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(54) **System and method for operating a combustor**

(57) A system (60) for operating a combustor (10) includes a nozzle (14) and a fuel passage (30, 32) and air passage (44) through the nozzle (14). A fuel supply (62), (64) is in fluid communication with the fuel inlet (34, 38), and an air supply (68) is in fluid communication with the air inlet (50) and the fuel inlet (34, 38). A method for operating a combustor (10) includes flowing a fuel

through a fuel inlet (34, 38) in a nozzle (14) and flowing air through an air inlet (50) in the nozzle (14). The method further includes sensing an operating parameter of the combustor (10), generating a signal reflective of the operating parameter, and controlling a flow of at least one of air or diluent to the fuel inlet (34, 38) based on the signal reflective of the operating parameter.

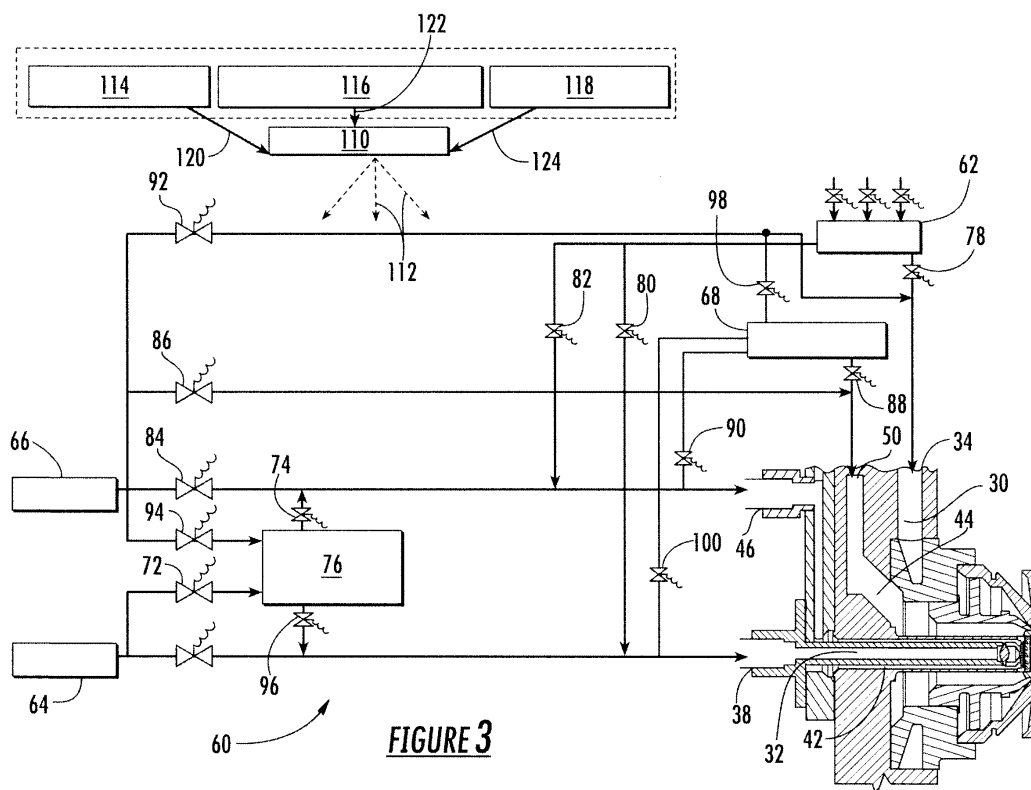


FIGURE 3

Description

FIELD OF THE INVENTION

[0001] The present invention generally involves a system and method for operating a combustor. In particular embodiments, the systems and methods of the present invention may be used for operating a combustor in a gas turbine.

BACKGROUND OF THE INVENTION

[0002] Combustors are commonly used to ignite fuel to produce combustion gases having a high temperature and pressure. For example, gas turbines typically include one or more combustors to generate power or thrust. A typical gas turbine used to generate electrical power includes an axial compressor at the front, one or more combustors around the middle, and a turbine at the rear. Ambient air may be supplied to the compressor, and rotating blades and stationary vanes in the compressor progressively impart kinetic energy to the working fluid (air) to produce a compressed working fluid at a highly energized state. The compressed working fluid exits the compressor and flows through one or more nozzles in each combustor where the compressed working fluid mixes with fuel and ignites to generate combustion gases having a high temperature, pressure, and velocity. The combustion gases expand in the turbine to produce work. For example, expansion of the combustion gases in the turbine may rotate a shaft connected to a generator to produce electricity.

[0003] The fuel supplied to the combustor may be a liquid fuel, a gaseous fuel, or a combination of liquid and gaseous fuels, depending on various factors such as the operating mode, operating level, and availability of various fuels. If the liquid fuel, gaseous fuel, and/or other fluids are not evenly mixed with the compressed working fluid prior to combustion, localized hot spots may form in the combustor, particularly near the nozzle exits. The localized hot spots may increase the production of nitrous oxides in the fuel rich regions, while the fuel lean regions may increase the production of carbon monoxide and unburned hydrocarbons, all of which are undesirable exhaust emissions. In addition, the fuel rich regions may increase the chance for the flame in the combustor to flash back into the nozzles and/or become attached inside the nozzles which may damage the nozzles. Although flame flash back and flame holding may occur with any fuel, they occur more readily with high reactive fuels, such as hydrogen, that have a higher burning rate, flame velocity, and wider flammability range.

[0004] The presence and location of the fuel rich regions and fuel lean regions may vary with the operating mode, operating level, and/or type of fuel being used, and a variety of systems and methods exist to allow higher operating combustor temperatures while minimizing undesirable emissions, flash back, and flame holding.

For example, some systems and methods reduce undesirable emissions at lower operating levels by injecting atomizing air near the reduced flow of liquid fuel to enhance dispersion of the liquid fuel with the compressed working fluid prior to combustion. Other systems and methods reduce undesirable emissions and/or flame holding events at higher operating levels by injecting a diluent, such as water, steam, combustion exhaust gases, or an inert gas, near the increased flow of liquid and/or gaseous fuel to reduce the peak flame temperature in the combustor and/or cool the downstream surface of the nozzle. However, the various systems and methods often require specialized nozzle designs and typically have reduced effectiveness at reducing undesirable emissions and/or flame holding events across the entire range of combustor operating modes and levels. Therefore, a system and method for operating a combustor over a wide range of operating modes and levels to improve combustor efficiency, reduce undesirable emissions, and/or prevent flash back and flame holding events would be useful.

