate at a first connection ring 450 that extends around an outer surface of the second housing portion 102b. The first connection ring 450 of the second housing portion 102b abuts a second end 420b of the connection sleeve 420 when the connection sleeve 420 is coupling the first housing portion 102a to the second housing portion 102b. In one embodiment, a seal (not shown) is positioned between the connections between the sleeve 420 and the first and second housing portions 102a and 102b to seal the combustion chamber 200.

[0032] Close up section view 408 in Figure 6D illustrates the connection between the second housing portion 102b and the third housing portion 102c. The third housing portion 102c can be referred to as the combustor cover 102c. The combustor cover 102c includes internal threads 460 that extend from an open end 462 of the combustor cover 102c a select distance. The combustor cover 102c further includes a closed end 464. The internal threads 460 of the combustor cover 102c are engaged with external threads 150 on the second housing portion 102b. The external threads 150 extend from a second end 152 of the second portion 102b to a second ring 154 that extends around an outer surface of the second portion 102b. As illustrated, an edge about the open end 462 of the cover 102c engages the second ring 154 when the cover 102c is threadably engaged with the second housing portion 102b. In one embodiment, a seal (not shown) is positioned between the cover 102c and the second housing portion 102b to seal the combustor 500 from external elements.

[0033] Close up section view 408 in Figure 6D further illustrates the combustor 500 of an embodiment. A similar combustor is described in U.S. Provisional Application No. 61/664015, titled "Apparatuses and Methods Implementing a Downhole Combustor", filed on June 25, 2012. The combustor 500 includes a fuel delivery conduit 508 that is coupled to a delivery passage, similar to delivery passage 302c, in the second portion 102b of the housing 102. The fuel delivery conduit 508 is coupled to deliver fuel to a pre-mix fuel injector 506. Also coupled to the pre-mix fuel injector is an air delivery conduit 512. The air delivery conduit 512 receives air through a delivery passage, such as delivery passage 302c, illustrated in the second portion 102b of the housing 102. In one embodiment, the air is delivered from the delivery passages 302c into an inner chamber 511 formed in the third housing portion 102c of the housing 102. The air and

the fuel are mixed in the pre-mix fuel injector 506 and are delivered into an ignition cavity 502. The ignition cavity 502 is designed to ensure consistent and reliable ignition of the air/fuel mixture as described further in U.S. Provisional Application No. 61/664,015 even in a relatively high pressure environment. That is, combustion can be achieved with the present design of the thermal gas lift 100 even though the pressure in the combustion area of the thermal gas lift 100 can reach 2,000 psi or more while the thermal gas lift 100 itself is subject to pressures of 30,000 psi or more in deep oil reserves. One or more glow plugs 514 are used to initiate combustion in the ignition cavity 502. The combustor 500 further includes a fuel injector plate 504 which includes a plurality of fuel injector ports that are in fluid communication with a fuel delivery passage in the second portion 102b of the housing 102. Also illustrated in Figure 6D is an air injection plate 516. The air injection plate 516 includes a plurality of passages that pass air into the combustion chamber 200 of the housing 102. In particular, the plurality of passages in the air injection plate 516, are in fluid communication with the air delivery passages in the second portion 102b of the housing 102. The air from the air injection plate 516 (which in one embodiment is an air swirl plate 516) and the fuel from the fuel injector plate 504 are mixed and burned in the combustion chamber 200 of housing 102. The fuel and the air in combustion chamber 200 are initially ignited by the ignited air-fuel mixture from the ignition cavity 502. Once the fuel and air in the combustion chamber 200 are ignited, the power to the glow plugs 514 is shut off. As described above, in one embodiment, one of the connectors 108 or 110 provides a connection to a conductive path through the housing 102 to supply the power to the one or more glow plugs.

[0034] The chemical energy of the gas in the combustion chamber 200 is converted into thermal energy due to the combustion of the air-fuel mixture, and temperature rises in the combustion chamber 200. The heat from the hot gases is used by the thermal exchange system 300 in the first housing portion 102a to heat up oil 206 from the oil reservoir 205 entering in the oil intake ports 104 of the housing 102. The thermal exchange system 300 includes heat exchange tubes 320. The incoming oil 206 from the oil input ports 104 flows around the heat exchange tubes 320 therein receiving heat from the exchange tubes 320. Some of the tubes 320 have exhaust passages 321 (or combustion chamber exhaust ports 321) that allow the hot gases to escape from the combustion chamber 200 into the oil 206 passing through the first housing portion 102a and out the oil and gas outlet ports 106. The heat exchange tubes 320 can be further seen in the cross-sectional top view of Figure 5A. In

particular, Figure 5A illustrates a top cross-sectional view of the thermal gas lift 100 along line 5A-5A of Figure 2. As illustrated in this view, top views of the heat exchange tubes 320 in the oil and exhaust gas mixing chamber 207 of the first section 102a of the housing 102 are shown. Some of the heat exchange tubes 320 include exhaust passages 321 (or exhaust ports) that allow the exhaust gas from the combustion chamber 200 to travel into the oil and exhaust gas mixing chamber 207. Also illustrated in Figure 5A is the oil and gas outlet ports 106 through the first housing portion 102a and passages 302a that deliver the fuel and air to the combustor 500. As discussed above, one of the passages 302a can be used as a path for a conductor to provide power to the one or more glow plugs 514 for initial ignition of the combustor 500. Figure 5B illustrates a cross sectional top view along line 5B-5B of Figure 2. This view is below the oil and gas outlet ports 106 in the first housing section 102a but still above the heat exchange tubes 320.

