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(54) TRAPPED VORTEX COMBUSTOR CAVITY MANIFOLD FOR GAS TURBINE ENGINE

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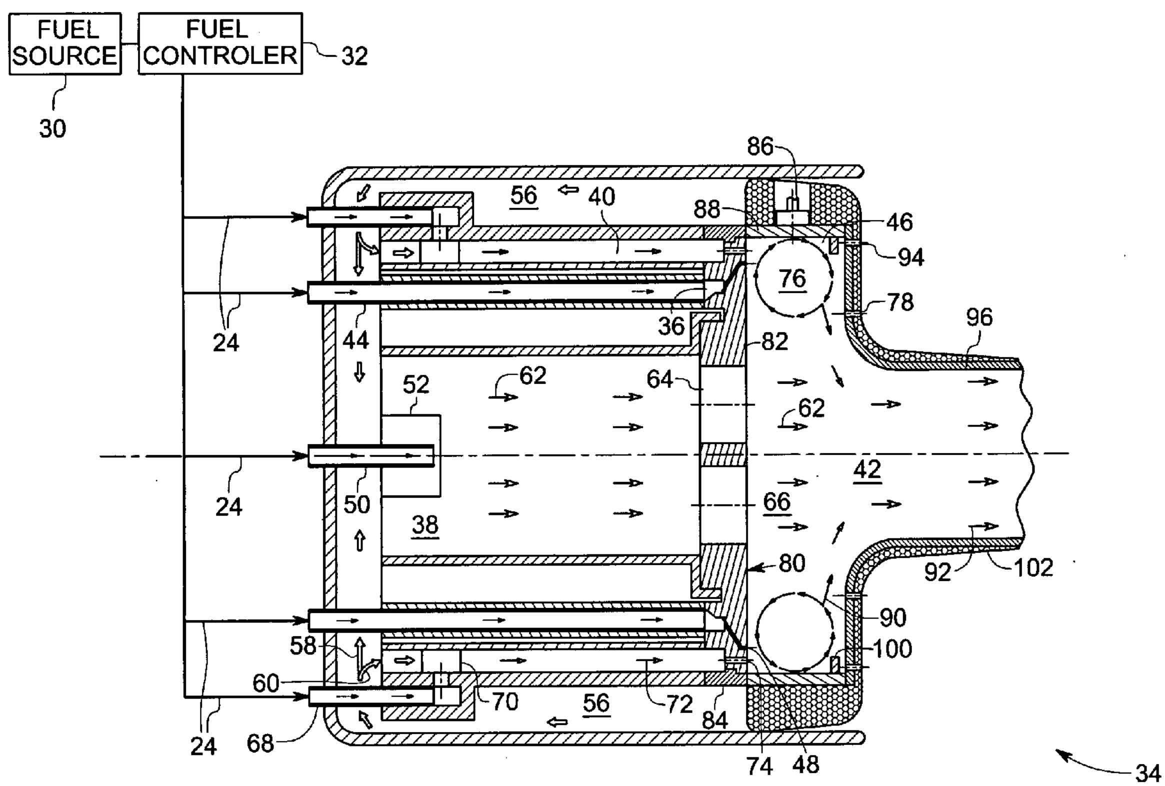
(57) ABSTRACT

In accordance with one embodiment, the present technique provides a combustor assembly for use in a gas-turbine device. The combustor assembly includes a first combustion zone and a second combustion zone. The combustor assembly further includes a first premix chamber configured to receive a fuel and air to facilitate a first fuel-air mixture having a first fuel-to-air ratio, wherein the first premix chamber is fluidiclly coupled to the combustion chamber at the first combustion zone. The combustor assembly also includes a second premix chamber configured to receive a fuel and air to facilitate a second fuel-air mixture having a second fuel-to-air ratio, wherein the second premix chamber is fluidiclly coupled to the combustion chamber at the second combustion zone, wherein the second combustion zone is radially outboard of the first combustion zone.



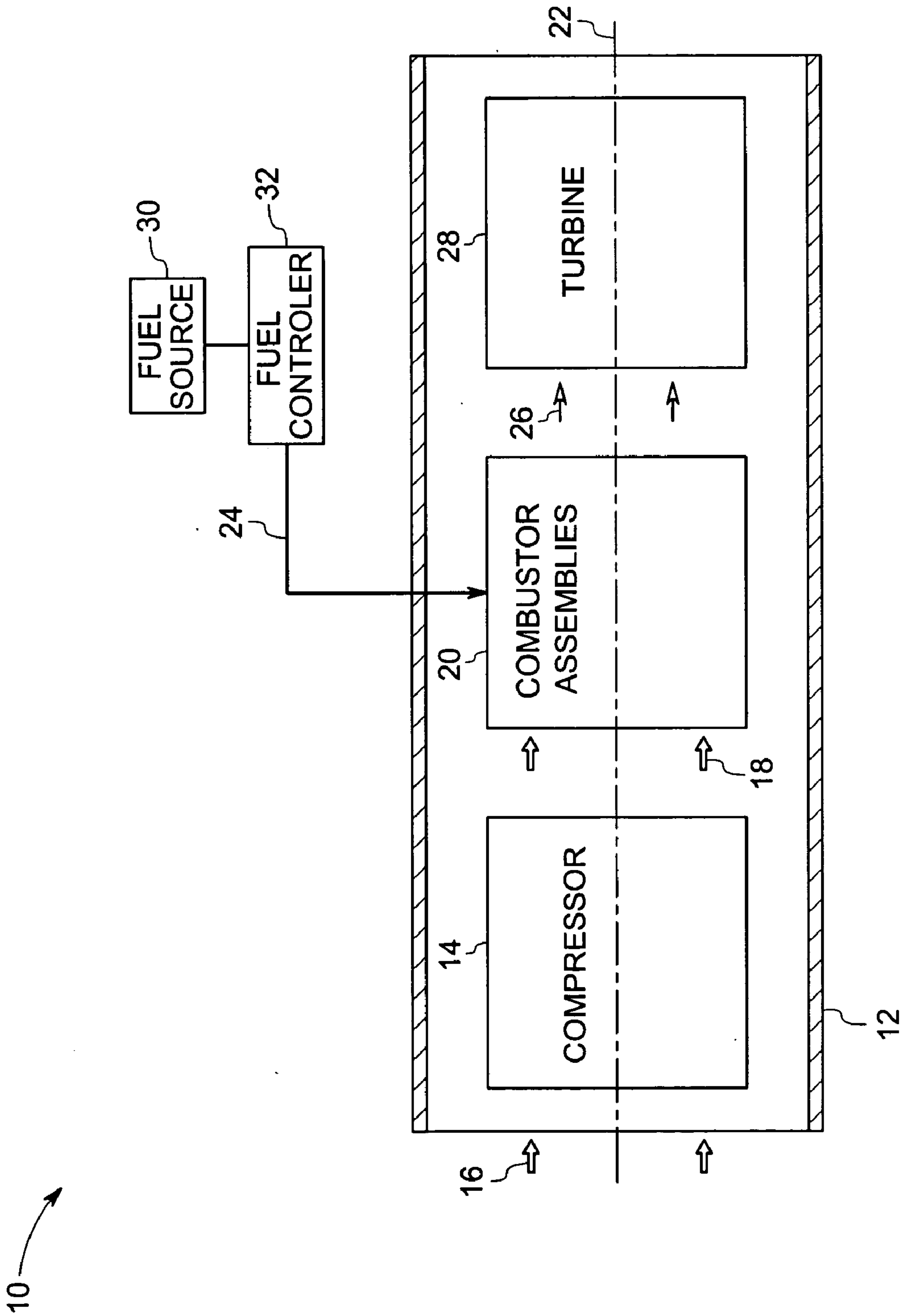
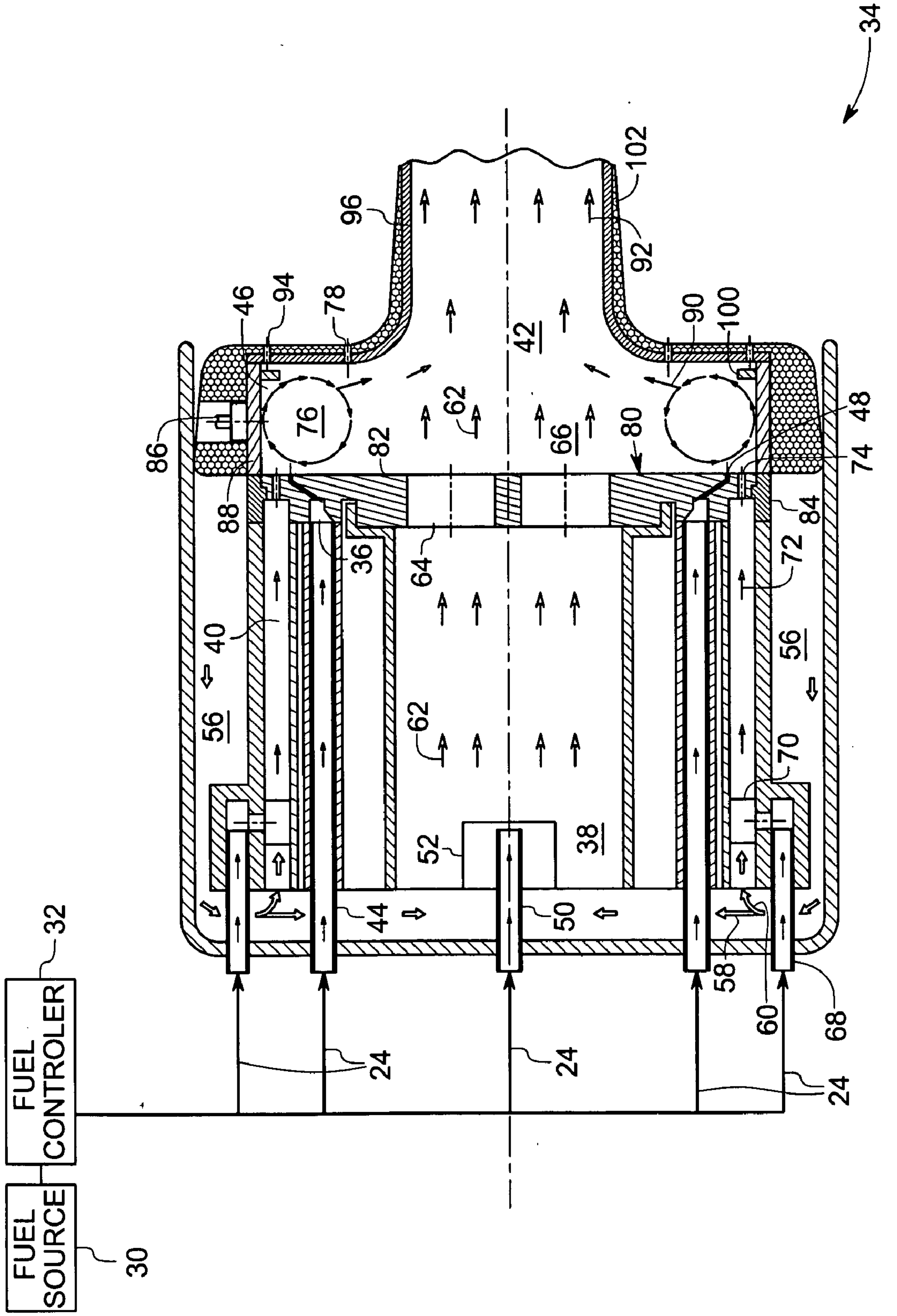