BRIEF DESCRIPTION OF THE INVENTION

[0005] Aspects and advantages of the invention are set forth below in the following description, or may be obvious from the description, or may be learned through practice of the invention.

[0006] In one aspect, the present invention resides in a system for operating a combustor including a nozzle, a fuel passage through the nozzle having a fuel inlet and a fuel outlet, and an air passage through the nozzle having an air inlet and an air outlet. A fuel supply is in fluid communication with the fuel inlet, and an air supply is in fluid communication with the air inlet and the fuel inlet.

[0007] The present invention also resides in a method for operating a combustor that includes flowing a fuel through a fuel inlet in a nozzle and flowing air through an air inlet in the nozzle. The method further includes sensing an operating parameter of the combustor, generating a signal reflective of the operating parameter, and controlling a flow of at least one of air or diluent to the fuel inlet based on the signal reflective of the operating parameter.

[0008] Those of ordinary skill in the art will better appreciate the features and aspects of such embodiments, and others, upon review of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a simplified cross-section of an exemplary combustor according to one embodiment of the present invention;

Fig. 2 is a simplified cross-section of an exemplary nozzle shown in Fig. 1;

Fig. 3 is a simplified schematic and block diagram of a system for operating the combustor shown in Fig. 1 connected to the nozzle shown in Fig. 2 according to one embodiment of the present invention;

Fig. 4 is a block diagram of a method for operating the combustor shown in Fig. 1 according to one embodiment of the present invention;

Fig. 5 is an illustrative graph of improved emissions for a given fuel-water ratio using embodiments of the present invention; and

Fig. 6 is an illustrative graph of pressure oscillations in a combustor over a range of fuel-water ratios using embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Reference will now be made in detail to present embodiments of the invention, one or more examples of which are illustrated in the accompanying drawings. The detailed description uses numerical and letter designations to refer to features in the drawings. Like or similar designations in the drawings and description have been used to refer to like or similar parts of the invention.

[0011] Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that modifications and variations can be made in the present invention without departing from the scope or spirit thereof. For instance, features illustrated or described as part of one embodiment may be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0012] Various embodiments of the present invention include a system and method for operating a combustor. In particular embodiments, liquid and/or gas fuels may flow through a nozzle in the combustor, and a controller may adjust the fuel flow and/or the injection of a diluent and/or air into the fuel flow to enhance the efficiency of the combustor, reduce undesirable emissions, and/or prevent or reduce the occurrence or damaging effects of flash back and flame holding. Although described generally in the context of a combustor incorporated into a gas turbine, embodiments of the present invention may be applied to any combustor and are not limited to a gas turbine combustor unless specifically recited in the claims.

[0013] Figure 1 shows a simplified cross-section view of an exemplary combustor 10, such as would be included in a gas turbine, according to one embodiment of the present invention. A casing 12 may surround the com-

bustor 10 to contain the compressed working fluid flowing to the combustor 10. As shown, the combustor 10 may include one or more nozzles 14 radially arranged in a top cap 16. An end cover 18 and a liner 20 generally surround a combustion chamber 22 located downstream from the nozzles 14. A flow sleeve 24 with flow holes 26 may surround the liner 20 to define an annular passage 28 between the flow sleeve 24 and the liner 20. The compressed working fluid may pass through the flow holes 26 in the flow sleeve 24 to flow along the outside of the liner 20 to provide film or convective cooling to the liner 20. When the compressed working fluid reaches the end cover 18, the compressed working fluid reverses direction to flow through the one or more nozzles 14 where it mixes with fuel before igniting in the combustion chamber 22 to produce combustion gases having a high temperature and pressure.

[0014] Fig. 2 provides a simplified cross-section of an exemplary nozzle 14 shown in Fig. 1. The nozzle 14 may comprise an existing nozzle having one or more separate fuel, diluent, and/or air passages that extend through the nozzle 14. For example, in a particular embodiment shown in Fig. 2, a gaseous fuel passage 30 and a liquid fuel passage 32 may extend through the nozzle 14 to provide fluid communication for fuel through the nozzle 14. The gaseous fuel passage 30 has a gaseous fuel inlet 34 and a gaseous fuel outlet 36 so that the gaseous fuel passage 30 provides fluid communication for the gaseous fuel through the nozzle 14 and into the combustion chamber 22. Similarly, the liquid fuel passage 32 has a liquid fuel inlet 38 and a liquid fuel outlet 40 so that the liquid fuel passage 32 provides fluid communication for the liquid fuel through the nozzle 14 and into the combustion chamber 22. In this manner, the combustor 10 may operate using gaseous fuel only, liquid fuel only, or a combination of gaseous and liquid fuels, depending on the operating mode or level of the combustor 10 and/or the availability of various liquid and gaseous fuels.

[0015] The nozzle 14 may also include a diluent passage 42 and/or an air passage 44 through the nozzle 14. The diluent passage 42 has a diluent inlet 46 and a diluent outlet 48 so that the diluent passage 42 provides fluid communication through the nozzle 14 and into the combustion chamber 22. Similarly, the air passage 44 has an air inlet 50 and an air outlet 52 so that the air passage 44 provides fluid communication through the nozzle 14 and into the combustion chamber 22. The diluent and air passages 42, 44 are generally located in the nozzles so that the respective diluent and air outlets 48, 52 are proximate to one or more fuel outlets 36, 40. For example, as shown in Fig. 2, the liquid fuel passage 32 and liquid fuel outlet 40 may be generally aligned with or along an axial centerline 54 of the nozzle 14, with the gaseous fuel passage 30 and gaseous fuel outlet 36 generally located radially outward from the liquid fuel passage 32. Similarly, the diluent and air passages 42, 44 may be generally aligned with the one or more fuel passages 30, 32 so that the diluent and air outlets 48, 52 are proximate to one or

more of the fuel outlets 36, 40. However, the various fuel, diluent, and air passages may extend through the nozzle at various angles, depending on the relative location of the various inlets and outlets, and the particular orientation or location of the various passages is not a limitation of the present invention unless specifically recited in the claims.