[0035] Figure 5C illustrates a cross sectional top view along line 5C-5C of Figure 2. Figure 5C illustrates, mid portions of some of the heat exchange tubes 320. Figure 5D illustrates a cross sectional top view along line 5D-5D of Figure 2. Figure 5D illustrates the oil intake ports 104 through the first housing section 102a. Finally, Figure 5E illustrates a cross sectional top view along line 5E-5E of Figure 2. Figure 5E illustrates a top of the fuel injector plate 504, the air swirl plate 516 and a plurality of passages 302c through the second housing portion 102b. As discussed above, the passages 302c provide paths for the fuel and air to the combustor 500 as well as a conductor path to provide power to the glow plugs 514 of the combustor 500.

[0036] As discussed above, the downhole combustor 500 may have many different applications. For example, referring to Figure 7, a power generator 600 is illustrated. In this embodiment, the combustor 500 transitions into an axial flow turbo-expander 602. The configuration heats the oil and the combination of the heated oil and exhaust gases turns a progressive cavity pump 604 having a rotationally mounted rod 606 with offset helically swept fins 608 and 610. The rotation of the progressive cavity pump 604 is used to generate direct mechanical work. The mechanical work in one embodiment can be used to generate electricity. This embodiment is useful when the well bore is really deep and the losses from power supplied externally at those distances are great. Hence, a power generating source down the well bore is beneficial in this situation. Another embodiment that uses a downhole combustor 500 is illustrated in Figure 8. Figure 8 illustrates a reforming system 700. A reforming system 700, similar to the thermal lift system described above, is used to improve

oil mobility with a mixture of heat plus the hydrogenation of the oil with a catalyst to generate byproducts such as H_2 , H_2O , CO and CO_2 . In an embodiment of the reformation system, the downhole combustor 500 will support a reaction temperature of approximately $200^{\circ}C$ to $800^{\circ}C$ depending on different reaction temperatures and reaction times. An exhaust gas of CO_2 will act as a solvent, lowering the heavy oil viscosity and density. For higher Hydrogen to Carbon ratio fuels (such as methane) a steam reformer section is added to alter the chemical composition to a lighter mobile oil for ease of transportation. Lower Hydrogen to Carbon ratio fuels (such as propane) can react with water in the heavy oil to add additional H_2 for the reaction process. The reformer system 700 of Figure 8 includes a high pressure combustor 500 that combusts gases delivered through the housing 102 as discussed above. Exhaust gases are passed through the reformer heat exchange system 700 which heats the oil that enters the oil inlet ports 104 in the housing 102. The exhaust gases are then injected into the oil in the oil and exhaust gas mixture chamber 207 and the reformed hydrocarbon is passed out the oil and gas outlet ports 106 of the housing. Hence, the downhole combustor system described above has many different applications.

[0037] Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement, which is calculated to achieve the same purpose, may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. Therefore, it is manifestly intended that this invention be limited only by the claims and the equivalents thereof.

CLAIMS

1. A downhole combustor system comprising:
 - a longitudinally extending housing configured and arranged to be positioned down a wellbore of a production well, the housing including:
 - a first housing portion having an oil and gas mixing chamber, the first housing portion having at least one inlet port to the oil and gas mixing chamber to allow passage of oil from an oil reservoir in communication with the wellbore into the oil and gas mixture chamber, the first housing portion further having at least one outlet port out of the oil and gas mixing chamber to allow passage of mixed oil from the oil reserve and exhaust gas out of the oil and gas mixing chamber into the wellbore, the at least one outlet port spaced a longitudinal distance above the at least one inlet port; and
 - a second housing portion comprising a combustion chamber below the first housing portion, the second housing portion coupled to the first housing portion;
 - a combustor below the combustion chamber configured and arranged to combust fuel in the combustion chamber;
 - a plurality of heat exchange tubes received within the first portion of the housing proximate the oil and gas mixing chamber and laterally adjacent to the at least one inlet port, the heat exchange tubes coupled to transfer heat of exhaust gases generated in the combustion chamber and passing through the plurality of heat exchange tubes to oil entering the first portion of the housing through the at least one inlet port; and
 - at least one exhaust port positioned to deliver exhaust gases from at least some of the plurality of heat exchange tubes into the oil and gas mixing chamber.

2. The downhole combustor system of claim 1, wherein:
 - the housing has a plurality of delivery passages; and
 - further comprising at least one input delivery connector in fluid communication with at least one of the delivery passages to deliver at least one of air and fuel to the combustor.

3. The downhole combustor system of claim 1, further comprising:
a third housing portion coupled to the second housing and housing the combustor.
4. The downhole combustor system of claim 3, further comprising:
a sleeve configured and arranged to couple the second housing portion to the first housing portion.
5. The downhole combustor of claim 1, wherein:
the plurality of heat exchange tubes forms at least a part of a heat exchange system received in the housing proximate the combustion chamber, the heat exchange system configured and arranged to transfer heat from the combustion chamber to oil within the first portion of the housing.
6. The downhole combustor of claim 1 further comprising:
at least one of a thermal gas lift system, an energy generating system and an oil reforming system.
7. A downhole combustor system for a production well, the downhole combustor system comprising:
a housing configured for disposition in a wellbore and comprising an oil and exhaust gas mixing chamber and a combustion chamber, the housing having at least one oil input port passing through an outer shell of the housing allowing passage into the housing of oil from an oil reservoir in communication with the wellbore, the housing further having at least one oil and exhaust gas output port passing through the outer shell of the housing at a longitudinally spaced distance from the at least one oil input port, the at least one oil and exhaust gas output port configured and arranged to pass oil and exhaust gas out of the housing, the housing further having at least one delivery passage within the outer shell of the housing;
at least one delivery connector coupled to the housing, the at least one delivery connector in fluid communication with at least one associated delivery passage;

a combustor configured and arranged to combust fuel in a combustion chamber, the combustor configured and arranged to receive fuel and air passed through the at least one delivery passage;

a plurality of heat exchange tubes received within the housing proximate the oil and exhaust mixing chamber, each heat exchange tube coupled to receive exhaust gases generated in the combustion chamber, to transfer heat from the exhaust gases to oil in the housing; and

exhaust ports positioned to pass exhaust gases from a least some heat exchange tubes of the plurality to the oil and exhaust gas mixing chamber.

