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(54) **Title**: SYSTEM AND METHOD FOR A TURBINE COMBUSTOR

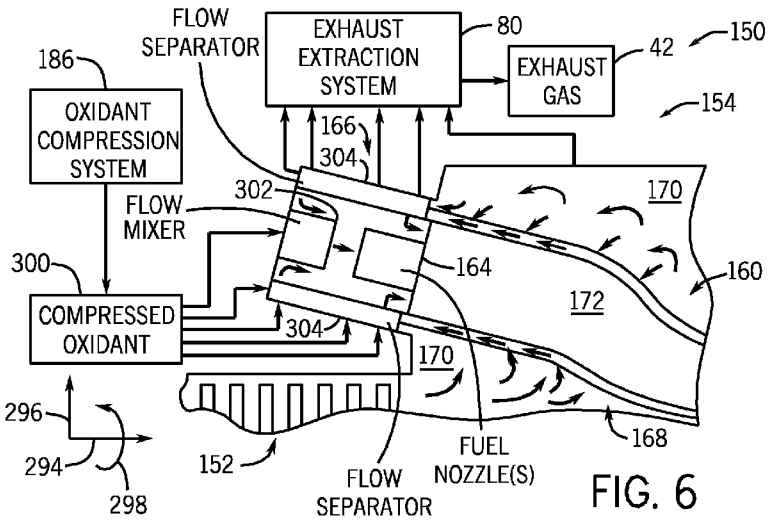


FIG. 6

(57) **Abstract**: A system includes a turbine combustor that includes a head end portion having a head end chamber, a combustion portion having a combustion chamber disposed downstream from the head end chamber, a cap disposed between the head end chamber and the combustion chamber, and a flow distributor configured to distribute an exhaust flow circumferentially around the head end chamber. The flow distributor includes at least one exhaust gas flow path.

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

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SYSTEM AND METHOD FOR A TURBINE COMBUSTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and benefit of U.S. Non-Provisional Patent Application No. 14/067,726, entitled "SYSTEM AND METHOD FOR A TURBINE COMBUSTOR," filed on October 30, 2013, U.S. Provisional Patent Application No. 61/747,203, entitled "SYSTEM AND METHOD FOR A TURBINE COMBUSTOR," filed on December 28, 2012, U.S. Provisional Patent Application No. 61/722,118, entitled "SYSTEM AND METHOD FOR DIFFUSION COMBUSTION IN A STOICHIOMETRIC EXHAUST GAS RECIRCULATION GAS TURBINE SYSTEM," filed on November 2, 2012, U.S. Provisional Patent Application No. 61/722,115, entitled "SYSTEM AND METHOD FOR DIFFUSION COMBUSTION WITH FUEL-DILUENT MIXING IN A STOICHIOMETRIC EXHAUST GAS RECIRCULATION GAS TURBINE SYSTEM," filed on November 2, 2012, U.S. Provisional Patent Application No. 61/722,114, entitled "SYSTEM AND METHOD FOR DIFFUSION COMBUSTION WITH OXIDANT-DILUENT MIXING IN A STOICHIOMETRIC EXHAUST GAS RECIRCULATION GAS TURBINE SYSTEM," filed on November 2, 2012, and U.S. Provisional Patent Application No. 61/722,111, entitled "SYSTEM AND METHOD FOR LOAD CONTROL WITH DIFFUSION COMBUSTION IN A STOICHIOMETRIC EXHAUST GAS RECIRCULATION GAS TURBINE SYSTEM," filed on November 2, 2012, all of which are herein incorporated by reference in their entirety for all purposes.

BACKGROUND OF THE INVENTION

[0002] The subject matter disclosed herein relates to gas turbine engines, and, more particularly, to systems and methods for turbine combustors of gas turbine engines.

[0003] Gas turbine engines are used in a wide variety of applications, such as power generation, aircraft, and various machinery. Gas turbine engines generally

combust a fuel with an oxidant (e.g., air) in a combustor section to generate hot combustion products, which then drive one or more turbine stages of a turbine section. In turn, the turbine section drives one or more compressor stages of a compressor section, thereby compressing oxidant for intake into the combustor section along with the fuel. Again, the fuel and oxidant mix in the combustor section, and then combust to produce the hot combustion products. Gas turbine engines generally premix the fuel and oxidant along one or more flow paths upstream from a combustion chamber of the combustor section. Unfortunately, certain components of the combustor section are exposed to high temperatures, which may reduce the life of the components. Furthermore, gas turbine engines typically consume a vast amount of air as the oxidant, and output a considerable amount of exhaust gas into the atmosphere. In other words, the exhaust gas is typically wasted as a byproduct of the gas turbine operation.

BRIEF DESCRIPTION OF THE INVENTION

[0004] Certain embodiments commensurate in scope with the originally claimed invention are summarized below. These embodiments are not intended to limit the scope of the claimed invention, but rather these embodiments are intended only to provide a brief summary of possible forms of the invention. Indeed, the invention may encompass a variety of forms that may be similar to or different from the embodiments set forth below.

[0005] In a first embodiment, a system includes a turbine combustor that includes a head end portion having a head end chamber, a combustion portion having a combustion chamber disposed downstream from the head end chamber, a cap disposed between the head end chamber and the combustion chamber, and a flow distributor configured to distribute an exhaust flow circumferentially around the head end chamber. The flow distributor includes at least one exhaust gas flow path.

[0006] In a second embodiment, a system includes an oxidant compressor and a gas turbine engine that includes a combustor section having a turbine combustor, a turbine driven by combustion products from the turbine combustor, and an exhaust

gas compressor driven by the turbine. The exhaust gas compressor is configured to compress and route an exhaust flow to the turbine combustor and the oxidant compressor is configured to compress and route an oxidant flow to the turbine combustor. The gas turbine engine also includes an exhaust extraction port coupled to the combustor section and a flow distributor configured to distribute an exhaust flow circumferentially around a head end chamber of the turbine combustor. The flow distributor includes at least one exhaust gas flow path.

[0007] In a third embodiment, a method includes extracting a first exhaust flow of an exhaust gas at a combustion section of a gas turbine engine, routing a second exhaust flow of the exhaust gas toward an end plate of a head end portion of a turbine combustor in the combustion section, and routing a third exhaust flow of the exhaust gas toward a cap of the head end portion. The cap is disposed between a head end region and a combustion region. The method also includes routing an oxidant flow into the head end portion and distributing at least one of the first exhaust flow, the second exhaust flow, or the third exhaust flow circumferentially around the head end portion using a flow distributor. The flow distributor includes at least one exhaust gas flow path.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0009] FIG. 1 is a diagram of an embodiment of a system having a turbine-based service system coupled to a hydrocarbon production system;

[0010] FIG. 2 is a diagram of an embodiment of the system of FIG. 1, further illustrating a control system and a combined cycle system;

[0011] FIG. 3 is a diagram of an embodiment of the system of FIGS. 1 and 2, further illustrating details of a gas turbine engine, exhaust gas supply system, and exhaust gas processing system;

[0012] FIG. 4 is a flow chart of an embodiment of a process for operating the system of FIGS. 1-3;

[0013] FIG. 5 is a flow chart of an embodiment of a process for operating a gas turbine engine with exhaust gas recirculation;

[0014] FIG. 6 is a schematic diagram of an embodiment of a combustor section of a gas turbine engine with exhaust gas recirculation;

[0015] FIG. 7 is a schematic diagram of an embodiment of a turbine combustor of the gas turbine engine of FIG. 6, illustrating a flow distributor;

[0016] FIG. 8 is a radial cross-sectional view of an embodiment of a turbine combustor taken along line 8-8 of FIG. 7;

[0017] FIG. 9 is a radial cross-sectional view of an embodiment of a turbine combustor taken along line 8-8 of FIG. 7;

[0018] FIG. 10 is a cross-sectional view of an embodiment of a turbine combustor of the gas turbine engine of FIG. 6, illustrating a flow distributor coupled to an oxidant intake port;

[0019] FIG. 11 is a cross-sectional view of an embodiment of a turbine combustor of the gas turbine engine of FIG. 6, illustrating a flow distributor coupled to an exhaust extraction port;

[0020] FIG. 12 is a schematic diagram of an embodiment of a turbine combustor of the gas turbine engine of FIG. 6, illustrating a flow distributor;

[0021] FIG. 13 is a radial cross-sectional view of an embodiment of a turbine combustor taken along line 13-13 of FIG. 12;

[0022] FIG. 14 is a radial cross-sectional view of an embodiment of a turbine combustor taken along line 13-13 of FIG. 12;

[0023] FIG. 15 is a cross-sectional view of an embodiment of a turbine combustor of the gas turbine engine of FIG. 6, illustrating a flow distributor coupled to an exhaust gas flow path;

[0024] FIG. 16 is a cross-sectional view of an embodiment of a turbine combustor of the gas turbine engine of FIG. 6, illustrating a flow distributor coupled to an exhaust extraction port;

[0025] FIG. 17 is an exploded schematic of various embodiments of flow distributors that may be removably coupled to the turbine combustor;

[0026] FIG. 18 is a radial cross-sectional view of an embodiment of a turbine combustor with a plurality of flow distributors;

[0027] FIG. 19 is a radial cross-sectional view of an embodiment of a turbine combustor with a plurality of passages; and

[0028] FIG. 20 is a radial cross-sectional view of an embodiment of a turbine combustor with a plurality of passages of different diameters.

DETAILED DESCRIPTION OF THE INVENTION

[0029] One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be

a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0030] When introducing elements of various embodiments of the present invention, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

[0031] As discussed in detail below, the disclosed embodiments relate generally to gas turbine systems with exhaust gas recirculation (EGR), and particularly stoichiometric operation of the gas turbine systems using EGR. For example, the gas turbine systems may be configured to recirculate the exhaust gas along an exhaust recirculation path, stoichiometrically combust fuel and oxidant along with at least some of the recirculated exhaust gas, and capture the exhaust gas for use in various target systems. The recirculation of the exhaust gas along with stoichiometric combustion may help to increase the concentration level of carbon dioxide (CO_2) in the exhaust gas, which can then be post treated to separate and purify the CO_2 and nitrogen (N_2) for use in various target systems. The gas turbine systems also may employ various exhaust gas processing (e.g., heat recovery, catalyst reactions, etc.) along the exhaust recirculation path, thereby increasing the concentration level of CO_2, reducing concentration levels of other emissions (e.g., carbon monoxide, nitrogen oxides, and unburnt hydrocarbons), and increasing energy recovery (e.g., with heat recovery units). Furthermore, the gas turbine engines may be configured to combust the fuel and oxidant with one or more diffusion flames (e.g., using diffusion fuel nozzles), premix flames (e.g., using premix fuel nozzles), or any combination thereof. In certain embodiments, the diffusion flames may help to maintain stability and operation within certain limits for stoichiometric combustion, which in turn helps to increase production of CO_2. For example, a gas turbine system operating with diffusion flames may enable a greater quantity of EGR, as compared to a gas turbine system operating with premix flames. In turn, the increased quantity of EGR helps to increase CO_2 production. Possible target systems include pipelines, storage tanks,

carbon sequestration systems, and hydrocarbon production systems, such as enhanced oil recovery (EOR) systems.

[0032] The disclosed embodiments provide systems and methods for turbine combustors of gas turbine systems with EGR. Specifically, the turbine combustor may include a head end portion having a head end chamber, a combustion portion having a combustion chamber disposed downstream from the head end chamber, a cap disposed between the head end chamber and the combustion chamber, and a flow distributor configured to distribute an exhaust flow circumferentially around the head end chamber. The flow distributor may include at least one exhaust gas flow path. In addition, the flow distributor may direct the exhaust flow into the head end chamber or to an exhaust gas extraction system and/or a hydrocarbon production system. In addition, the turbine combustor may include a mixing region to mix the exhaust flow with the oxidant flow to provide the oxidant-exhaust mixture, which may be directed into the head end chamber by the flow distributor. The turbine combustor may combust the oxidant-exhaust mixture together with a fuel to generate combustion products or gases that may be used to drive a turbine. In certain embodiments, the turbine combustor may be part of a stoichiometeric exhaust gas recirculation (SEGR) gas turbine engine. The SEGR gas turbine engine may include a combustor section having the turbine combustor, a turbine driven by the combustion products from the turbine combustor, and an exhaust gas compressor driven by the turbine. The exhaust gas compressor may compress and route an exhaust flow to the turbine combustor and an oxidant compressor may compress and route the oxidant flow to the turbine combustor. In addition, an exhaust extraction port may be coupled to the combustor section. Use of such embodiments of turbine combustors may provide several advantages compared to previous turbine combustors. For example, the disclosed embodiments of turbine combustors may directly provide the exhaust flow used in other applications, such as the hydrocarbon production system. In addition, such turbine combustors may provide improved cooling of internal components of the turbine combustor. Specifically, even though large amounts of the exhaust flow are removed from the turbine combustor, the internal configuration of the turbine combustor enables internal surfaces of the combustor that are exposed to high

temperatures to be cooled by the exhaust flow. For example, the exhaust flow may be circumferentially distributed by the flow distributor to certain portions of the turbine combustor for increased cooling. Thus, such turbine combustors may have increased longevity and/or reduced maintenance costs compared to previous combustors.

[0033] FIG. 1 is a diagram of an embodiment of a system 10 having an hydrocarbon production system 12 associated with a turbine-based service system 14. As discussed in further detail below, various embodiments of the turbine-based service system 14 are configured to provide various services, such as electrical power, mechanical power, and fluids (e.g., exhaust gas), to the hydrocarbon production system 12 to facilitate the production or retrieval of oil and/or gas. In the illustrated embodiment, the hydrocarbon production system 12 includes an oil/gas extraction system 16 and an enhanced oil recovery (EOR) system 18, which are coupled to a subterranean reservoir 20 (e.g., an oil, gas, or hydrocarbon reservoir). The oil/gas extraction system 16 includes a variety of surface equipment 22, such as a Christmas tree or production tree 24, coupled to an oil/gas well 26. Furthermore, the well 26 may include one or more tubulars 28 extending through a drilled bore 30 in the earth 32 to the subterranean reservoir 20. The tree 24 includes one or more valves, chokes, isolation sleeves, blowout preventers, and various flow control devices, which regulate pressures and control flows to and from the subterranean reservoir 20. While the tree 24 is generally used to control the flow of the production fluid (e.g., oil or gas) out of the subterranean reservoir 20, the EOR system 18 may increase the production of oil or gas by injecting one or more fluids into the subterranean reservoir 20.

[0034] Accordingly, the EOR system 18 may include a fluid injection system 34, which has one or more tubulars 36 extending through a bore 38 in the earth 32 to the subterranean reservoir 20. For example, the EOR system 18 may route one or more fluids 40, such as gas, steam, water, chemicals, or any combination thereof, into the fluid injection system 34. For example, as discussed in further detail below, the EOR system 18 may be coupled to the turbine-based service system 14, such that the system 14 routes an exhaust gas 42 (e.g., substantially or entirely free of oxygen) to the EOR system 18 for use as the injection fluid 40. The fluid injection system 34

routes the fluid 40 (e.g., the exhaust gas 42) through the one or more tubulars 36 into the subterranean reservoir 20, as indicated by arrows 44. The injection fluid 40 enters the subterranean reservoir 20 through the tubular 36 at an offset distance 46 away from the tubular 28 of the oil/gas well 26. Accordingly, the injection fluid 40 displaces the oil/gas 48 disposed in the subterranean reservoir 20, and drives the oil/gas 48 up through the one or more tubulars 28 of the hydrocarbon production system 12, as indicated by arrows 50. As discussed in further detail below, the injection fluid 40 may include the exhaust gas 42 originating from the turbine-based service system 14, which is able to generate the exhaust gas 42 on-site as needed by the hydrocarbon production system 12. In other words, the turbine-based system 14 may simultaneously generate one or more services (e.g., electrical power, mechanical power, steam, water (e.g., desalinated water), and exhaust gas (e.g., substantially free of oxygen)) for use by the hydrocarbon production system 12, thereby reducing or eliminating the reliance on external sources of such services.

[0035] In the illustrated embodiment, the turbine-based service system 14 includes a stoichiometric exhaust gas recirculation (SEGR) gas turbine system 52 and an exhaust gas (EG) processing system 54. The gas turbine system 52 may be configured to operate in a stoichiometric combustion mode of operation (e.g., a stoichiometric control mode) and a non-stoichiometric combustion mode of operation (e.g., a non-stoichiometric control mode), such as a fuel-lean control mode or a fuel-rich control mode. In the stoichiometric control mode, the combustion generally occurs in a substantially stoichiometric ratio of a fuel and oxidant, thereby resulting in substantially stoichiometric combustion. In particular, stoichiometric combustion generally involves consuming substantially all of the fuel and oxidant in the combustion reaction, such that the products of combustion are substantially or entirely free of unburnt fuel and oxidant. One measure of stoichiometric combustion is the equivalence ratio, or phi (ϕ), which is the ratio of the actual fuel/oxidant ratio relative to the stoichiometric fuel/oxidant ratio. An equivalence ratio of greater than 1.0 results in a fuel-rich combustion of the fuel and oxidant, whereas an equivalence ratio of less than 1.0 results in a fuel-lean combustion of the fuel and oxidant. In contrast, an equivalence ratio of 1.0 results in combustion that is neither fuel-rich nor fuel-lean,

thereby substantially consuming all of the fuel and oxidant in the combustion reaction. In context of the disclosed embodiments, the term stoichiometric or substantially stoichiometric may refer to an equivalence ratio of approximately 0.95 to approximately 1.05. However, the disclosed embodiments may also include an equivalence ratio of 1.0 plus or minus 0.01, 0.02, 0.03, 0.04, 0.05, or more. Again, the stoichiometric combustion of fuel and oxidant in the turbine-based service system 14 may result in products of combustion or exhaust gas (e.g., 42) with substantially no unburnt fuel or oxidant remaining. For example, the exhaust gas 42 may have less than 1, 2, 3, 4, or 5 percent by volume of oxidant (e.g., oxygen), unburnt fuel or hydrocarbons (e.g., HCs), nitrogen oxides (e.g., NO_X), carbon monoxide (CO), sulfur oxides (e.g., SO_X), hydrogen, and other products of incomplete combustion. By further example, the exhaust gas 42 may have less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 1000, 2000, 3000, 4000, or 5000 parts per million by volume (ppmv) of oxidant (e.g., oxygen), unburnt fuel or hydrocarbons (e.g., HCs), nitrogen oxides (e.g., NO_X), carbon monoxide (CO), sulfur oxides (e.g., SO_X), hydrogen, and other products of incomplete combustion. However, the disclosed embodiments also may produce other ranges of residual fuel, oxidant, and other emissions levels in the exhaust gas 42. As used herein, the terms emissions, emissions levels, and emissions targets may refer to concentration levels of certain products of combustion (e.g., NO_X, CO, SO_X, O_2, N_2, H_2, HCs, etc.), which may be present in recirculated gas streams, vented gas streams (e.g., exhausted into the atmosphere), and gas streams used in various target systems (e.g., the hydrocarbon production system 12).

[0036] Although the SEGR gas turbine system 52 and the EG processing system 54 may include a variety of components in different embodiments, the illustrated EG processing system 54 includes a heat recovery steam generator (HRSG) 56 and an exhaust gas recirculation (EGR) system 58, which receive and process an exhaust gas 60 originating from the SEGR gas turbine system 52. The HRSG 56 may include one or more heat exchangers, condensers, and various heat recovery equipment, which collectively function to transfer heat from the exhaust gas 60 to a stream of water, thereby generating steam 62. The steam 62 may be used in one or more steam

turbines, the EOR system 18, or any other portion of the hydrocarbon production system 12. For example, the HRSG 56 may generate low pressure, medium pressure, and/or high pressure steam 62, which may be selectively applied to low, medium, and high pressure steam turbine stages, or different applications of the EOR system 18. In addition to the steam 62, a treated water 64, such as a desalinated water, may be generated by the HRSG 56, the EGR system 58, and/or another portion of the EG processing system 54 or the SEGR gas turbine system 52. The treated water 64 (e.g., desalinated water) may be particularly useful in areas with water shortages, such as inland or desert regions. The treated water 64 may be generated, at least in part, due to the large volume of air driving combustion of fuel within the SEGR gas turbine system 52. While the on-site generation of steam 62 and water 64 may be beneficial in many applications (including the hydrocarbon production system 12), the on-site generation of exhaust gas 42, 60 may be particularly beneficial for the EOR system 18, due to its low oxygen content, high pressure, and heat derived from the SEGR gas turbine system 52. Accordingly, the HRSG 56, the EGR system 58, and/or another portion of the EG processing system 54 may output or recirculate an exhaust gas 66 into the SEGR gas turbine system 52, while also routing the exhaust gas 42 to the EOR system 18 for use with the hydrocarbon production system 12. Likewise, the exhaust gas 42 may be extracted directly from the SEGR gas turbine system 52 (i.e., without passing through the EG processing system 54) for use in the EOR system 18 of the hydrocarbon production system 12.

[0037] The exhaust gas recirculation is handled by the EGR system 58 of the EG processing system 54. For example, the EGR system 58 includes one or more conduits, valves, blowers, exhaust gas treatment systems (e.g., filters, particulate removal units, gas separation units, gas purification units, heat exchangers, heat recovery units, moisture removal units, catalyst units, chemical injection units, or any combination thereof), and controls to recirculate the exhaust gas along an exhaust gas circulation path from an output (e.g., discharged exhaust gas 60) to an input (e.g., intake exhaust gas 66) of the SEGR gas turbine system 52. In the illustrated embodiment, the SEGR gas turbine system 52 intakes the exhaust gas 66 into a compressor section having one or more compressors, thereby compressing the exhaust

gas 66 for use in a combustor section along with an intake of an oxidant 68 and one or more fuels 70. The oxidant 68 may include ambient air, pure oxygen, oxygen-enriched air, oxygen-reduced air, oxygen-nitrogen mixtures, or any suitable oxidant that facilitates combustion of the fuel 70. The fuel 70 may include one or more gas fuels, liquid fuels, or any combination thereof. For example, the fuel 70 may include natural gas, liquefied natural gas (LNG), syngas, methane, ethane, propane, butane, naphtha, kerosene, diesel fuel, ethanol, methanol, biofuel, or any combination thereof.

[0038] The SEGR gas turbine system 52 mixes and combusts the exhaust gas 66, the oxidant 68, and the fuel 70 in the combustor section, thereby generating hot combustion gases or exhaust gas 60 to drive one or more turbine stages in a turbine section. In certain embodiments, each combustor in the combustor section includes one or more premix fuel nozzles, one or more diffusion fuel nozzles, or any combination thereof. For example, each premix fuel nozzle may be configured to mix the oxidant 68 and the fuel 70 internally within the fuel nozzle and/or partially upstream of the fuel nozzle, thereby injecting an oxidant-fuel mixture from the fuel nozzle into the combustion zone for a premixed combustion (e.g., a premixed flame). By further example, each diffusion fuel nozzle may be configured to isolate the flows of oxidant 68 and fuel 70 within the fuel nozzle, thereby separately injecting the oxidant 68 and the fuel 70 from the fuel nozzle into the combustion zone for diffusion combustion (e.g., a diffusion flame). In particular, the diffusion combustion provided by the diffusion fuel nozzles delays mixing of the oxidant 68 and the fuel 70 until the point of initial combustion, i.e., the flame region. In embodiments employing the diffusion fuel nozzles, the diffusion flame may provide increased flame stability, because the diffusion flame generally forms at the point of stoichiometry between the separate streams of oxidant 68 and fuel 70 (i.e., as the oxidant 68 and fuel 70 are mixing). In certain embodiments, one or more diluents (e.g., the exhaust gas 60, steam, nitrogen, or another inert gas) may be pre-mixed with the oxidant 68, the fuel 70, or both, in either the diffusion fuel nozzle or the premix fuel nozzle. In addition, one or more diluents (e.g., the exhaust gas 60, steam, nitrogen, or another inert gas) may be injected into the combustor at or downstream from the point of combustion within each combustor. The use of these diluents may help temper the flame (e.g.,

premix flame or diffusion flame), thereby helping to reduce NO_X emissions, such as nitrogen monoxide (NO) and nitrogen dioxide (NO_2). Regardless of the type of flame, the combustion produces hot combustion gases or exhaust gas 60 to drive one or more turbine stages. As each turbine stage is driven by the exhaust gas 60, the SEGR gas turbine system 52 generates a mechanical power 72 and/or an electrical power 74 (e.g., via an electrical generator). The system 52 also outputs the exhaust gas 60, and may further output water 64. Again, the water 64 may be a treated water, such as a desalinated water, which may be useful in a variety of applications on-site or off-site.

[0039] Exhaust extraction is also provided by the SEGR gas turbine system 52 using one or more extraction points 76. For example, the illustrated embodiment includes an exhaust gas (EG) supply system 78 having an exhaust gas (EG) extraction system 80 and an exhaust gas (EG) treatment system 82, which receive exhaust gas 42 from the extraction points 76, treat the exhaust gas 42, and then supply or distribute the exhaust gas 42 to various target systems. The target systems may include the EOR system 18 and/or other systems, such as a pipeline 86, a storage tank 88, or a carbon sequestration system 90. The EG extraction system 80 may include one or more conduits, valves, controls, and flow separations, which facilitate isolation of the exhaust gas 42 from the oxidant 68, the fuel 70, and other contaminants, while also controlling the temperature, pressure, and flow rate of the extracted exhaust gas 42. The EG treatment system 82 may include one or more heat exchangers (e.g., heat recovery units such as heat recovery steam generators, condensers, coolers, or heaters), catalyst systems (e.g., oxidation catalyst systems), particulate and/or water removal systems (e.g., gas dehydration units, inertial separators, coalescing filters, water impermeable filters, and other filters), chemical injection systems, solvent based treatment systems (e.g., absorbers, flash tanks, etc.), carbon capture systems, gas separation systems, gas purification systems, and/or a solvent based treatment system, exhaust gas compressors, any combination thereof. These subsystems of the EG treatment system 82 enable control of the temperature, pressure, flow rate, moisture content (e.g., amount of water removal), particulate content (e.g., amount of particulate removal), and gas composition (e.g., percentage of CO_2, N_2, etc.).