[0016] Fig. 3 shows a simplified schematic and block diagram of a system 60 for operating the combustor 10 shown in Fig. 1 connected to the nozzle 14 shown in Fig. 2 according to one embodiment of the present invention. As shown, the system 60 may include a gaseous fuel supply 62, a liquid fuel supply 64, a diluent supply 66, and an air supply 68 in fluid communication with the nozzle 14 and with one another. Possible liquid fuels supplied to the nozzle 14 may include light and heavy fuel oil, oil slurries, naphtha, petroleum, coal tar, crude oil, and gasoline, and possible gaseous fuels supplied to the nozzle 14 may include blast furnace gas, carbon monoxide, coke oven gas, natural gas, methane, vaporized liquefied natural gas (LNG), hydrogen, syngas, butane, propane, and olefins. Possible diluents supplied to the nozzle 14 may include water, steam, fuel additives, various inert gases such as nitrogen and/or various non-flammable gases such as carbon dioxide or combustion exhaust gases. The air supply 68 may provide compressed air to the nozzle 14, such as compressed air produced by an external compressor or compressed working fluid delivered from the gas turbine compressor.

[0017] The fuel supply 62, 64 is in fluid communication with the nozzle through the one or more fuel inlets (e.g., the gaseous and/or liquid fuel inlets 34, 38) and/or the diluent inlet 46. In this manner, the system 60 may support various fuel operating modes for the combustor 10 by supplying liquid fuel to the combustion chamber 22 through the liquid fuel inlet 38 and/or diluent inlet 46 and gaseous fuel to the combustion chamber 22 through the gaseous fuel inlet 34, the liquid fuel inlet 38, and/or the diluent inlet 46. For example, the combustor 10 may operate using only liquid fuel supplied through valve 70 to the liquid fuel passage 32 and/or through valves 72 and 74 to the diluent passage 42. If desired, a homogenizer 76 connected between the liquid fuel supply 64 and diluent supply 66 may be used to emulsify the liquid fuel and diluent prior to injection into the combustion chamber 22 through the liquid fuel passage 32 and/or the diluent passage 42. Alternately, the combustor 10 may also operate using a combination of liquid and gaseous fuel, with the liquid fuel supplied through valve 70 to the liquid fuel passage 32 and/or through valves 72 and 74 to the diluent passage 42, and the gaseous fuel supplied through valve 78 to the gaseous passage 30 and/or through valve 80 to the diluent passage 32. Lastly, the combustor 10 may operate using only gaseous fuel supplied through valve 78 to the gaseous fuel passage 30, through valve 80 to the liquid fuel passage 32, and/or through valve 82 to the diluent passage 44. As a result, the combustor 10 may operate with a staged supply of liquid and/or gaseous

fuel simultaneously supplied through the liquid fuel passage 32, the diluent passage 42, and the gaseous fuel passage 30.

[0018] The diluent supply 66 is in fluid communication with the nozzle 14 through the diluent inlet 46, the one or more fuel inlets (e.g., the gaseous and/or liquid fuel inlets 34, 38), and/or the air inlet 50. Similarly, the air supply 68 is in fluid communication with the nozzle 14 through the air inlet 50, the one or more fuel inlets (e.g., the gaseous and/or liquid fuel inlets 34, 38), and/or the diluent inlet 46. In this manner, the diluent may be supplied through valve 84 to the diluent passage 42 and/or through valve 86 to the air passage 44, and the air may be supplied through valve 88 to the air passage 44 and/or through valve 90 to the diluent passage 42 for a number of purposes. For example, during reduced power or turn-down operations, the air may be supplied through the air and/or diluent passages 44, 42 to inject air proximate to the liquid fuel outlet 40 to disperse or atomize the liquid fuel exiting the nozzle 14 to enhance mixing between the liquid fuel and the compressed working fluid prior to combustion. During higher power operations, and for some design considerations during lower power operations that benefit from adjustments to the fuel outlets, the diluent may be supplied through the diluent and/or air passages 42, 44 and/or the air may be supplied through the air and/or diluent passages 44, 42 to inject the diluent and/or air proximate to the liquid and/or gaseous fuel outlets 40, 36 to cool the downstream surface of the nozzle 14 and/or reduce the peak flame temperature of the combustion flame. Maintaining the desired temperature on the downstream surface of the nozzle 14 protects the nozzle 14 from excessive wear, premature failure, and/or carbon deposition (coking) on the surface of the nozzle 14. Reducing the peak flame temperature of the combustion flame reduces the production of undesirable emissions. Lastly, the diluent may be supplied through the diluent and/or air passages 42, 44 and/or the air may be supplied through the air and/or diluent passages 44, 42 to inject the diluent and/or air proximate to the liquid and/or gaseous fuel outlets 40, 36 in response to a flash back or flame holding event to cool the surface of the nozzle 14 and/or prevent or extinguish the flame holding.

[0019] As shown in Fig. 3, the diluent may also be supplied through valve 92 to the gaseous fuel inlet 34 and/or through valves 94 and 96 to the liquid fuel inlet 38, and the air may also be supplied through valve 98 to the gaseous fuel inlet 34 and/or through valve 100 to the liquid fuel inlet 38 to flow diluent and/or air through the respective fuel passages 30, 32 for a number of purposes. For example, during reduced power or turndown operations, the diluent and/or air may be supplied to one or more fuel inlets 34, 38 to disperse or atomize the fuel flowing through the fuel passages 34, 38 to disburse the fuel and enhance mixing between the fuel and the compressed working fluid prior to combustion. During higher power operations, the diluent may be supplied through the homogenizer 76 to emulsify the liquid fuel prior to injection

into the combustion chamber 22. The emulsified liquid fuel may cool the downstream surface of the nozzle 14 and/or reduce the peak flame temperature of the combustion flame. Cooling the downstream surface of the nozzle 14 protects the nozzle 14 from excessive wear, premature failure, and/or carbon deposition (coking) on the surface of the nozzle 14. Reducing the peak flame temperature of the combustion flame reduces the production of undesirable emissions. During lower power operations, the diluent may be supplied through the valves 94, 96, and/or homogenizer 76 to increase the volume of the combustible fluid in the desired delivery passage prior to injection into the combustion chamber 22. As the volume of the combustible mixture is increased, the pressure increases, improving the shape of the exit jet and reducing deposits/coking on the surface of the nozzle 14. An additional combustible fluid pressure increase and improvement of atomization may be achieved by delivering air through valves 90, 98, 100 and mixing air with the combustible fluid. Air will create an effervescent (bubbling) effect, which will further promote better atomization and a more uniform combustion flame. In addition, the diluent and/or air may be supplied to one or more fuel inlets 34, 38 in response to a flame holding event to cool the surface of the nozzle 14 proximate to the flame holding and/or extinguish the flame holding. The diluent and/or air may also be supplied to one or more fuel inlets 34, 38 to purge fuel from a particular fuel passage 30, 32. For example, the diluent and/or air may be supplied to the liquid fuel inlet 38 to purge the liquid fuel from the liquid fuel passage 32 when transitioning to gaseous fuel only combustion.