8. The downhole combustor system of claim 7, wherein the housing further comprises:

a first housing portion, the first housing portion having a first end and an opposed, second end, the first housing portion forming the oil and gas mixture chamber;

a second housing portion, a first end of the second housing portion coupled to the second end of the first housing portion, the second housing portion comprising the combustion chamber; and

a third housing portion coupled to a second end of the second housing portion and containing the combustor.

9. The downhole combustor system of claim 7, wherein the plurality of heat exchange tubes form at least part of a heat exchange system received in the housing proximate the combustion chamber, the heat exchange system configured and arranged to transfer heat generated in the combustion chamber to oil in the oil and exhaust gas mixing chamber.

10. The downhole combustor system of claim 7, further comprising:

at least one of a thermal gas lift system, an energy generating system and an oil reforming system.

11. The downhole combustor system of claim 2, wherein the plurality of delivery passages in the housing is configured and arranged to cool the housing.

12. A method of extracting oil from an oil reservoir, the method comprising:
 - positioning a downhole combustor in a wellbore in communication with the oil reservoir;
 - sealing the wellbore between a casing structure lining the wellbore and an exterior of a housing containing an oil and gas mixing chamber, a combustor and a combustion chamber of the combustor system with a packing seal;
 - delivering fuel to the combustor through passages in the housing;
 - initiating an ignition system of the combustor to combust the fuel in the combustion chamber;
 - heating oil passing into the housing from the oil reservoir below the packing seal with a plurality of heat exchange tubes positioned within the oil and gas mixing chamber that are in communication with exhaust gases from the combustion chamber;
 - mixing the oil passed into the housing with exhaust gases exiting at least some of the plurality of heat exchange tubes into the oil and gas mixing chamber;
 - and
 - venting exhaust gases mixed with oil from the housing into the wellbore above the packing seal.
13. The method of claim 12, further comprising:
 - cooling the housing with the fuel delivered through passages in the housing.
14. The method of claim 12, further comprising:
 - reforming oil, at least in part in the combustor with the exhaust gases from the combustion chamber.
15. The method of claim 12, further comprising:
 - generating mechanical work using energy from the exhaust gases from the combustion chamber.

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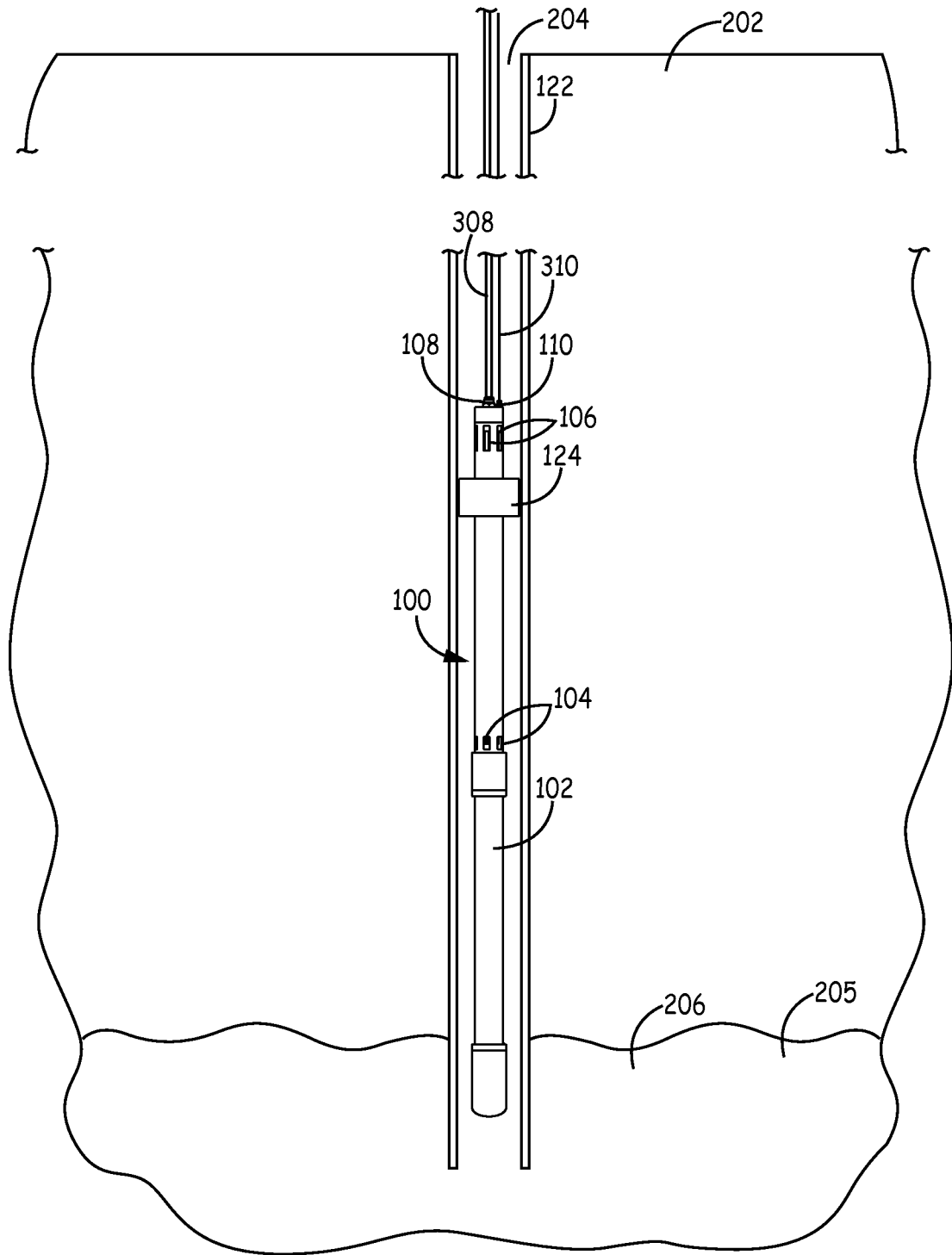