[0040] The extracted exhaust gas 42 is treated by one or more subsystems of the EG treatment system 82, depending on the target system. For example, the EG treatment system 82 may direct all or part of the exhaust gas 42 through a carbon capture system, a gas separation system, a gas purification system, and/or a solvent based treatment system, which is controlled to separate and purify a carbonaceous gas (e.g., carbon dioxide) 92 and/or nitrogen (N_2) 94 for use in the various target systems. For example, embodiments of the EG treatment system 82 may perform gas separation and purification to produce a plurality of different streams 95 of exhaust gas 42, such as a first stream 96, a second stream 97, and a third stream 98. The first stream 96 may have a first composition that is rich in carbon dioxide and/or lean in nitrogen (e.g., a CO_2 rich, N_2 lean stream). The second stream 97 may have a second composition that has intermediate concentration levels of carbon dioxide and/or nitrogen (e.g., intermediate concentration CO_2, N_2 stream). The third stream 98 may have a third composition that is lean in carbon dioxide and/or rich in nitrogen (e.g., a CO_2 lean, N_2 rich stream). Each stream 95 (e.g., 96, 97, and 98) may include a gas dehydration unit, a filter, a gas compressor, or any combination thereof, to facilitate delivery of the stream 95 to a target system. In certain embodiments, the CO_2 rich, N_2 lean stream 96 may have a CO_2 purity or concentration level of greater than approximately 70, 75, 80, 85, 90, 95, 96, 97, 98, or 99 percent by volume, and a N_2 purity or concentration level of less than approximately 1, 2, 3, 4, 5, 10, 15, 20, 25, or 30 percent by volume. In contrast, the CO_2 lean, N_2 rich stream 98 may have a CO_2 purity or concentration level of less than approximately 1, 2, 3, 4, 5, 10, 15, 20, 25, or 30 percent by volume, and a N_2 purity or concentration level of greater than approximately 70, 75, 80, 85, 90, 95, 96, 97, 98, or 99 percent by volume. The intermediate concentration CO_2, N_2 stream 97 may have a CO_2 purity or concentration level and/or a N_2 purity or concentration level of between approximately 30 to 70, 35 to 65, 40 to 60, or 45 to 55 percent by volume. Although the foregoing ranges are merely non-limiting examples, the CO_2 rich, N_2 lean stream 96 and the CO_2 lean, N_2 rich stream 98 may be particularly well suited for use with the EOR system 18 and the other systems 84. However, any of these rich, lean, or intermediate concentration CO_2 streams 95 may be used, alone or in various combinations, with the EOR system 18 and the other systems 84. For example, the EOR system 18 and the other systems 84

(e.g., the pipeline 86, storage tank 88, and the carbon sequestration system 90) each may receive one or more CO_2 rich, N_2 lean streams 96, one or more CO_2 lean, N_2 rich streams 98, one or more intermediate concentration CO_2, N_2 streams 97, and one or more untreated exhaust gas 42 streams (i.e., bypassing the EG treatment system 82).

[0041] The EG extraction system 80 extracts the exhaust gas 42 at one or more extraction points 76 along the compressor section, the combustor section, and/or the turbine section, such that the exhaust gas 42 may be used in the EOR system 18 and other systems 84 at suitable temperatures and pressures. The EG extraction system 80 and/or the EG treatment system 82 also may circulate fluid flows (e.g., exhaust gas 42) to and from the EG processing system 54. For example, a portion of the exhaust gas 42 passing through the EG processing system 54 may be extracted by the EG extraction system 80 for use in the EOR system 18 and the other systems 84. In certain embodiments, the EG supply system 78 and the EG processing system 54 may be independent or integral with one another, and thus may use independent or common subsystems. For example, the EG treatment system 82 may be used by both the EG supply system 78 and the EG processing system 54. Exhaust gas 42 extracted from the EG processing system 54 may undergo multiple stages of gas treatment, such as one or more stages of gas treatment in the EG processing system 54 followed by one or more additional stages of gas treatment in the EG treatment system 82.

[0042] At each extraction point 76, the extracted exhaust gas 42 may be substantially free of oxidant 68 and fuel 70 (e.g., unburnt fuel or hydrocarbons) due to substantially stoichiometric combustion and/or gas treatment in the EG processing system 54. Furthermore, depending on the target system, the extracted exhaust gas 42 may undergo further treatment in the EG treatment system 82 of the EG supply system 78, thereby further reducing any residual oxidant 68, fuel 70, or other undesirable products of combustion. For example, either before or after treatment in the EG treatment system 82, the extracted exhaust gas 42 may have less than 1, 2, 3, 4, or 5 percent by volume of oxidant (e.g., oxygen), unburnt fuel or hydrocarbons (e.g., HCs), nitrogen oxides (e.g., NO_X), carbon monoxide (CO), sulfur oxides (e.g., SO_X), hydrogen, and other products of incomplete combustion. By further example, either before or after treatment in the EG treatment system 82, the extracted exhaust

gas 42 may have less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 1000, 2000, 3000, 4000, or 5000 parts per million by volume (ppmv) of oxidant (e.g., oxygen), unburnt fuel or hydrocarbons (e.g., HCs), nitrogen oxides (e.g., NO_X), carbon monoxide (CO), sulfur oxides (e.g., SO_X), hydrogen, and other products of incomplete combustion. Thus, the exhaust gas 42 is particularly well suited for use with the EOR system 18.

[0043] The EGR operation of the turbine system 52 specifically enables the exhaust extraction at a multitude of locations 76. For example, the compressor section of the system 52 may be used to compress the exhaust gas 66 without any oxidant 68 (i.e., only compression of the exhaust gas 66), such that a substantially oxygen-free exhaust gas 42 may be extracted from the compressor section and/or the combustor section prior to entry of the oxidant 68 and the fuel 70. The extraction points 76 may be located at interstage ports between adjacent compressor stages, at ports along the compressor discharge casing, at ports along each combustor in the combustor section, or any combination thereof. In certain embodiments, the exhaust gas 66 may not mix with the oxidant 68 and fuel 70 until it reaches the head end portion and/or fuel nozzles of each combustor in the combustor section. Furthermore, one or more flow separators (e.g., walls, dividers, baffles, or the like) may be used to isolate the oxidant 68 and the fuel 70 from the extraction points 76. With these flow separators, the extraction points 76 may be disposed directly along a wall of each combustor in the combustor section.

[0044] Once the exhaust gas 66, oxidant 68, and fuel 70 flow through the head end portion (e.g., through fuel nozzles) into the combustion portion (e.g., combustion chamber) of each combustor, the SEGR gas turbine system 52 is controlled to provide a substantially stoichiometric combustion of the exhaust gas 66, oxidant 68, and fuel 70. For example, the system 52 may maintain an equivalence ratio of approximately 0.95 to approximately 1.05. As a result, the products of combustion of the mixture of exhaust gas 66, oxidant 68, and fuel 70 in each combustor is substantially free of oxygen and unburnt fuel. Thus, the products of combustion (or exhaust gas) may be extracted from the turbine section of the SEGR gas turbine system 52 for use as the exhaust gas 42 routed to the EOR system 18. Along the turbine section, the extraction

points 76 may be located at any turbine stage, such as interstage ports between adjacent turbine stages. Thus, using any of the foregoing extraction points 76, the turbine-based service system 14 may generate, extract, and deliver the exhaust gas 42 to the hydrocarbon production system 12 (e.g., the EOR system 18) for use in the production of oil/gas 48 from the subterranean reservoir 20.

[0045] FIG. 2 is a diagram of an embodiment of the system 10 of FIG. 1, illustrating a control system 100 coupled to the turbine-based service system 14 and the hydrocarbon production system 12. In the illustrated embodiment, the turbine-based service system 14 includes a combined cycle system 102, which includes the SEGR gas turbine system 52 as a topping cycle, a steam turbine 104 as a bottoming cycle, and the HRSG 56 to recover heat from the exhaust gas 60 to generate the steam 62 for driving the steam turbine 104. Again, the SEGR gas turbine system 52 receives, mixes, and stoichiometrically combusts the exhaust gas 66, the oxidant 68, and the fuel 70 (e.g., premix and/or diffusion flames), thereby producing the exhaust gas 60, the mechanical power 72, the electrical power 74, and/or the water 64. For example, the SEGR gas turbine system 52 may drive one or more loads or machinery 106, such as an electrical generator, an oxidant compressor (e.g., a main air compressor), a gear box, a pump, equipment of the hydrocarbon production system 12, or any combination thereof. In some embodiments, the machinery 106 may include other drives, such as electrical motors or steam turbines (e.g., the steam turbine 104), in tandem with the SEGR gas turbine system 52. Accordingly, an output of the machinery 106 driven by the SEGR gas turbines system 52 (and any additional drives) may include the mechanical power 72 and the electrical power 74. The mechanical power 72 and/or the electrical power 74 may be used on-site for powering the hydrocarbon production system 12, the electrical power 74 may be distributed to the power grid, or any combination thereof. The output of the machinery 106 also may include a compressed fluid, such as a compressed oxidant 68 (e.g., air or oxygen), for intake into the combustion section of the SEGR gas turbine system 52. Each of these outputs (e.g., the exhaust gas 60, the mechanical power 72, the electrical power 74, and/or the water 64) may be considered a service of the turbine-based service system 14.

[0046] The SEGR gas turbine system 52 produces the exhaust gas 42, 60, which may be substantially free of oxygen, and routes this exhaust gas 42, 60 to the EG processing system 54 and/or the EG supply system 78. The EG supply system 78 may treat and delivery the exhaust gas 42 (e.g., streams 95) to the hydrocarbon production system 12 and/or the other systems 84. As discussed above, the EG processing system 54 may include the HRSG 56 and the EGR system 58. The HRSG 56 may include one or more heat exchangers, condensers, and various heat recovery equipment, which may be used to recover or transfer heat from the exhaust gas 60 to water 108 to generate the steam 62 for driving the steam turbine 104. Similar to the SEGR gas turbine system 52, the steam turbine 104 may drive one or more loads or machinery 106, thereby generating the mechanical power 72 and the electrical power 74. In the illustrated embodiment, the SEGR gas turbine system 52 and the steam turbine 104 are arranged in tandem to drive the same machinery 106. However, in other embodiments, the SEGR gas turbine system 52 and the steam turbine 104 may separately drive different machinery 106 to independently generate mechanical power 72 and/or electrical power 74. As the steam turbine 104 is driven by the steam 62 from the HRSG 56, the steam 62 gradually decreases in temperature and pressure. Accordingly, the steam turbine 104 recirculates the used steam 62 and/or water 108 back into the HRSG 56 for additional steam generation via heat recovery from the exhaust gas 60. In addition to steam generation, the HRSG 56, the EGR system 58, and/or another portion of the EG processing system 54 may produce the water 64, the exhaust gas 42 for use with the hydrocarbon production system 12, and the exhaust gas 66 for use as an input into the SEGR gas turbine system 52. For example, the water 64 may be a treated water 64, such as a desalinated water for use in other applications. The desalinated water may be particularly useful in regions of low water availability. Regarding the exhaust gas 60, embodiments of the EG processing system 54 may be configured to recirculate the exhaust gas 60 through the EGR system 58 with or without passing the exhaust gas 60 through the HRSG 56.

[0047] In the illustrated embodiment, the SEGR gas turbine system 52 has an exhaust recirculation path 110, which extends from an exhaust outlet to an exhaust inlet of the system 52. Along the path 110, the exhaust gas 60 passes through the EG

processing system 54, which includes the HRSG 56 and the EGR system 58 in the illustrated embodiment. The EGR system 58 may include one or more conduits, valves, blowers, gas treatment systems (e.g., filters, particulate removal units, gas separation units, gas purification units, heat exchangers, heat recovery units such as heat recovery steam generators, moisture removal units, catalyst units, chemical injection units, or any combination thereof) in series and/or parallel arrangements along the path 110. In other words, the EGR system 58 may include any flow control components, pressure control components, temperature control components, moisture control components, and gas composition control components along the exhaust recirculation path 110 between the exhaust outlet and the exhaust inlet of the system 52. Accordingly, in embodiments with the HRSG 56 along the path 110, the HRSG 56 may be considered a component of the EGR system 58. However, in certain embodiments, the HRSG 56 may be disposed along an exhaust path independent from the exhaust recirculation path 110. Regardless of whether the HRSG 56 is along a separate path or a common path with the EGR system 58, the HRSG 56 and the EGR system 58 intake the exhaust gas 60 and output either the recirculated exhaust gas 66, the exhaust gas 42 for use with the EG supply system 78 (e.g., for the hydrocarbon production system 12 and/or other systems 84), or another output of exhaust gas. Again, the SEGR gas turbine system 52 intakes, mixes, and stoichiometrically combusts the exhaust gas 66, the oxidant 68, and the fuel 70 (e.g., premixed and/or diffusion flames) to produce a substantially oxygen-free and fuel-free exhaust gas 60 for distribution to the EG processing system 54, the hydrocarbon production system 12, or other systems 84.

[0048] As noted above with reference to FIG. 1, the hydrocarbon production system 12 may include a variety of equipment to facilitate the recovery or production of oil/gas 48 from a subterranean reservoir 20 through an oil/gas well 26. For example, the hydrocarbon production system 12 may include the EOR system 18 having the fluid injection system 34. In the illustrated embodiment, the fluid injection system 34 includes an exhaust gas injection EOR system 112 and a steam injection EOR system 114. Although the fluid injection system 34 may receive fluids from a variety of sources, the illustrated embodiment may receive the exhaust gas 42 and the

steam 62 from the turbine-based service system 14. The exhaust gas 42 and/or the steam 62 produced by the turbine-based service system 14 also may be routed to the hydrocarbon production system 12 for use in other oil/gas systems 116.

[0049] The quantity, quality, and flow of the exhaust gas 42 and/or the steam 62 may be controlled by the control system 100. The control system 100 may be dedicated entirely to the turbine-based service system 14, or the control system 100 may optionally also provide control (or at least some data to facilitate control) for the hydrocarbon production system 12 and/or other systems 84. In the illustrated embodiment, the control system 100 includes a controller 118 having a processor 120, a memory 122, a steam turbine control 124, a SEGR gas turbine system control 126, and a machinery control 128. The processor 120 may include a single processor or two or more redundant processors, such as triple redundant processors for control of the turbine-based service system 14. The memory 122 may include volatile and/or non-volatile memory. For example, the memory 122 may include one or more hard drives, flash memory, read-only memory, random access memory, or any combination thereof. The controls 124, 126, and 128 may include software and/or hardware controls. For example, the controls 124, 126, and 128 may include various instructions or code stored on the memory 122 and executable by the processor 120. The control 124 is configured to control operation of the steam turbine 104, the SEGR gas turbine system control 126 is configured to control the system 52, and the machinery control 128 is configured to control the machinery 106. Thus, the controller 118 (e.g., controls 124, 126, and 128) may be configured to coordinate various sub-systems of the turbine-based service system 14 to provide a suitable stream of the exhaust gas 42 to the hydrocarbon production system 12.

[0050] In certain embodiments of the control system 100, each element (e.g., system, subsystem, and component) illustrated in the drawings or described herein includes (e.g., directly within, upstream, or downstream of such element) one or more industrial control features, such as sensors and control devices, which are communicatively coupled with one another over an industrial control network along with the controller 118. For example, the control devices associated with each element may include a dedicated device controller (e.g., including a processor, memory, and

control instructions), one or more actuators, valves, switches, and industrial control equipment, which enable control based on sensor feedback 130, control signals from the controller 118, control signals from a user, or any combination thereof. Thus, any of the control functionality described herein may be implemented with control instructions stored and/or executable by the controller 118, dedicated device controllers associated with each element, or a combination thereof.

[0051] In order to facilitate such control functionality, the control system 100 includes one or more sensors distributed throughout the system 10 to obtain the sensor feedback 130 for use in execution of the various controls, e.g., the controls 124, 126, and 128. For example, the sensor feedback 130 may be obtained from sensors distributed throughout the SEGR gas turbine system 52, the machinery 106, the EG processing system 54, the steam turbine 104, the hydrocarbon production system 12, or any other components throughout the turbine-based service system 14 or the hydrocarbon production system 12. For example, the sensor feedback 130 may include temperature feedback, pressure feedback, flow rate feedback, flame temperature feedback, combustion dynamics feedback, intake oxidant composition feedback, intake fuel composition feedback, exhaust composition feedback, the output level of mechanical power 72, the output level of electrical power 74, the output quantity of the exhaust gas 42, 60, the output quantity or quality of the water 64, or any combination thereof. For example, the sensor feedback 130 may include a composition of the exhaust gas 42, 60 to facilitate stoichiometric combustion in the SEGR gas turbine system 52. For example, the sensor feedback 130 may include feedback from one or more intake oxidant sensors along an oxidant supply path of the oxidant 68, one or more intake fuel sensors along a fuel supply path of the fuel 70, and one or more exhaust emissions sensors disposed along the exhaust recirculation path 110 and/or within the SEGR gas turbine system 52. The intake oxidant sensors, intake fuel sensors, and exhaust emissions sensors may include temperature sensors, pressure sensors, flow rate sensors, and composition sensors. The emissions sensors may includes sensors for nitrogen oxides (e.g., NO_X sensors), carbon oxides (e.g., CO sensors and CO_2 sensors), sulfur oxides (e.g., SO_X sensors), hydrogen (e.g., H_2

sensors), oxygen (e.g., O_2 sensors), unburnt hydrocarbons (e.g., HC sensors), or other products of incomplete combustion, or any combination thereof.

[0052] Using this feedback 130, the control system 100 may adjust (e.g., increase, decrease, or maintain) the intake flow of exhaust gas 66, oxidant 68, and/or fuel 70 into the SEGR gas turbine system 52 (among other operational parameters) to maintain the equivalence ratio within a suitable range, e.g., between approximately 0.95 to approximately 1.05, between approximately 0.95 to approximately 1.0, between approximately 1.0 to approximately 1.05, or substantially at 1.0. For example, the control system 100 may analyze the feedback 130 to monitor the exhaust emissions (e.g., concentration levels of nitrogen oxides, carbon oxides such as CO and CO_2, sulfur oxides, hydrogen, oxygen, unburnt hydrocarbons, and other products of incomplete combustion) and/or determine the equivalence ratio, and then control one or more components to adjust the exhaust emissions (e.g., concentration levels in the exhaust gas 42) and/or the equivalence ratio. The controlled components may include any of the components illustrated and described with reference to the drawings, including but not limited to, valves along the supply paths for the oxidant 68, the fuel 70, and the exhaust gas 66; an oxidant compressor, a fuel pump, or any components in the EG processing system 54; any components of the SEGR gas turbine system 52, or any combination thereof. The controlled components may adjust (e.g., increase, decrease, or maintain) the flow rates, temperatures, pressures, or percentages (e.g., equivalence ratio) of the oxidant 68, the fuel 70, and the exhaust gas 66 that combust within the SEGR gas turbine system 52. The controlled components also may include one or more gas treatment systems, such as catalyst units (e.g., oxidation catalyst units), supplies for the catalyst units (e.g., oxidation fuel, heat, electricity, etc.), gas purification and/or separation units (e.g., solvent based separators, absorbers, flash tanks, etc.), and filtration units. The gas treatment systems may help reduce various exhaust emissions along the exhaust recirculation path 110, a vent path (e.g., exhausted into the atmosphere), or an extraction path to the EG supply system 78.

[0053] In certain embodiments, the control system 100 may analyze the feedback 130 and control one or more components to maintain or reduce emissions levels (e.g., concentration levels in the exhaust gas 42, 60, 95) to a target range, such as less than

approximately 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000, 2000, 3000, 4000, 5000, or 10000 parts per million by volume (ppmv). These target ranges may be the same or different for each of the exhaust emissions, e.g., concentration levels of nitrogen oxides, carbon monoxide, sulfur oxides, hydrogen, oxygen, unburnt hydrocarbons, and other products of incomplete combustion. For example, depending on the equivalence ratio, the control system 100 may selectively control exhaust emissions (e.g., concentration levels) of oxidant (e.g., oxygen) within a target range of less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 250, 500, 750, or 1000 ppmv; carbon monoxide (CO) within a target range of less than approximately 20, 50, 100, 200, 500, 1000, 2500, or 5000 ppmv; and nitrogen oxides (NO_X) within a target range of less than approximately 50, 100, 200, 300, 400, or 500 ppmv. In certain embodiments operating with a substantially stoichiometric equivalence ratio, the control system 100 may selectively control exhaust emissions (e.g., concentration levels) of oxidant (e.g., oxygen) within a target range of less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, or 100 ppmv; and carbon monoxide (CO) within a target range of less than approximately 500, 1000, 2000, 3000, 4000, or 5000 ppmv. In certain embodiments operating with a fuel-lean equivalence ratio (e.g., between approximately 0.95 to 1.0), the control system 100 may selectively control exhaust emissions (e.g., concentration levels) of oxidant (e.g., oxygen) within a target range of less than approximately 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, or 1500 ppmv; carbon monoxide (CO) within a target range of less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, or 200 ppmv; and nitrogen oxides (e.g., NO_X) within a target range of less than approximately 50, 100, 150, 200, 250, 300, 350, or 400 ppmv. The foregoing target ranges are merely examples, and are not intended to limit the scope of the disclosed embodiments.

[0054] The control system 100 also may be coupled to a local interface 132 and a remote interface 134. For example, the local interface 132 may include a computer workstation disposed on-site at the turbine-based service system 14 and/or the hydrocarbon production system 12. In contrast, the remote interface 134 may include a computer workstation disposed off-site from the turbine-based service system 14 and the hydrocarbon production system 12, such as through an internet connection.

These interfaces 132 and 134 facilitate monitoring and control of the turbine-based service system 14, such as through one or more graphical displays of sensor feedback 130, operational parameters, and so forth.

[0055] Again, as noted above, the controller 118 includes a variety of controls 124, 126, and 128 to facilitate control of the turbine-based service system 14. The steam turbine control 124 may receive the sensor feedback 130 and output control commands to facilitate operation of the steam turbine 104. For example, the steam turbine control 124 may receive the sensor feedback 130 from the HRSG 56, the machinery 106, temperature and pressure sensors along a path of the steam 62, temperature and pressure sensors along a path of the water 108, and various sensors indicative of the mechanical power 72 and the electrical power 74. Likewise, the SEGR gas turbine system control 126 may receive sensor feedback 130 from one or more sensors disposed along the SEGR gas turbine system 52, the machinery 106, the EG processing system 54, or any combination thereof. For example, the sensor feedback 130 may be obtained from temperature sensors, pressure sensors, clearance sensors, vibration sensors, flame sensors, fuel composition sensors, exhaust gas composition sensors, or any combination thereof, disposed within or external to the SEGR gas turbine system 52. Finally, the machinery control 128 may receive sensor feedback 130 from various sensors associated with the mechanical power 72 and the electrical power 74, as well as sensors disposed within the machinery 106. Each of these controls 124, 126, and 128 uses the sensor feedback 130 to improve operation of the turbine-based service system 14.

[0056] In the illustrated embodiment, the SEGR gas turbine system control 126 may execute instructions to control the quantity and quality of the exhaust gas 42, 60, 95 in the EG processing system 54, the EG supply system 78, the hydrocarbon production system 12, and/or the other systems 84. For example, the SEGR gas turbine system control 126 may maintain a level of oxidant (e.g., oxygen) and/or unburnt fuel in the exhaust gas 60 below a threshold suitable for use with the exhaust gas injection EOR system 112. In certain embodiments, the threshold levels may be less than 1, 2, 3, 4, or 5 percent of oxidant (e.g., oxygen) and/or unburnt fuel by volume of the exhaust gas 42, 60; or the threshold levels of oxidant (e.g., oxygen)

and/or unburnt fuel (and other exhaust emissions) may be less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 1000, 2000, 3000, 4000, or 5000 parts per million by volume (ppmv) in the exhaust gas 42, 60. By further example, in order to achieve these low levels of oxidant (e.g., oxygen) and/or unburnt fuel, the SEGR gas turbine system control 126 may maintain an equivalence ratio for combustion in the SEGR gas turbine system 52 between approximately 0.95 and approximately 1.05. The SEGR gas turbine system control 126 also may control the EG extraction system 80 and the EG treatment system 82 to maintain the temperature, pressure, flow rate, and gas composition of the exhaust gas 42, 60, 95 within suitable ranges for the exhaust gas injection EOR system 112, the pipeline 86, the storage tank 88, and the carbon sequestration system 90. As discussed above, the EG treatment system 82 may be controlled to purify and/or separate the exhaust gas 42 into one or more gas streams 95, such as the CO_2 rich, N_2 lean stream 96, the intermediate concentration CO_2, N_2 stream 97, and the CO_2 lean, N_2 rich stream 98. In addition to controls for the exhaust gas 42, 60, and 95, the controls 124, 126, and 128 may execute one or more instructions to maintain the mechanical power 72 within a suitable power range, or maintain the electrical power 74 within a suitable frequency and power range.

[0057] FIG. 3 is a diagram of embodiment of the system 10, further illustrating details of the SEGR gas turbine system 52 for use with the hydrocarbon production system 12 and/or other systems 84. In the illustrated embodiment, the SEGR gas turbine system 52 includes a gas turbine engine 150 coupled to the EG processing system 54. The illustrated gas turbine engine 150 includes a compressor section 152, a combustor section 154, and an expander section or turbine section 156. The compressor section 152 includes one or more exhaust gas compressors or compressor stages 158, such as 1 to 20 stages of rotary compressor blades disposed in a series arrangement. Likewise, the combustor section 154 includes one or more combustors 160, such as 1 to 20 combustors 160 distributed circumferentially about a rotational axis 162 of the SEGR gas turbine system 52. Furthermore, each combustor 160 may include one or more fuel nozzles 164 configured to inject the exhaust gas 66, the oxidant 68, and/or the fuel 70. For example, a head end portion 166 of each

combustor 160 may house 1, 2, 3, 4, 5, 6, or more fuel nozzles 164, which may inject streams or mixtures of the exhaust gas 66, the oxidant 68, and/or the fuel 70 into a combustion portion 168 (e.g., combustion chamber) of the combustor 160.

[0058] The fuel nozzles 164 may include any combination of premix fuel nozzles 164 (e.g., configured to premix the oxidant 68 and fuel 70 for generation of an oxidant/fuel premix flame) and/or diffusion fuel nozzles 164 (e.g., configured to inject separate flows of the oxidant 68 and fuel 70 for generation of an oxidant/fuel diffusion flame). Embodiments of the premix fuel nozzles 164 may include swirl vanes, mixing chambers, or other features to internally mix the oxidant 68 and fuel 70 within the nozzles 164, prior to injection and combustion in the combustion chamber 168. The premix fuel nozzles 164 also may receive at least some partially mixed oxidant 68 and fuel 70. In certain embodiments, each diffusion fuel nozzle 164 may isolate flows of the oxidant 68 and the fuel 70 until the point of injection, while also isolating flows of one or more diluents (e.g., the exhaust gas 66, steam, nitrogen, or another inert gas) until the point of injection. In other embodiments, each diffusion fuel nozzle 164 may isolate flows of the oxidant 68 and the fuel 70 until the point of injection, while partially mixing one or more diluents (e.g., the exhaust gas 66, steam, nitrogen, or another inert gas) with the oxidant 68 and/or the fuel 70 prior to the point of injection. In addition, one or more diluents (e.g., the exhaust gas 66, steam, nitrogen, or another inert gas) may be injected into the combustor (e.g., into the hot products of combustion) either at or downstream from the combustion zone, thereby helping to reduce the temperature of the hot products of combustion and reduce emissions of NO_X (e.g., NO and NO_2). Regardless of the type of fuel nozzle 164, the SEGR gas turbine system 52 may be controlled to provide substantially stoichiometric combustion of the oxidant 68 and fuel 70.