[0020] As shown in Fig. 3, the system 60 may also include a controller 110 that positions the various valves previously discussed to supply the various fuels, diluent, and air to the desired passages at optimum flow rates. As described herein, the technical effect of the controller 110 is to transmit a control signal 112 to the various valves to remotely position the various valves to achieve the desired flow paths and flow rates. The controller 110 may comprise a stand alone component or a sub-component included in any computer system known in the art, such as a laptop, a personal computer, a mini computer, or a mainframe computer. The various controller 110 and computer systems discussed herein are not limited to any particular hardware architecture or configuration. Embodiments of the systems and methods set forth herein may be implemented by one or more general-purpose or customized controllers adapted in any suitable manner to provide the desired functionality. For example, the controller 110 may be adapted to provide additional functionality, either complementary or unrelated to the present subject matter. When software is used, any suitable programming, scripting, or other type of language or combinations of languages may be used to implement the teachings contained herein. However, some systems and methods set forth and disclosed herein may also be implemented by hard-wired logic or other circuitry, includ-

ing, but not limited to, application-specific circuits. Of course, various combinations of computer-executed software and hard-wired logic or other circuitry may be suitable as well.

[0021] The controller 110 may be operably connected to one or more sensors that generate one or more parameter signals reflective of operating parameters of the combustor 10. By way of illustration and not as a limitation of the invention, the sensors may be broadly organized as combustor/gas turbine performance sensors 114, fluid sensors 116, and stability sensors 118. The combustion/gas turbine sensors 114 may be located throughout the combustor 10 or gas turbine to provide real time or near real-time parameter signals 120 reflective of the operating parameters of the combustor 10 or gas turbine. For example, the combustion/gas turbine sensors 114 may monitor and provide parameter signals 120 reflective of the pressure of the compressed working fluid (compressor discharge pressure), temperature of the compressed working fluid, various temperatures inside the combustor 10, gas turbine exhaust temperature, power level, or any number of other operating parameters of the combustor 10 or gas turbine. The fluid sensors 116 may be positioned in various fluid supplies to the combustor 10 to provide parameter signals 122 reflective of the physical characteristics of the various fluids. For example, the fluid sensors 116 may monitor and provide parameter signals 122 reflective of the ambient air temperature and/or humidity, diluent temperature and/or pressure, or pressure, temperature, and/or calorie content of the fuel. The stability sensors 118 may similarly be positioned throughout the combustor 10 and/or gas turbine to provide parameter signals 124 reflective of abnormal conditions in the combustor 10 and/or gas turbine. For example, the stability sensors 118 may monitor and provide parameter signals 124 reflective of temperatures inside or proximate to each nozzle 14 to indicate a flashback or flame holding event, pressure amplitudes and/or frequencies inside the combustor 10 to indicate combustor flame stability, or emissions content to indicate excessive undesirable emissions.

[0022] Fig. 4 provides a block diagram of a method for operating the combustor 10 shown in Fig. 1 according to one embodiment of the present invention. The method may include generating an operating mode signal 126 reflective of the desired operating mode for the combustor 10. The operating mode signal 126 may be generated manually, for example by an operator as indicated by block 128, or automatically, for example in response to a sensed operating level of the combustor 10. In block 130, the operating mode signal 126 actuates one or more of the valves downstream from the fuel supply (e.g., valves 70, 78), diluent supply (e.g., valve 84), and/or air supply (valve 88) to flow the fuel (liquid or gaseous) through the fuel inlet 34, 38, the diluent through the diluent inlet 46, and/or the air through the air inlet 50.

[0023] As shown in block 132, the method may further include monitoring one or more operating parameters of

the combustor 10 and generating one or more parameter signals reflective of the operating parameters. For example, combustor/gas turbine performance sensors 114 may generate parameter signals 120 reflective of the pressure of the compressed working fluid (compressor discharge pressure), temperature of the compressed working fluid, various temperatures inside the combustor 10, gas turbine exhaust temperature, power level, or any number of other operating parameters of the combustor 10 or gas turbine. The fluid sensors 116 may generate parameter signals 122 reflective of the ambient air temperature and/or humidity, diluent temperature and/or pressure, or pressure, temperature, and/or calorie content of the fuel. The stability sensors 118 may generate parameter signals 124 reflective of temperatures inside or proximate to each nozzle 114, pressure amplitudes and/or frequencies inside the combustor 10, or emissions content to indicate excessive undesirable emissions.

[0024] The controller 110 receives the one or more parameter signals 120, 122, 124 and/or the operating mode signal 126 and generates the control signal 112. At block 136, the control signal 112 adjusts the flow of at least one of the fuel, diluent, or air through the nozzle 14 to the combustor 10. For example, during normal operations, the controller 110 may simply adjust the flow rate of one or more of the fuel, diluent, or air through the respective fuel, diluent, or air passages in response to a change in power demand, ambient temperature, fuel quality, or various other operating parameters of the combustor 10 or gas turbine. Specifically, the control signal 112 from the controller 110 may adjust the fuel supply in response to the fluid sensor 116 parameter signal 122 to allow the combustor 10 to operate using multiple liquid and gaseous fuels having different heat values or Wobbe indices without adversely affecting the combustor flame stability, creating excessive pressure oscillations, and/or increasing the risk or occurrence of flame holding. In this manner, the system 60 may optimize fuel and/or diluent consumption to increase the combustor 10 efficiency and reduce operating costs. Alternately, or in addition, the control signal 112 from the controller 110 may adjust the flow rate of one or more of the fuel, diluent, or air through one or more of the cross connected fuel, diluent, or air passages in response to a change in the operating mode signal 126. For example, the control signal 112 from the controller 110 may adjust the diluent and/or air flow through the liquid fuel passage 32 to purge the liquid fuel from the liquid fuel passage 32 in anticipation of operating in a gaseous fuel only mode.