FIG. 1

2 / 10

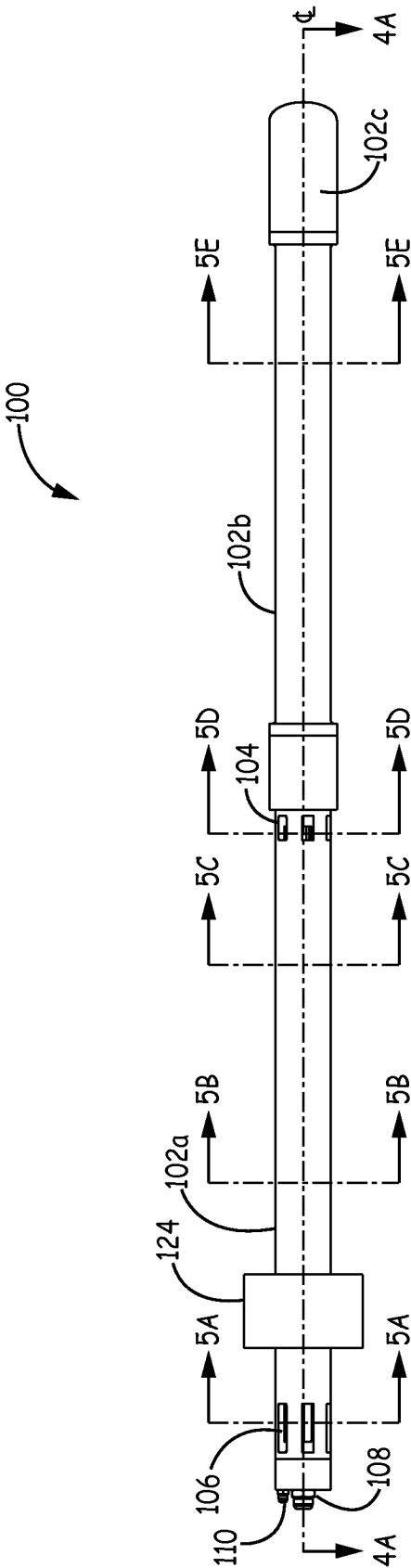


FIG. 2

3 / 10

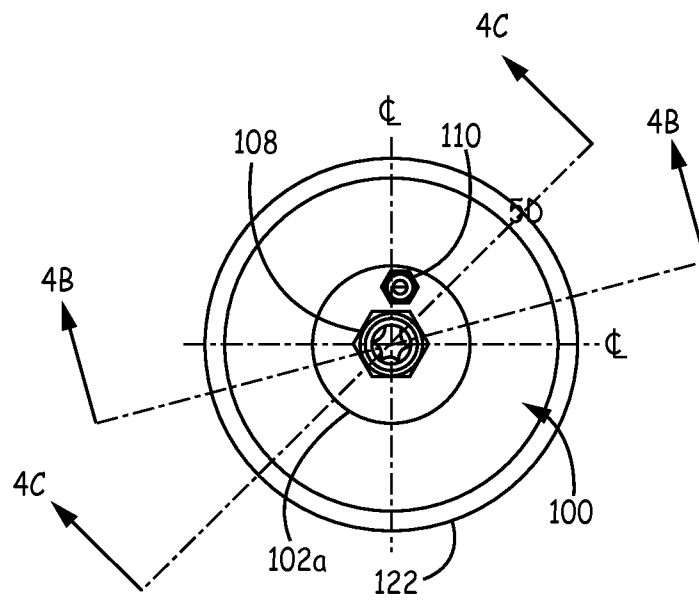


FIG. 3

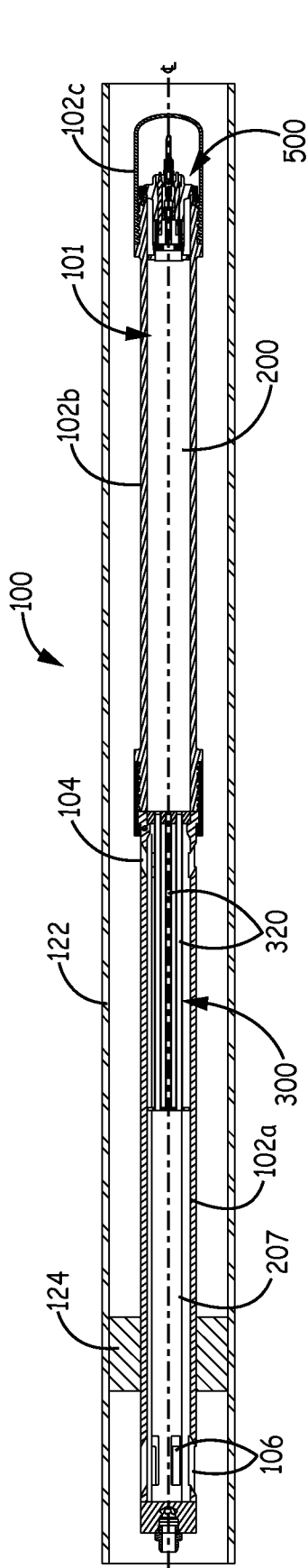


FIG. 4A

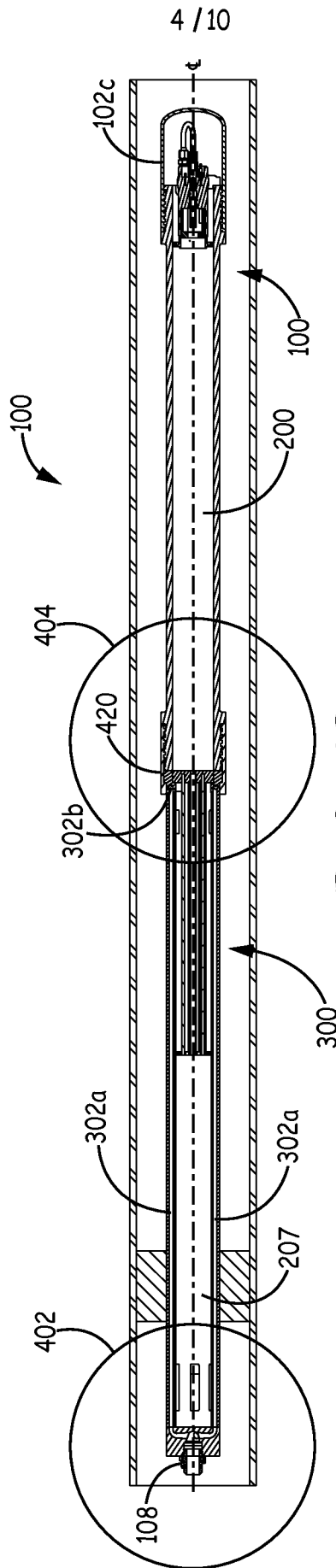


FIG. 4B