[0059] In diffusion combustion embodiments using the diffusion fuel nozzles 164, the fuel 70 and oxidant 68 generally do not mix upstream from the diffusion flame, but rather the fuel 70 and oxidant 68 mix and react directly at the flame surface and/or the flame surface exists at the location of mixing between the fuel 70 and oxidant 68. In particular, the fuel 70 and oxidant 68 separately approach the flame surface (or diffusion boundary/interface), and then diffuse (e.g., via molecular and viscous

diffusion) along the flame surface (or diffusion boundary/interface) to generate the diffusion flame. It is noteworthy that the fuel 70 and oxidant 68 may be at a substantially stoichiometric ratio along this flame surface (or diffusion boundary/interface), which may result in a greater flame temperature (e.g., a peak flame temperature) along this flame surface. The stoichiometric fuel/oxidant ratio generally results in a greater flame temperature (e.g., a peak flame temperature), as compared with a fuel-lean or fuel-rich fuel/oxidant ratio. As a result, the diffusion flame may be substantially more stable than a premix flame, because the diffusion of fuel 70 and oxidant 68 helps to maintain a stoichiometric ratio (and greater temperature) along the flame surface. Although greater flame temperatures can also lead to greater exhaust emissions, such as NO_X emissions, the disclosed embodiments use one or more diluents to help control the temperature and emissions while still avoiding any premixing of the fuel 70 and oxidant 68. For example, the disclosed embodiments may introduce one or more diluents separate from the fuel 70 and oxidant 68 (e.g., after the point of combustion and/or downstream from the diffusion flame), thereby helping to reduce the temperature and reduce the emissions (e.g., NO_X emissions) produced by the diffusion flame.

[0060] In operation, as illustrated, the compressor section 152 receives and compresses the exhaust gas 66 from the EG processing system 54, and outputs a compressed exhaust gas 170 to each of the combustors 160 in the combustor section 154. Upon combustion of the fuel 60, oxidant 68, and exhaust gas 170 within each combustor 160, additional exhaust gas or products of combustion 172 (i.e., combustion gas) is routed into the turbine section 156. Similar to the compressor section 152, the turbine section 156 includes one or more turbines or turbine stages 174, which may include a series of rotary turbine blades. These turbine blades are then driven by the products of combustion 172 generated in the combustor section 154, thereby driving rotation of a shaft 176 coupled to the machinery 106. Again, the machinery 106 may include a variety of equipment coupled to either end of the SEGR gas turbine system 52, such as machinery 106, 178 coupled to the turbine section 156 and/or machinery 106, 180 coupled to the compressor section 152. In certain embodiments, the machinery 106, 178, 180 may include one or more electrical

generators, oxidant compressors for the oxidant 68, fuel pumps for the fuel 70, gear boxes, or additional drives (e.g. steam turbine 104, electrical motor, etc.) coupled to the SEGR gas turbine system 52. Non-limiting examples are discussed in further detail below with reference to TABLE 1. As illustrated, the turbine section 156 outputs the exhaust gas 60 to recirculate along the exhaust recirculation path 110 from an exhaust outlet 182 of the turbine section 156 to an exhaust inlet 184 into the compressor section 152. Along the exhaust recirculation path 110, the exhaust gas 60 passes through the EG processing system 54 (e.g., the HRSG 56 and/or the EGR system 58) as discussed in detail above.

[0061] Again, each combustor 160 in the combustor section 154 receives, mixes, and stoichiometrically combusts the compressed exhaust gas 170, the oxidant 68, and the fuel 70 to produce the additional exhaust gas or products of combustion 172 to drive the turbine section 156. In certain embodiments, the oxidant 68 is compressed by an oxidant compression system 186, such as a main oxidant compression (MOC) system (e.g., a main air compression (MAC) system) having one or more oxidant compressors (MOCs). The oxidant compression system 186 includes an oxidant compressor 188 coupled to a drive 190. For example, the drive 190 may include an electric motor, a combustion engine, or any combination thereof. In certain embodiments, the drive 190 may be a turbine engine, such as the gas turbine engine 150. Accordingly, the oxidant compression system 186 may be an integral part of the machinery 106. In other words, the compressor 188 may be directly or indirectly driven by the mechanical power 72 supplied by the shaft 176 of the gas turbine engine 150. In such an embodiment, the drive 190 may be excluded, because the compressor 188 relies on the power output from the turbine engine 150. However, in certain embodiments employing more than one oxidant compressor is employed, a first oxidant compressor (e.g., a low pressure (LP) oxidant compressor) may be driven by the drive 190 while the shaft 176 drives a second oxidant compressor (e.g., a high pressure (HP) oxidant compressor), or vice versa. For example, in another embodiment, the HP MOC is driven by the drive 190 and the LP oxidant compressor is driven by the shaft 176. In the illustrated embodiment, the oxidant compression system 186 is separate from the machinery 106. In each of these embodiments, the

compression system 186 compresses and supplies the oxidant 68 to the fuel nozzles 164 and the combustors 160. Accordingly, some or all of the machinery 106, 178, 180 may be configured to increase the operational efficiency of the compression system 186 (e.g., the compressor 188 and/or additional compressors).

[0062] The variety of components of the machinery 106, indicated by element numbers 106A, 106B, 106C, 106D, 106E, and 106F, may be disposed along the line of the shaft 176 and/or parallel to the line of the shaft 176 in one or more series arrangements, parallel arrangements, or any combination of series and parallel arrangements. For example, the machinery 106, 178, 180 (e.g., 106A through 106F) may include any series and/or parallel arrangement, in any order, of: one or more gearboxes (e.g., parallel shaft, epicyclic gearboxes), one or more compressors (e.g., oxidant compressors, booster compressors such as EG booster compressors), one or more power generation units (e.g., electrical generators), one or more drives (e.g., steam turbine engines, electrical motors), heat exchange units (e.g., direct or indirect heat exchangers), clutches, or any combination thereof. The compressors may include axial compressors, radial or centrifugal compressors, or any combination thereof, each having one or more compression stages. Regarding the heat exchangers, direct heat exchangers may include spray coolers (e.g., spray intercoolers), which inject a liquid spray into a gas flow (e.g., oxidant flow) for direct cooling of the gas flow. Indirect heat exchangers may include at least one wall (e.g., a shell and tube heat exchanger) separating first and second flows, such as a fluid flow (e.g., oxidant flow) separated from a coolant flow (e.g., water, air, refrigerant, or any other liquid or gas coolant), wherein the coolant flow transfers heat from the fluid flow without any direct contact. Examples of indirect heat exchangers include intercooler heat exchangers and heat recovery units, such as heat recovery steam generators. The heat exchangers also may include heaters. As discussed in further detail below, each of these machinery components may be used in various combinations as indicated by the non-limiting examples set forth in TABLE 1.

[0063] Generally, the machinery 106, 178, 180 may be configured to increase the efficiency of the compression system 186 by, for example, adjusting operational speeds of one or more oxidant compressors in the system 186, facilitating

compression of the oxidant 68 through cooling, and/or extraction of surplus power. The disclosed embodiments are intended to include any and all permutations of the foregoing components in the machinery 106, 178, 180 in series and parallel arrangements, wherein one, more than one, all, or none of the components derive power from the shaft 176. As illustrated below, TABLE 1 depicts some non-limiting examples of arrangements of the machinery 106, 178, 180 disposed proximate and/or coupled to the compressor and turbine sections 152, 156.

106A	106B	106C	106D	106E	106F
MOC	GEN				
MOC	GBX	GEN			
LP MOC	HP MOC	GEN			
HP MOC	GBX	LP MOC	GEN		
MOC MOC	GBX	GEN			
HP MOC	GBX	GEN	LP MOC		
MOC MOC	GBX GBX	GEN DRV			
DRV	GBX	LP MOC	HP MOC	GBX	GEN
DRV	GBX	HP MOC	LP MOC	GEN	
HP MOC	GBX CLR	LP MOC	GEN		
HP MOC	GBX CLR	LP MOC	GBX	GEN	
HP MOC	GBX HTR STGN	LP MOC	GEN		
MOC	GEN	DRV			
MOC	DRV	GEN			
DRV	MOC	GEN			
DRV	CLU	MOC	GEN		
DRV	CLU	MOC	GBX	GEN	

TABLE 1

[0064] As illustrated above in TABLE 1, a cooling unit is represented as CLR, a clutch is represented as CLU, a drive is represented by DRV, a gearbox is represented as GBX, a generator is represented by GEN, a heating unit is represented by HTR, a main oxidant compressor unit is represented by MOC, with low pressure and high pressure variants being represented as LP MOC and HP MOC, respectively, and a steam generator unit is represented as STGN. Although TABLE 1 illustrates the machinery 106, 178, 180 in sequence toward the compressor section 152 or the turbine section 156, TABLE 1 is also intended to cover the reverse sequence of the machinery 106, 178, 180. In TABLE 1, any cell including two or more components is intended to cover a parallel arrangement of the components. TABLE 1 is not intended to exclude any non-illustrated permutations of the machinery 106, 178, 180. These components of the machinery 106, 178, 180 may enable feedback control of temperature, pressure, and flow rate of the oxidant 68 sent to the gas turbine engine 150. As discussed in further detail below, the oxidant 68 and the fuel 70 may be supplied to the gas turbine engine 150 at locations specifically selected to facilitate isolation and extraction of the compressed exhaust gas 170 without any oxidant 68 or fuel 70 degrading the quality of the exhaust gas 170.

[0065] The EG supply system 78, as illustrated in FIG. 3, is disposed between the gas turbine engine 150 and the target systems (e.g., the hydrocarbon production system 12 and the other systems 84). In particular, the EG supply system 78, e.g., the EG extraction system (EGES) 80), may be coupled to the gas turbine engine 150 at one or more extraction points 76 along the compressor section 152, the combustor section 154, and/or the turbine section 156. For example, the extraction points 76 may be located between adjacent compressor stages, such as 2, 3, 4, 5, 6, 7, 8, 9, or 10 interstage extraction points 76 between compressor stages. Each of these interstage extraction points 76 provides a different temperature and pressure of the extracted exhaust gas 42. Similarly, the extraction points 76 may be located between adjacent turbine stages, such as 2, 3, 4, 5, 6, 7, 8, 9, or 10 interstage extraction points 76 between turbine stages. Each of these interstage extraction points 76 provides a different temperature and pressure of the extracted exhaust gas 42. By further example, the extraction points 76 may be located at a multitude of locations

throughout the combustor section 154, which may provide different temperatures, pressures, flow rates, and gas compositions. Each of these extraction points 76 may include an EG extraction conduit, one or more valves, sensors, and controls, which may be used to selectively control the flow of the extracted exhaust gas 42 to the EG supply system 78.

[0066] The extracted exhaust gas 42, which is distributed by the EG supply system 78, has a controlled composition suitable for the target systems (e.g., the hydrocarbon production system 12 and the other systems 84). For example, at each of these extraction points 76, the exhaust gas 170 may be substantially isolated from injection points (or flows) of the oxidant 68 and the fuel 70. In other words, the EG supply system 78 may be specifically designed to extract the exhaust gas 170 from the gas turbine engine 150 without any added oxidant 68 or fuel 70. Furthermore, in view of the stoichiometric combustion in each of the combustors 160, the extracted exhaust gas 42 may be substantially free of oxygen and fuel. The EG supply system 78 may route the extracted exhaust gas 42 directly or indirectly to the hydrocarbon production system 12 and/or other systems 84 for use in various processes, such as enhanced oil recovery, carbon sequestration, storage, or transport to an offsite location. However, in certain embodiments, the EG supply system 78 includes the EG treatment system (EGTS) 82 for further treatment of the exhaust gas 42, prior to use with the target systems. For example, the EG treatment system 82 may purify and/or separate the exhaust gas 42 into one or more streams 95, such as the CO_2 rich, N_2 lean stream 96, the intermediate concentration CO_2, N_2 stream 97, and the CO_2 lean, N_2 rich stream 98. These treated exhaust gas streams 95 may be used individually, or in any combination, with the hydrocarbon production system 12 and the other systems 84 (e.g., the pipeline 86, the storage tank 88, and the carbon sequestration system 90).

[0067] Similar to the exhaust gas treatments performed in the EG supply system 78, the EG processing system 54 may include a plurality of exhaust gas (EG) treatment components 192, such as indicated by element numbers 194, 196, 198, 200, 202, 204, 206, 208, and 210. These EG treatment components 192 (e.g., 194 through 210) may be disposed along the exhaust recirculation path 110 in one or more series arrangements, parallel arrangements, or any combination of series and parallel

arrangements. For example, the EG treatment components 192 (e.g., 194 through 210) may include any series and/or parallel arrangement, in any order, of: one or more heat exchangers (e.g., heat recovery units such as heat recovery steam generators, condensers, coolers, or heaters), catalyst systems (e.g., oxidation catalyst systems), particulate and/or water removal systems (e.g., inertial separators, coalescing filters, water impermeable filters, and other filters), chemical injection systems, solvent based treatment systems (e.g., absorbers, flash tanks, etc.), carbon capture systems, gas separation systems, gas purification systems, and/or a solvent based treatment system, or any combination thereof. In certain embodiments, the catalyst systems may include an oxidation catalyst, a carbon monoxide reduction catalyst, a nitrogen oxides reduction catalyst, an aluminum oxide, a zirconium oxide, a silicone oxide, a titanium oxide, a platinum oxide, a palladium oxide, a cobalt oxide, or a mixed metal oxide, or a combination thereof. The disclosed embodiments are intended to include any and all permutations of the foregoing components 192 in series and parallel arrangements. As illustrated below, TABLE 2 depicts some non-limiting examples of arrangements of the components 192 along the exhaust recirculation path 110.

194	196	198	200	202	204	206	208	210
CU	HRU	BB	MRU	PRU				
CU	HRU	HRU	BB	MRU	PRU	DIL		
CU	HRSG	HRSG	BB	MRU	PRU			
OCU	HRU	OCU	HRU	OCU	BB	MRU	PRU	
HRU CU	HRU CU	BB	MRU	PRU				
HRSG OCU	HRSG OCU	BB	MRU	PRU	DIL			
OCU	HRSG OCU	OCU	HRSG OCU	OCU	BB	MRU	PRU	DIL
OCU	HRSG ST	HRSG ST	BB	COND	INER	WFIL	CFIL	DIL
OCU HRSG ST	OCU HRSG ST	BB	COND	INER	FIL	DIL		
OCU	HRSG ST	HRSG ST	OCU	BB	MRU HE COND	MRU WFIL	PRU INER	PRU FIL CFIL
CU	HRU COND	HRU COND	HRU COND	BB	MRU HE COND WFIL	PRU INER	PRU FIL CFIL	DIL

TABLE 2

[0068] As illustrated above in TABLE 2, a catalyst unit is represented by CU, an oxidation catalyst unit is represented by OCU, a booster blower is represented by BB, a heat exchanger is represented by HX, a heat recovery unit is represented by HRU, a heat recovery steam generator is represented by HRSG, a condenser is represented by COND, a steam turbine is represented by ST, a particulate removal unit is represented by PRU, a moisture removal unit is represented by MRU, a filter is represented by FIL, a coalescing filter is represented by CFIL, a water impermeable filter is

represented by WFIL, an inertial separator is represented by INER, and a diluent supply system (e.g., steam, nitrogen, or other inert gas) is represented by DIL. Although TABLE 2 illustrates the components 192 in sequence from the exhaust outlet 182 of the turbine section 156 toward the exhaust inlet 184 of the compressor section 152, TABLE 2 is also intended to cover the reverse sequence of the illustrated components 192. In TABLE 2, any cell including two or more components is intended to cover an integrated unit with the components, a parallel arrangement of the components, or any combination thereof. Furthermore, in context of TABLE 2, the HRU, the HRSG, and the COND are examples of the HE; the HRSG is an example of the HRU; the COND, WFIL, and CFIL are examples of the WRU; the INER, FIL, WFIL, and CFIL are examples of the PRU; and the WFIL and CFIL are examples of the FIL. Again, TABLE 2 is not intended to exclude any non-illustrated permutations of the components 192. In certain embodiments, the illustrated components 192 (e.g., 194 through 210) may be partially or completed integrated within the HRSG 56, the EGR system 58, or any combination thereof. These EG treatment components 192 may enable feedback control of temperature, pressure, flow rate, and gas composition, while also removing moisture and particulates from the exhaust gas 60. Furthermore, the treated exhaust gas 60 may be extracted at one or more extraction points 76 for use in the EG supply system 78 and/or recirculated to the exhaust inlet 184 of the compressor section 152.

[0069] As the treated, recirculated exhaust gas 66 passes through the compressor section 152, the SEGR gas turbine system 52 may bleed off a portion of the compressed exhaust gas along one or more lines 212 (e.g., bleed conduits or bypass conduits). Each line 212 may route the exhaust gas into one or more heat exchangers 214 (e.g., cooling units), thereby cooling the exhaust gas for recirculation back into the SEGR gas turbine system 52. For example, after passing through the heat exchanger 214, a portion of the cooled exhaust gas may be routed to the turbine section 156 along line 212 for cooling and/or sealing of the turbine casing, turbine shrouds, bearings, and other components. In such an embodiment, the SEGR gas turbine system 52 does not route any oxidant 68 (or other potential contaminants) through the turbine section 156 for cooling and/or sealing purposes, and thus any

leakage of the cooled exhaust gas will not contaminate the hot products of combustion (e.g., working exhaust gas) flowing through and driving the turbine stages of the turbine section 156. By further example, after passing through the heat exchanger 214, a portion of the cooled exhaust gas may be routed along line 216 (e.g., return conduit) to an upstream compressor stage of the compressor section 152, thereby improving the efficiency of compression by the compressor section 152. In such an embodiment, the heat exchanger 214 may be configured as an interstage cooling unit for the compressor section 152. In this manner, the cooled exhaust gas helps to increase the operational efficiency of the SEGR gas turbine system 52, while simultaneously helping to maintain the purity of the exhaust gas (e.g., substantially free of oxidant and fuel).

[0070] FIG. 4 is a flow chart of an embodiment of an operational process 220 of the system 10 illustrated in FIGS 1-3. In certain embodiments, the process 220 may be a computer implemented process, which accesses one or more instructions stored on the memory 122 and executes the instructions on the processor 120 of the controller 118 shown in FIG. 2. For example, each step in the process 220 may include instructions executable by the controller 118 of the control system 100 described with reference to FIG. 2.

[0071] The process 220 may begin by initiating a startup mode of the SEGR gas turbine system 52 of FIGS. 1-3, as indicated by block 222. For example, the startup mode may involve a gradual ramp up of the SEGR gas turbine system 52 to maintain thermal gradients, vibration, and clearance (e.g., between rotating and stationary parts) within acceptable thresholds. For example, during the startup mode 222, the process 220 may begin to supply a compressed oxidant 68 to the combustors 160 and the fuel nozzles 164 of the combustor section 154, as indicated by block 224. In certain embodiments, the compressed oxidant may include a compressed air, oxygen, oxygen-enriched air, oxygen-reduced air, oxygen-nitrogen mixtures, or any combination thereof. For example, the oxidant 68 may be compressed by the oxidant compression system 186 illustrated in FIG. 3. The process 220 also may begin to supply fuel to the combustors 160 and the fuel nozzles 164 during the startup mode 222, as indicated by block 226. During the startup mode 222, the process 220 also

may begin to supply exhaust gas (as available) to the combustors 160 and the fuel nozzles 164, as indicated by block 228. For example, the fuel nozzles 164 may produce one or more diffusion flames, premix flames, or a combination of diffusion and premix flames. During the startup mode 222, the exhaust gas 60 being generated by the gas turbine engine 156 may be insufficient or unstable in quantity and/or quality. Accordingly, during the startup mode, the process 220 may supply the exhaust gas 66 from one or more storage units (e.g., storage tank 88), the pipeline 86, other SEGR gas turbine systems 52, or other exhaust gas sources.

[0072] The process 220 may then combust a mixture of the compressed oxidant, fuel, and exhaust gas in the combustors 160 to produce hot combustion gas 172, as indicated by block 230. In particular, the process 220 may be controlled by the control system 100 of FIG. 2 to facilitate stoichiometric combustion (e.g., stoichiometric diffusion combustion, premix combustion, or both) of the mixture in the combustors 160 of the combustor section 154. However, during the startup mode 222, it may be particularly difficult to maintain stoichiometric combustion of the mixture (and thus low levels of oxidant and unburnt fuel may be present in the hot combustion gas 172). As a result, in the startup mode 222, the hot combustion gas 172 may have greater amounts of residual oxidant 68 and/or fuel 70 than during a steady state mode as discussed in further detail below. For this reason, the process 220 may execute one or more control instructions to reduce or eliminate the residual oxidant 68 and/or fuel 70 in the hot combustion gas 172 during the startup mode.

[0073] The process 220 then drives the turbine section 156 with the hot combustion gas 172, as indicated by block 232. For example, the hot combustion gas 172 may drive one or more turbine stages 174 disposed within the turbine section 156. Downstream of the turbine section 156, the process 220 may treat the exhaust gas 60 from the final turbine stage 174, as indicated by block 234. For example, the exhaust gas treatment 234 may include filtration, catalytic reaction of any residual oxidant 68 and/or fuel 70, chemical treatment, heat recovery with the HRSG 56, and so forth. The process 220 may also recirculate at least some of the exhaust gas 60 back to the compressor section 152 of the SEGR gas turbine system 52, as indicated by block 236. For example, the exhaust gas recirculation 236 may involve passage through the

exhaust recirculation path 110 having the EG processing system 54 as illustrated in FIGS. 1-3.

[0074] In turn, the recirculated exhaust gas 66 may be compressed in the compressor section 152, as indicated by block 238. For example, the SEGR gas turbine system 52 may sequentially compress the recirculated exhaust gas 66 in one or more compressor stages 158 of the compressor section 152. Subsequently, the compressed exhaust gas 170 may be supplied to the combustors 160 and fuel nozzles 164, as indicated by block 228. Steps 230, 232, 234, 236, and 238 may then repeat, until the process 220 eventually transitions to a steady state mode, as indicated by block 240. Upon the transition 240, the process 220 may continue to perform the steps 224 through 238, but may also begin to extract the exhaust gas 42 via the EG supply system 78, as indicated by block 242. For example, the exhaust gas 42 may be extracted from one or more extraction points 76 along the compressor section 152, the combustor section 154, and the turbine section 156 as indicated in FIG. 3. In turn, the process 220 may supply the extracted exhaust gas 42 from the EG supply system 78 to the hydrocarbon production system 12, as indicated by block 244. The hydrocarbon production system 12 may then inject the exhaust gas 42 into the earth 32 for enhanced oil recovery, as indicated by block 246. For example, the extracted exhaust gas 42 may be used by the exhaust gas injection EOR system 112 of the EOR system 18 illustrated in FIGS. 1-3.

[0075] FIG. 5 is a flow chart of a process 260 for operating the gas turbine engine 150 with exhaust gas recirculation. In a step 262, the process 260 compresses the oxidant 68 in the oxidant compressor 188 to generate compressed oxidant. Again, the oxidant 68 may include air, oxygen, oxygen-enriched air, oxygen-reduced air, oxygen nitrogen mixtures, or any combination thereof. For example, if the oxidant 68 includes air, then the compressor 188 may include an air compressor. In step 264, the exhaust gas 66 is compressed in a compressor section 152, such as an exhaust gas compressor of the gas turbine engine 150, to generate compressed exhaust gas 170. In a step 266, the compressed exhaust gas 170 and the compressed oxidant are routed from the compressor section 152 and the oxidant compressor 188, respectively, to one or more combustors 160 of the gas turbine engine 150. In a step 268, the compressed

exhaust gas 170 is isolated from the compressed oxidant prior to a flow mixer associated with each combustor 160, as described in detail below. In a step 270, the compressed exhaust gas 170 is split into first and second portions with a flow separator associated with each combustor 160, as described in detail below. In a step 272, the first portion of the compressed exhaust gas 170 is extracted for use in one or more applications, such as the oil/gas extraction system 16, the enhanced oil recovery (EOR) system 18, or another system 84. In a step 274, the second portion of the compressed exhaust gas 170 is mixed with oxidant to generate an exhaust gas/oxidant mixture using the flow mixer. In a step 276, the exhaust gas/oxidant mixture and the fuel 70 are injected into a combustion chamber of the combustion portion 168 of the combustor 160 to provide a combustible mixture. The fuel 70 may either be mixed with the exhaust gas/oxidant mixture in fuel nozzles (e.g., a premix design) or the fuel 70 may be kept separate from the exhaust gas/oxidant mixture until exiting the fuel nozzles (e.g., a diffusion design). In a step 278, the combustible mixture is combusted to generate the combustion gas or exhaust gas 172. In a step 280, the combustion gas or exhaust gas 172 is expanded in the turbine stages 174 of the gas turbine engine 150 to generate the exhaust gas 60. In a step 282, the expanded exhaust gas 60 is recirculated from the turbine stages 174 to the compressor stages 158 of the compressor section 152. The process 260 may then repeat by compressing oxidant in the oxidant compressor 188 to generate compressed oxidant in the step 262. With the overall process 260 for operating the gas turbine engine 150 shown in FIG. 5 in mind, specific embodiments of the combustor section 154 are shown in FIGS. 6-16 and discussed below.

[0076] FIG. 6 is a schematic diagram of an embodiment of the combustor section 154 that includes various features that are shown in detail in FIGS. 7-16. Elements in FIG. 6 in common with those shown in previous figures are labeled with the same reference numerals. The axial direction of the combustor 160 is indicated by arrow 294, the radial direction is indicated by arrow 296, and the circumferential direction is indicated by arrow 298. As shown in FIG. 6, the oxidant compression system 186 generates a compressed oxidant 300 that may be provided to various locations of the combustor 160. For example, the compressed oxidant 300 may be provided to a flow

mixer 302 to combine the compressed oxidant 300 with the compressed exhaust gas 170. As discussed in detail below, the flow mixer 302 may help to improve mixing of the oxidant 300 and exhaust gas 170 when space or length for mixing is limited. The compressed oxidant 300 may include air, oxygen, oxygen-enriched air, oxygen-reduced air, or oxygen nitrogen mixtures. The exhaust gas 170 may be substantially free of oxygen and unburnt fuel, and may result from stoichiometric combustion and exhaust gas recirculation, as discussed above. Thus, the exhaust gas 170 may be used as a diluent with the oxidant 300. Additionally or alternatively, the compressed oxidant 300 may be provided to a flow separator 304 that separates the compressed exhaust gas 170 into two or more portions. For example, the flow separator 304 may provide a portion of the compressed exhaust gas 170 to the exhaust extraction system 80 as the extracted exhaust gas 42. In addition, the flow separator 304 may also help to isolate the oxidant 300 from the exhaust gas 170. As shown in FIG. 6, the flow mixer 302 and the flow separator 304 may be disposed in the head end portion 166 of the combustor 160. Further details of the flow mixer 302 and the flow separator 304 are described below with respect to FIGS. 7-16.