FUEL SOURCE
30
FUEL CONTROLER
32
24
TURBINE
28
26
22
COMBUSTOR ASSEMBLIES
20
18
COMPRESSOR
14
16
12
10

FIG.1


FUEL SOURCE
FUEL CONTROLER
30
32
34
24
36
38
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42
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46
48
50
52
56
58
60
62
64
66
68
70
72
74
76
78
80
82
84
86
88
90
92
94
96
100
102

FIG.2

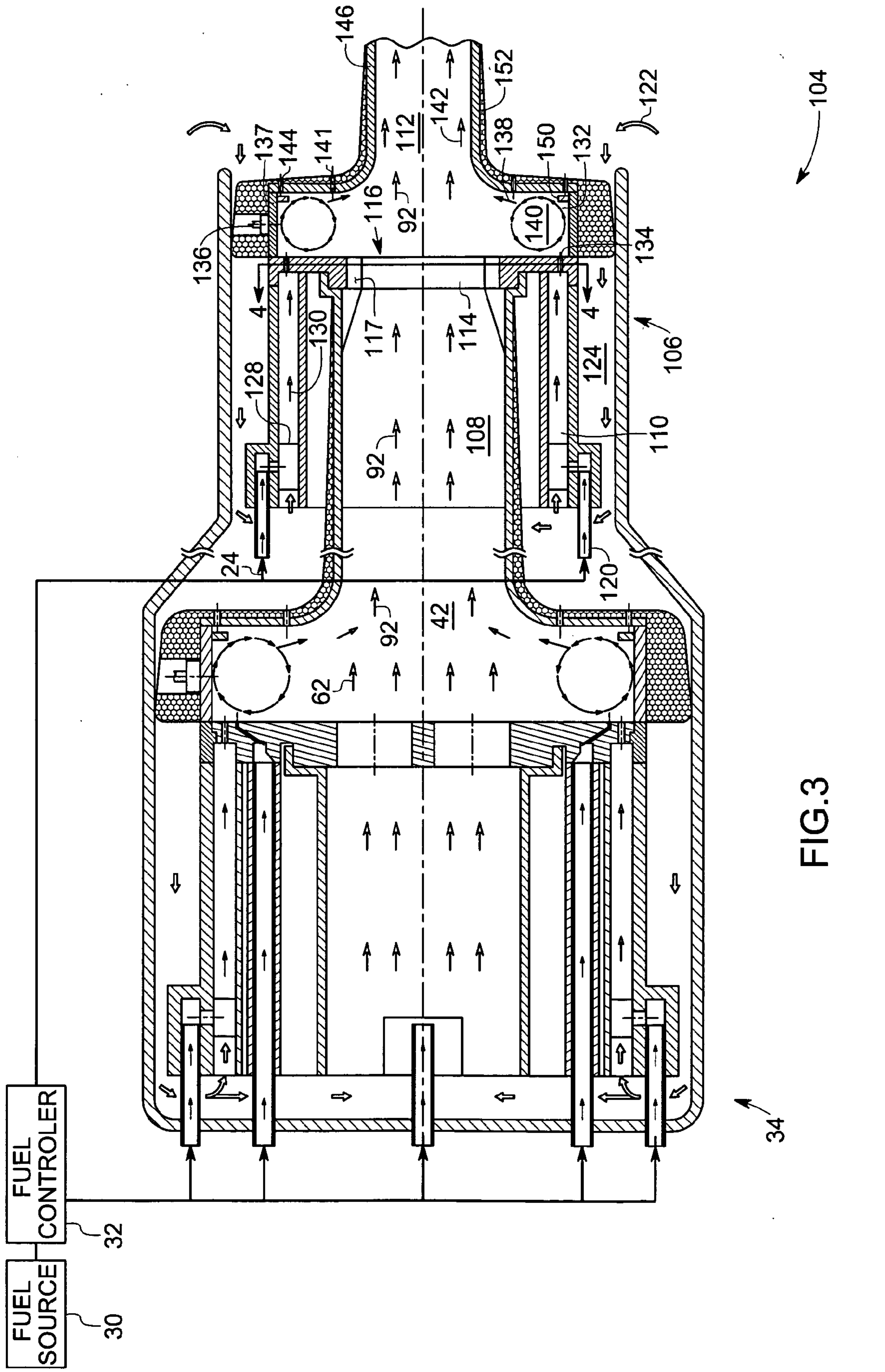
FUEL SOURCE
30
FUEL CONTROLER
32
34
104
106
122
146
152
142
112
116
92
140
108
124
110
114
117
120
24
42
62