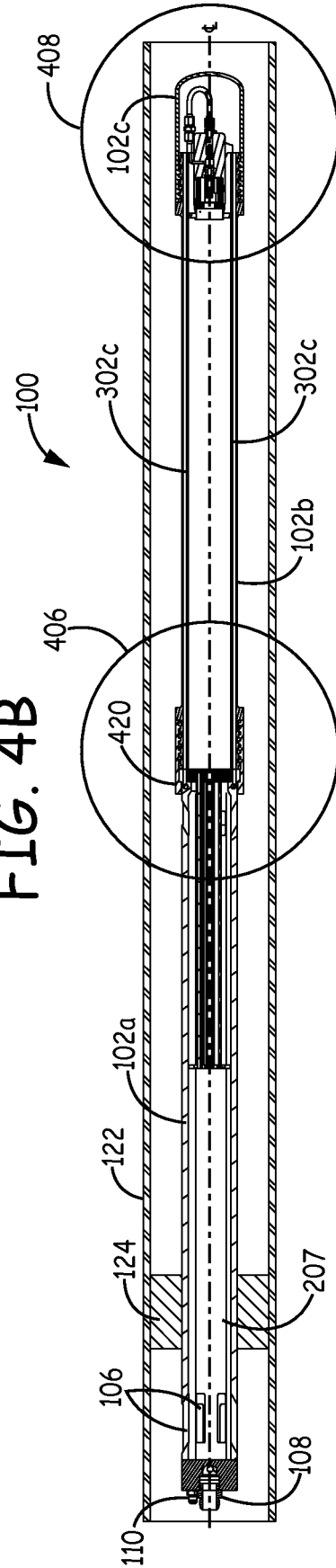


FIG. 4C

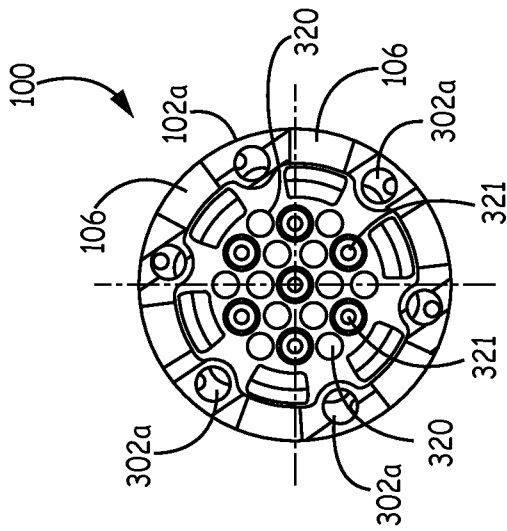


FIG. 5A

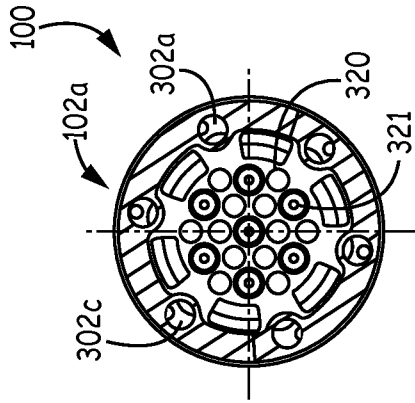


FIG. 5B

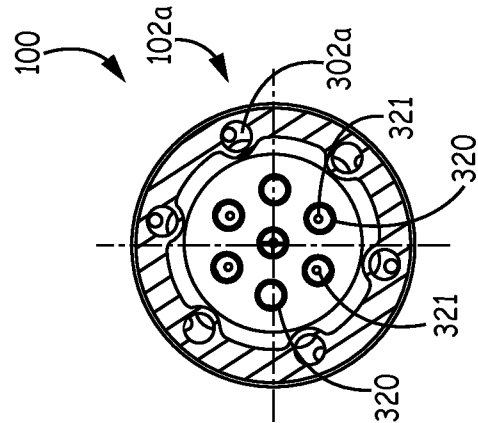


FIG. 5C

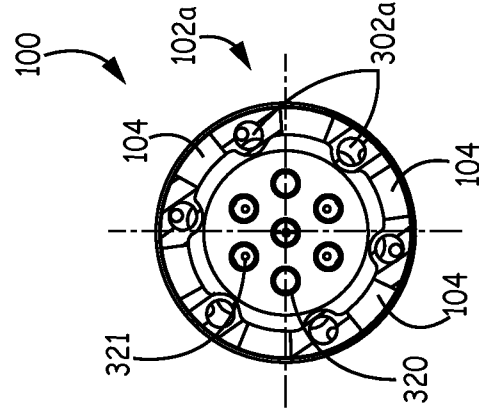


FIG. 5D