[0077] FIG. 7 is a schematic diagram of the head end portion 166 of the combustor 160. As shown in FIG. 7, the combustor 160 is generally defined by a combustion casing 320, a flow sleeve 322, and a combustion liner 324. As illustrated, the flow sleeve 322 is disposed about the combustion liner 324. In certain embodiments, the flow sleeve 322 and the combustion liner 324 are coaxial with one another to define a first flow path 326 (e.g., annular passage), which may enable passage of the compressed exhaust gas 170 for cooling of the combustion liner 324 and for entry into the head end portion 166. In addition, the combustion casing 320 and the flow sleeve 322 may define a second flow path 328 (e.g., annular passage), which may also enable passage of the compressed exhaust gas 170 for cooling and for entry into the head end portion 166. A first exhaust extraction port 330 may be coupled to the combustion casing 320. As illustrated, the first exhaust extraction port 330 may be a radial port, thereby extracting the exhaust gas 42 radially 296 from the combustor 160. The first exhaust extraction port 330 may convey the compressed exhaust gas 170 (e.g., exhaust gas 42) from the second flow path 328 to the exhaust gas extraction system

80. In certain embodiments, a cap 331 may be disposed between the head end portion 166 and the combustion portion 168.

[0078] As shown in FIG. 7, the flow separator 304 separates the compressed exhaust gas 170 from the oxidant 68. Specifically, the flow separator 304 may include the flow sleeve 322 and/or a flow distributor 332, which may be disposed between the combustion casing 320 and the combustion liner 324 downstream (with respect to the direction of flowing compressed exhaust gas 170) of the first exhaust extraction port 330. In other embodiments, the flow separator 304 may also include other walls of the combustor 160, such as the combustion casing 320 and the combustion liner 324. The flow distributor 332 may extend crosswise across the first and second flow paths 326 and 328. In certain embodiments, the flow distributor 332 may extend completely circumferentially 298 around the head end portion 166, as discussed in detail below. In other embodiments, the flow distributor 332 may include a plurality of distributor portions spaced circumferentially 298 around the head end portion 166. For example, the flow distributor 332 may include a first distributor portion 394 and a second distributor portion 396 which may be different from one another (e.g., circumferentially 298 offset from one another). In various embodiments, the flow distributor may include 2, 3, 4, 5, 6, or more distributor portions. In certain embodiments, the first distributor portion 394 may include a plurality of first inserts 398 disposed circumferentially 298 and the second distributor portion 396 may include a plurality of second inserts 400 disposed circumferentially 298.

[0079] As discussed in detail below, the flow distributor 332 may include one or more paths or passages for routing of various fluids (e.g., gases) into, out of, or to certain portions of the combustor 160. Thus, by disposing a plurality of flow distributors 332 circumferentially 298 about the head end portion 166, differential flows of exhaust gas 42, oxidant 68, compressed exhaust gas 170, and so forth may be provided circumferentially 298 about the head end portion 166, which may include exhaust gas extraction, oxidant injection, flow toward the cap 331, flow into mixing regions, or any combination thereof.

[0080] As shown in FIG. 7, the flow distributor 332 of the first distributor portion 394 may include an exhaust gas flow path 334 that routes the compressed exhaust gas 170 in the second flow path 328 into the head end portion 166. Specifically, the exhaust gas flow path 334 may route the compressed exhaust gas 170 to a cooling region 335 adjacent the cap 331 in the head end portion 166 to help cool the cap 331. In certain embodiments, the exhaust gas flow path 334 may be referred to more generally as a cooling gas flow path, especially if a gas other than the compressed exhaust gas 170 is used for cooling.

[0081] As illustrated in FIG. 7, an oxidant intake port 336 may be coupled to the flow distributor 332 of both the first and section portions 394 and 396. As illustrated, the oxidant intake port 336 may be a radial port, thereby supplying the oxidant 68 to the combustor 160 radially 296. The oxidant intake port 336 may be configured to route the oxidant 68 from the oxidant compression system 186 to the combustor 160. In certain embodiments, the flow distributor 332 may include an oxidant flow path 338 that routes the oxidant 68 from the oxidant intake port 336 into the head end portion 166. Specifically, the oxidant flow path 338 may route the oxidant 68 to a mixing region 346 adjacent the flow distributor 332 to provide an oxidant-exhaust mixture 348.

[0082] As illustrated in FIG. 7, a second exhaust extraction port 344 may be coupled to the flow distributor 332 of the second distributor portion 396. As illustrated, the second exhaust extraction port 344 may be a radial port, thereby extracting the compressed exhaust gas 170 radially 296 from the combustor 160. In certain embodiments, the flow distributor 332 of the second distributor portion 396 may include an exhaust gas extraction flow path 345 that routes the exhaust gas 42 through the flow distributor 332 to the exhaust extraction system 80.

[0083] As shown in FIG. 7, the flow distributors 332 of both the first and second portions 394 and 396 provide the oxidant 68 to the mixing region 346. However, the flow distributor 332 of the first distributor portion 394 provides the compressed exhaust gas 170 to the cooling region 335 and the flow distributor of the first portion 396 provides the compressed exhaust gas 170 to the exhaust extraction system 80.

Thus, in certain embodiments, the relative sizes of the first and second portions 394 and 396 may be adjusted to achieve a desired allocation of the compressed exhaust gas 170 for cooling and extraction. In addition, as described below, the circumferential 298 placement of the first and second portions 394 and 396 may be adjusted for various reasons, such as to provide additional cooling where desired or extraction where space is available about the combustor 160. For example, the spacing between the first and second portions 394 (e.g., inserts) may be varied. In further embodiments, the plurality of first inserts 398 may differ from one another. For example, the diameters of the exhaust gas paths 334 may not all be the same and/or the diameters of the oxidant flow paths 338 may differ from one another. Similarly, the plurality of second inserts 400 may also differ from one another. Thus, the placement of the flow distributors 332, spacing of flow distributors 332, diameters, shapes, sizes, positions, and/or placement of passages of the flow distributors 332 may be used to vary the circumferential 298 distribution about the head end portion 166 of the flows of the exhaust gas 42, oxidant 68, compressed exhaust gas 170, and so forth.

[0084] In certain embodiments, the flow distributor 332 does not extend completely circumferentially 298 about the head end portion 166, as discussed in detail below. Thus, some of the compressed exhaust gas 170 may flow past, or bypass, one or more flow distributors 332 (e.g., the flow separator 304) through intermediate spaces between flow distributors 332 to combine with the oxidant 68 to form the oxidant-exhaust mixture 348. As shown in FIG. 7, several walls are disposed downstream of the flow distributor 332. Specifically, a first wall 402 is disposed circumferentially 298 about the head end portion 166, a second wall 404 is disposed circumferentially 298 about the first wall 402 to define the first flow path 326, and a third wall 406 is disposed circumferentially 298 about the second wall 404. In certain embodiments, there may be no flow path between the second and third walls 404 and 406. In other words, the second and third walls 404 and 406 may be considered a single, integral wall. As shown in FIG. 7, the first wall 402 may generally coincide with the combustion liner 324, the second wall 404 may generally coincide with the flow sleeve 322, and the third wall 406 may generally coincide with the combustion

casing 320. However, in other embodiments, the first, second, and third walls 402, 402, and 406 may be disposed at different locations. As shown in FIG. 7, the mixing region 346 is enclosed by the first and second walls 402 and 404.

[0085] Next, the oxidant-exhaust mixture 348 may travel to an end plate 340 before turning and entering the fuel nozzles 164. The fuel 70 may be supplied to the combustor 160 via a fuel supply system 342. Specifically, an axial fuel manifold 408 may supply the fuel 70 axially 294 to one or more fuel intake ports 410 coupled to a central portion 341 of the end plate 340. As shown in FIG. 7, the oxidant-exhaust mixture 348 then enters the fuel nozzles 164 to be combined with the fuel 70 from the fuel supply system 342 before being combusted in the combustion portion 168 (e.g., premix fuel nozzles). In other embodiments, the oxidant-exhaust mixture 348 is not combined with the fuel 70 until exiting the fuel nozzles 164 (e.g., diffusion fuel nozzles). In addition, the controller 118 may be used to control the exhaust extraction system 80 and the oxidant compression system 186.

[0086] FIG. 8 is a radial cross-sectional view of the combustor 160 taken along the line 8-8 of FIG. 7. As shown in FIG. 8, the path of the compressed exhaust gas 170 in the second flow path 328 may be blocked by an annular ring 360, which may be part of the flow distributor 332. Thus, for the first inserts 398 (e.g., the first distributor portion 394), the compressed exhaust gas 170 in the second flow path 328 is forced into the exhaust gas path 334. Specifically, the compressed exhaust gas 170 enters an entrance 362 of the exhaust gas path 334 and enters the head end chamber 166 through an exit 364 to help cool the cap 331. For the second inserts 400 (e.g., the second distributor portion 396), the compressed exhaust gas 170 in the second flow path 328 is forced into the exhaust gas extraction flow path 345. Specifically, the compressed exhaust gas 170 enters an entrance 368 of the exhaust gas extraction flow path 345 and exits an exit 370 to be extracted through the second exhaust extraction port 344. In addition, the oxidant 68 enters an oxidant entrance 420 of the oxidant path 400 and exits an oxidant exit 422 into the first flow path 326 to mix with the compressed exhaust gas 170 to generate the oxidant-exhaust mixture 348.

[0087] As shown in FIG. 8, a plurality of first inserts 398 may be spaced apart from one another circumferentially 298 about the head end portion 166 (e.g., fuel nozzles 164) and a plurality of second inserts 400 may also be spaced apart from one another circumferentially 298. Thus, the compressed exhaust gas 170 in the first flow path 326 passes through gaps 366 between the first and second inserts 398 and 400. In other embodiments, the first and second inserts 398 and 400 may not be evenly spaced apart from one another circumferentially 298. For example, the plurality of first and second inserts 398 and 400 may be disposed within approximately 60 degrees of top dead center of the combustor 160 because of packaging constraints associated with can-annular combustors. In addition, the first and second inserts 398 and 400 may not be distributed circumferentially 298 in an alternating arrangement, as shown in FIG. 8. For example, if more extraction of the compressed exhaust gas 170 is desired, a pattern of two of the second inserts 400 followed circumferentially 298 by one of the first inserts 398 may be repeated circumferentially 298. If additional extraction of the compressed exhaust gas 170 is desired, a pattern of 3, 4, 5, 6 or more of the second inserts 400 followed circumferentially 298 by one of the first inserts 398 may be repeated circumferentially 298. In other embodiments, the arrangement of the first and second inserts 398 and 400 may not follow a repeating pattern. For example, the first inserts 398 may be disposed generally near top dead center of the combustor and the second inserts 400 may be disposed generally opposite from top dead center. Thus, the first and second inserts 398 and 400 may be arranged circumferentially 298 to achieve desired flow rates and/or placement of extracted compressed exhaust gas 170 and compressed exhaust gas 170 used for cooling the cap 331.

[0088] FIG. 9 is a radial cross-sectional view of the combustor 160 taken along the line 8-8 of FIG. 7. As shown in FIG. 9, a second annular ring 380 may be disposed in the first flow path 326. The second annular ring 380, which may be part of the flow distributor 332, may include a plurality of openings 382 for the compressed exhaust gas 170 to pass through. Thus, the second annular ring 380 and the openings 382 may be used to adjust the flow rate of the compressed exhaust gas 170 through the first flow path 326. For example, providing more openings 382 may enable additional compressed exhaust gas 170 to flow through the first flow path 326. The openings

382 may be disposed circumferentially 298 about the fuel nozzles 164. Although the openings 382 are shown as circular openings in FIG. 9, the sizes, shapes, and/or locations of the openings 382 may be adjusted to provide the desired flow rate of the compressed exhaust gas 170 through the first flow path 326 and/or to accommodate packaging limitations of individual combustors 160. As shown in FIG. 9, a plurality of entrances 362 for the exhaust gas flow path 334 may be disposed circumferentially 298 in the first annular ring 360. In certain embodiments, the number of entrances 362 may be adjusted to provide a desired amount of cooling of the cap 331. In addition, the locations of the entrances 362 may be varied to provide cooling of the cap 331 where desired. In addition, a plurality of entrances 368 of the exhaust gas extraction flow path 345 may be disposed circumferentially 298 in the first annular ring 360. Thus, the entrances 362 may be disposed in one or more arcuate portions of the head end portion 166 (e.g., first annular ring 360) and the entrances 368 may be disposed in one or more different arcuate portions. Although the entrances 362 and 368 are shown spaced apart from one another circumferentially 298 in FIG. 9, in other embodiments, the entrances 362 and 368 may be disposed within approximately 60 degrees of top dead center of the combustor 160.

[0089] FIG. 10 is a cross-sectional view of an embodiment of the combustor 160. Elements in FIG. 10 in common with those shown in FIG. 7 are labeled with the same reference numerals. The cross-sectional view shown in FIG. 10 is similar to the view shown in FIG. 7, but focuses on the shape and arrangement of the components of the combustor 160 near the first distributor portion 394 of the flow distributor 332. For example, in the illustrated embodiment, the second flow path 328 includes a contoured surface 390 near the flow distributor 332 to help guide the compressed exhaust gas 170 into the entrance 362. In addition, the contoured surface 390 may be used to adjust the flow rate of the compressed exhaust gas 170 through the exhaust gas flow path 334 in the flow distributor 332. Similarly, the first flow path 326 may include various contoured surfaces to adjust the flow rate of the compressed exhaust gas 170 through the first flow path 326. Further, the first and second walls 402 and 404 may converge in the direction of the flow of the oxidant-exhaust mixture 348, which may help increase the velocity of the oxidant-exhaust mixture 348. As

discussed below, numbers, placement, shapes, and/or diameters of the exhaust gas flow path 334 and the oxidant flow path 338 may be varied in a plurality of flow distributors 332 disposed circumferentially 298 about the head end portion 166.

[0090] FIG. 11 is a cross-sectional view of an embodiment of the combustor 160. Elements in FIG. 11 in common with those shown in FIG. 7 are labeled with the same reference numerals. The cross-sectional view shown in FIG. 11 is similar to the view shown in FIG. 7, but focuses on the shape and arrangement of the components of the combustor 160 near the second distributor portion 396 of the flow distributor 332. For example, in the illustrated embodiment, the second flow path 328 includes the contoured surface 390 near the flow distributor 332 to help guide the compressed exhaust gas 170 into the entrance 368 of the exhaust gas extraction flow path 345. In addition, the contoured surface 390 may be used to adjust the flow rate of the compressed exhaust gas 170 through the exhaust gas extraction flow path 345 in the flow distributor 332. Similarly, the first flow path 326 may include various contoured surfaces to adjust the flow rate of the compressed exhaust gas 170 through the first flow path 326. Further, the first and second walls 402 and 404 may converge in the direction of the flow of the oxidant-exhaust mixture 348, which may help increase the velocity of the oxidant-exhaust mixture 348. As discussed below, numbers, placement, shapes, and/or diameters of the exhaust gas extraction flow path 345 and the oxidant flow path 338 may be varied in a plurality of flow distributors 332 disposed circumferentially 298 about the head end portion 166.

[0091] FIG. 12 is a schematic diagram of an embodiment of the head end portion 166 of the combustor section 154. Elements in FIG. 12 in common with those shown in FIG. 7 are labeled referenced with the same reference numerals. As shown in FIG. 12, a portion of the compressed exhaust gas 170 in the second flow path 328 exits the combustor 160 radially 296 through the first exhaust gas extraction port 330 to enter the exhaust gas extraction system 80. Another portion of the compressed exhaust gas 170 in the second flow path 328 flows toward the first distributor portion 394 of the flow distributor 332. Prior to reaching the flow distributor 332, the compressed exhaust gas 170 combines with the oxidant 68 entering the combustor 160 radially 296 through the oxidant intake port 336 to produce the oxidant-exhaust mixture 348

in the mixing region 346. The oxidant-exhaust mixture 348 then enters the entrance 362 of the exhaust gas path 334 and enters the head end chamber 166 through the exit 364 to help cool the cap 331. The exhaust gas path 334 may also be referred to more generally as a cooling gas path as the oxidant-exhaust mixture 348 includes more than just exhaust gas (i.e., oxidant 68). Backflow of the oxidant 68 into the first exhaust extraction port 330 may be blocked by the flow of the compressed exhaust gas 170 toward the flow distributor 332. In further embodiments, a baffle, wall, or similar device may be used to prevent the oxidant 68 from entering the first exhaust extraction port 330.

[0092] In the illustrated embodiment of FIG. 12, an oxidant-exhaust mixture path 430 is coupled to the exhaust gas path 334 to route the oxidant-exhaust mixture 348 from the second flow path 328 to the first flow path 326 downstream of the first distributor portion 394 of the flow distributor 332. As shown in FIG. 12, the compressed exhaust gas 170 in the first flow path 326 may flow past, or bypass, the flow distributor 332 to combine with the oxidant-exhaust mixture 348 downstream of the flow distributor 332, thereby increasing the concentration of the compressed exhaust gas 170 of the oxidant-exhaust mixture 348. In other embodiments, the oxidant-exhaust mixture path 430 may not be coupled to the exhaust gas path 334. Instead, the oxidant-exhaust mixture path 430 may have an entrance separate from the entrance 362.

[0093] Next, the oxidant-exhaust mixture 348 may travel to the end plate 340 before turning and entering the fuel nozzles 164. The fuel 70 may be supplied to the combustor 160 via the fuel supply system 342. Specifically, the axial fuel manifold 408 may supply the fuel 70 axially 294 to one or more fuel intake ports 410 coupled to the end plate 340. As shown in FIG. 12, the oxidant-exhaust mixture 348 then enters the fuel nozzles 164 to be combined with the fuel 70 from the fuel supply system 342 before being combusted in the combustion portion 168 (e.g., premix fuel nozzles). In other embodiments, the oxidant-exhaust mixture 348 is not combined with the fuel 70 until exiting the fuel nozzles 164 (e.g., diffusion fuel nozzles). In addition, the controller 118 may be used to control the exhaust extraction system 80 and the oxidant compression system 186.

[0094] As illustrated in FIG. 12, the second exhaust extraction port 344 may be coupled to the flow distributor 332 of the second distributor portion 396. As illustrated, the second exhaust extraction port 344 may be a radial port, thereby extracting the exhaust gas 170 radially 296 from the combustor 160. In certain embodiments, the flow distributor 332 of the second distributor portion 396 may include the exhaust gas extraction flow path 345 that routes the compressed exhaust gas 170 from the first flow path 326 through the flow distributor 332 to the exhaust extraction system 80. Thus, the flow distributor 332 of the second distributor portion 396 may include only one flow path, unlike the flow distributor 332 of the first distributor portion 394 that includes more than one flow path.

[0095] FIG. 13 is a radial cross-sectional view of the combustor 160 taken along the line 13-13 of FIG. 12. As shown in FIG. 13, the path of the compressed exhaust gas 170 in the second flow path 328 may be blocked by the annular ring 360, which may be part of the flow distributor 332. Thus, for the first inserts 398 (e.g., the first distributor portion 394), the compressed exhaust gas 170 in the second flow path 328 is forced into the exhaust gas path 334 and the oxidant-exhaust mixture path 430. Specifically, the compressed exhaust gas 170 enters the entrance 362 of the exhaust gas path 334 and enters the head end chamber 166 through the exit 364 to help cool the cap 331. In addition, the compressed exhaust gas 170 enters an entrance 432 of the oxidant-exhaust mixture path 430 and enters the first flow path 326 through an exit 434 to combine with the compressed exhaust gas 170 in the first flow path 326. As described above, in certain embodiments, the oxidant-exhaust mixture path 430 may be coupled to the exhaust gas path 334. In such embodiments, the entrance 432 may be omitted and the compressed exhaust gas 170 may enter the entrance 362 to enter both the exhaust gas path 334 and the oxidant-exhaust mixture path 430. For the second inserts 400 (e.g., the second distributor portion 396), the compressed exhaust gas 170 in the first flow path 326 is forced into the exhaust gas extraction flow path 345. Specifically, the compressed exhaust gas 170 enters the entrance 368 of the exhaust gas extraction flow path 345 and exits the exit 370 to be extracted through the second exhaust extraction port 344.

[0096] As shown in FIG. 13, a plurality of first inserts 398 may be spaced apart from one another circumferentially 298 about the head end portion 166 (e.g., fuel nozzles 164) and a plurality of second inserts 400 may also be spaced apart from one another circumferentially 298. Thus, the compressed exhaust gas 170 in the first flow path 326 passes through gaps 366 between the first and second inserts 398 and 400. In other embodiments, the first and second inserts 398 and 400 may not be evenly spaced apart from one another circumferentially 298. For example, the plurality of first and second inserts 398 and 400 may be disposed within approximately 60 degrees of top dead center of the combustor 160 because of packaging constraints associated with can-annular combustors. In addition, the first and second inserts 398 and 400 may not be distributed circumferentially 298 in an alternating arrangement, as shown in FIG. 8. For example, if more extraction of the compressed exhaust gas 170 is desired, a pattern of two of the second inserts 400 followed circumferentially 298 by one of the first inserts 398 may be repeated circumferentially 298. If additional extraction of the compressed exhaust gas 170 is desired, a pattern of 3, 4, 5, 6 or more of the second inserts 400 followed circumferentially 298 by one of the first inserts 398 may be repeated circumferentially 298. In other embodiments, the arrangement of the first and second inserts 398 and 400 may not follow a repeating pattern. For example, the first inserts 398 may be disposed generally near top dead center of the combustor and the second inserts 400 may be disposed generally opposite from top dead center. Thus, the first and second inserts 398 and 400 may be arranged circumferentially 298 to achieve desired flow rates and/or placement of extracted compressed exhaust gas 170 and compressed exhaust gas 170 used for cooling the cap 331.

[0097] FIG. 14 is a radial cross-sectional view of the combustor 160 taken along the line 13-13 of FIG. 12. As shown in FIG. 14, the second annular ring 380 may be disposed in the first flow path 326. The second annular ring 380, which may be part of the flow distributor 332, may include a plurality of openings 382 for the compressed exhaust gas 170 to pass through. Thus, the second annular ring 380 and the openings 382 may be used to adjust the flow rate of the compressed exhaust gas 170 through the first flow path 326. For example, providing more openings 382 may enable additional compressed exhaust gas 170 to flow through the first flow path 326. The

openings 382 may be disposed circumferentially 298 about the fuel nozzles 164. Although the openings 382 are shown as circular openings in FIG. 14, the sizes, shapes, and/or locations of the openings 382 may be adjusted to provide the desired flow rate of the compressed exhaust gas 170 through the first flow path 326 and/or to accommodate packaging limitations of individual combustors 160. Although the entrances 362 and exits 364 are shown spaced apart from one another circumferentially 298 in FIG. 9, in other embodiments, the entrances 362 and exits 364 may be disposed within approximately 60 degrees of top dead center of the combustor 160.

[0098] FIG. 15 is a cross-sectional view of an embodiment of the combustor 160. Elements in FIG. 15 in common with those shown in FIG. 12 are labeled with the same reference numerals. The cross-sectional view shown in FIG. 15 is similar to the view shown in FIG. 12, but focuses on the shape and arrangement of the components of the combustor 160 near the first distributor portion 394 of the flow distributor 332. For example, in the illustrated embodiment, the second flow path 328 includes a contoured surface 390 near the flow distributor 332 to help guide the oxidant-exhaust mixture 348 into the entrance 362. In addition, the contoured surface 390 may be used to adjust the flow rate of the oxidant-exhaust mixture 348 through the exhaust gas flow path 334 and/or the oxidant-exhaust mixture path 430 in the flow distributor 332. Similarly, the first flow path 326 may include various contoured surfaces to adjust the flow rate of the compressed exhaust gas 170 through the first flow path 326. Further, the first and second walls 402 and 404 may converge in the direction of the flow of the oxidant-exhaust mixture 348, which may help increase the velocity of the oxidant-exhaust mixture 348. As discussed below, numbers, placement, shapes, and/or diameters of the exhaust gas path 334 and the oxidant-exhaust mixture path 430 may be varied in a plurality of flow distributors 332 disposed circumferentially 298 about the head end portion 166.

[0099] FIG. 16 is a cross-sectional view of an embodiment of the combustor 160. Elements in FIG. 16 in common with those shown in FIG. 12 are labeled with the same reference numerals. The cross-sectional view shown in FIG. 16 is similar to the view shown in FIG. 12, but focuses on the shape and arrangement of the components

of the combustor 160 near the second distributor portion 396 of the flow distributor 332. For example, in the illustrated embodiment, the second flow path 328 includes the contoured surface 390 near the flow distributor 332 to help guide the oxidant-exhaust mixture 348 toward the flow distributor 332. Similarly, the first flow path 326 may include various contoured surfaces to adjust the flow rate of the oxidant-exhaust mixture 348 through the first flow path 326. Further, the first and second walls 402 and 404 may converge in the direction of the flow of the oxidant-exhaust mixture 348, which may help increase the velocity of the oxidant-exhaust mixture 348. As discussed below, numbers, placement, shapes, and/or diameters of the exhaust gas extraction flow path 345 may be varied in a plurality of flow distributors 332 disposed circumferentially 298 about the head end portion 166.

[00100] FIG. 17 is an exploded schematic of various configurations of the flow distributors 334, which may be removably coupled to various circumferential 298 positions of the combustor 160. As illustrated, the flow distributors 334 include a plurality of swappable flow distributors 450, 452, 454, 456, 458, 460, 462, 464, 466, 468, 470, and 472, which differ in a variety of respects, such as having different passages, different passage geometries, and/or different numbers of passages. Thus, the flow distributors 450, 452, 454, 456, 458, 460, 462, 464, 466, 468, 470, and 472 may selectively swapped out at each circumferential 298 position of the flow distributor 332 to provide different flow arrangements for different operating conditions of the combustor 160. The flow distributors 450, 452, 454, 456, 458, 460, 462, 464, 466, 468, 470, and 472 are shown as axial cross-sections. As shown below, the diameters, shapes, numbers, placement, and/or positions of the flow paths of the flow distributors 332 may be varied to obtain different flow distributors 332, which may then be placed circumferentially 298 about the head end portion 166.

[00101] For example, flow distributors 450, 452, 454, 456, 466, 468, and 470 may all include the exhaust gas flow path 334 that routes the compressed exhaust gas 170 to the cap 331. A diameter 476 of the exhaust gas flow path 334 may be varied to adjust the flow rate of the compressed exhaust gas 170. For example, the diameter 476 of the exhaust gas flow path 334 of flow distributors 450, 452, and 456 may be less than the diameter 476 of flow distributor 454. By increasing the diameter 476, the

flow rate of the compressed exhaust gas 170 to the cap 331 may be increased, while decreasing the diameter 476 may decrease the flow rate of the compressed exhaust gas 170. In certain embodiments, one or more of the flow distributors may include a plurality of exhaust gas flow paths 334. For example, flow distributor 452 includes two exhaust gas flow paths 334, which may be used to provide the compressed exhaust gas 170 for cooling different locations of the combustor 160.

