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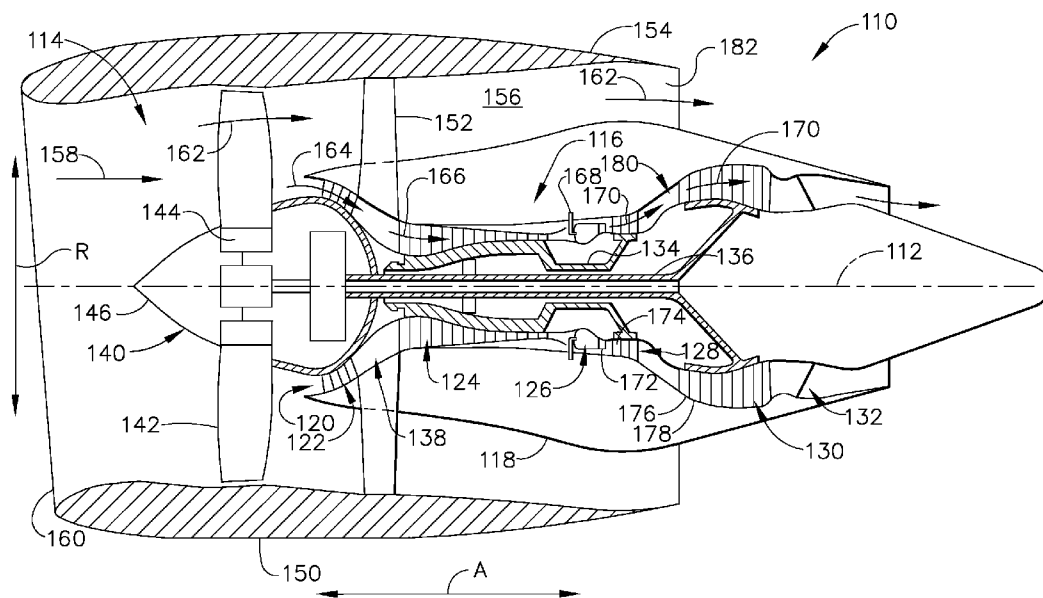


FIG. 1

(57) Abstract: A deflector for a gas turbine engine combustor. The combustor includes a liner defining a combustion zone and a mixer assembly configured to supply the combustion zone with a predetermined mixture of fuel and air. The deflector includes a deflector body configured to couple to the liner. The deflector body includes a first surface configured to reflect thermal radiation to a predetermined focal area, and an aperture extending through the deflector body and configured to receive the mixer assembly therethrough.

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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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DEFLECTOR FOR GAS TURBINE ENGINE COMBUSTORS AND METHOD OF USING THE SAME

BACKGROUND

[0001] The field of the disclosure relates generally to gas turbine engines and, more particularly, to deflectors for use in gas turbine engine combustors.

[0002] Combustors are used to ignite fuel and air mixtures in gas turbine engines to generate high energy working gases. Known combustors include an outer liner and an inner liner defining an annular combustion chamber in which the fuel and air are mixed and burned. A dome mounted at the upstream end of the combustion chamber includes mixers for mixing the fuel and air. Ignitors mounted downstream from the mixers ignite the mixture, and it burns in the combustion chamber. At least some combustors further include a deflector coupled to the dome and surrounding the mixer that prevent hot combustion gases produced within the combustion chamber from impinging directly upon the dome and upstream components.

[0003] Air pollution concerns have led to stricter combustion emissions standards. These standards regulate the emission of nitrogen oxides (NO_x), as well as other types of exhaust emissions, from the gas turbine engine. Generally, NO_x is formed during the combustion process due to high flame temperatures in the combustor. At least some combustors reduce NO_x by using a lean fuel and air mixture that tends to lower the flame temperature. For lean mixtures, the volume percent of air in the mixture may typically be increased up to a limit, sometimes referred to as a blowout limit, at which the air and fuel mixture can no longer maintain a flame. As such, to reduce NO_x emissions, combustors typically use a lean fuel and air mixture as close to the blowout limit as possible. Lean fuel and air mixtures, however, may increase combustion dynamics and flame instability because of the low temperature flame. Flame instability and combustion dynamics generally reduces combustor and overall gas turbine engine efficiency and durability.

BRIEF DESCRIPTION

[0004] In one embodiment, a deflector for a gas turbine engine combustor is provided. The combustor includes a liner defining a combustion zone and a mixer assembly that is configured

to supply the combustion zone with a predetermined mixture of fuel and air. The deflector includes a deflector body that is configured to couple to the liner and including a first surface that is configured to reflect thermal radiation to a predetermined focal area. The deflector body defines an aperture extending therethrough. The aperture is configured to receive the mixer assembly therethrough.