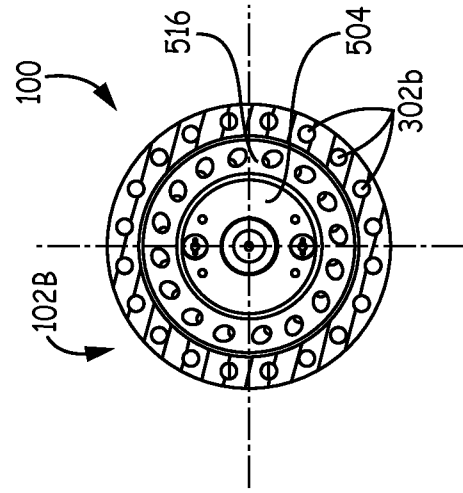


FIG. 5E

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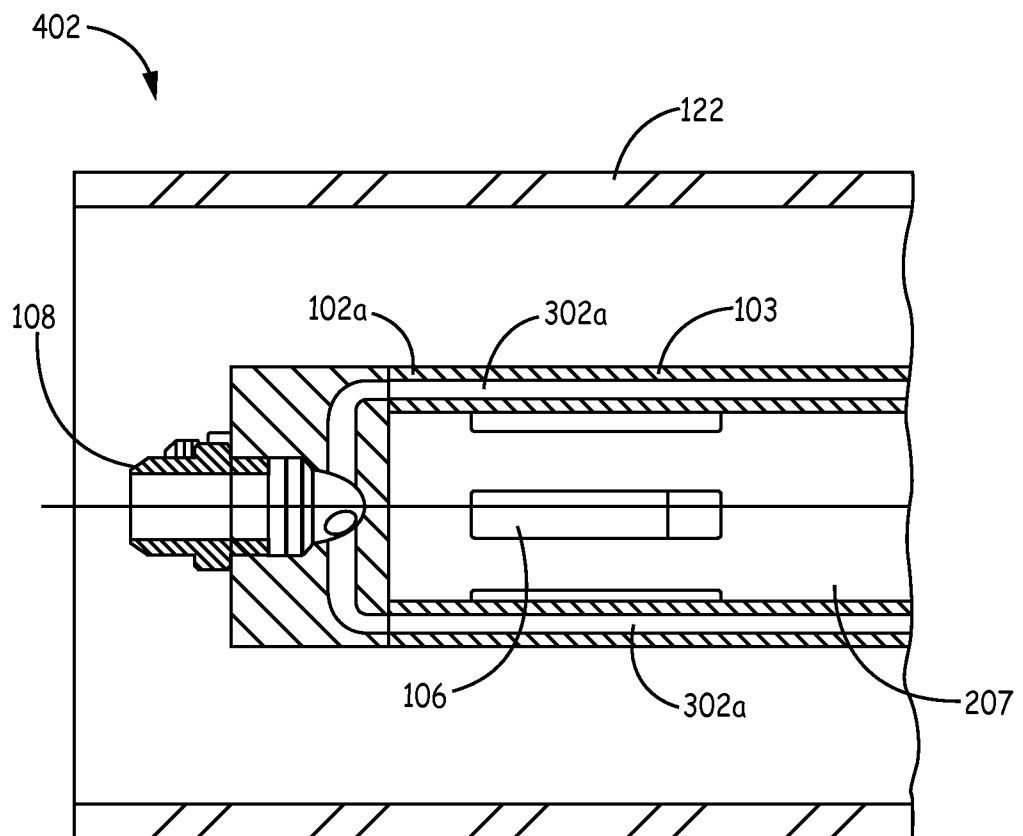


FIG. 6A

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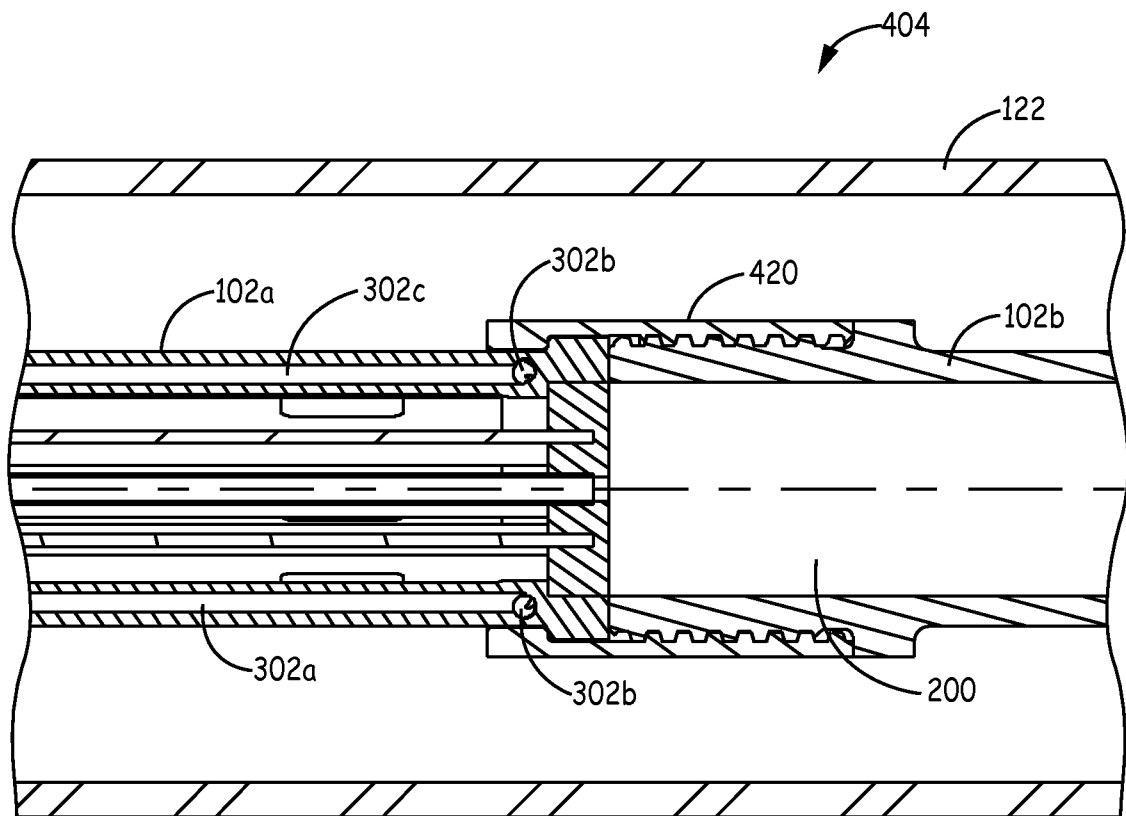