[00102] Flow distributors 450, 452, 454, 456, 458, 460, 462, 464, 468, 470, and 472 may all include the oxidant flow path 338 that routes the oxidant 68 into the head end portion 166. A diameter 478 of the oxidant flow path 338 may be varied to adjust the flow rate of the oxidant 68. For example, the diameter 478 of the oxidant flow path 338 of flow distributors 450, 454, 458, 462, 468, 470, and 472 may be less than the diameter 478 of flow distributors 452 and 464. By increasing the diameter 478, the flow rate of the oxidant 68 may be increased, while decreasing the diameter 478 may decrease the flow rate of the oxidant 68.

[00103] Flow distributors 456, 458, 460, 462, 464, 468, 470, and 472 may all include the exhaust gas extraction flow path 345 that routes the exhaust gas 42 to the exhaust extraction system 80. A diameter 480 of the exhaust gas extraction flow path 345 may be varied to adjust the flow rate of the exhaust gas 42. For example, the diameter 480 of the exhaust gas extraction flow path 345 of flow distributors 458, 464, 470, and 472 may be less than the diameter 480 of flow distributors 460 and 462. By increasing the diameter 480, the flow rate of the exhaust gas 42 may be increased, while decreasing the diameter 480 may decrease the flow rate of the exhaust gas 42. In certain embodiments, the flow distributors may include a plurality of exhaust gas extraction flow paths 345. For example, flow distributor 472 includes two exhaust gas extraction flow paths 345, which may be used to provide the exhaust gas 42 from different paths, such as the first and second flow paths 326 and 328. In other embodiments, the exhaust gas extraction flow path 345 may couple with other paths, such as the exhaust gas flow path 334 in flow distributor 468.

[00104] In flow distributor 466, the exhaust gas flow path 334 is coupled to the oxidant-exhaust mixture path 430. Thus, the oxidant-exhaust mixture 348 may be

routed to both the cap 331 and to the fuel nozzles 164. As with the previously-described flow distributors 334, diameters of the exhaust gas flow path 334 and the oxidant-exhaust mixture path 430 may be varied to achieve a desired split of the oxidant-exhaust mixture 348.

[00105] In flow distributor 468, an exhaust gas path 474 is coupled to both the exhaust gas flow path 334 and the exhaust gas extraction flow path 345. The exhaust gas path 474 may route the compressed exhaust gas 170 through the flow distributor 468 to be combined with the oxidant 68 flowing through the oxidant flow path 338. As with the previously-described flow distributors 334, diameters of the exhaust gas path 474, exhaust gas flow path 334, and the exhaust gas extraction flow path 345 may be varied to achieve a desired split of the compressed exhaust gas 170.

[00106] In one or more of the flow distributors 450, 452, 454, 456, 458, 460, 462, 464, 466, 468, 470, and 472, relative diameters of different paths within a single flow distributor may be different from one another. For example, the diameter 476 of the exhaust gas flow path 334 may be larger or smaller than the diameter 478 of the oxidant flow path 338 or the diameter 480 of the exhaust gas extraction flow path 345. Similarly, the diameter 478 may be larger or smaller than diameters 476 or 480 and the diameter 480 may be larger or smaller than diameters 476 or 478. The relationship between the diameters 476, 478, and 480 may also vary going from one flow distributor to another circumferentially 298 about the head end portion 166. As shown in FIG. 17, the diameter 478 of the oxidant flow path 338 in flow distributor 452 is larger than the diameter 476 of the exhaust gas flow path 334, whereas the diameter 478 is smaller than the diameter 476 in flow distributor 454. Similarly, the diameter 478 of the oxidant flow path 338 is smaller than the diameter 480 of the exhaust gas extraction flow path 345 in flow distributor 462, whereas the diameter 478 larger than the diameter 480 in flow distributor 464.

[00107] FIG. 18 is a radial cross-sectional view of an embodiment of the turbine combustor 160 with a plurality of flow distributors 334. Specifically, the combustor 160 includes flow distributors 334 disposed at first 490, second 492, third 494, fourth 496, fifth 498, sixth 500, seventh, 502, eighth 504, ninth 506, tenth 508, eleventh 510,

twelfth 512, thirteenth 514, fourteenth 516, fifteenth 518, and sixteenth 520 positions circumferentially 298 disposed about the combustor 160. Each of the flow distributors 334 disposed at the positions 490, 492, 494, 496, 498, 500, 502, 504, 506, 508, 510, 512, 514, 516, 518, and 520 may be the same or different from one another. For example, any of the flow distributors 450, 452, 454, 456, 458, 460, 462, 464, 466, 468, 470, and 472 shown in FIG. 17 may be used in one or more of the positions 490, 492, 494, 496, 498, 500, 502, 504, 506, 508, 510, 512, 514, 516, 518, and 520. In certain embodiments, flow distributors 334 disposed at positions 490, 492, 494, 496, 514, 516, 518, and 520 may different from flow distributors 334 disposed at positions 498, 500, 502, 504, 506, 508, 510, and 512. In other embodiments, two types of flow distributors 334 may be disposed in an alternating arrangement. For example, flow distributors 334 disposed at positions 490, 494, 498, 502, 506, 510, 514, and 518 may be different from flow distributors 334 disposed at positions 492, 496, 500, 504, 508, 512, 516, and 520. In further embodiments, 2, 3, 4, or more different types of flow distributors 334 may be disposed in various patterns. Thus, the plurality of flow distributors 334 may be selected and disposed at the various positions 490, 492, 494, 496, 498, 500, 502, 504, 506, 508, 510, 512, 514, 516, 518, and 520 depending on the specific uses of the combustor 160. In further embodiments, the sizes of passages within the flow distributors 334 may be varied circumferentially 298 about the head end portion 166. For example, it may be desirable to have more or less oxidant injection or exhaust flow at different circumferential 298 positions. Where more flow is desired, the sizes of the passages may be larger than where less flow is desired.

[00108] FIG. 19 is a radial cross-sectional view of an embodiment of the turbine combustor with a plurality of passages 530, which may be any of the exhaust gas flow path 334, oxidant flow path 338, exhaust gas extraction flow path 345, oxidant-exhaust mixture path 430, and/or exhaust gas path 474 described above. The illustrated passages 530 may be disposed in one or more flow distributors 334, such as those described in detail above. As shown in FIG. 19, the passages 530 may not be disposed uniformly circumferentially 298 about the combustor 160. For example, the passages 530 disposed in a first region 532 may be spaced further apart from one another than the passages disposed in a second region 534. Passages 530 disposed in a

third region 536 may be disposed apart from one another an intermediate distance compared to the passages 530 of the first and second regions 532 and 534. Such an arrangement of passages 530 may be used to provide a desired flow of gas in a particular location of the combustor 160. For example, if the passages 530 are exhaust gas flow paths 334, additional cooling of the cap 331 may be provided in the second region 534 compared to the first region 532. In certain embodiments, the second region 534 may be closest to the compressor discharge where the pressure of the exhaust may be higher. Thus, a higher concentration of passages 530 may be desirable in the second region 534. In further embodiments, fewer or more regions of passages 530 may be disposed circumferentially 298 about the combustor 160.

[00109] FIG. 20 is a radial cross-sectional view of an embodiment of the turbine combustor 160 with a plurality of passages 530 of different diameters. For example, diameters 550 of the passages 530 of the first region 532 may be less than diameters 552 of the passages 530 of the second region 534. Passages 530 disposed in the third region 536 may have diameters 554 intermediate in dimension compared to the diameters 550 and 552 of the first and second regions 532 and 534, respectively. Varying the diameters 550, 552, and 554 may be used to achieve desired flow rates of the gases flowing through the passages 530. For example, the passages 530 of the second region 534 may provide higher flow rates compared to the passages 530 of the first region 532, which may be desirable in embodiments in which the second region 534 is closer to the compressor discharge. In other embodiments, the diameters 550, 552, and 554 of the passages 530 may be varied differently than that shown in FIG. 20. For example, diameters 550 of the first region 532 may be greater than diameters 552 of the second region 534. In other embodiments, the diameters 550, 552, and 554 may follow regular or non-regular patterns circumferentially 298 about the combustor 160.

[00110] As described above, certain embodiments of the combustor 160 may include the head end portion 166, the combustion portion 168 disposed downstream from the head end portion 166, and the cap 331 disposed between the head end portion 166 and the combustion portion 68. In addition, the combustor 160 may include the flow distributor 332 to distribute the exhaust gas 42 or the compressed

exhaust gas 170 circumferentially 298 around the head end chamber 166. Specifically, the flow distributor 332 directs the compressed exhaust gas 170 into the head end portion 166. The flow distributor 332 may also direct the compressed exhaust gas 170 to the exhaust extraction system 80 and the flow distributor 332 may receive the oxidant 68 from the oxidant compressor system 186. The combustor 160 may also include the mixing region 346, which may be upstream or downstream of the flow distributor 332, to mix the compressed exhaust gas 170 with the oxidant 68 to provide the oxidant-exhaust mixture 348. In the disclosed embodiments, the compressed exhaust gas 170 and/or the oxidant-exhaust mixture 348 may be directed by the flow distributor 332 to cool the combustion liner 324 or cap 331, thereby extending the life span of the combustion liner 324 or cap 331. In addition, the circumferential arrangement of the flow distributor 332 may be used to direct flows of gases where desired. For example, the flow distributor 332 may be used to direct the compressed exhaust gas 170 and/or the oxidant-exhaust mixture 348 to portions of the cap 331 for additional cooling. Diameters of passages 530 may be increased and/or additional flow distributors 332 (e.g., first or second inserts 398 or 400) disposed where higher flow rates are desired.

ADDITIONAL DESCRIPTION

[00111] The present embodiments provide systems and methods for turbine combustors of gas turbine engines. It should be noted that any one or a combination of the features described above may be utilized in any suitable combination. Indeed, all permutations of such combinations are presently contemplated. By way of example, the following clauses are offered as further description of the present disclosure:

[00112] Embodiment 1. A system, comprising: a turbine combustor, comprising: a head end portion having a head end chamber; a combustion portion having a combustion chamber disposed downstream from the head end chamber; a cap disposed between the head end chamber and the combustion chamber; and a flow distributor configured to distribute an exhaust flow circumferentially around the head end chamber, wherein the flow distributor comprises at least one exhaust gas flow path.

[00113] Embodiment 2. The system of embodiment 1, wherein the flow distributor comprises: a first flow distributor portion configured to distribute the exhaust flow along a first portion of the head end chamber; and a second flow distributor portion configured to distribute the exhaust flow along a second portion of the head end chamber.

[00114] Embodiment 3. The system defined in any preceding embodiment, wherein the first and second flow distributor portions are different from one another.

[00115] Embodiment 4. The system defined in any preceding embodiment, wherein the first flow distributor portion is configured to distribute the exhaust flow at a first flow rate, wherein the second flow distributor portion is configured to distribute the exhaust flow at a second flow rate.

[00116] Embodiment 5. The system defined in any preceding embodiment, wherein the first and second flow rates are different from one another.

[00117] Embodiment 6. The system defined in any preceding embodiment, wherein the first flow distributor portion comprises a first arcuate portion of the head end chamber, and the second flow distributor portion comprises a second arcuate portion of the head end chamber.

[00118] Embodiment 7. The system defined in any preceding embodiment, wherein the first and second flow distributor portions are circumferentially offset from one another.

[00119] Embodiment 8. The system defined in any preceding embodiment, wherein the first flow distributor portion comprises a first radial insert and the second flow distributor portion comprises a second radial insert.

[00120] Embodiment 9. The system defined in any preceding embodiment, wherein the first flow distributor portion comprises a plurality of first radial inserts, and the second flow distributor portion comprises a plurality of second radial inserts.

[00121] Embodiment 10. The system defined in any preceding embodiment, wherein the plurality of first radial inserts is uniformly disposed circumferentially around the head end chamber, and the plurality of second radial inserts is uniformly disposed circumferentially around the head end chamber.

[00122] Embodiment 11. The system defined in any preceding embodiment, wherein each of the plurality of first radial inserts is spaced apart from one another by a first distance, and each of the plurality of second radial inserts is spaced apart from one another by a second distance.

[00123] Embodiment 12. The system defined in any preceding embodiment, wherein the first distance is less than the second distance, and the plurality of first radial inserts is disposed near a compressor discharge of the turbine combustor.

[00124] Embodiment 13. The system defined in any preceding embodiment, wherein each of the plurality of first radial inserts comprises at least one first passage comprising a first exhaust gas flow path, a first oxidant flow path, a first exhaust gas extraction flow path, a first cooling gas flow path, a first oxidant-exhaust mixture path, or any combination thereof, wherein each of the plurality of second radial inserts comprises at least one second passage comprising a second exhaust gas flow path, a second oxidant flow path, a second exhaust gas extraction flow path, a second cooling gas flow path, a second oxidant-exhaust mixture path, or any combination thereof.

[00125] Embodiment 14. The system defined in any preceding embodiment, wherein a first diameter of the at least one first passage is different from a second diameter of the at least one second passage.

[00126] Embodiment 15. The system defined in any preceding embodiment, wherein the first diameter is greater than the second diameter, and the first radial inserts are disposed near a compressor discharge of the turbine combustor.

[00127] Embodiment 16. The system defined in any preceding embodiment, wherein the plurality of first radial inserts and the plurality of second radial inserts are disposed circumferentially around the head end chamber in a repeating pattern.

[00128] Embodiment 17. The system defined in any preceding embodiment, wherein the repeating pattern comprises at least one of two first radial inserts followed circumferentially by one second radial insert, three first radial inserts followed circumferentially by one second radial insert, four first radial inserts followed circumferentially by one second radial insert, or any combination thereof.

[00129] Embodiment 18. The system defined in any preceding embodiment, wherein the first flow distributor portion comprises the exhaust gas flow path configured to convey the exhaust flow radially to a cooling region adjacent the cap and a first oxidant flow path configured to convey an oxidant flow radially from an oxidant compressor system, and wherein the second flow distributor portion comprises an exhaust gas extraction flow path configured to convey the exhaust flow radially to an exhaust extraction system and a second oxidant flow path configured to convey the oxidant flow radially from the oxidant compressor system.

[00130] Embodiment 19. The system defined in any preceding embodiment, wherein the first flow distributor portion comprises a cooling gas flow path configured to convey an oxidant-exhaust mixture radially to a cooling region adjacent the cap and an oxidant-exhaust mixture path configured to convey the oxidant-exhaust mixture axially from a mixing region upstream of the flow distributor, and wherein the second flow distributor portion comprises an exhaust gas extraction flow path configured to convey the exhaust flow radially to an exhaust extraction system.

[00131] Embodiment 20. The system defined in any preceding embodiment, wherein the turbine combustor comprises an exhaust extraction port configured to extract the exhaust flow from the turbine combustor.

[00132] Embodiment 21. The system defined in any preceding embodiment, wherein the exhaust extraction port is coupled to a casing disposed about the turbine combustor upstream of the flow distributor, coupled to the flow distributor, or any combination thereof.

[00133] Embodiment 22. The system defined in any preceding embodiment, wherein the turbine combustor comprises an oxidant intake port configured to supply an oxidant flow to the turbine combustor.

[00134] Embodiment 23. The system defined in any preceding embodiment, wherein the oxidant intake port is coupled to a casing disposed about the turbine combustor upstream of the flow distributor, coupled to the flow distributor, or any combination thereof.

[00135] Embodiment 24. The system defined in any preceding embodiment, comprising a mixing region configured to mix the exhaust flow with an oxidant flow to provide an oxidant-exhaust mixture.

[00136] Embodiment 25. The system defined in any preceding embodiment, wherein the mixing region is disposed either upstream or downstream of the flow distributor.

[00137] Embodiment 26. The system defined in any preceding embodiment, wherein the flow distributor comprises a plurality of flow distributor portions, and each of the plurality of flow distributor portions comprises the at least one exhaust gas flow path.

[00138] Embodiment 27. The system defined in any preceding embodiment, wherein spacings between each of the plurality of flow distributor portions are different from one another.

[00139] Embodiment 28. The system defined in any preceding embodiment, wherein diameters of the exhaust gas flow paths of the plurality of flow distributor portions are different from one another.

[00140] Embodiment 29. The system defined in any preceding embodiment, comprising a gas turbine engine having the turbine combustor, a turbine driven by combustion products from the turbine combustor, and an exhaust gas compressor driven by the turbine, wherein the exhaust gas compressor is configured to compress and route an exhaust gas to the turbine combustor.

[00141] Embodiment 30. The system defined in any preceding embodiment, comprising an exhaust gas extraction system coupled to the gas turbine engine, and a hydrocarbon production system coupled to the exhaust gas extraction system.

[00142] Embodiment 31. The system defined in any preceding embodiment, wherein the gas turbine engine is a stoichiometric exhaust gas recirculation (SEGR) gas turbine engine.

[00143] Embodiment 32. A system, comprising: an oxidant compressor; and a gas turbine engine, comprising: a combustor section having a turbine combustor; a turbine driven by combustion products from the turbine combustor; an exhaust gas compressor driven by the turbine, wherein the exhaust gas compressor is configured to compress and route an exhaust flow to the turbine combustor, and the oxidant compressor is configured to compress and route an oxidant flow to the turbine combustor; an exhaust extraction port coupled to the combustor section; and a flow distributor configured to distribute an exhaust flow circumferentially around a head end chamber of the turbine combustor, wherein the flow distributor comprises at least one exhaust gas flow path.

[00144] Embodiment 33. The system defined in any preceding embodiment, wherein the exhaust extraction port is coupled to a casing disposed about the turbine combustor upstream of the flow distributor, coupled to the flow distributor, or any combination thereof.

[00145] Embodiment 34 The system defined in any preceding embodiment, wherein the turbine combustor comprises an oxidant intake port configured to supply the oxidant flow to the turbine combustor.

[00146] Embodiment 35. The system defined in any preceding embodiment, wherein the oxidant intake port is coupled to a casing disposed about the turbine combustor upstream of the flow distributor, coupled to the flow distributor, or any combination thereof.

[00147] Embodiment 36. The system defined in any preceding embodiment, comprising a mixing region configured to mix the exhaust flow with the oxidant flow to provide the oxidant-exhaust mixture.

[00148] Embodiment 37. The system defined in any preceding embodiment, wherein the mixing region is disposed either upstream or downstream of the flow distributor.

[00149] Embodiment 38. The system defined in any preceding embodiment, comprising: wherein the flow distributor comprises a plurality of radial inserts each comprising at least one passage, and at least one insert comprises the exhaust gas flow path.

[00150] Embodiment 39. The system defined in any preceding embodiment, wherein the at least one passage comprises the exhaust gas flow path, an oxidant flow path, an exhaust gas extraction flow path, a cooling gas flow path, an oxidant-exhaust mixture path, or any combination thereof.

[00151] Embodiment 40. The system defined in any preceding embodiment, wherein diameters of the passages of the plurality of radial inserts are different from one another.

[00152] Embodiment 41. The system defined in any preceding embodiment, wherein spacings between each of the plurality of radial inserts are different from one another.

[00153] Embodiment 42. The system defined in any preceding embodiment, wherein the flow distributor comprises a plurality of flow distributor portions, and each of the plurality of flow distributor portions comprises the at least one exhaust gas flow path.

[00154] Embodiment 43. The system defined in any preceding embodiment, wherein spacings between each of the plurality of flow distributor portions are different from one another.

[00155] Embodiment 44. The system defined in any preceding embodiment, wherein diameters of the exhaust gas flow paths of the plurality of flow distributor portions are different from one another.

[00156] Embodiment 45. The system defined in any preceding embodiment, comprising a stoichiometric exhaust gas recirculation (SEGR) turbine system having the oxidant compressor and the gas turbine engine.

[00157] Embodiment 46. The system defined in any preceding embodiment, comprising an exhaust gas extraction system coupled to the exhaust extraction port of the SEGR turbine system, and a hydrocarbon production system coupled to the exhaust gas extraction system.

[00158] Embodiment 47. A method, comprising: extracting a first exhaust flow of an exhaust gas at a combustion section of a gas turbine engine; routing a second exhaust flow of the exhaust gas toward an end plate of a head end portion of a turbine combustor in the combustion section; routing a third exhaust flow of the exhaust gas toward a cap of the head end portion, wherein the cap is disposed between a head end region and a combustion region; routing an oxidant flow into the head end portion; and distributing at least one of the first exhaust flow, the second exhaust flow, or the third exhaust flow circumferentially around the head end portion using a flow distributor, wherein the flow distributor comprises at least one exhaust gas flow path.

[00159] Embodiment 48. The method or system defined in any preceding embodiment, wherein extracting the first exhaust flow comprises extracting the first exhaust flow through an exhaust extraction port coupled to a casing disposed about the turbine combustor or the flow distributor.

[00160] Embodiment 49. The method or system defined in any preceding embodiment, wherein routing the oxidant flow comprises supplying the oxidant flow through an oxidant intake port coupled to a casing disposed about the turbine combustor or the flow distributor.

[00161] Embodiment 50. The method or system defined in any preceding embodiment, wherein routing the third exhaust flow comprises routing the third exhaust flow through the exhaust gas flow path.

[00162] Embodiment 51. The method or system defined in any preceding embodiment, comprising differentially distributing the at least one of the first exhaust flow, the second exhaust flow, or the third exhaust flow circumferentially around the head end portion using the flow distributor.

[00163] Embodiment 52. The method or system defined in any preceding embodiment, comprising stoichiometrically combusting a mixture of a fuel flow, the oxidant flow, and the second and third exhaust flows.

[00164] Embodiment 53. The method or system defined in any preceding embodiment, comprising routing the first exhaust flow to a hydrocarbon production system.

[00165] Embodiment 54. The method or system defined in any preceding embodiment, wherein the turbine combustor is configured to combust a mixture of a fuel and an oxidant with an equivalence ratio of approximately 0.95 to approximately 1.05.

[00166] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

CLAIMS:

1. A system, comprising:

a turbine combustor, comprising:

a head end portion having a head end chamber;

a combustion portion having a combustion chamber disposed downstream from the head end chamber;

a cap disposed between the head end chamber and the combustion chamber; and

a flow distributor configured to distribute an exhaust flow circumferentially around the head end chamber, wherein the flow distributor comprises at least one exhaust gas flow path.

2. The system of claim 1, wherein the flow distributor comprises:

a first flow distributor portion configured to distribute the exhaust flow along a first portion of the head end chamber; and

a second flow distributor portion configured to distribute the exhaust flow along a second portion of the head end chamber.

3. The system of claim 2, wherein the first and second flow distributor portions are different from one another.

4. The system of claim 2, wherein the first flow distributor portion is configured to distribute the exhaust flow at a first flow rate, wherein the second flow distributor portion is configured to distribute the exhaust flow at a second flow rate.

5. The system of claim 4, wherein the first and second flow rates are different from one another.

6. The system of claim 2, wherein the first flow distributor portion comprises a first arcuate portion of the head end chamber, and the second flow distributor portion comprises a second arcuate portion of the head end chamber.

7. The system of claim 2, wherein the first and second flow distributor portions are circumferentially offset from one another.

8. The system of claim 7, wherein the first flow distributor portion comprises a first radial insert and the second flow distributor portion comprises a second radial insert.

9. The system of claim 2, wherein the first flow distributor portion comprises a plurality of first radial inserts, and the second flow distributor portion comprises a plurality of second radial inserts.

10. The system of claim 9, wherein the plurality of first radial inserts is uniformly disposed circumferentially around the head end chamber, and the plurality of second radial inserts is uniformly disposed circumferentially around the head end chamber.

11. The system of claim 9, wherein each of the plurality of first radial inserts is spaced apart from one another by a first distance, and each of the plurality of second radial inserts is spaced apart from one another by a second distance.

12. The system of claim 11, wherein the first distance is less than the second distance, and the plurality of first radial inserts is disposed near a compressor discharge of the turbine combustor.

13. The system of claim 9, wherein each of the plurality of first radial inserts comprises at least one first passage comprising a first exhaust gas flow path, a first oxidant flow path, a first exhaust gas extraction flow path, a first cooling gas flow path, a first oxidant-exhaust mixture path, or any combination thereof, wherein each of the plurality of second radial inserts comprises at least one second passage comprising a second exhaust gas flow path, a second oxidant flow path, a second exhaust gas extraction flow path, a second cooling gas flow path, a second oxidant-exhaust mixture path, or any combination thereof.

14. The system of claim 13, wherein a first diameter of the at least one first passage is different from a second diameter of the at least one second passage.

15. The system of claim 14, wherein the first diameter is greater than the second diameter, and the first radial inserts are disposed near a compressor discharge of the turbine combustor.

16. The system of claim 9, wherein the plurality of first radial inserts and the plurality of second radial inserts are disposed circumferentially around the head end chamber in a repeating pattern.

17. The system of claim 16, wherein the repeating pattern comprises at least one of two first radial inserts followed circumferentially by one second radial insert, three first radial inserts followed circumferentially by one second radial insert, four first radial inserts followed circumferentially by one second radial insert, or any combination thereof.

18. The system of claim 2, wherein the first flow distributor portion comprises the exhaust gas flow path configured to convey the exhaust flow radially to a cooling region adjacent the cap and a first oxidant flow path configured to convey an oxidant flow radially from an oxidant compressor system, and wherein the second flow distributor portion comprises an exhaust gas extraction flow path configured to convey the exhaust flow radially to an exhaust extraction system and a second oxidant flow path configured to convey the oxidant flow radially from the oxidant compressor system.

19. The system of claim 2, wherein the first flow distributor portion comprises a cooling gas flow path configured to convey an oxidant-exhaust mixture radially to a cooling region adjacent the cap and an oxidant-exhaust mixture path configured to convey the oxidant-exhaust mixture axially from a mixing region upstream of the flow distributor, and wherein the second flow distributor portion comprises an exhaust

gas extraction flow path configured to convey the exhaust flow radially to an exhaust extraction system.

20. The system of claim 1, wherein the turbine combustor comprises an exhaust extraction port configured to extract the exhaust flow from the turbine combustor.

21. The system of claim 20, wherein the exhaust extraction port is coupled to a casing disposed about the turbine combustor upstream of the flow distributor, coupled to the flow distributor, or any combination thereof.

22. The system of claim 1, wherein the turbine combustor comprises an oxidant intake port configured to supply an oxidant flow to the turbine combustor.

23. The system of claim 22, wherein the oxidant intake port is coupled to a casing disposed about the turbine combustor upstream of the flow distributor, coupled to the flow distributor, or any combination thereof.

24. The system of claim 1, comprising a mixing region configured to mix the exhaust flow with an oxidant flow to provide an oxidant-exhaust mixture.