[0005] In another embodiment, a combustor for a gas turbine engine is provided. The combustor includes a liner defining a combustion zone. A mixer assembly is configured to supply the combustion zone with a predetermined mixture of fuel and air. The combustor further includes a deflector coupled to the liner. The deflector includes a deflector body that is configured to couple to the liner and including a first surface that is configured to reflect thermal radiation to a predetermined focal area. The deflector body defines an aperture extending therethrough. The aperture is configured to receive the mixer assembly therethrough.

[0006] In a further embodiment, a method for stabilizing a flame within a gas turbine engine combustor is provided. The combustor includes a liner defining a combustion zone, a mixer assembly, and a deflector coupled to the liner. The deflector includes a deflector body that is configured to couple to the liner. The deflector body includes a first surface and defines an aperture extending therethrough. The aperture is configured to receive the mixer assembly therethrough. The method includes generating the flame within the combustion zone using a predetermined mixture of fuel and air supplied by the mixture assembly. The method further includes reflecting thermal radiation of the flame to a predetermined focal area.

DRAWINGS

[0007] These and other features, aspects, and advantages of the present disclosure 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:

[0008] FIG. 1 is a schematic, cross-sectional illustration of an exemplary turbofan engine in accordance with an example embodiment of the present disclosure.

[0009] FIG. 2 is a cross-sectional view of an exemplary combustor that may be used with the turbofan engine shown in FIG. 1.

[0010] FIG. 3 is a perspective view of an exemplary deflector that may be used with the combustor shown in FIG. 2.

[0011] Unless otherwise indicated, the drawings provided herein are meant to illustrate features of embodiments of this disclosure. These features are believed to be applicable in a wide variety of systems comprising one or more embodiments of this disclosure. As such, the drawings are not meant to include all conventional features known by those of ordinary skill in the art to be required for the practice of the embodiments disclosed herein.

DETAILED DESCRIPTION

[0012] In the following specification and claims, reference will be made to a number of terms, which shall be defined to have the following meanings.

[0013] The singular forms “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise.

[0014] “Optional” or “optionally” means that the subsequently described event or circumstance may or may not occur, and that the description includes instances where the event occurs and instances where it does not.

[0015] Approximating language, as used herein throughout the specification and claims, may be applied to modify any quantitative representation that could permissibly vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term or terms, such as “about,” “approximately,” and “substantially,” are not to be limited to the precise value specified. In at least some instances, the approximating language may correspond to the precision of an instrument for measuring the value. Here and throughout the specification and claims, range limitations may be combined and/or interchanged; such ranges are identified and include all the sub-ranges contained therein unless context or language indicates otherwise.

[0016] Embodiments of a deflector for a gas turbine engine combustor as described herein provide an apparatus for lean combustion systems that facilitates increasing combustor flame stability and reducing emissions thereof. Specifically, the deflector includes a body with a downstream surface that reflects thermal radiation of a combustor flame within the combustor to a predetermined focal area. The downstream surface is formed in a predetermined shape, such

as but not limited to, a parabolic shape to facilitate thermal radiation reflection from the downstream surface to the predetermined focal area. Furthermore, the deflector may also include a reflective thermal barrier coating that further facilitates reflecting thermal radiation of the combustion flame. By reflecting thermal radiation from the deflector and back into the combustion flame, reactants and products within cooler areas of the combustion flame may increase in temperature to facilitate stabilizing the combustion flame while maintaining a lean fuel/air mixture. Stabilizing the combustion flame reduces combustion dynamics and allows for the combustor to operate closer to a lean blowout limit to reduce NO_x emissions.

[0017] FIG. 1 is a schematic cross-sectional view of a gas turbine engine in accordance with an exemplary embodiment of the present disclosure. In the exemplary embodiment, the gas turbine engine is a high-bypass turbofan jet engine 110, referred to herein as “turbofan engine 110.” As shown in FIG. 1, turbofan engine 110 defines an axial direction A (extending parallel to a longitudinal centerline 112 provided for reference) and a radial direction R (extending perpendicular to longitudinal centerline 112). In general, turbofan engine 110 includes a fan case assembly 114 and a gas turbine engine 116 disposed downstream from fan case assembly 114.