FIG. 6B

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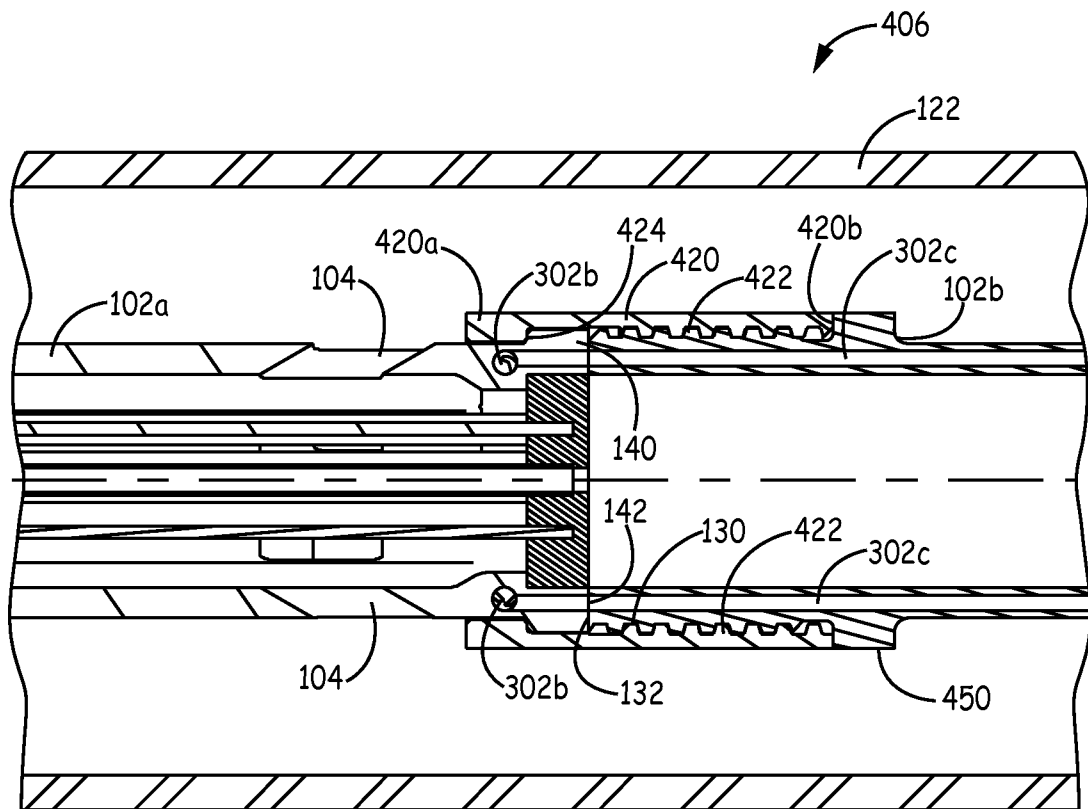