25. The system of claim 24, wherein the mixing region is disposed either upstream or downstream of the flow distributor.

26. The system of claim 1, wherein the flow distributor comprises a plurality of flow distributor portions, and each of the plurality of flow distributor portions comprises the at least one exhaust gas flow path.

27. The system of claim 26, wherein spacings between each of the plurality of flow distributor portions are different from one another.

28. The system of claim 26, wherein diameters of the exhaust gas flow paths of the plurality of flow distributor portions are different from one another.

29. The system of claim 1, comprising a gas turbine engine having the turbine combustor, a turbine driven by combustion products from the turbine combustor, and an exhaust gas compressor driven by the turbine, wherein the exhaust gas compressor is configured to compress and route an exhaust gas to the turbine combustor.

30. The system of claim 29, comprising an exhaust gas extraction system coupled to the gas turbine engine, and a hydrocarbon production system coupled to the exhaust gas extraction system.

31. The system of claim 29, wherein the gas turbine engine is a stoichiometric exhaust gas recirculation (SEGR) gas turbine engine.

32. A system, comprising:

an oxidant compressor; and

a gas turbine engine, comprising:

a combustor section having a turbine combustor;

a turbine driven by combustion products from the turbine combustor;

an exhaust gas compressor driven by the turbine, wherein the exhaust gas compressor is configured to compress and route an exhaust flow to the turbine combustor, and the oxidant compressor is configured to compress and route an oxidant flow to the turbine combustor;

an exhaust extraction port coupled to the combustor section; and

a flow distributor configured to distribute an exhaust flow circumferentially around a head end chamber of the turbine combustor, wherein the flow distributor comprises at least one exhaust gas flow path.

33. The system of claim 32, wherein the exhaust extraction port is coupled to a casing disposed about the turbine combustor upstream of the flow distributor, coupled to the flow distributor, or any combination thereof.

34. The system of claim 32, wherein the turbine combustor comprises an oxidant intake port configured to supply the oxidant flow to the turbine combustor.

35. The system of claim 34, wherein the oxidant intake port is coupled to a casing disposed about the turbine combustor upstream of the flow distributor, coupled to the flow distributor, or any combination thereof.

36. The system of claim 32, comprising a mixing region configured to mix the exhaust flow with the oxidant flow to provide the oxidant-exhaust mixture.

37. The system of claim 36, wherein the mixing region is disposed either upstream or downstream of the flow distributor.

38. The system of claim 32, wherein the flow distributor comprises a plurality of radial inserts each comprising at least one passage, and at least one insert comprises the exhaust gas flow path.

39. The system of claim 38, wherein the at least one passage comprises the exhaust gas flow path, an oxidant flow path, an exhaust gas extraction flow path, a cooling gas flow path, an oxidant-exhaust mixture path, or any combination thereof.

40. The system of claim 38, wherein diameters of the passages of the plurality of radial inserts are different from one another.

41. The system of claim 38, wherein spacings between each of the plurality of radial inserts are different from one another.

42. The system of claim 32, wherein the flow distributor comprises a plurality of flow distributor portions, and each of the plurality of flow distributor portions comprises the at least one exhaust gas flow path.

43. The system of claim 42, wherein spacings between each of the plurality of flow distributor portions are different from one another.

44. The system of claim 42, wherein diameters of the exhaust gas flow paths of the plurality of flow distributor portions are different from one another.

45. The system of claim 32, comprising a stoichiometric exhaust gas recirculation (SEGR) turbine system having the oxidant compressor and the gas turbine engine.

46. The system of claim 45, comprising an exhaust gas extraction system coupled to the exhaust extraction port of the SEGR turbine system, and a hydrocarbon production system coupled to the exhaust gas extraction system.

47. A method, comprising:

extracting a first exhaust flow of an exhaust gas at a combustion section of a gas turbine engine;

routing a second exhaust flow of the exhaust gas toward an end plate of a head end portion of a turbine combustor in the combustion section;

routing a third exhaust flow of the exhaust gas toward a cap of the head end portion, wherein the cap is disposed between a head end region and a combustion region;

routing an oxidant flow into the head end portion; and

distributing at least one of the first exhaust flow, the second exhaust flow, or the third exhaust flow circumferentially around the head end portion using a flow distributor, wherein the flow distributor comprises at least one exhaust gas flow path.

48. The method of claim 47, wherein extracting the first exhaust flow comprises extracting the first exhaust flow through an exhaust extraction port coupled to a casing disposed about the turbine combustor or the flow distributor.

49. The method of claim 47, wherein routing the oxidant flow comprises supplying the oxidant flow through an oxidant intake port coupled to a casing disposed about the turbine combustor or the flow distributor.

50. The method of claim 47, wherein routing the third exhaust flow comprises routing the third exhaust flow through the exhaust gas flow path.

51. The method of claim 47, comprising differentially distributing the at least one of the first exhaust flow, the second exhaust flow, or the third exhaust flow circumferentially around the head end portion using the flow distributor.

52. The method of claim 47, comprising stoichiometrically combusting a mixture of a fuel flow, the oxidant flow, and the second and third exhaust flows.

53. The method of claim 47, comprising routing the first exhaust flow to a hydrocarbon production system.

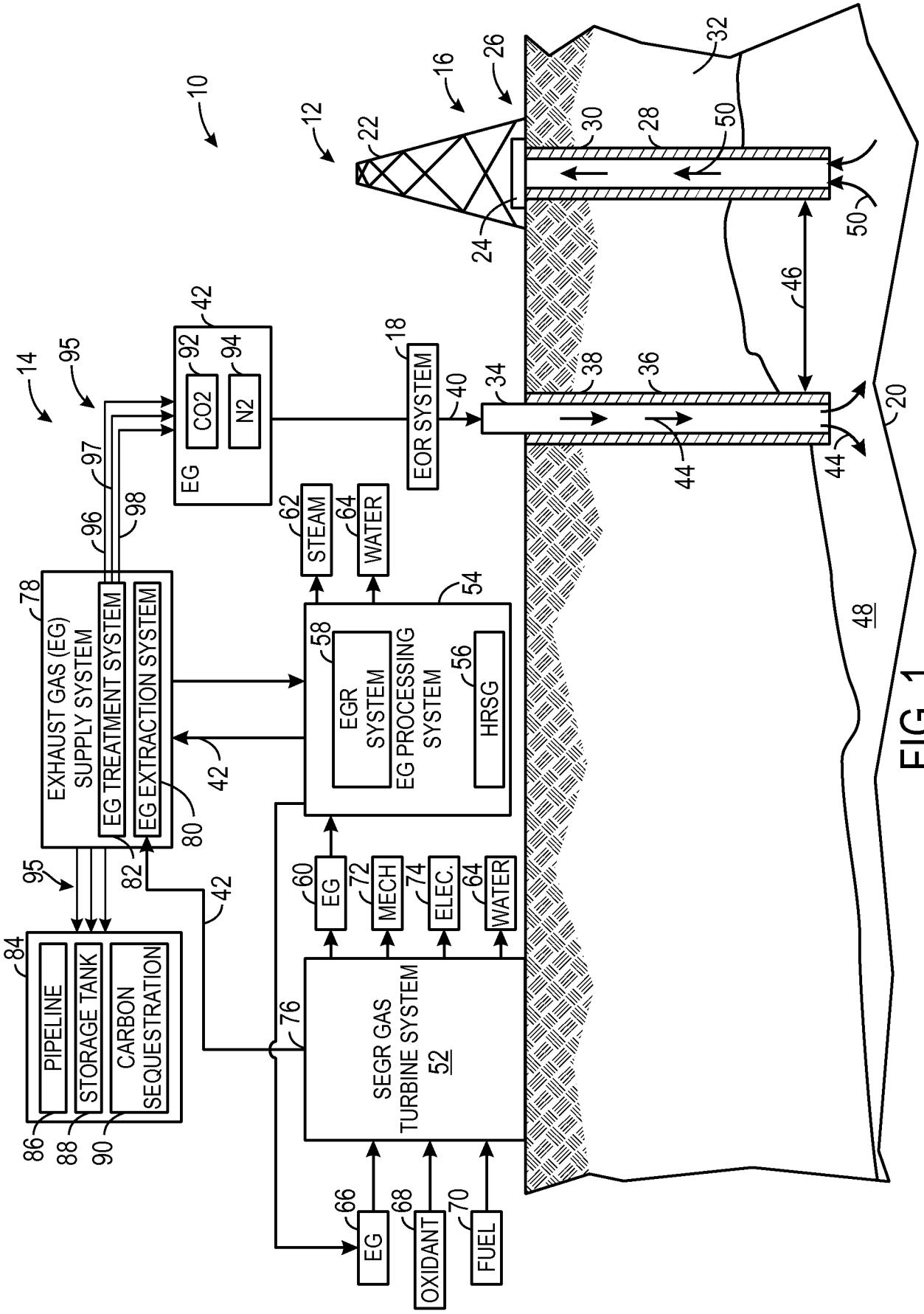

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64
66
68
70
72
74
76
78
80
82
84
86
88
90
92
94
95
96
97
98
EG
CO2
N2
EOR SYSTEM
STEAM
WATER
EXHAUST GAS (EG) SUPPLY SYSTEM
EG TREATMENT SYSTEM
EG EXTRACTION SYSTEM
EGR SYSTEM
EG PROCESSING SYSTEM
HRSG
EG
MECH
ELEC.
WATER
PIPELINE
STORAGE TANK
CARBON SEQUESTRATION
SEGR GAS TURBINE SYSTEM 52
EG
OXIDANT
FUEL

FIG. 1

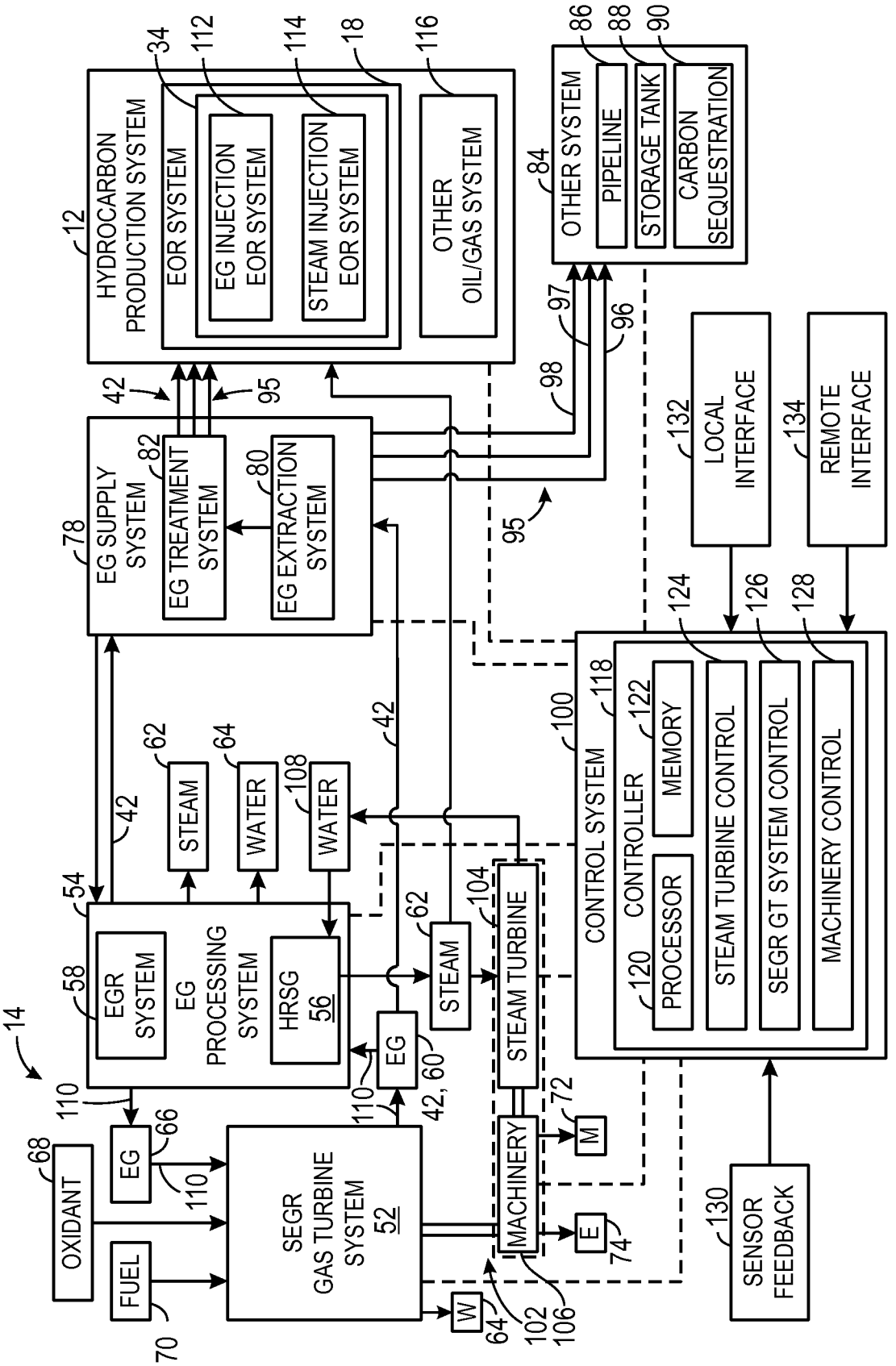

HYDROCARBON PRODUCTION SYSTEM
12
EOR SYSTEM
34
EG INJECTION EOR SYSTEM
112
STEAM INJECTION EOR SYSTEM
114
18
OTHER OIL/GAS SYSTEM
116
OTHER SYSTEM
84
PIPELINE
86
STORAGE TANK
88
CARBON SEQUESTRATION
90
EG SUPPLY SYSTEM
78
EG TREATMENT SYSTEM
82
EG EXTRACTION SYSTEM
80
42
95
97
96
98
LOCAL INTERFACE
132
REMOTE INTERFACE
134
CONTROL SYSTEM
100
CONTROLLER
118
PROCESSOR
120
MEMORY
122
STEAM TURBINE CONTROL
124
SEGR GT SYSTEM CONTROL
126
MACHINERY CONTROL
128
14
EG PROCESSING SYSTEM
54
EGR SYSTEM
58
HRSG 56
STEAM
62
WATER
64
WATER
108
STEAM
62
STEAM TURBINE
104
EG
42, 60
110
OXIDANT
68
FUEL
70
EG
66
SEGR GAS TURBINE SYSTEM 52
MACHINERY
72
M
E
74
W
64
102
106
SENSOR FEEDBACK
130

FIG. 2

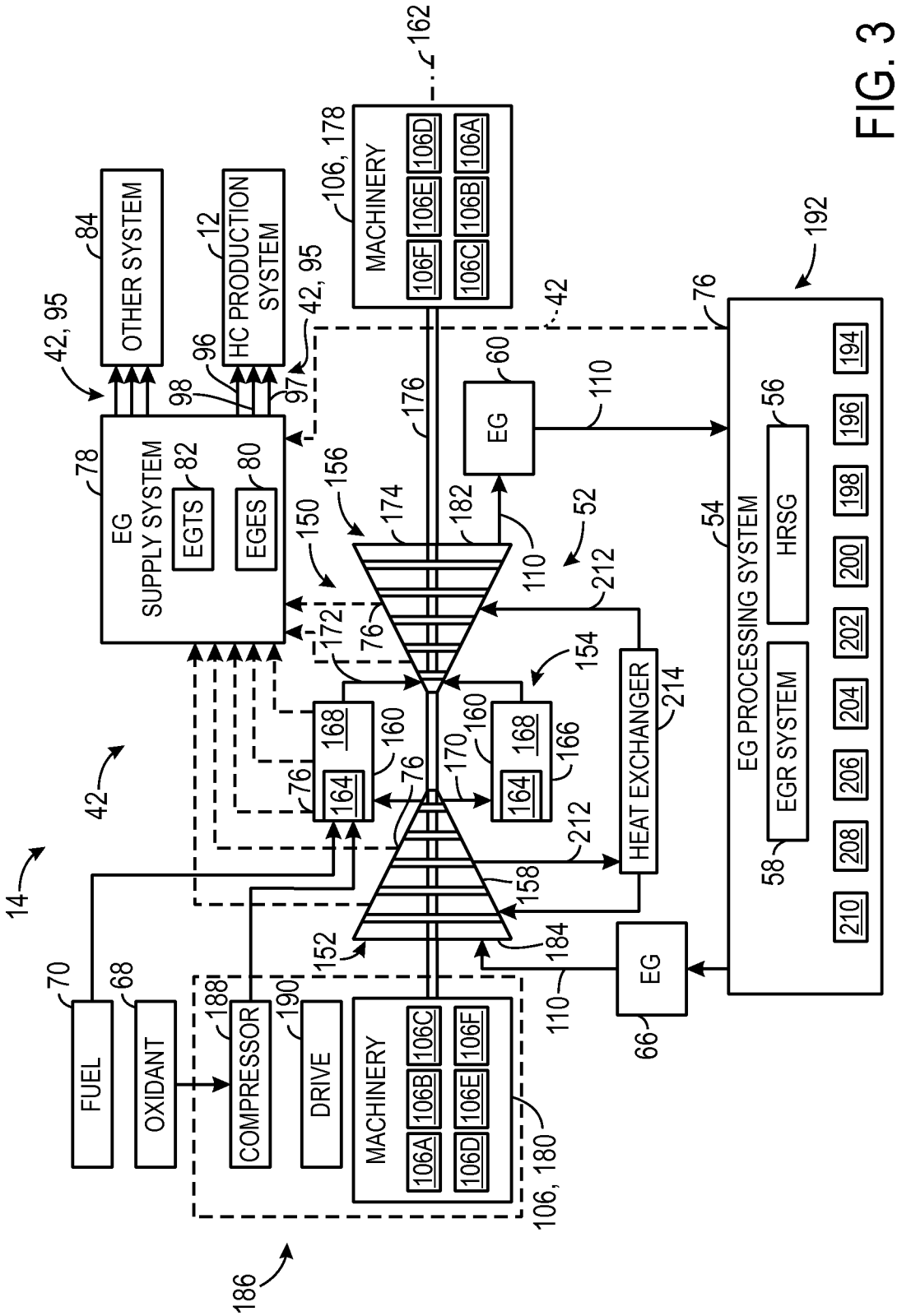

10
14
42
42, 95
42, 95
78
EG SUPPLY SYSTEM
82
EGTS
80
EGES
84
OTHER SYSTEM
12
HC PRODUCTION SYSTEM
96
98
97
162
106, 178
MACHINERY
106D
106E
106B
106F
106C
106A
42
76
192
60
EG
110
176
156
174
150
182
52
110
212
172
76
154
214
HEAT EXCHANGER
168
160
164
76
170
160
168
166
164
212
158
152
184
110
66
EG
54
EG PROCESSING SYSTEM
56
HRSG
58
EGR SYSTEM
194
196
198
200
202
204
206
208
210
70
68
188
190
FUEL
OXIDANT
COMPRESSOR
DRIVE
MACHINERY
106A
106B
106C
106D
106E
106F
106, 180
186

FIG. 3

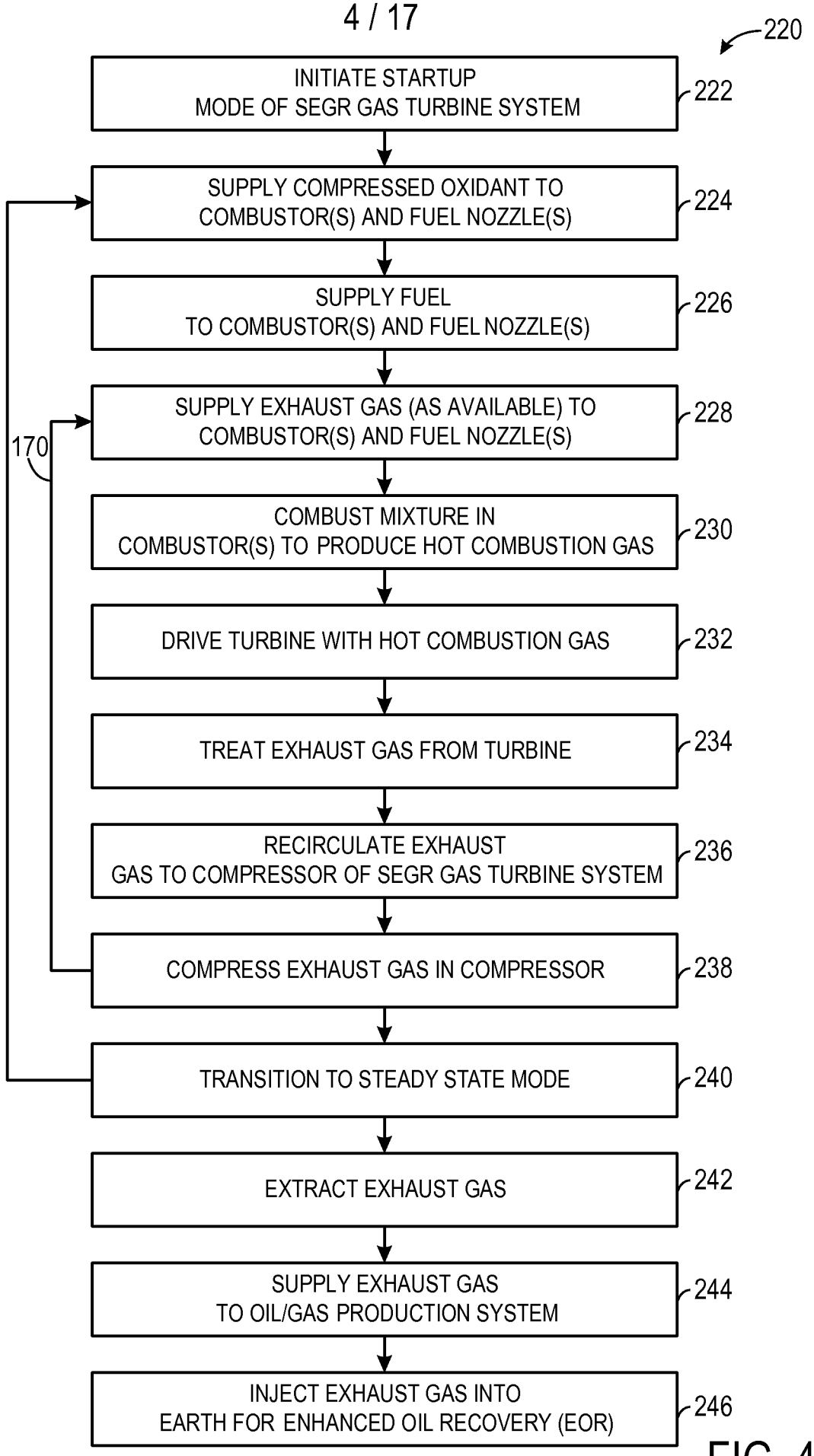

220
INITIATE STARTUP MODE OF SEGR GAS TURBINE SYSTEM
222
SUPPLY COMPRESSED OXIDANT TO COMBUSTOR(S) AND FUEL NOZZLE(S)
224
SUPPLY FUEL TO COMBUSTOR(S) AND FUEL NOZZLE(S)
226
SUPPLY EXHAUST GAS (AS AVAILABLE) TO COMBUSTOR(S) AND FUEL NOZZLE(S)
228
170
COMBUST MIXTURE IN COMBUSTOR(S) TO PRODUCE HOT COMBUSTION GAS
230
DRIVE TURBINE WITH HOT COMBUSTION GAS
232
TREAT EXHAUST GAS FROM TURBINE
234
RECIRCULATE EXHAUST GAS TO COMPRESSOR OF SEGR GAS TURBINE SYSTEM
236
COMPRESS EXHAUST GAS IN COMPRESSOR
238
TRANSITION TO STEADY STATE MODE
240
EXTRACT EXHAUST GAS
242
SUPPLY EXHAUST GAS TO OIL/GAS PRODUCTION SYSTEM
244
INJECT EXHAUST GAS INTO EARTH FOR ENHANCED OIL RECOVERY (EOR)
246

FIG. 4

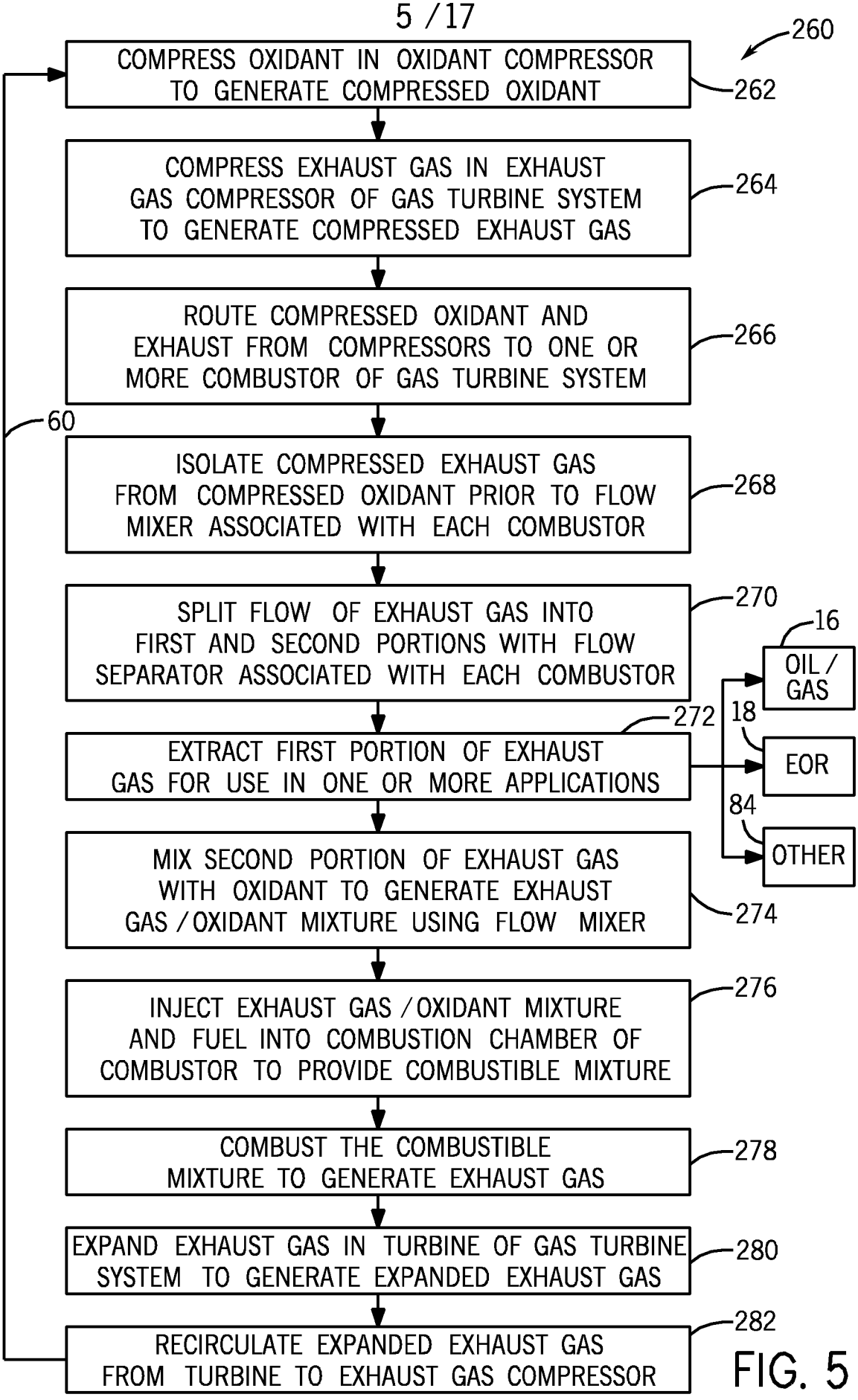

260
COMPRESS OXIDANT IN OXIDANT COMPRESSOR TO GENERATE COMPRESSED OXIDANT
262
COMPRESS EXHAUST GAS IN EXHAUST GAS COMPRESSOR OF GAS TURBINE SYSTEM TO GENERATE COMPRESSED EXHAUST GAS
264
ROUTE COMPRESSED OXIDANT AND EXHAUST FROM COMPRESSORS TO ONE OR MORE COMBUSTOR OF GAS TURBINE SYSTEM
266
60
ISOLATE COMPRESSED EXHAUST GAS FROM COMPRESSED OXIDANT PRIOR TO FLOW MIXER ASSOCIATED WITH EACH COMBUSTOR
268
SPLIT FLOW OF EXHAUST GAS INTO FIRST AND SECOND PORTIONS WITH FLOW SEPARATOR ASSOCIATED WITH EACH COMBUSTOR
270
16
OIL / GAS
18
EOR
84
OTHER
272
EXTRACT FIRST PORTION OF EXHAUST GAS FOR USE IN ONE OR MORE APPLICATIONS
MIX SECOND PORTION OF EXHAUST GAS WITH OXIDANT TO GENERATE EXHAUST GAS / OXIDANT MIXTURE USING FLOW MIXER
274
INJECT EXHAUST GAS / OXIDANT MIXTURE AND FUEL INTO COMBUSTION CHAMBER OF COMBUSTOR TO PROVIDE COMBUSTIBLE MIXTURE
276
COMBUST THE COMBUSTIBLE MIXTURE TO GENERATE EXHAUST GAS
278
EXPAND EXHAUST GAS IN TURBINE OF GAS TURBINE SYSTEM TO GENERATE EXPANDED EXHAUST GAS
280
RECIRCULATE EXPANDED EXHAUST GAS FROM TURBINE TO EXHAUST GAS COMPRESSOR
282