FIG.3

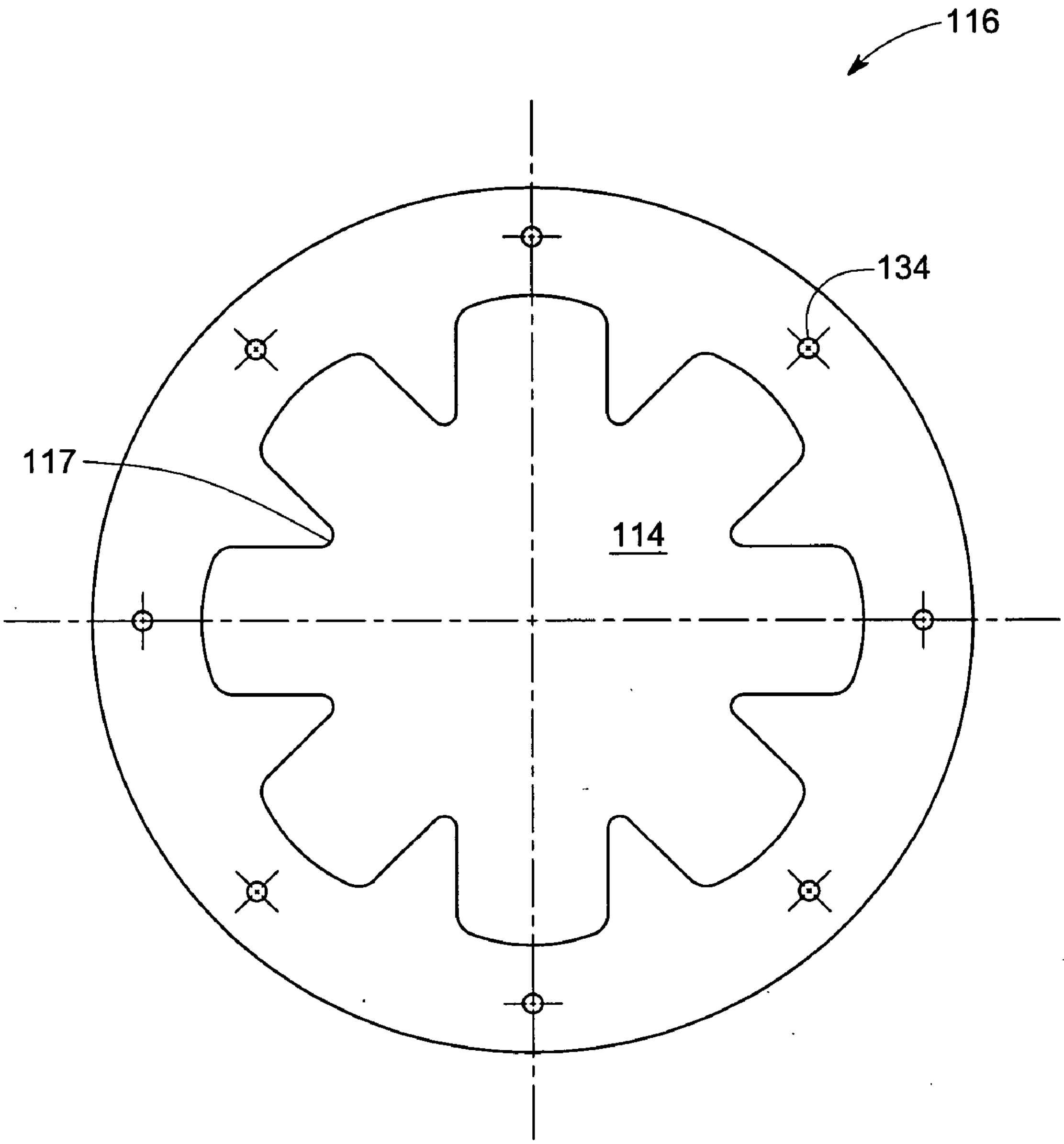

FIG.4

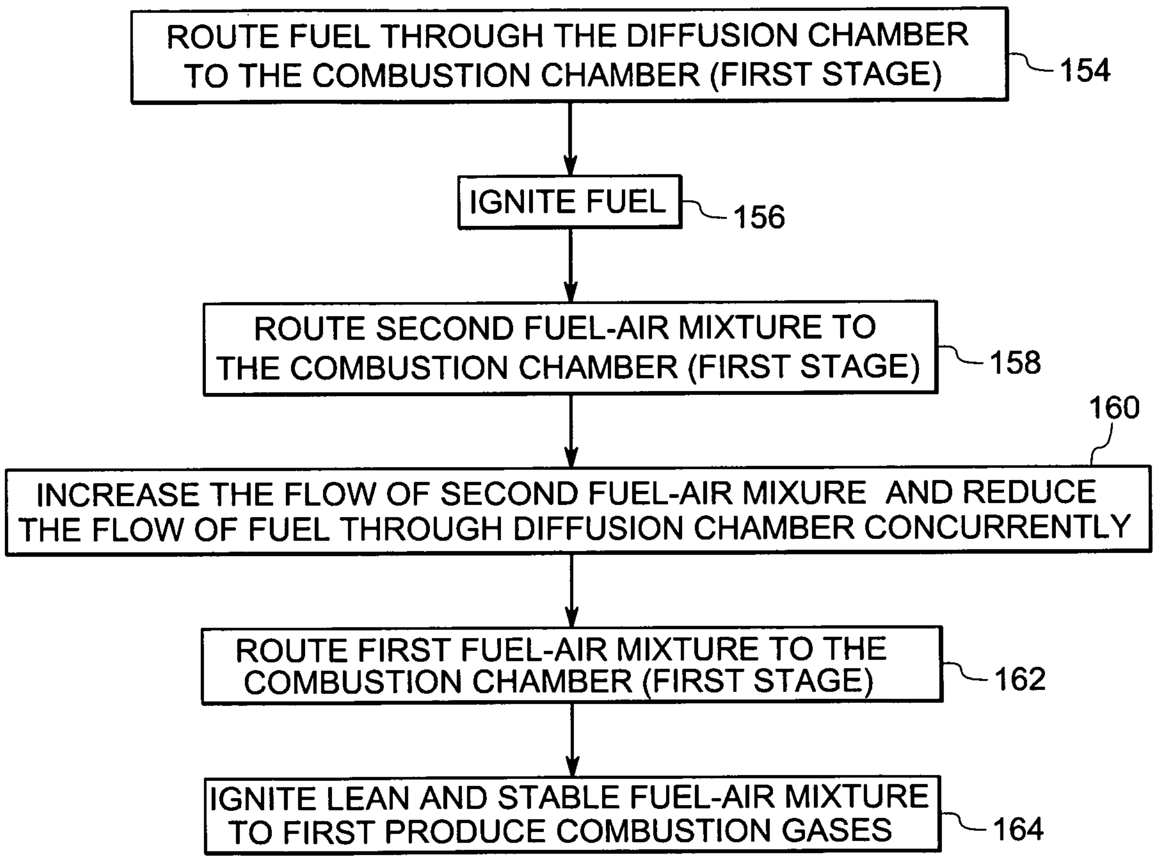
ROUTE FUEL THROUGH THE DIFFUSION CHAMBER TO THE COMBUSTION CHAMBER (FIRST STAGE)
154
IGNITE FUEL
156
ROUTE SECOND FUEL-AIR MIXTURE TO THE COMBUSTION CHAMBER (FIRST STAGE)
158
160
INCREASE THE FLOW OF SECOND FUEL-AIR MIXURE AND REDUCE THE FLOW OF FUEL THROUGH DIFFUSION CHAMBER CONCURRENTLY
ROUTE FIRST FUEL-AIR MIXTURE TO THE COMBUSTION CHAMBER (FIRST STAGE)
162
IGNITE LEAN AND STABLE FUEL-AIR MIXTURE TO FIRST PRODUCE COMBUSTION GASES
164