FIG. 6C

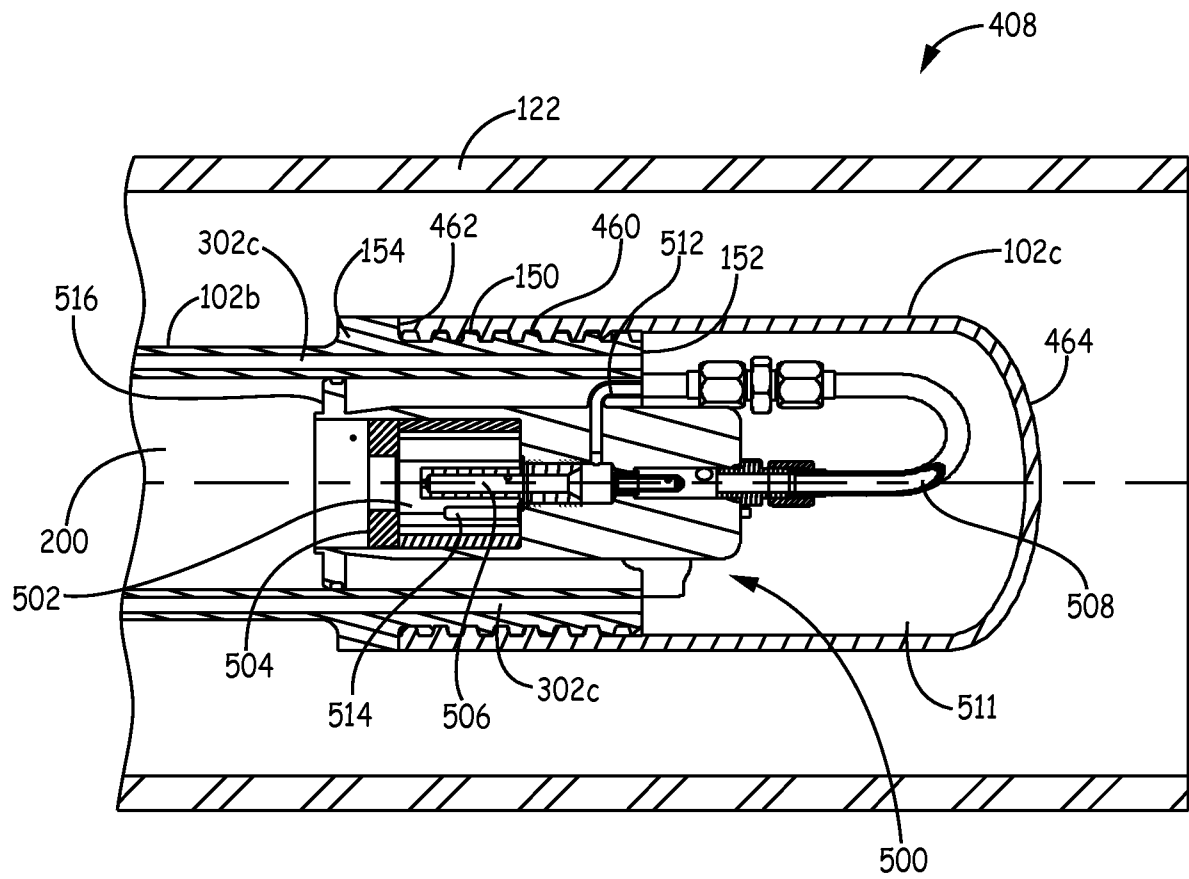


FIG. 6D

10/10

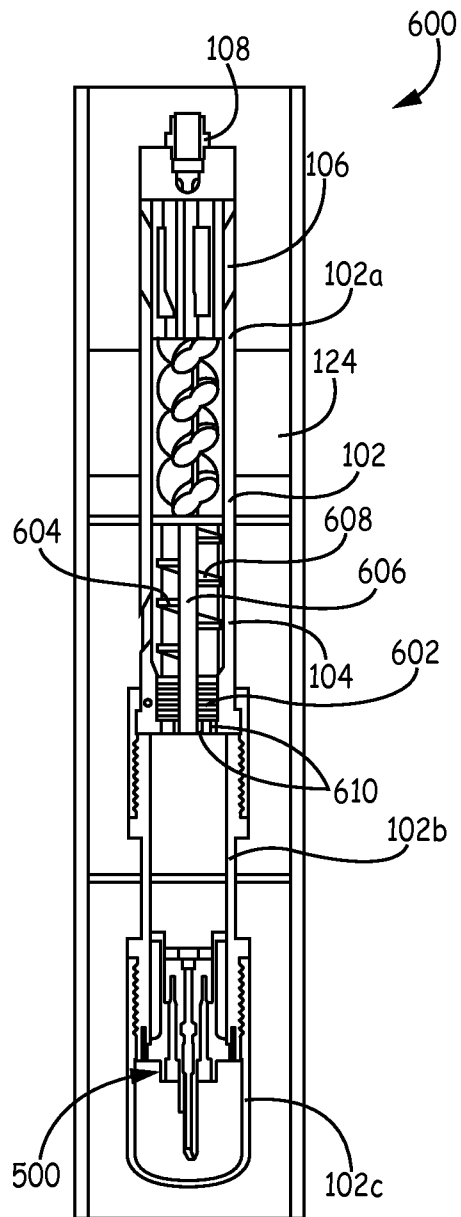


FIG. 7

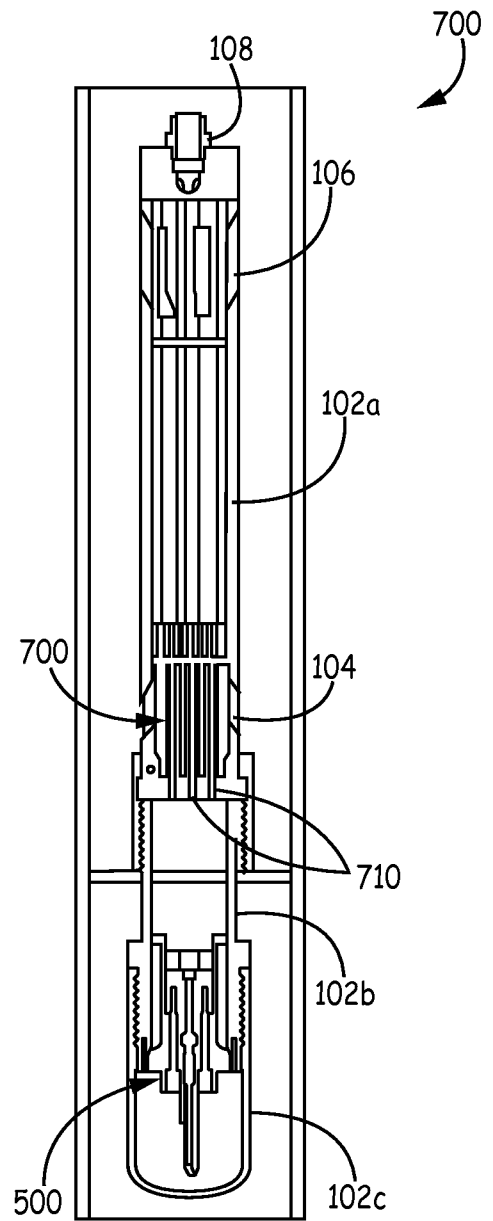


FIG. 8