FIG. 5

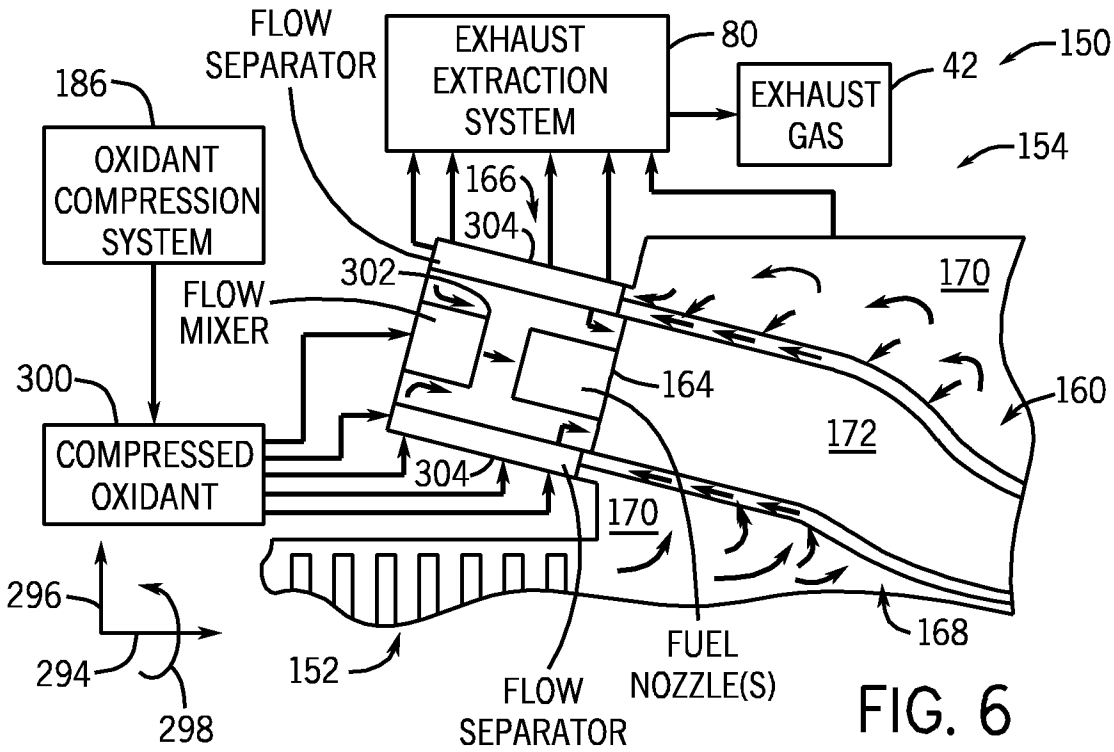

FLOW SEPARATOR
EXHAUST EXTRACTION SYSTEM
80
42
150
EXHAUST GAS
154
186
OXIDANT COMPRESSION SYSTEM
166
304
302
170
FLOW MIXER
300
164
160
COMPRESSED OXIDANT
172
304
170
296
294
298
152
FLOW SEPARATOR
FUEL NOZZLE(S)
168

FIG. 6

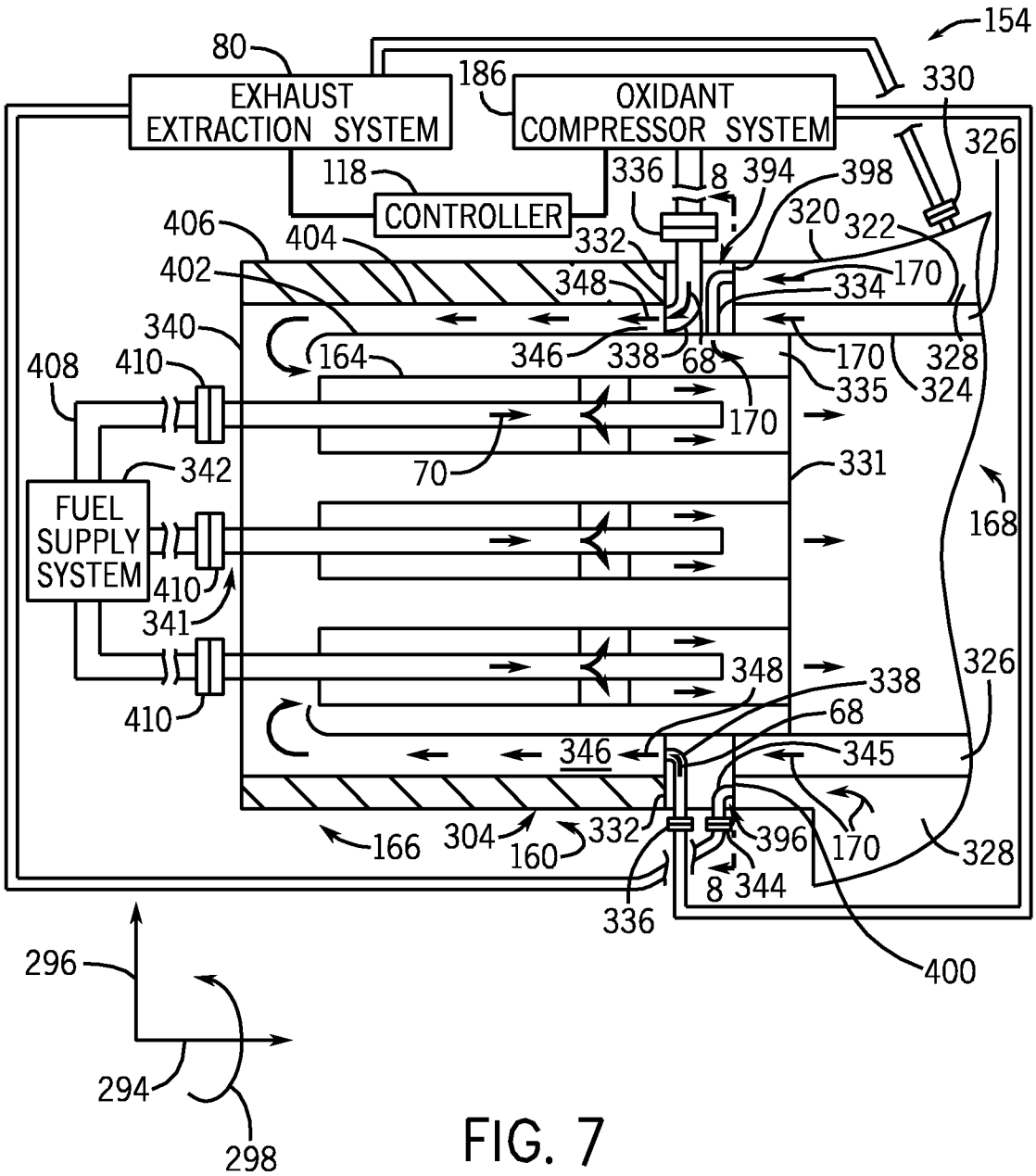

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OXIDANT COMPRESSOR SYSTEM
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CONTROLLER
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FUEL SUPPLY SYSTEM
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FIG. 7