FIG.5

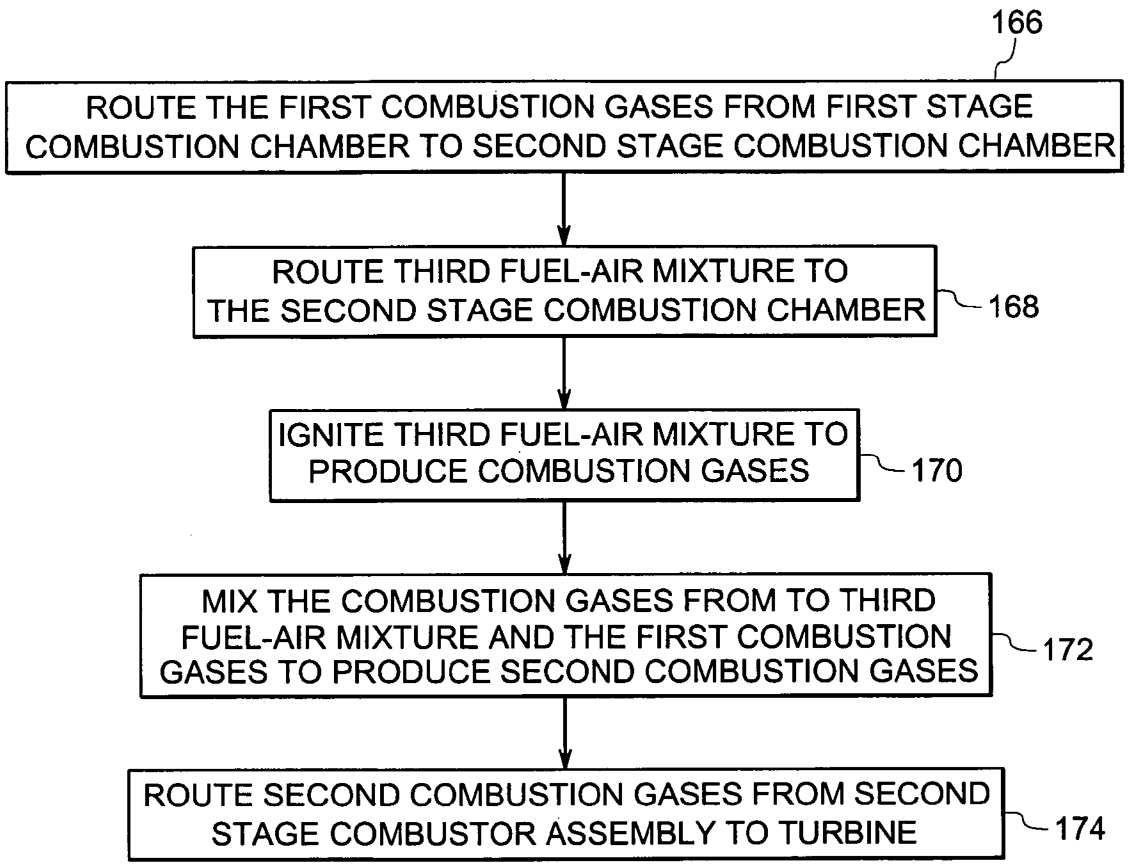
166
ROUTE THE FIRST COMBUSTION GASES FROM FIRST STAGE COMBUSTION CHAMBER TO SECOND STAGE COMBUSTION CHAMBER
ROUTE THIRD FUEL-AIR MIXTURE TO THE SECOND STAGE COMBUSTION CHAMBER
168
IGNITE THIRD FUEL-AIR MIXTURE TO PRODUCE COMBUSTION GASES
170
MIX THE COMBUSTION GASES FROM TO THIRD FUEL-AIR MIXTURE AND THE FIRST COMBUSTION GASES TO PRODUCE SECOND COMBUSTION GASES
172
ROUTE SECOND COMBUSTION GASES FROM SECOND STAGE COMBUSTOR ASSEMBLY TO TURBINE
174

FIG.6

TRAPPED VORTEX COMBUSTOR CAVITY MANIFOLD FOR GAS TURBINE ENGINE

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH & DEVELOPMENT

[0001] This invention was made with Government support under contract number DE-FC26-01NT41020 awarded by the Department of Energy. The Government has certain rights in this invention.

BACKGROUND

[0002] The present invention relates generally to fuel aeration and combustion with respect to a combustion device, such as a gas turbine device.

[0003] In traditional gas turbine devices, air is drawn from the environment, mixed with fuel and, subsequently, ignited to produce combustion gases, which may be used to drive a machine element or to generate power, for instance. Traditional gas turbine devices generally include three main systems: a compressor, a combustor and a turbine. The compressor pressurizes air and sends this air towards the combustor. The combustor can be configured as multiple can combustors or as an annulus in direct fluid communication with the turbine. The compressed air and the fuel are mixed and burnt in the combustor, and the resulting combustion gases actuate a turbine, generating power or driving a machine element, for instance. That is, the combustion gases flow across a turbine and actuate the turbine that, in turn, drives a shaft to power the compressor and produces output power for powering an electrical generator or for powering an aircraft, to name but few examples.

[0004] Gas turbine engines are typically operated for extended periods of time, and exhaust emissions from the combustion gases are a concern, often subject to regulatory limits. For example, during combustion, nitrogen combines with oxygen to produce oxides of nitrogen (NOx), and these NOx emissions are often subject to regulatory limits and are generally undesired. Traditionally, gas turbine devices reduce the amount of NOx emissions by decreasing the fuel-to-air ratio, and these devices are often referred to as lean devices. Lean device reduce the combustion temperature within the combustion chamber and, in turn, reduce the amount of NOx emissions produced during combustion. Unfortunately, traditional lean combustion devices are susceptible to combustion instabilities that cause the fuel-to-air mixture to vary and are also susceptible to inefficiencies that increase carbon monoxide (CO) emissions, for instance.

[0005] Another method commonly used to reduce peak temperatures and, thereby, to reduce NOx emissions, is to inject water or steam into the combustor. However, water or steam injection is a relatively expensive technique, and these techniques can cause the undesirable side effect of quenching carbon monoxide (CO) burnout reactions. Additionally, water or steam injection methods are limited in their ability to reach the extremely low levels of pollutants required in many localities.

[0006] Another method used to reduce NOx emissions is to stage the introduction of fuel to the combustor. This reduces the time at the highest temperature and makes the head end of the combustor leaner. Again, the problems associated with very lean premixing can be limiting. The tendency of the staged fuel to burn rich is also limiting.

[0007] Thus, there exists a need to provide a combustion technique that reduces NOx emissions.

BRIEF DESCRIPTION

[0008] Briefly, in accordance with one embodiment, the present technique provides a combustor assembly for use in a gas-turbine device. The combustor assembly includes a first combustion zone and a second combustion zone. The combustor assembly further includes a first premix chamber configured to receive a fuel and air to facilitate a first fuel-air mixture having a first fuel-to-air ratio, wherein the first premix chamber is fluidiclly coupled to the combustion chamber at the first combustion zone. The combustor assembly also includes a second premix chamber configured to receive a fuel and air to facilitate a second fuel-air mixture having a second fuel-to-air ratio, wherein the second premix chamber is fluidiclly coupled to the combustion chamber at the second combustion zone, wherein the second combustion zone is radially outboard of the first combustion zone.

[0009] In accordance with another aspect, the present technique provides an exemplary method of providing combustion gases for a gas-turbine device. The method includes supplying fuel and compressed air to a first premix chamber of a combustor assembly to produce a first fuel-air mixture having a first fuel-to-air ratio. The method includes routing the first fuel-air mixture to a first combustion zone of a combustion chamber of the combustor assembly. The method also includes supplying fuel and compressed air to a second premix chamber of the combustor assembly to produce a second fuel-air mixture having a second fuel-to-air ratio. The method further includes routing the second fuel-air mixture to a second combustion zone of the combustion chamber of the combustor assembly to generate a vortex flow of the second fuel-air mixture in the second combustion zone, wherein the second combustion zone is disposed radially outboard of the first combustion zone.