[0025] As another example, the control signal 112 from the controller 110 may adjust the flow rate of one or more of the fuel, diluent, or air through one or more of the cross connected fuel or diluent passages in response to the stability sensor 118 parameter signal 124. For example, the control signal 112 and the controller 110 may adjust the diluent and/or air flow through one or more of the fuel passages 30, 32 in response to a detected flame holding event and/or excessive amount of undesirable emis-

sions. Fig. 5 provides an exemplary graph of nitrous oxide emissions associated with various diluent to fuel ratios for non-emulsified fuel (dashed curve) compared to emulsified fuel (solid curve). As shown, the system 60 may adjust the amount of diluent flow through the mixing piping and/or homogenizer 76 to adjust the combustible fluid pressure and diluent to fuel ratio in the emulsified fuel injected through the liquid fuel passage 32, thereby reducing the nitrous oxide emissions for the same diluent to fuel ratio. Similarly, Fig. 6 provides an exemplary graph of pressure oscillations associated with various diluent to fuel ratios for non-emulsified fuel (dashed curve) compared to emulsified fuel (solid curve). As shown, the system 60 may adjust the amount of diluent flow through the homogenizer 76 to adjust the diluent to fuel ratio in the emulsified fuel injected through the liquid fuel passage 32, thereby minimizing pressure fluctuations in the combustor 10. One of ordinary skill in the art will readily appreciate these and other examples of how the system 60 described and illustrated with respect to Figs. 1-3 enables the controller 110 to adjust or fine-tune the various fluid flows through the combustor 10 to not only improve combustor efficiency during normal operations but to also respond to abnormal conditions detected by the various sensors.

[0026] 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 and examples are intended to be within the scope of the claims if they include 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 languages of the claims.

Claims

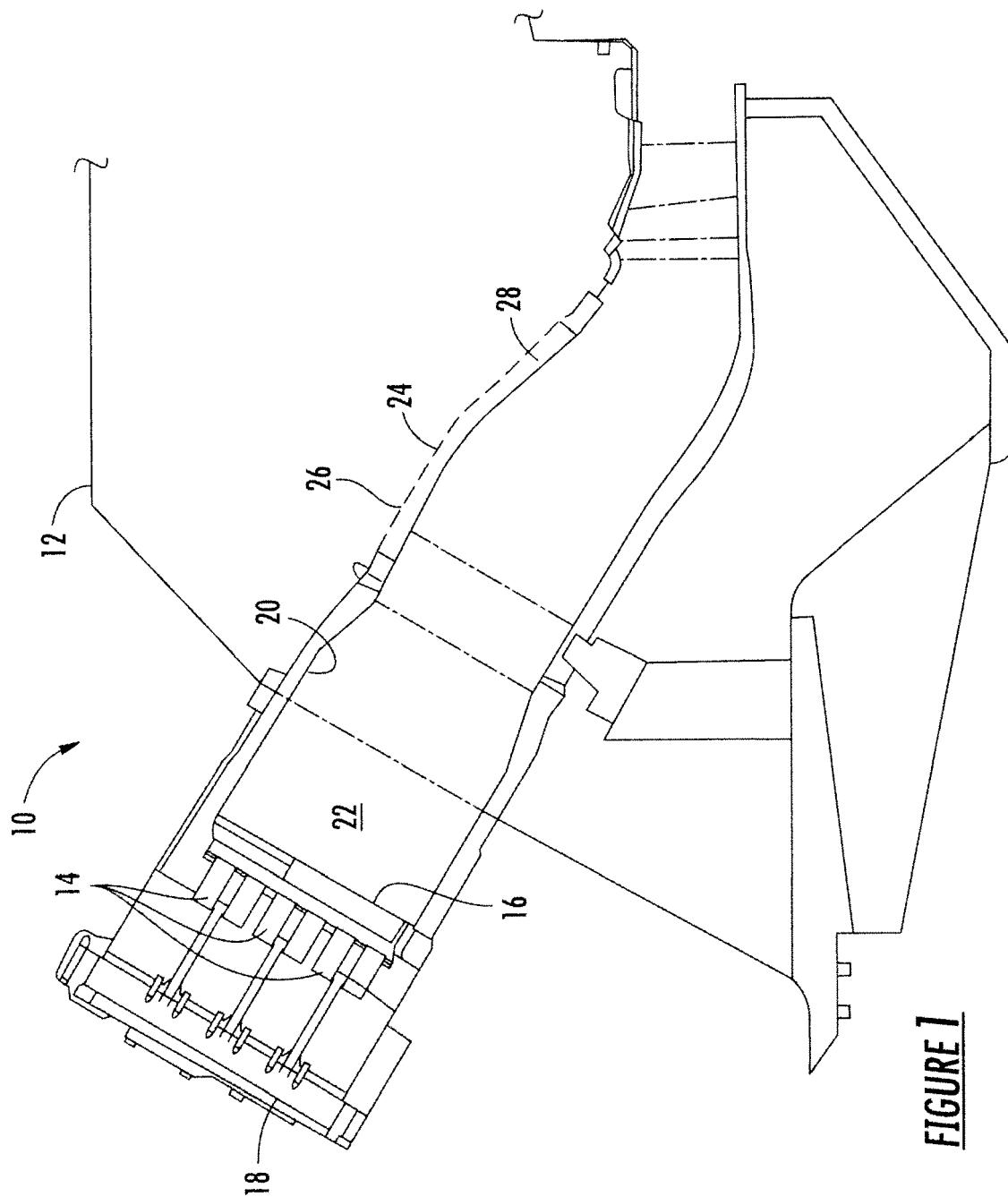
1. A system (60) for operating a combustor (10) comprising:
 - a. a nozzle (14);
 - b. a fuel passage (30, 32) through said nozzle (14), wherein said fuel passage (30, 32) has a fuel inlet (34, 38) and a fuel outlet (36, 40);
 - c. an air passage (44) through said nozzle (14), wherein said air passage (44) has an air inlet (50) and an air outlet (52);
 - d. a fuel supply (62, 64) in fluid communication with said fuel inlet (34, 38); and
 - e. an air supply (68) in fluid communication with said air inlet (50) and said fuel inlet (34, 38).
2. The system (60) as in claim 1, wherein said fuel sup-

ply (62, 64) is in fluid communication with said air inlet (50).