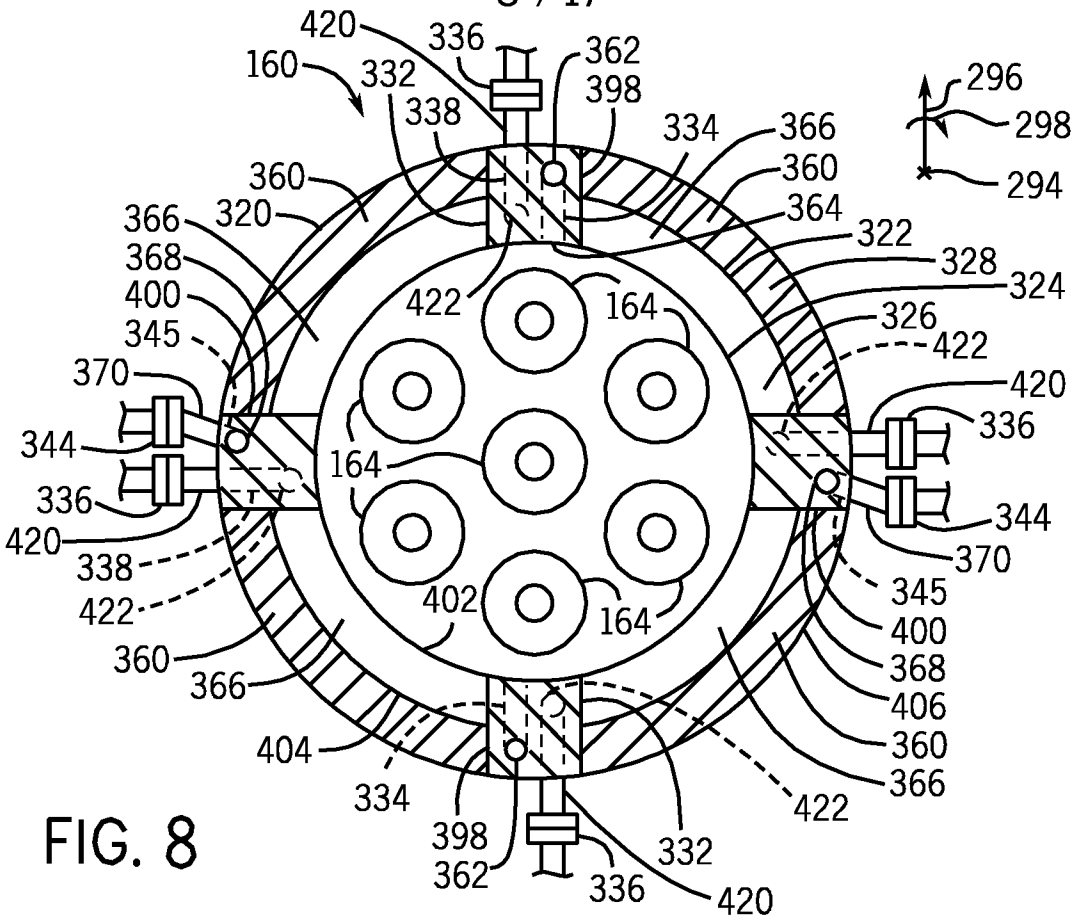

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FIG. 8

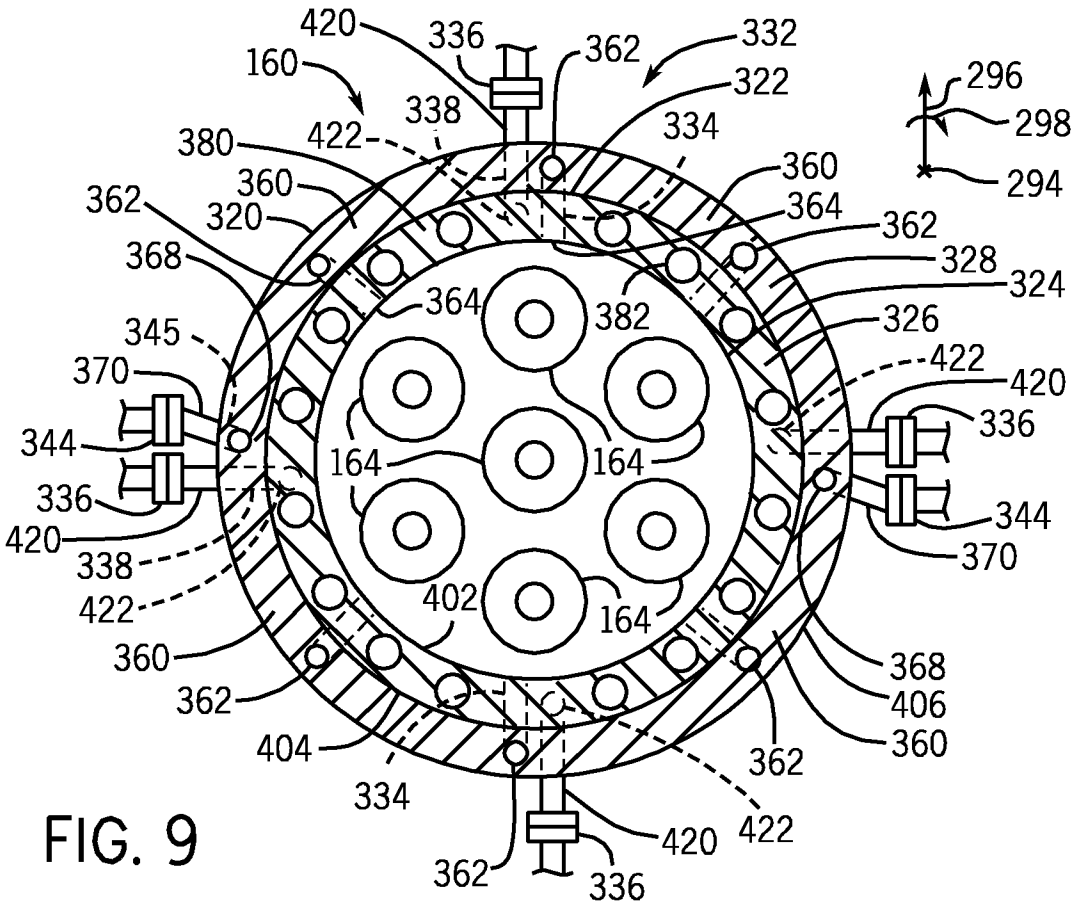

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FIG. 9

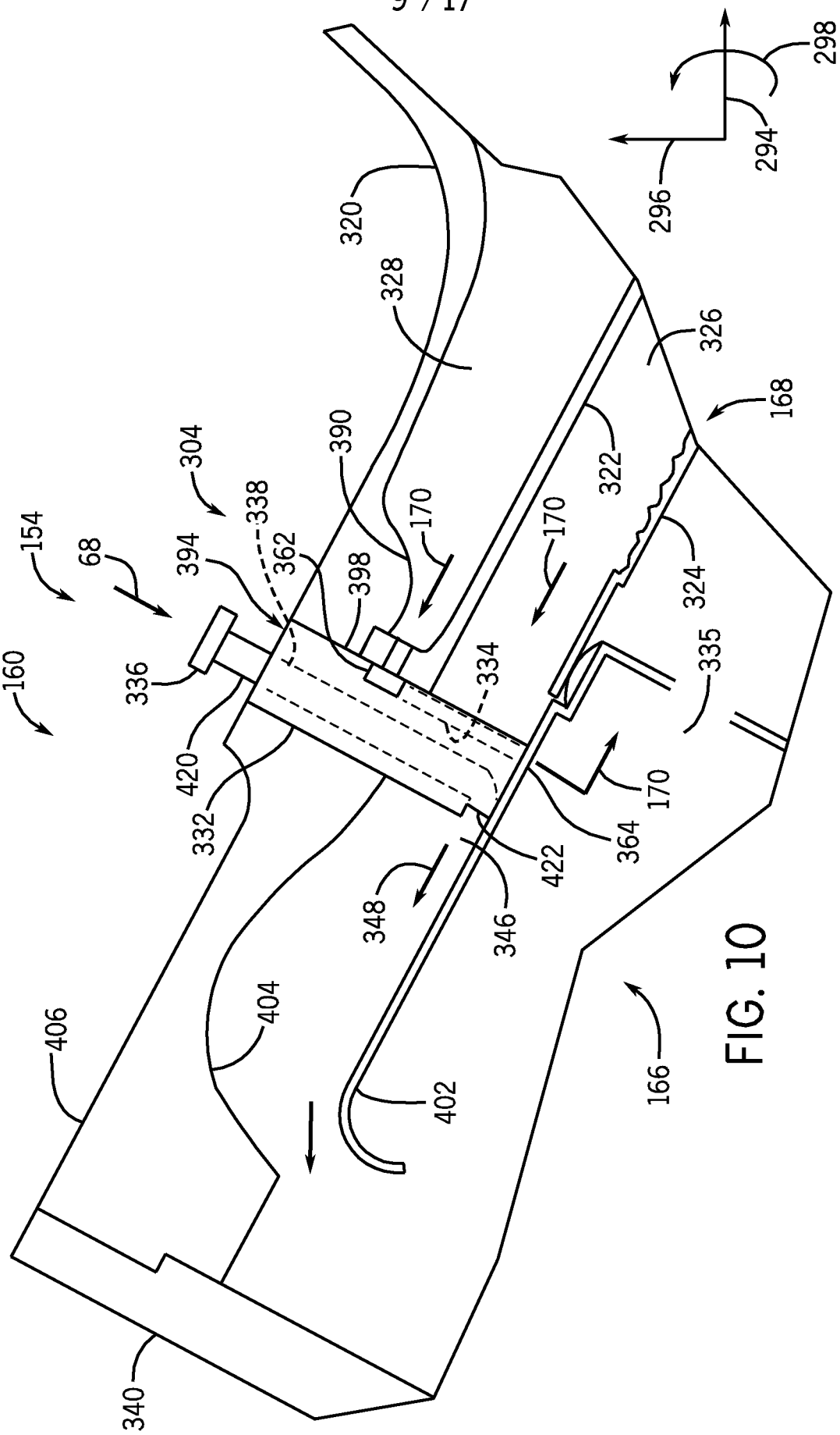

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FIG. 10

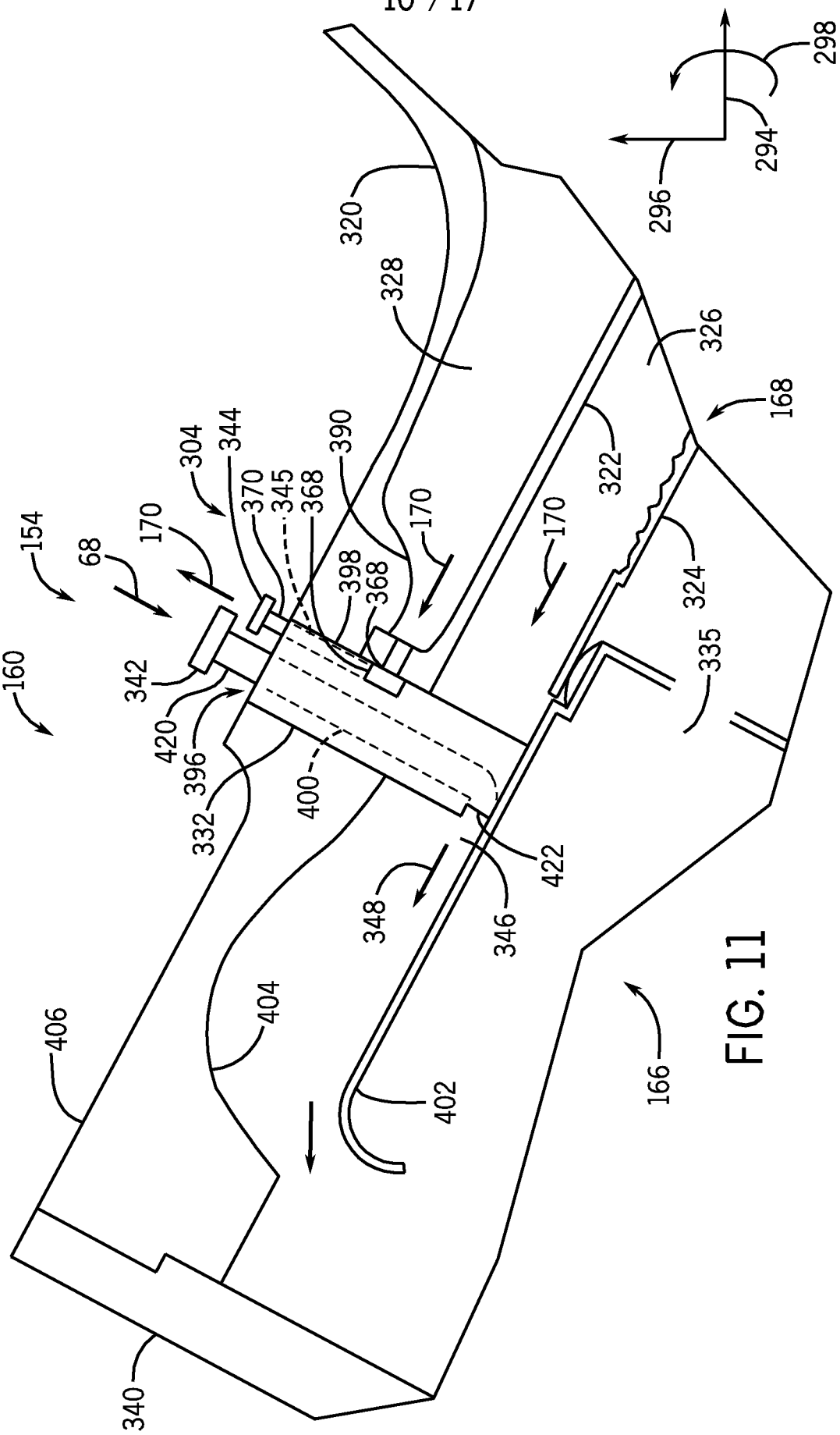

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FIG. 11

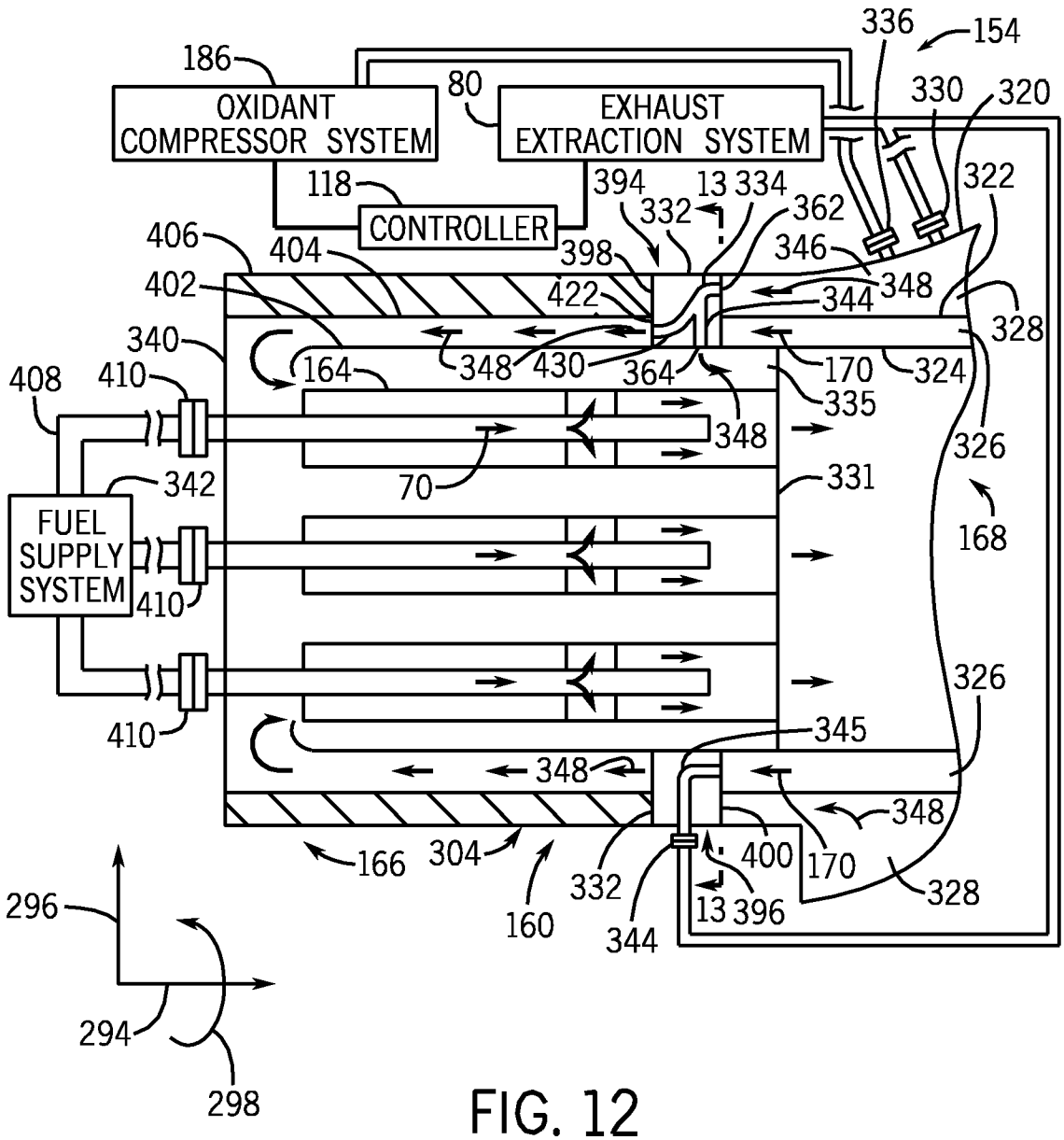

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FIG. 12

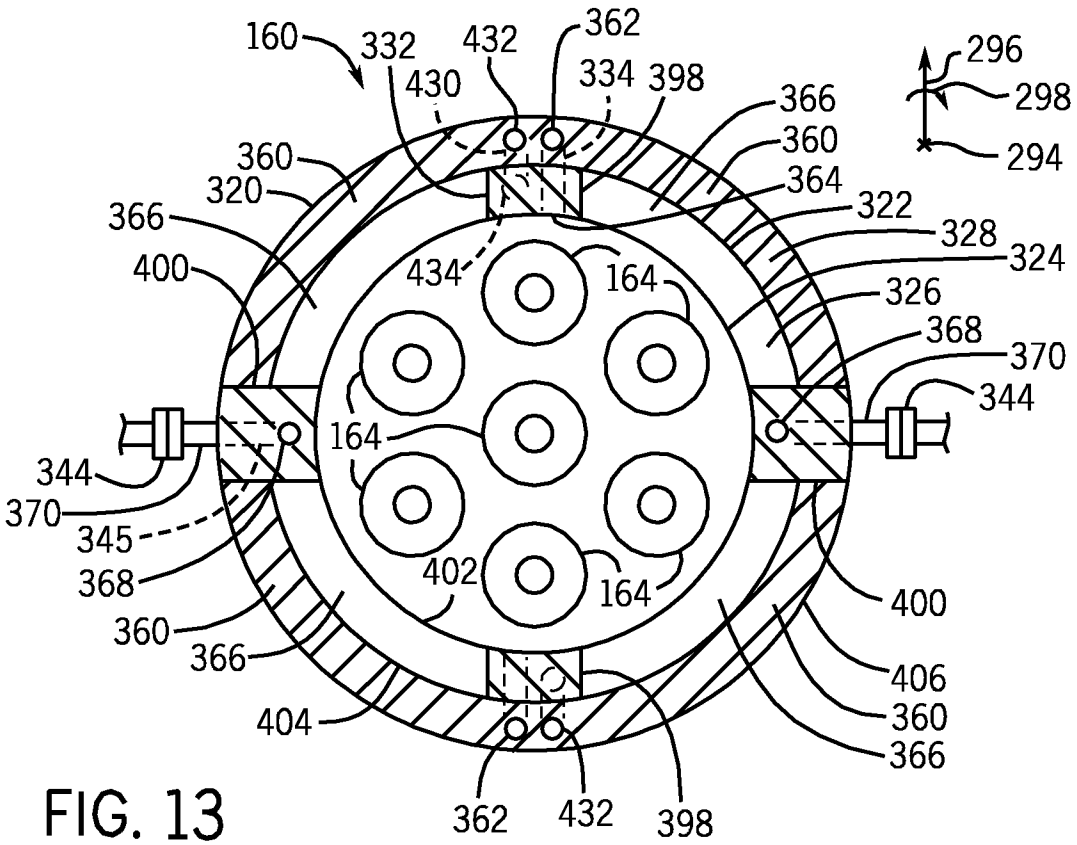

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FIG. 13

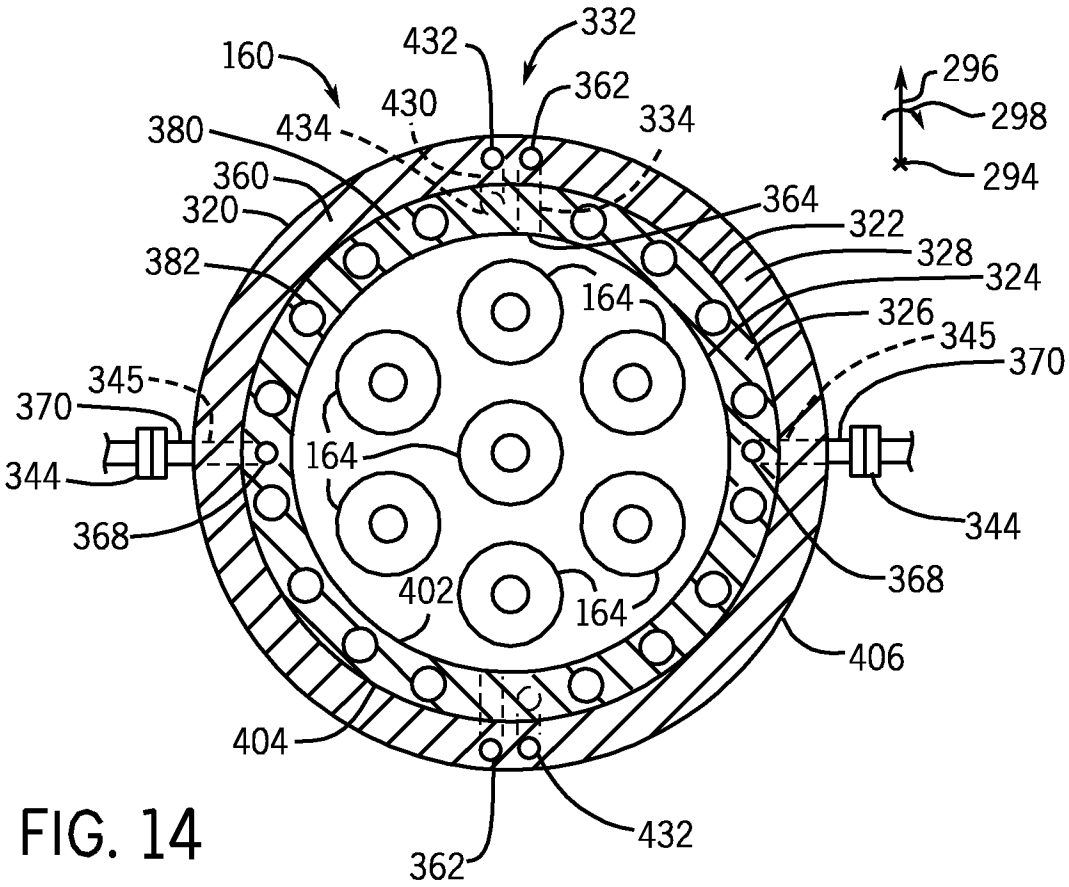

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FIG. 14

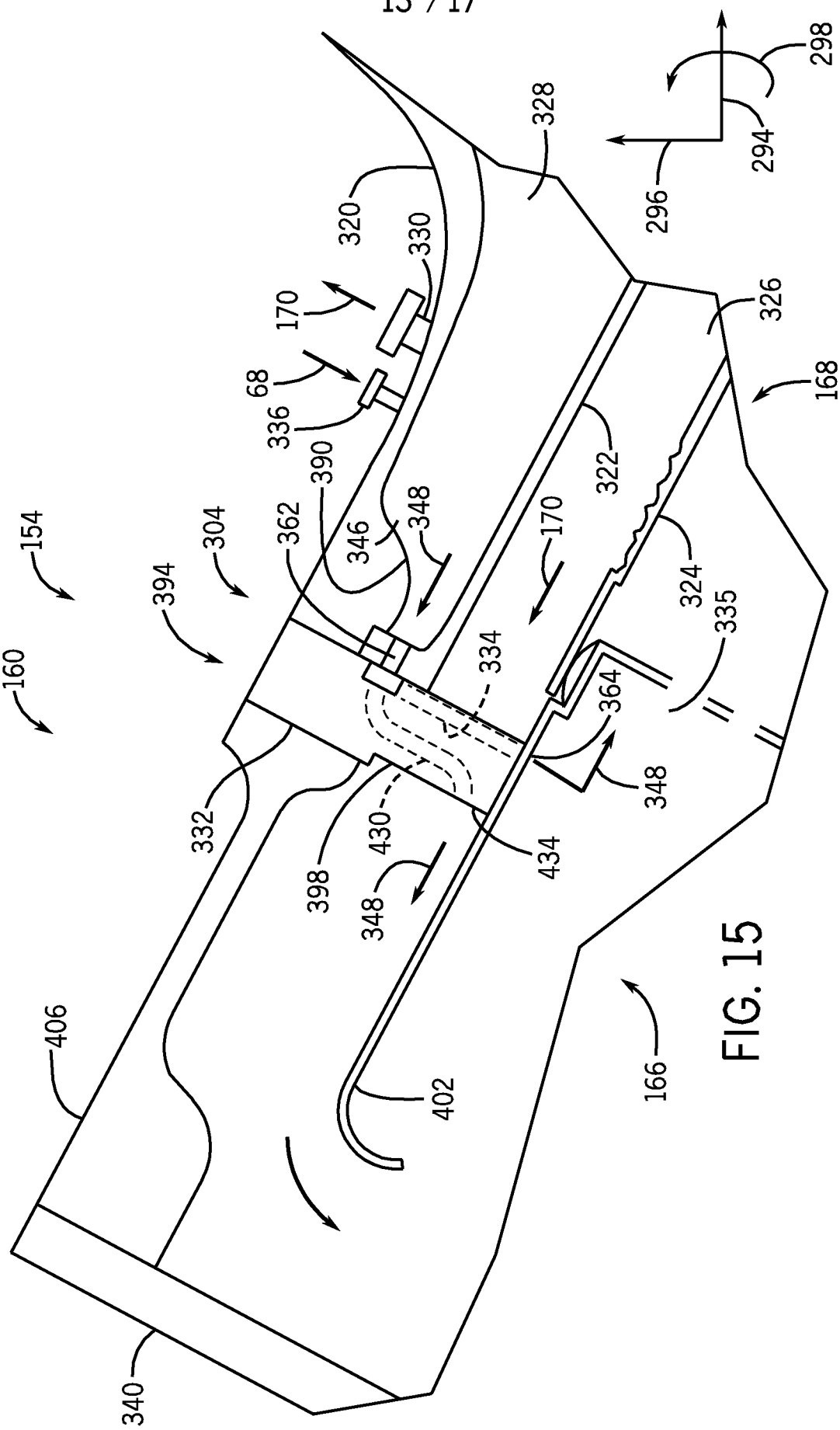

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FIG. 15

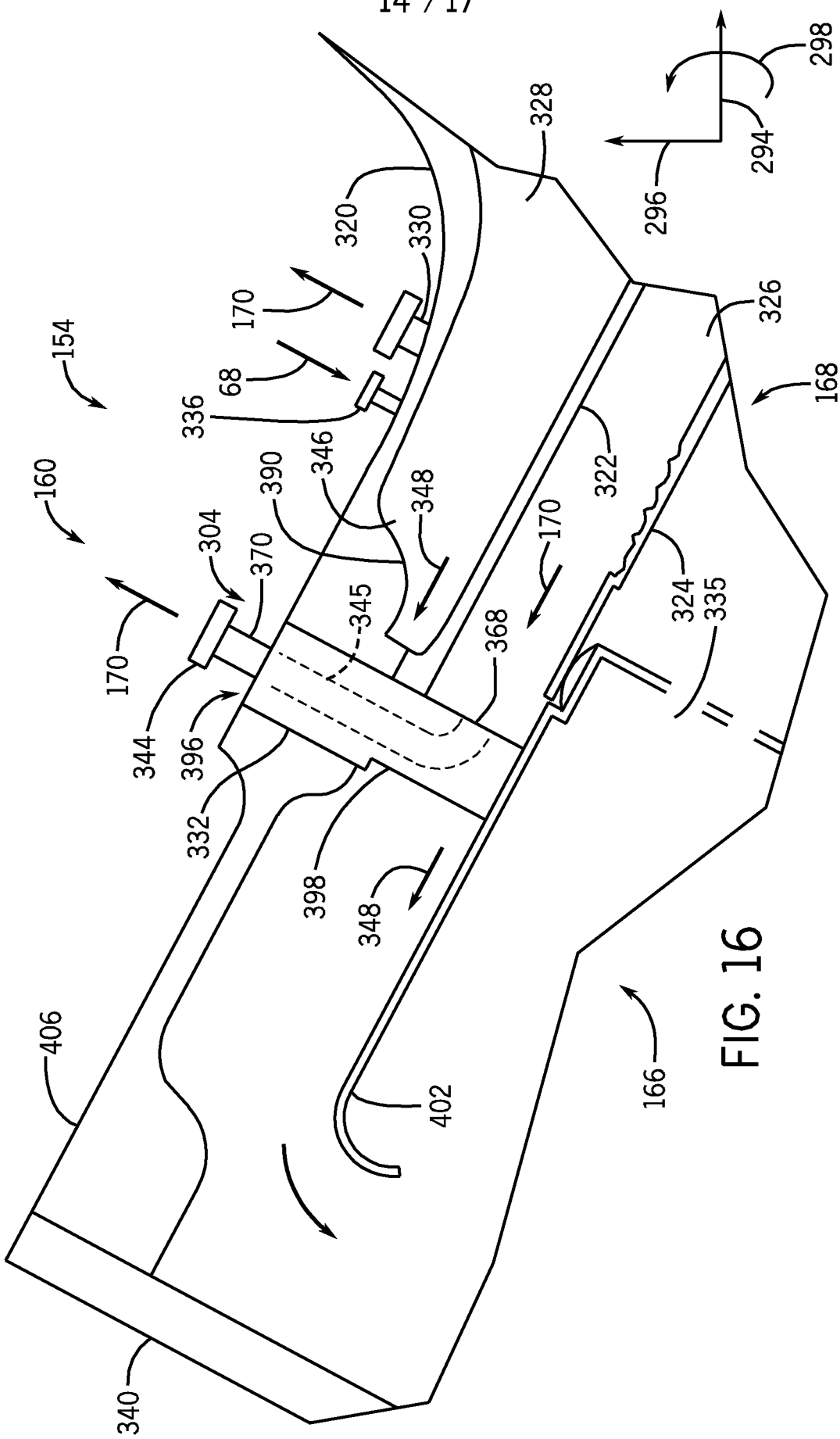

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FIG. 16

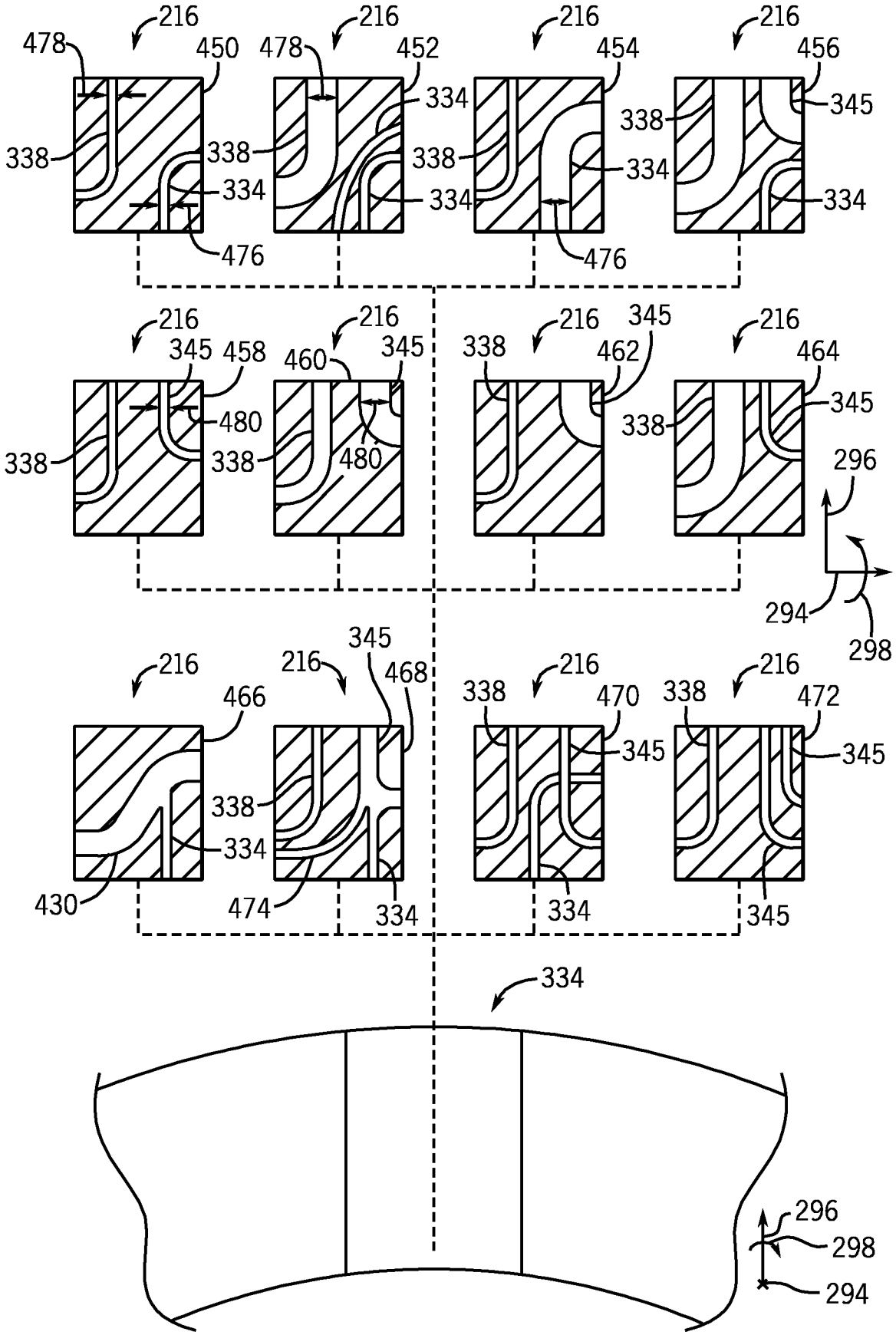

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FIG. 17

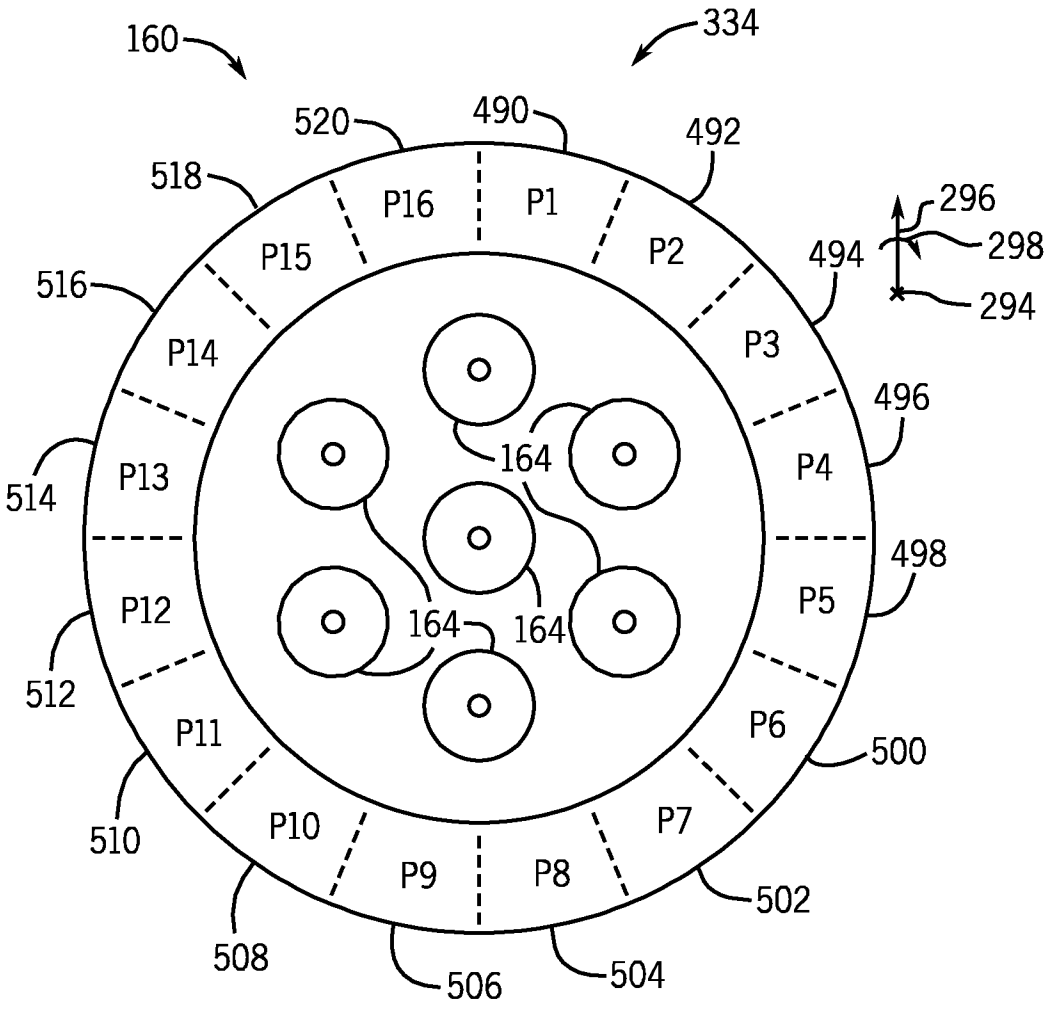

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FIG. 18

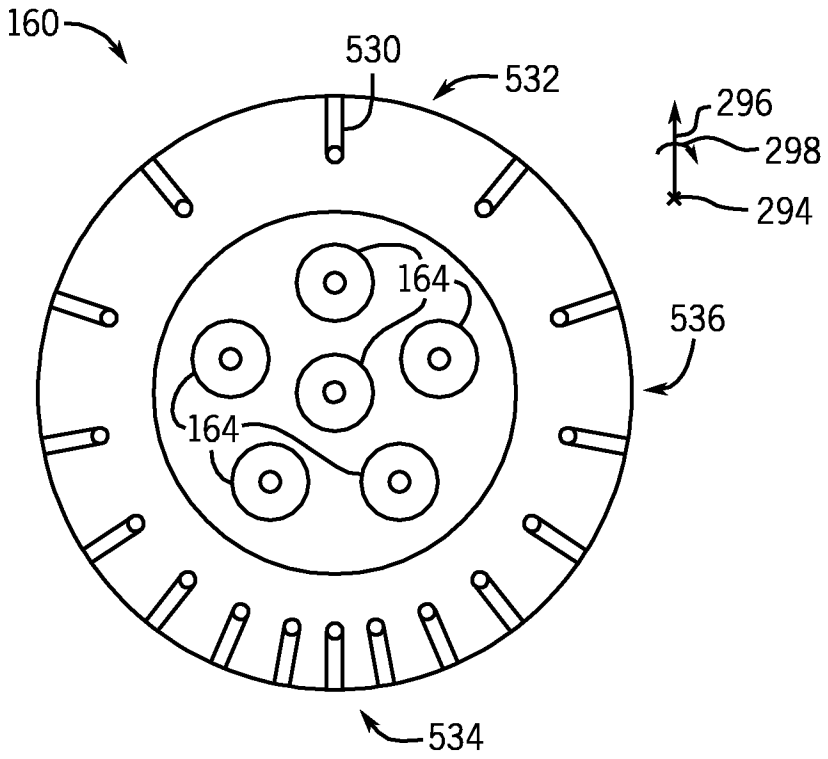

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FIG. 19

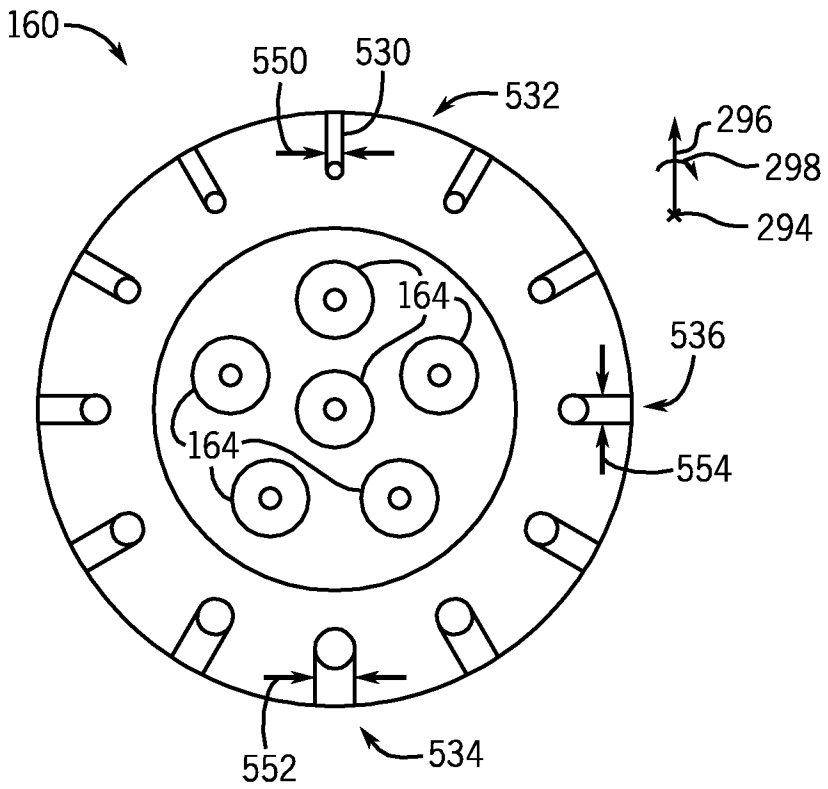

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FIG. 20

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/067951

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01D25/30 F02C3/34 F02C7/18 F23R3/02 F23C9/08
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)
F01D F02C F23R F23C

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 3 969 892 A (STETTLER RICHARD J ET AL) 20 July 1976 (1976-07-20) column 4, line 31 - column 6, line 35; figure 4 -----	1-31, 33-53 32
X	JP S52 68029 U (NOT AVAILABLE) 20 May 1977 (1977-05-20) figure 1 -----	1,47
X	JP 2005 140358 A (NISSAN MOTOR) 2 June 2005 (2005-06-02) abstract; figure 1 -----	1,47
X	WO 2010/141777 A1 (EXXONMOBIL UPSTREAM RES CO [US]; TECHNOLOGY LICENSING GEORGIA TECH RES) 9 December 2010 (2010-12-09) paragraphs [0084], [0099] - [0102]; figures 3f,6a,6b ----- -/--	1,32,47

[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
7 April 2014	17/04/2014

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	Coli, Enrico

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/067951

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/072443 A1 (STATOIL ASA [NO]; LYNGHJEM ARNE [NO]; JAKOBSEN JON [NO]; KOBRO HENRIK) 26 August 2004 (2004-08-26)	1,47
Y	page 11, line 5 - page 12, line 14; figure 4	32

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/067951

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