DRAWINGS

[0010] 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:

[0011] **FIG. 1** is a diagrammatic representation of a gas turbine device, in accordance with an exemplary embodiment of present technique;

[0012] **FIG. 2** is a partial and diagrammatic, cross-sectional view of a single stage trapped vortex combustor assembly, in accordance with an exemplary embodiment of present technique;

[0013] **FIG. 3** is a partial and diagrammatic, cross-sectional view of a two-stage trapped vortex combustor assembly, in accordance with an exemplary embodiment of present technique;

[0014] **FIG. 4** is a front view of an end plate of the second stage trapped vortex combustion chamber of **FIG. 3** along line **4-4**;

[0015] **FIG. 5** is a flowchart illustrating an exemplary process for establishing lean and stable fuel for combustion in a single stage combustor assembly of a gas turbine, in accordance with aspects of present technique; and

[0016] **FIG. 6** is a flowchart illustrating an exemplary process for establishing lean and stable fuel for combustion in a two-stage combustor assembly of a gas turbine, in accordance with aspects of present technique.

DETAILED DESCRIPTION

[0017] As a preliminary matter, the definition of the term "or" for the purpose of the following discussion and the appended claims is intended to be an inclusive "or." That is, the term "or" is not intended to differentiate between two mutually exclusive alternatives. Rather, the term "or" when employed as a conjunction between two elements is defined as including one element by itself, the other element itself, and combinations and permutations of the elements. For example, a discussion or recitation employing the terminology "A" or "B" includes: "A", by itself "B" by itself and any combination thereof, such as "AB" and/or "BA."

[0018] The present technique is generally directed towards combustion in a gas turbine device. Gas turbine devices, exemplary embodiments of which are discussed further below, are used in many applications, such as commercial aircrafts and power plants, to name but few applications. Typically, a gas turbine device works on the principle that liquid or gaseous fuel, such as propane, natural gas, syngas or kerosene to name but few types of fuel, is ignited in a combustion zone to produce combustion gases, and these combustion gases are used to actuate a turbine.

[0019] Turning now to the drawings, and referring first to **FIG. 1**, an exemplary embodiment of a gas turbine device **10** in accordance with the present technique is illustrated diagrammatically. It is worth noting that the following discussion relates to exemplary embodiments, and the appended claims should not be limited to the embodiments discussed herein. The gas turbine device **10** includes an outer casing **12** that protects and secures the various internal components of the gas turbine device **10**. Additionally, as discussed further below, the outer casing **12** provides a structure that directs airflow with respect to the gas turbine device **10**.

[0020] To generate airflow, the exemplary gas turbine device **10** includes a compressor **14**. During operation, the compressor **14** draws in air **16** from the atmosphere surrounding the gas turbine device **10** and, then, forces the air **16** downstream in the device. Resultantly, the compressor increases the pressure of the air. In other words, the compressor **14** compresses the air **16** in the environment, and, as such, increases its pressure to produce compressed air **18** and airflow. The compressor **14** acts as a source of compressed air throughout the device and, specifically, the combustors, as discussed further below. By way of example, the compressor **14** is capable of increasing the pressure of the air **16** by a factor of 30, and beyond.

[0021] The compressed air **18** is directed downstream into the device and into a plurality of combustor assemblies **20** (i.e., combustor cans) that are disposed concentrically about the longitudinal axis **22** of the gas turbine device **10**. As illustrated, the combustor assemblies **20** have a generally cylindrical shape, however, other shapes are envisaged. As discussed further below, the combustor assemblies **20** receive the compressed air **18** and fuel **24** and facilitate the formation of a fuel-air mixture. In turn, the combustor assemblies **20** ignite the fuel-air mixture to produce exhaust gases or combustion gases **26**, which drive the turbine **28**. In the exemplary device, the fuel **24** for the plurality of combustors **20** is provided by a fuel source **30**. By way of example, the fuel source **30** is a fuel manifold that directs fuel to the various combustor assemblies. The fuel source **30** (i.e., the fuel manifold) is under the direction of a fuel controller **32**. In the exemplary embodiment, the delivery of fuel **24** to various components of the combustor assemblies **20** is controlled individually using a system of valves, for example. Thus, a desired quantities of fuel may be provided to various components in the combustor assembly **20** at a desired times and in a manner independent from one another.

[0022] After formation in the plurality of combustor assemblies **20**, the combustion gases **26** flow through the turbine **28**, and this flow drives the turbine **28**. Advantageously, the rotation of the turbine **28** is harnessed to cause rotation of a generator rotor, for example, thereby producing power. Alternatively, the rotation of the turbine **28** may be harnessed to drive a machine element.

[0023] **FIG. 2** is a partial and diagrammatic, cross-sectional view of a single stage trapped vortex combustor assembly **34**, in accordance with an exemplary embodiment of present technique. More specifically, **FIG. 2** illustrates a detail portion of a combustor can or combustor assembly **34** similar to one of the combustor assemblies **20** discussed above in **FIG. 1**. In continuation of the discussion above, the fuel source **30** and the fuel controller **32** direct fuel **24** into various distribution mechanisms and aeration chambers of the combustor assembly. The fuel **24** can be one of several possible fuel sources such as propane, natural gas, hydrogen, or syngas, and can include dilutes, such as nitrogen, steam or carbon dioxide (CO2). Of course, other types of fuels are also envisaged. In the exemplary assembly, fuel **24** is provided to a diffusion chamber **36**, a primary premix chamber (e.g., first premix chamber **38**), and a secondary premix chamber (e.g., second remix chamber **40**) of the combustor assembly **34**. In turn, these regions provide the appropriate fuel or fuel-air mixtures to a combustion chamber **42**, as discussed further below.

[0024] Fuel **24** is provided to the combustion chamber **42**, among other pathways, through the diffusion chamber **36**. Fuel **24** from the plurality of inlet tubes **44** of the diffusion chamber **36**, is introduced into a secondary combustion zone or second combustion zone **46** of the combustion chamber **42** via a plurality of apertures **48**. Advantageously, the delivery of the diffusion fuel **24** through the plurality of apertures **48** is believed to minimize the thermal gradient with respect to the surfaces defining the combustion chamber **42**. As discussed further below, fuel **24** from the diffusion chamber **36** facilitates an increase in the richness of the fuel-air mixture in the combustion chamber **42**, if such richness is desired and/or if conditions warrant.

[0025] In the exemplary combustor assembly **34**, some of the introduced fuel **24** is aerated prior to insertion into the combustion chamber **42**. For example, fuel **24** travels through a plurality of inlet tubes **50** of the primary premix chamber **38**. This aeration at least occurs partially in a first premix device **52**. As discussed further below, the premix device **52** mixes air and fuel **24** to produce a fuel-air mixture. For aerating the fuel **24**, compressed air, which is originated at the compressor **14** (see **FIG. 1**), travels through an airflow chamber **56** and is then bifurcated into two portions, namely a first airflow portion **58** and a second airflow portion **60**. The first airflow portion **58** of the compressed air enters the primary premix chamber **38**. The premix device **52** facilitates aeration of the fuel **24**; in other words, the premix device **52** facilitates mixing of the fuel **24** and the first airflow portion **58** to produce a primary fuel-air mixture or first fuel-air mixture **62** with a first fuel-to-air ratio. Once mixed, the flow of the first airflow portion **58** drives the primary fuel-air mixture **62** towards a plurality of apertures **64** and, in turn, into the combustion chamber **42**. Specifically, the plurality of apertures **64** is located towards the center of the combustion chamber **42** and feeds into a primary combustion zone or first combustion zone **66** of the combustion chamber **42**, which is also located towards the center of the combustion chamber **42**. In the exemplary embodiment, fuel-air mixture from the primary premix chamber **38** is a relatively lean mixture.