3. The system (60) as in claim 1 or 2, further comprising a diluent passage (42) through said nozzle (14), wherein said diluent passage (42) has a diluent inlet (46) and a diluent outlet (48). 5
4. The system (60) as in claim 3, further comprising a diluent supply (66) in fluid communication with said diluent inlet (46) and at least one of said air inlet (50) or said fuel inlet (34, 38). 10
5. The system (60) as in claim 3 or 4, wherein said air supply (68) is in fluid communication with said diluent inlet (46). 15
6. The system (60) as in any preceding claim, wherein said fuel passage (30, 32) comprises a gaseous fuel passage (30) through said nozzle (14) having a gaseous fuel inlet (34) and a gaseous fuel outlet (36) and a liquid fuel passage (32) through said nozzle (14) having a liquid fuel inlet (38) and a liquid fuel outlet (40). 20
7. The system (60) as in claim 6, wherein said air supply (68) is in fluid communication with said gaseous fuel inlet (34) and said liquid fuel inlet (38). 25
8. The system (60) as in any preceding claim, further comprising a sensor (114, 116, 118) that generates a parameter signal (120, 122, 124) reflective of an operating parameter of the combustor (10). 30
9. The system (60) as in claim 8, wherein said parameter signal (120, 122, 124) is reflective of at least one of temperature, pressure, fuel quality, or emissions. 35
10. The system (60) as in claim 8 or 9, further comprising a controller (110) connected to said sensor (114, 116, 118), wherein said controller (110) receives said parameter signal (120, 122, 124) from said sensor (114, 116, 118) and generates a control signal (112) to at least one of said fuel supply (62, 64) or said diluent supply (66) based on said parameter signal (120, 122, 124). 40 45
11. A method for operating a combustor (10) comprising:
 - a. flowing a fuel through a fuel inlet (34, 38) in a nozzle (14); 50
 - b. flowing air through an air inlet (50) in said nozzle (14);
 - c. sensing an operating parameter of the combustor (10); 55
 - d. generating a signal reflective of said operating parameter; and
 - e. controlling a flow of at least one of air or diluent

to said fuel inlet (34, 38) based on said signal reflective of said operating parameter.

12. The method as in claim 11, further comprising generating the signal reflective of at least one of temperature, pressure, fuel quality, or emissions.
13. The method as in claim 11 or 12, further comprising controlling a flow of at least one of the fuel or diluent to said air inlet (50).
14. The method as in any of claims 11 to 13, further comprising controlling a flow of air to a diluent inlet (46).
15. The method as in any of claims 11 to 14, further comprising controlling a flow of fuel to a diluent inlet (46).



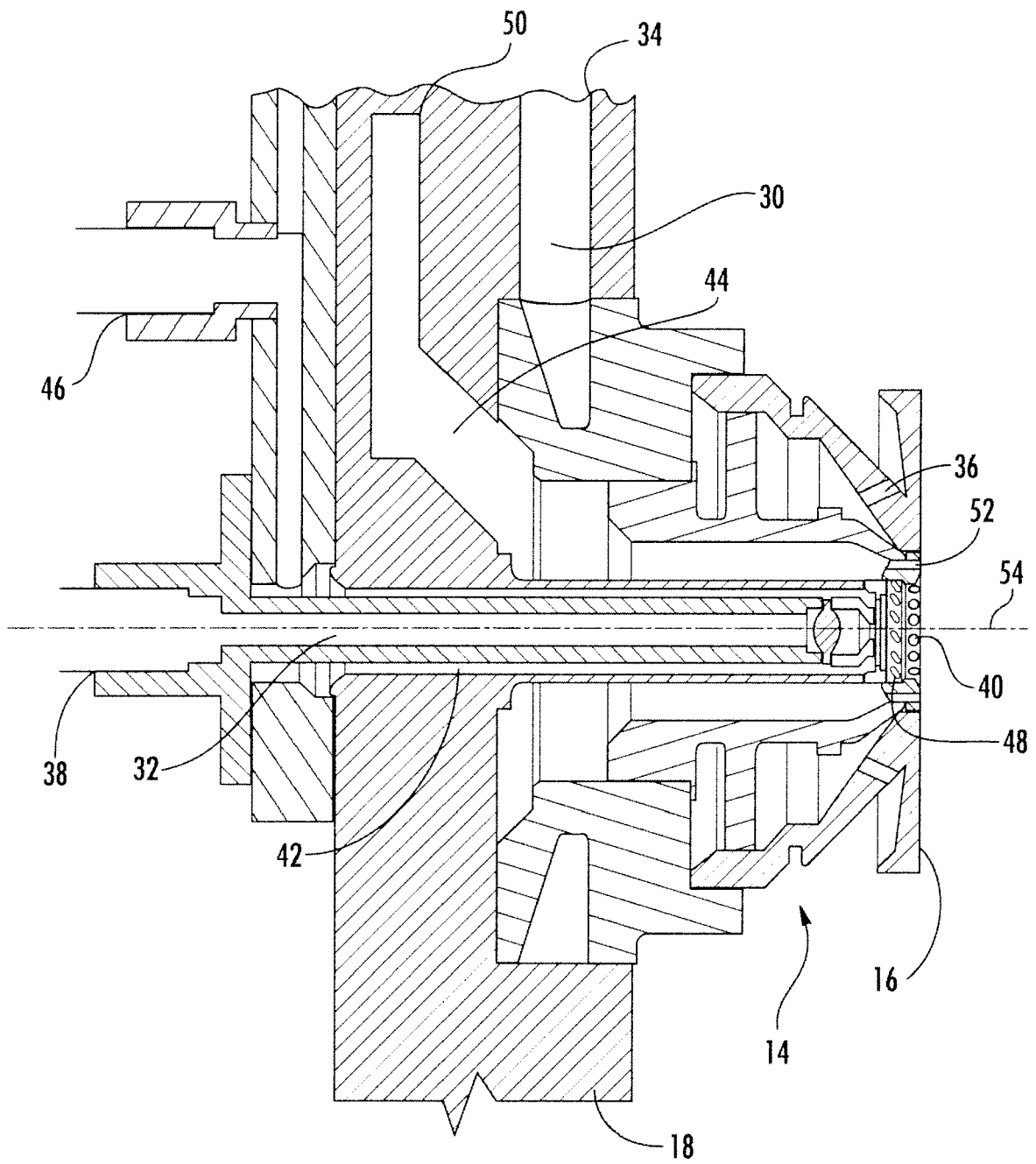


FIGURE 2

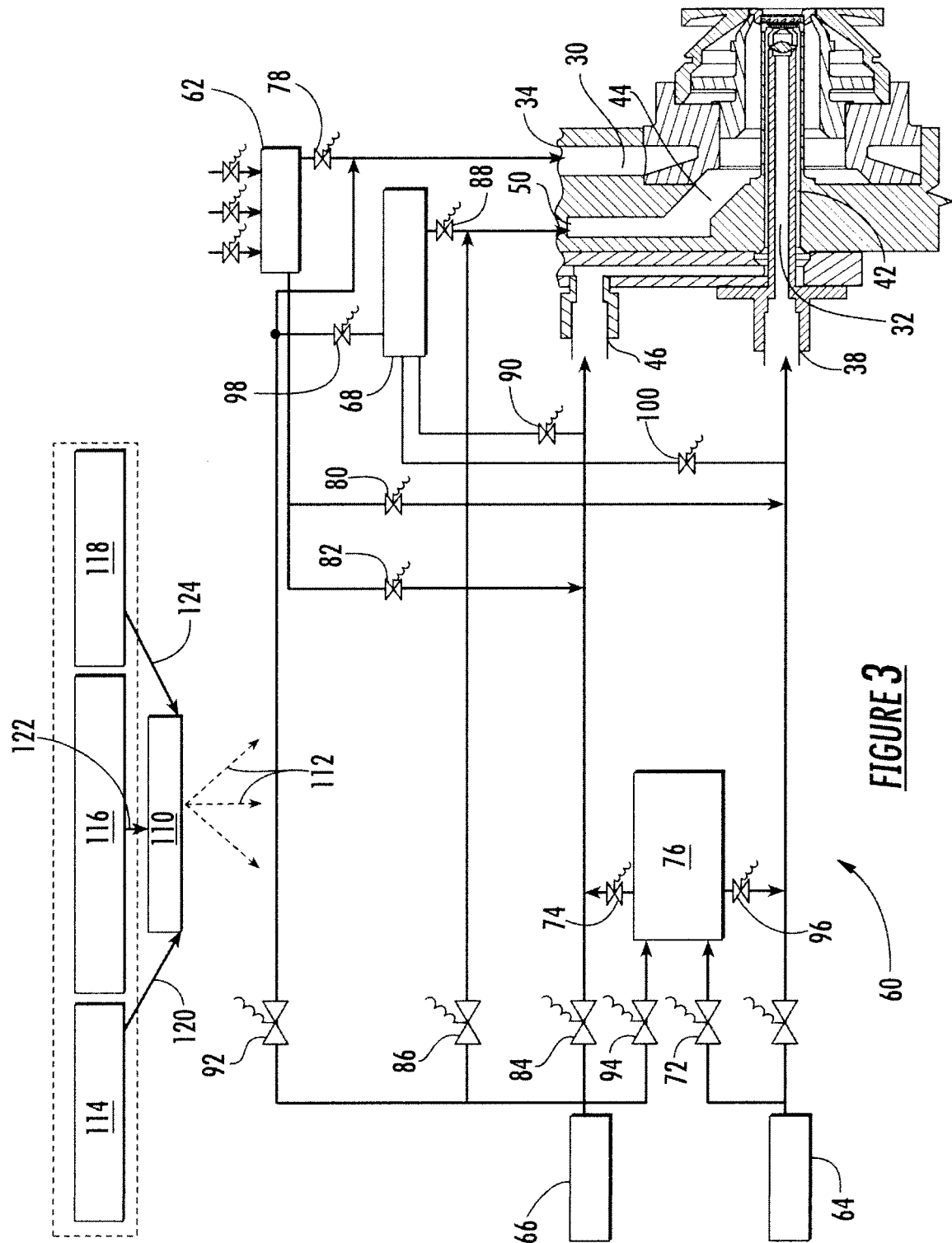


FIGURE 3

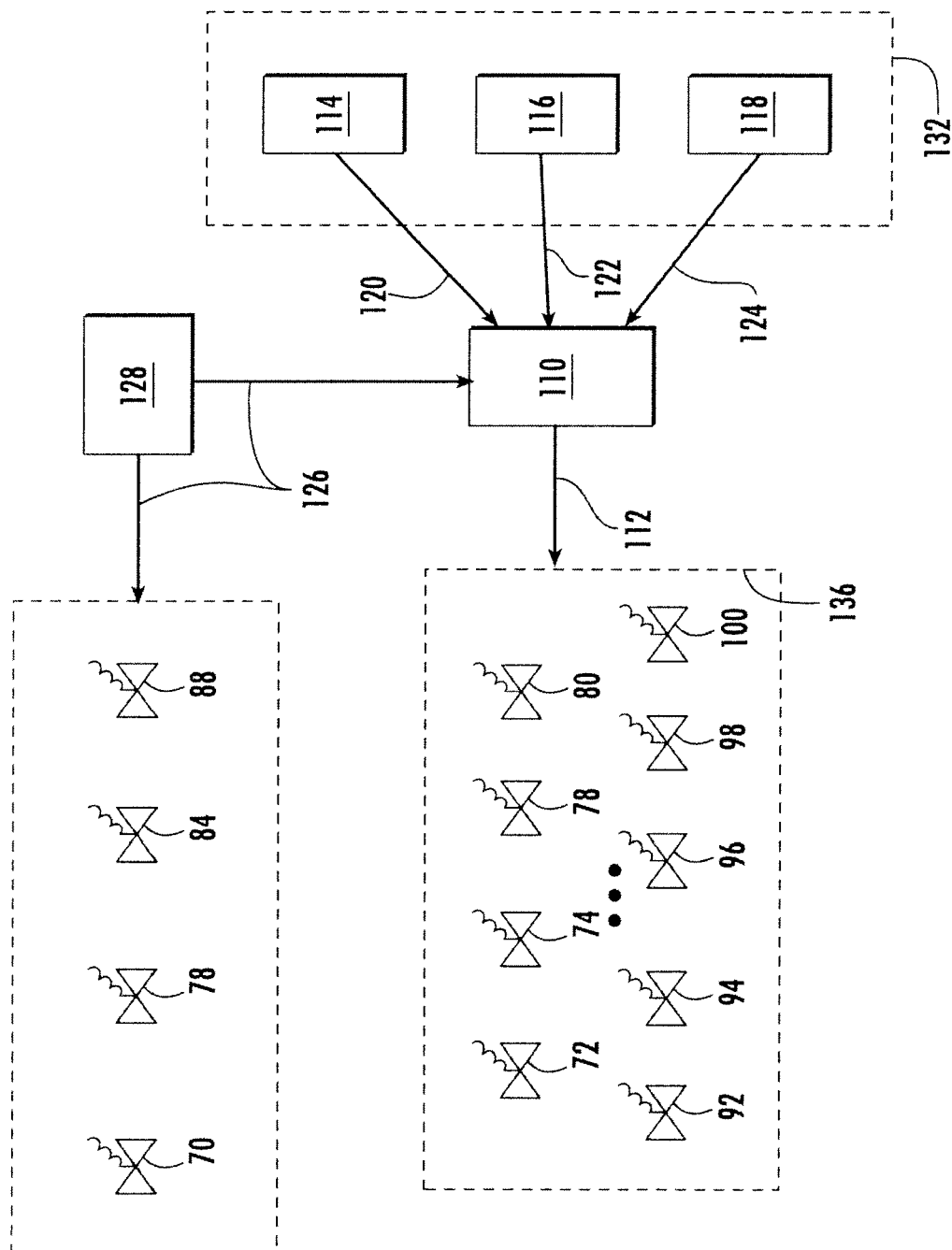