[0026] The exemplary combustor assembly **34** also includes a secondary aeration region, that is, the second premix chamber **40**. Fuel **24** is provided to the secondary premix chamber **40** by way of a plurality of fuel tubes **68**. As described above, compressed air travels through the airflow chamber **56**, and the second airflow portion **60** of the compressed air then enters the secondary premix chamber **40**. In a manner similar to the primary premix device **52**, a second premix device **70** facilitates mixing of fuel **24** and the second airflow portion **60** to produce a secondary fuel-air mixture or a second fuel-air mixture **72** with a second fuel-to-air ratio. In the exemplary embodiment, the second fuel-air mixture **72** has a higher fuel-to-air ratio than the first fuel-air mixture **62** produced in the primary premix chamber **38**. That is, the fuel-air mixture **72** produced in the secondary premix chamber **40** is richer than that produced in the primary premix chamber **38**. The compressed air **60** drives an airflow that pushes the fuel-air mixture **72** into the secondary combustion zone **46** of the combustion chamber **42** through a plurality of apertures **74**. Specifically, the second fuel-air mixture **72** is introduced into the secondary combustion zone **46**, which is radially outboard of the primary combustion zone **66**. The flow of the secondary fuel-air mixture and the design of the secondary premix zone facilitate avoiding flashbacks. The flashback is a process by which the flame travels in a direction opposite to a desired direction, i.e. the flame may travel from the combustion chamber towards the premix chambers.

[0027] As the second fuel-air mixture **72** is introduced into the combustion chamber, specifically in the secondary combustion zone **46**, the second fuel-air mixture **72** begins to travel in a vortex-like manner. In the exemplary combustor assembly, the introduced mixture (i.e., second fuel-air mixture **72**) is confined within the U-shaped secondary combustion zone **46**, and this U-shape induces the vortex flow **76**. For example, fuel-air mixture **72** introduced from the inlet **74** travels axially across the secondary combustion zone **46** and impacts the opposite sidewall, causing the secondary fuel-air mixture **72** to travel back towards the inlet **74**. As more fuel-air mixture **72** is introduced from the inlet **74**, the process repeats, and the vortex flow **76** is maintained. Advantageously, the exemplary assembly includes apertures **78** that facilitate the generation of vortex flow in the secondary combustion zone **46**. Moreover, as discussed further below, the fuel-to-air ratio of the fuel-air mixture, which is subjected to vortex flow can be increased by the introduction of fuel **24** through the diffusion chamber **36** and its corresponding inlet **44**.

[0028] In the exemplary combustor assembly **34**, the premix chambers **38**, **40** and the diffusion chamber **36** are separated from the combustion chamber **42** by an end plate assembly **80**. The end plate assembly **80** includes a first disk **82** that is disposed between the combustion chamber **42** and the primary premix chamber **38**, the diffusion chamber **36** and the secondary premix chamber **40** and a second disk **84** that circumscribes the first disk **82**. The materials of the first and second disks, in the exemplary embodiment, are varied with respect to one another to provide for materials that are best suited to the different operating climates, as discussed further below. For example, in the exemplary combustor, the construction of the first disk **82** is more robust to accommodate the higher combustion temperatures in the combustion chamber.

[0029] During operation, particularly while starting the gas turbine device, the fuel **24** through the diffusion chamber **36** is introduced into the secondary combustion zone **46** of the combustion chamber **42** and ignited by a first igniter **86** which is mounted over a combustion chamber wall **88**. Alternatively, in some embodiments, the combustor assemblies may include crossfire tubes instead of igniters in each combustor assembly. Crossfire tubes are tubes that transfer the flame due to ignition of fuel from one combustor assembly to another. In any event, fuel is ignited by an ignition source. Then, the secondary fuel-air mixture **72** is introduced into the secondary combustion zone **46**. As described above, the U-shape of the secondary combustion zone **46** creates the vortex flow **76** of the fuel-air mixture inside the secondary combustion zone **46**. Advantageously, this vortex flow facilitates the mixing of the fuel **24** from the diffusion chamber **36** and the secondary fuel-air mixture **72** to produce a flame and combustion products, which may include un-combusted fuel and fuel-air mixture. However, it is worth noting that the insertion of the fuel **24** from the diffusion chamber **36** is optional. In any event, the igniter **86** (or ignition source) ignites the fuel subjected to vortex flow in the secondary combustion zone **46**, as discussed above. It is believed that, in the combustion chamber **42**, the ignited fuel-air mixture produces a flame and combustion product **90**, which propagate into the primary combustion zone **66** and ignite the primary fuel-air mixture **62**, which is a leaner mixture. The flame **90** acts as a pilot for the fuel-air mixture in the primary combustion zone **66**. This flame is thought to provide a more stable combustion of the primary fuel-air mixture, and, as such, the flame facilitates lean and stable operation of the combustor assembly, thereby reducing the NOx emissions generated during combustion, for instance. Moreover, the combination product **90** enters the primary combustion zone and affects the fuel-air mixture therein.

[0030] Advantageously, the flow of fuel **24** to the diffusion chamber **36**, the primary premix manifold **38**, and the secondary premix manifold **40** is controlled to alter the quality and quantity of fuel-air mixture desired for a particular application. For example, while starting the gas turbine device, fuel **24** through the diffusion chamber **36** is provided to the combustion chamber **42** and ignited. Gradually, the secondary fuel-air mixture **72** from the secondary premix chamber **40** is introduced and mixed with the fuel **24** inside the combustion chamber. The flame due to the ignition of the fuel **24** through the diffusion chamber **36** ignites the rich fuel-air mixture **72** entering through the secondary premix chamber **40**. Once stabilized, supply of fuel **24** through the diffusion chamber **36** is gradually reduced, and the flow of the secondary fuel-air mixture **72** through the secondary premix chamber **40** is gradually increased.

[**0031**] Similarly, lean fuel-air mixture is beneficial for reducing the emission of NOx. Hence the lean fuel-air mixture **62** of primary premix chamber **38** is introduce into the combustion chamber **42** and ignited using the generated flame from the secondary combustion zone **46**. By controlling the quality of the fuel, various criteria for the effective functioning of the gas turbine device can be achieved. The combustion in the combustion chamber **42** (in both the secondary and primary combustion zones) results in first combustion gases **92**, which flow towards the turbine. A plurality of apertures **94** on the combustion chamber wall **96** and a disk **100** facilitate airflow into the combustion chamber **42**, which in-turn facilitates reducing the emissions of NOx. Additionally, the combustion chamber walls **88** and **96** include an impingement layer **102**. The impingement layer **102** has a plurality of pores that facilitates a flow of compressed air against the external combustion chamber walls, which, in turn, facilitates cooling of the combustion chamber walls.

[**0032**] **FIG. 3** is a partial and diagrammatic, cross-sectional view of a two-stage trapped vortex combustor assembly **104**, in accordance with an exemplary embodiment of present technique. The two-stage trapped vortex combustor assembly **104** includes the first stage trapped vortex combustor assembly **34** of **FIG. 2**, coupled to a second stage trapped vortex combustor assembly **106**. The second stage trapped vortex combustor assembly **106** includes a combustion gas chamber **108**, a third premix chamber **110** and a downstream combustion chamber **112**. Advantageously, the second stage trapped vortex combustor assembly is located relatively close to a turbine inlet, to facilitate improved reduction of NOx emissions.

[**0033**] The first combustion gases **92** from the first stage trapped vortex combustor assembly **34** travel towards the second stage trapped vortex combustor assembly **106**. These combustion gases **92** flow through an opening **114** in an end plate **116** into the downstream combustion chamber **112**.

[**0034**] As discussed above, the second stage combustor assembly **106** also includes the third premix chamber **110**. The fuel source **30** and the fuel controller **32** provide a fuel **24** to the inlet tubes **120** of the third premix chamber **110**. Compressed air **122** travels through an air chamber **124** and enters the third premix chamber **110**. As described above, a third premix device **128** facilitates mixing of fuel **24** and the compressed air **122** to produce a third fuel-air mixture **130** with a third fuel-to-air ratio. This fuel-air mixture **130** is then forced in to a third combustion zone **132** of the combustion chamber **112** through a plurality of apertures **134**.