FIGURE 4

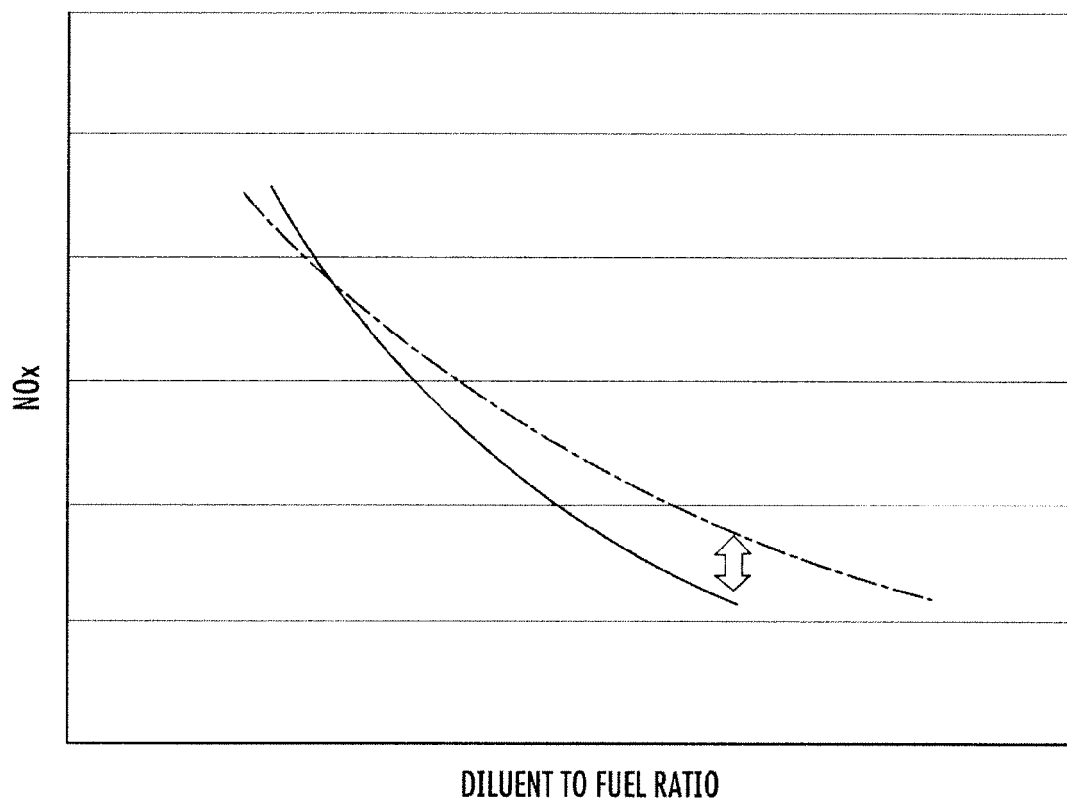


FIGURE 5

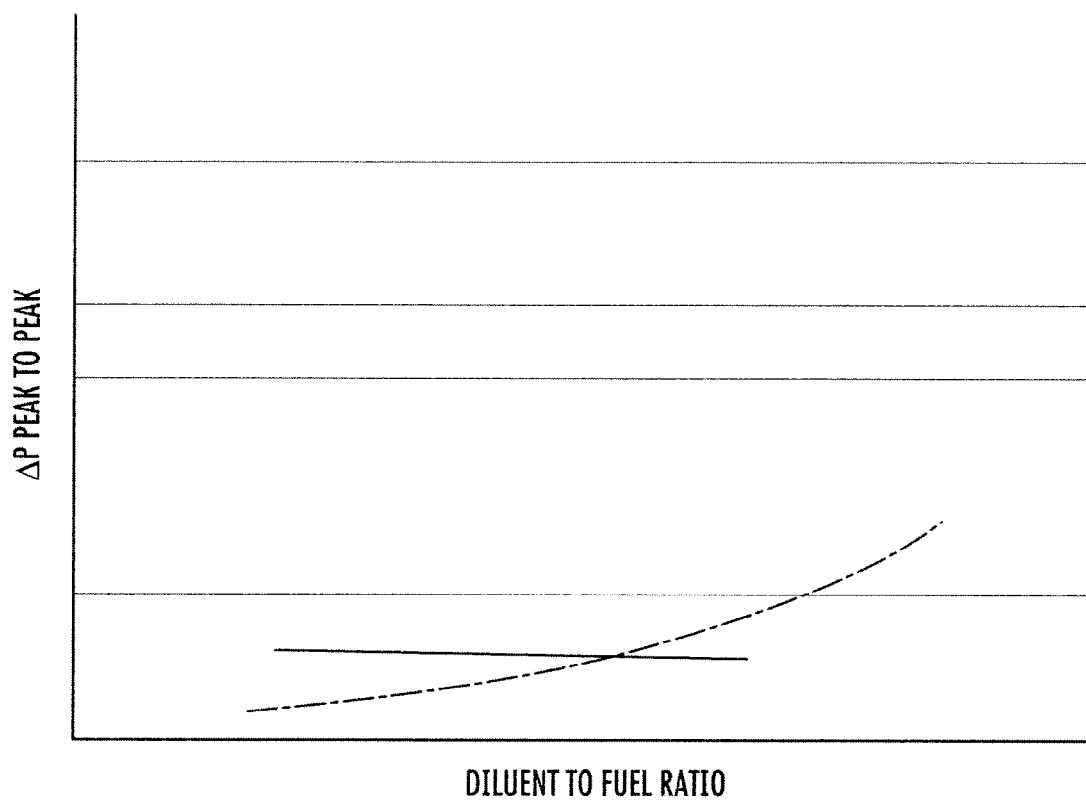


FIGURE 6