[**0035**] During operation, similar to the first stage combustor assembly, the fuel-air mixture **130** travels into the third combustion zone **132**. A second igniter **136** (i.e., ignition source) coupled to the combustion chamber wall **137**, ignites the fuel-air mixture **130** in the combustion zone **132** of the second stage combustion chamber **112**. As described above, the ignition source may include the igniter or a crossfire tube. The ignition of the fuel-air mixture **130** results in combustion gases **138**. As discussed above in **FIG. 2**, the U-shape of this combustion zone **132** facilitates the vortex flow **140** of the combustion gases **138**. This vortex flow, in turn, facilitates mixing of the combustion gases **138** with the first combustion gases **92** inside the combustion chamber **112** of the second stage combustor assembly to produce second combustion gases **142**. As described above, a plurality of apertures **144**, provided in the combustion chamber walls **146** and a disk **150** facilitate an air flow that in-turn reduces the emission of NOx. The combustion chamber walls **137** and **146** are also provided with an impingement layer **152**. As described above, the impingement layer **152** facilitates a flow of air along the external surfaces of the combustion chamber walls, which in-turn facilitates cooling of the combustion chamber walls. The number of stages in a combustor assembly may not be limited to two. In some embodiments, the combustor assembly may include as many stages as desired.

[**0036**] **FIG. 4** is a front view of the end plate **116** of the second stage trapped vortex combustion chamber of **FIG. 3**. The end plate **116** includes an opening **114** to facilitate free flow of the first combustion gas mixture **92** towards the combustion chamber **112** of the second stage combustor assembly **106**. As will be appreciated by those skilled in the art, the temperature of the combustion gases **92** from the first stage combustion chamber **42** are relatively high, and the end plate **116** needs to accommodate these combustion gases **92** to mitigate the likelihood of damage. Hence, the opening **114** is designed in such a way that it facilitates the free flow of the combustion gases **92** towards the combustion chamber **112** of the second stage combustor assembly **106** while concurrently benefiting the mixing of flame and combustion gases **138** due to the ignition of fuel-air mixture **130** and the first combustion gases **92**. Indeed, the exemplary end plate includes fingers **117** that partially facilitate the mixing of flame and combustion product **138** and the combustion gases **92** in the combustion chamber **112**. As illustrated, these fingers **117** are at least partially defined by the convoluted inner surface of the end plate **116**.

[**0037**] With **FIG. 2** in mind, **FIG. 5** is a flowchart illustrating an exemplary process for establishing lean and stable fuel-air mixture for combustion in a single stage combustor assembly of a gas turbine, in accordance with aspects of present technique. The process includes routing fuel **24** through the diffusion chamber **36** to the combustion chamber **42**, as represented by step **154** to start a gas turbine device. The igniter **86** ignites the fuel **24** to produce combustion product **92**, as represented by step **156**. Then, the fuel-air mixture **72** is routed to the combustion chamber **42** in such a way that it creates a vortex flow **76** inside the combustion chamber **42**. This vortex flow **76** facilitates mixing of the fuel-air mixture **72** with fuel **24** through diffusion chamber **36** to produce a flame and combustion product **90**, as represented by step **158**. The flow of the fuel-air mixture **72** from of the secondary premix chamber is gradually increased, and the flow of the fuel **24** from the diffusion chamber **36** is gradually reduced, as represented by step **160**. The process further includes introducing a primary fuel-air mixture **62** to the combustion chamber **42** through the primary premix chamber **38**, as represented by step **162**. As described above, the vortex flow **76** of the flame and the combustion product **90** in the secondary combustion zone also facilitates ignition of the primary fuel-air mixture **62** in the primary combustion zone **66**, as represented by step **164** to produce combustion gases **92**.

[0038] With **FIG. 3** in mind, **FIG. 6** is a flowchart illustrating an exemplary process for establishing lean and stable fuel-air mixture for combustion in a two-stage combustor assembly of a gas turbine, in accordance with aspects of present technique. The process includes igniting the lean fuel-air mixture **62** in the combustion chamber **42** of the first stage combustor assembly **34** to generate first combustion gases **92**. The process further includes routing the combustion gases **92** from the combustion chamber of the first stage combustor assembly **34** to the combustion chamber **112** of the second stage combustor assembly **106**, as represented by step **166**. Further, the fuel-air mixture **130** produced in the premix chamber **110** of the second stage combustor assembly **106** is routed to the combustion chamber **112** in such a way that it creates a vortex flow **140** inside the combustion chamber **112**, as represented by step **168**. The second igniter **136** ignites the fuel-air mixture **130** inside the combustion chamber **112** to produce a flame and combustion gases **138**, as represented by step **170**. The vortex flow **140** facilitates the mixing of the combustion gases **138** with the first combustion gases **92** to produce the second combustion gases **142**, as represented by step **172**. The combustion gases **142** from the combustion chamber **112** of the second stage combustor assembly **106** are then routed to the turbine to activate the turbine, as represented by step **174**.

[0039] While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

1. A combustor assembly for use with a gas-turbine device, the assembly comprising:

a combustion chamber having a first combustion zone and a second combustion zone;

a first premix chamber configured to receive a fuel and air to facilitate a first fuel-air mixture having a first fuel-to-air ratio, wherein the first premix chamber is fluidiclly coupled to the combustion chamber at the first combustion zone; and

a second premix chamber configured to receive a fuel and air to facilitate a second fuel-air mixture having a second fuel-to-air ratio, wherein the second premix chamber is fluidiclly coupled to the combustion chamber at the second combustion zone, wherein the second combustion zone is radially outboard of the first combustion zone.

2. The combustor assembly as recited in claim 1, wherein the second premix chamber is configured to avoid flashback.

3. The combustor assembly as recited in claim 1, wherein the second combustion zone is configured to produce a vortex flow of the second fuel-air mixture.

4. The combustor assembly as recited in claim 1, wherein the second premix chamber is configured to provide a lesser volume of compressed air to the combustion chamber than the first premix chamber.

5. The combustor assembly as recited in claim 1, further comprising a diffusion chamber configure to receive fuel and to provide the fuel to the secondary combustion zone.

6. The combustor assembly as recited in claim 1, wherein the second premix chamber is smaller in volume than the first premix chamber.

7. The combustor assembly as recited in claim 1, comprising an ignition source disposed adjacent to the second combustion zone and configured to ignite the second fuel-air mixture.

8. The combustor assembly as recited in claim 1, wherein walls of the combustion chamber comprises a plurality of aperture to facilitate air-flow towards the combustion chamber.

9. The combustor assembly as recited in claim 1, further comprises an impingement layer configured to direct compressed air along an outer surface of the combustion chamber.

10. A combustor assembly for use with a gas turbine device, the assembly comprising:

a combustion chamber having a first combustion zone and a second combustion zone;

a first premix chamber coupled to the combustion chamber at the first combustion zone and configured to receive fuel and air to produce a first fuel-air mixture; and

a second premix chamber coupled to the combustion chamber at the second combustion zone via an inlet and configured to receive fuel and air to produce a second fuel-air mixture, wherein the second combustion zone comprises an inner surface configured to facilitate a vortex flow of the second fuel-air mixture introduced into the second combustion zone.

11. The combustor assembly as recited in claim 10, wherein the second combustion zone has a U-shaped profile.

12. The combustor assembly as recited in claim 10, wherein the inlet is disposed on a first surface opposite to the inner surface of the combustion chamber, wherein the first and the inner surface are non-adjacent with respect to one another.

13. The combustor assembly as recited in claim 12, wherein the combustion chamber comprises a further surface extending from the first surface to the inner surface.

14. The combustor assembly as recited in claim 13, comprising an ignition source extending at least partially through the further surface.

15. The combustor assembly as recited in claim 10, further comprising a diffusion chamber configure to receive fuel and to provide the fuel to the secondary combustion zone.

16. A combustor assembly for use with a gas-turbine device, the assembly comprising:

a combustion chamber having a first combustion zone and a second combustion zone;

a first premix chamber configured to receive a fuel and air to facilitate a first fuel-air mixture having a first fuel-to-air ratio, wherein the first premix chamber is fluidiclly coupled to the combustion chamber; and at the first combustion zone;

a second premix chamber configured to receive a fuel and air to facilitate a second fuel-air mixture having a second fuel-to-air ratio, wherein the second premix chamber is fluidiclly coupled to the combustion chamber at the second combustion zone, wherein the second combustion zone is radially outboard of the first combustion zone; and

a diffusion chamber configured to provide a fuel to the combustion chamber.

17. The combustor assembly as recited in claim 16, wherein the diffusion chamber is disposed between the first and second premix chambers.

18. The combustor assembly as recited in claim 16, wherein the second combustion zone comprises an inner surface configured to facilitate a vortex flow of the second fuel-air mixture introduced into the second combustion zone.

19. A two-stage combustor assembly for use with a gas turbine device, the assembly comprising:

a first stage combustor assembly having a combustion chamber, wherein the combustion chamber comprises a first combustion zone and a second combustion zone, the first stage combustor assembly comprising:

a first premix chamber coupled to the combustion chamber of the first stage at the first combustion zone and configured to receive fuel and air to produce a first fuel-air mixture;

a second premix chamber coupled to the combustion chamber of the first stage combustor assembly at the second combustion zone via an inlet and configured to receive fuel and air to produce a second fuel-air mixture, wherein the second combustion zone comprises an inner surface configured to facilitate a vortex flow of the second fuel-air mixture introduced into the second combustion zone; and

a first ignition source disposed in the second combustion zone of the combustion chamber of the first stage combustor assembly, wherein the first ignition source ignites the second fuel-air mixture and the first fuel-air mixture to produce first combustion gases at the combustion chamber of the first stage combustor assembly; and

a second stage combustor assembly having a combustion chamber, wherein the combustion chamber comprises a third combustion zone and is configured to receive the first combustion gases from the first stage combustor assembly, the second stage combustor assembly comprising:

a third premix chamber coupled to the combustion chamber of the second stage combustor assembly at the third combustion zone via an inlet and configured to receive fuel and air to produce a third fuel-air mixture, wherein the third combustion zone comprises an inner surface configured to facilitate a vortex flow of the third fuel-air mixture introduced into the third combustion zone; and

a second ignition source disposed in the third combustion zone of the combustion chamber of the second stage combustor assembly, wherein the second ignition source ignites the third fuel-air mixture to produce combustion gases, wherein the combustion gases mix with the first combustion gases to produce second combustion gases at the combustion chamber of the second stage combustor assembly.

20. The two-stage combustor assembly as recited in claim 19, wherein the combustion chamber of the first stage combustor assembly comprises a diffusion chamber configured to receive fuel and to provide the fuel to the second combustion zone of the combustion chamber of the first stage combustor assembly.

21. The combustor assembly as recited in claim 19, wherein the combustion chamber of the first stage combustor assembly or the combustion chamber of the second stage combustor assembly comprises a plurality of aperture to facilitate airflow towards the combustion chamber.

22. The combustor assembly as recited in claim 19, wherein the first stage combustor assembly or the second stage combustor assembly further comprises an impingement layer configured to direct compressed air along an outer surface of the combustion chamber.

23. A gas-turbine device, the device comprising:

a compressor configured to generate an airflow;

a combustor assembly comprising a first stage combustor assembly having a combustion chamber, wherein the combustion chamber comprises a first combustion zone and a second combustion zone, the first stage combustor assembly comprising:

a first premix chamber configured to receive a fuel and air to facilitate a first fuel-air mixture having a first fuel-to-air ratio, wherein the first premix chamber is fluidiclly coupled to the combustion chamber of the first stage combustor assembly; and at the first combustion zone;

a second premix chamber fluidiclly coupled to the combustion chamber of the first stage combustor assembly at the second combustion zone via an inlet and configured to receive fuel and air to produce a second fuel-air mixture, wherein the second combustion zone comprises an inner surface configured to facilitate a vortex flow of the second fuel-air mixture introduced into the second combustion zone;

a first ignition source disposed in the second combustion zone of the combustion chamber of the first stage combustor assembly; and

an exhaust pathway located downstream of the compressor and the first and second premix chambers of the combustion chamber of the first stage combustor assembly with respect to the airflow; and

a turbine disposed downstream of the exhaust pathway with respect to the airflow.

24. The gas-turbine device as recited in claim 23, wherein the combustor assembly comprises a second stage combustor assembly coupled to the first stage combustor assembly, located down stream of the first stage combustor assembly with respect to the airflow and comprises a combustion chamber having a third combustion zone.

25. The gas-turbine device as recited in claim 24, wherein second stage combustor assembly comprises a combustion gas chamber configured to receive first combustion gases from the first stage combustor assembly and fluidiclly coupled to the combustion chamber of the second stage combustor assembly; and located up stream of the combustion chamber of the second stage combustor assembly with respect to the airflow.

26. The gas-turbine device as recited in claim 24, wherein second stage combustor assembly comprises a third premix chamber coupled to the combustion chamber of the second stage combustor assembly at the third combustion zone via an inlet and configured to receive fuel and air to produce a third fuel-air mixture having a third fuel-to-air ratio, wherein the third combustion zone comprises an inner surface configured to facilitate a vortex flow of the third fuel-air mixture introduced into the third combustion zone.

27. The gas-turbine device as recited in claim 26, further comprises a second ignition source disposed in the third combustion zone of the combustion chamber of the second stage combustor assembly, wherein the second ignition source ignites the third fuel-air mixture to produce combustion gases, wherein the combustion gases mix with first combustion gases to produce second combustion gases at the combustion chamber of the second stage combustor assembly.

28. A method of providing combustion gases for a gas-turbine device, the method comprising:

supplying fuel and compressed air to a first premix chamber of a combustor assembly;

producing a first fuel-air mixture having a first fuel-to-air ratio in the first premix chamber via the supplied fuel and compressed air;

routing the first fuel-air mixture to a first combustion zone of a combustion chamber of the combustor assembly;

supplying fuel and compressed air to a second premix chamber of the combustor assembly;

producing a second fuel-air mixture having a second fuel-to-air ratio in the second premix chamber via the supplied fuel and compressed air;

routing the second fuel-air mixture to a second combustion zone of the combustion chamber of the combustor assembly, wherein the second combustion zone is disposed radially outboard of the first combustion zone; and

generating a vortex flow of the second fuel-air mixture in the second combustion zone.

29. The method as recited in claim 28, further comprising supplying a fuel to a diffusion chamber of the combustor assembly and routing the fuel to the second combustion zone of the combustion chamber of the combustor assembly.

30. The method as recited in claim 29, further comprising igniting the fuel and the second fuel-air mixture to produce a flame and combustion gases.

31. The method as recited in claim 29, further comprising igniting the first fuel-air mixture using the flame to produce first combustion gases.

32. A method of providing combustion gases for a gas-turbine device, the method comprising:

igniting a first fuel-air mixture in a combustion chamber of a first stage combustor assembly to produce first combustion gases;

routing the first combustion gases to a third combustion zone of a combustion chamber of a second stage combustor assembly;

supplying fuel and compressed air to a third premix chamber of the second stage combustor assembly;

producing a third fuel-air mixture having a third fuel-to-air ratio in the third premix chamber of the second stage combustor assembly via the supplied fuel and compressed air;

routing the third fuel-air mixture to a third combustion zone of the combustion chamber of the second stage combustor assembly;

generating a vortex flow of the third fuel-air mixture in the third combustion zone of the combustion chamber of the second stage combustor assembly; and

igniting the third fuel-air mixture to generate a combustion gases and a flame, wherein the combustion gases mix with the first combustion gases to produce second combustion gases.

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