[0018] Gas turbine engine 116 includes a substantially tubular outer casing 118 that defines an annular inlet 120. Outer casing 118 encases, in serial flow relationship, a compressor section including a booster or low pressure (LP) compressor 122 and a high pressure (HP) compressor 124; an annular combustion section 126 including a plurality of circumferentially spaced fuel nozzle assemblies 218 (shown in FIG. 2); a turbine section including a high pressure (HP) turbine 128 and a low pressure (LP) turbine 130; and a jet exhaust nozzle section 132. A high pressure (HP) shaft or spool 134 drivingly connects HP turbine 128 to HP compressor 124. A low pressure (LP) shaft or spool 136 drivingly connects LP turbine 130 to LP compressor 122. The compressor section, combustion section 126, turbine section, and exhaust nozzle section 132 together define an air flow path 138.

[0019] In the exemplary embodiment, fan case assembly 114 includes a fan 140 having a plurality of fan blades 142 coupled to a disk 144 in a spaced apart manner. As depicted, fan blades 142 extend outwardly from disk 144 generally along radial direction R. Fan blades 142 and disk 144 are together rotatable about longitudinal centerline 112 by LP shaft 136.

[0020] Referring still to the exemplary embodiment of FIG. 1, disk 144 is covered by a rotatable front hub 146 aerodynamically contoured to promote an airflow through plurality of fan blades 142. Additionally, exemplary fan case assembly 114 includes an annular fan casing or outer nacelle 150 that circumferentially surrounds fan 140 and/or at least a portion of gas turbine engine 116. Nacelle 150 is supported relative to gas turbine engine 116 by an outlet guide vane (OGV) assembly 152. Moreover, a downstream section 154 of nacelle 150 may extend over an outer portion of gas turbine engine 116 so as to define a bypass airflow duct 156 between nacelle 150 and outer casing 118.

[0021] During operation of turbofan engine 110, a volume of air 158 enters turbofan engine 110 through an associated inlet 160 of nacelle 150 and/or fan case assembly 114. As air 158 passes across fan blades 142, a first portion of air 158 as indicated by arrow 162, known as fan stream air flow, is directed or routed into bypass airflow duct 156 and a second portion of air 158 as indicated by arrow 164 is directed or routed into air flow path 138, or more specifically into booster compressor 122. The ratio between first portion of air 162 and second portion of air 164 is commonly known as a bypass ratio. The pressure of second portion of air 164 is then increased, forming compressed air 166, as it is routed through booster compressor 122 and HP compressor 124 and into combustion section 126, where it is mixed with fuel 168 and burned to provide combustion gases 170.

[0022] Combustion gases 170 are routed through HP turbine 128 where a portion of thermal and/or kinetic energy from combustion gases 170 is extracted via sequential stages of HP turbine stator vanes 172 that are coupled to outer casing 118 and HP turbine rotor blades 174 that are coupled to HP shaft or spool 134, thus causing HP shaft or spool 134 to rotate, thereby supporting operation of HP compressor 124. Combustion gases 170 are then routed through LP turbine 130 where a second portion of thermal and kinetic energy is extracted from combustion gases 170 via sequential stages of LP turbine stator vanes 176 that are coupled to outer casing 118 and LP turbine rotor blades 178 that are coupled to LP shaft or spool 136, thus causing LP shaft or spool 136 to rotate, thereby supporting operation of booster compressor 122 and/or rotation of fan 140. Combustion gases 170 are subsequently routed through jet exhaust nozzle section 132 of gas turbine engine 116 to provide propulsive thrust. HP turbine 128, LP turbine 130, and jet exhaust nozzle section 132 at least partially define a hot gas path 180 for routing combustion gases 168 through gas turbine engine 116. Simultaneously, the pressure of fan stream air 162 is substantially increased as fan stream air 162 is routed through bypass airflow

duct 156, including through outlet guide vane assembly 152 before it is exhausted from a fan nozzle exhaust section 182 of turbofan engine 110, also providing propulsive thrust.

[0023] It should be appreciated, however, that the exemplary turbofan engine 110 depicted in FIG. 1 is by way of example only, and that in other exemplary embodiments, turbofan engine 110 may have any other suitable configuration. It should also be appreciated, that in still other exemplary embodiments, aspects of the present disclosure may be incorporated into any other suitable gas turbine engine. For example, in other exemplary embodiments, aspects of the present disclosure may be incorporated into, e.g., a turboprop engine, a military purpose engine, and a marine or land-based aero-derivative engine.

[0024] FIG. 2 is a cross-sectional view of an exemplary combustor 200 that may be used with turbofan engine 110 (shown in FIG. 1). In the exemplary embodiment, annular combustion section 126 includes a combustor 200 having a combustion zone or chamber 202 defined by annular, radially outer and radially inner liners 204 and 206. Specifically, outer liner 204 defines a radially outer boundary of combustion chamber 202, and inner liner 206 defines a radially inner boundary of combustion chamber 202. Liners 204 and 206 are spaced radially inward from an annular combustor casing 208 which extends circumferentially around liners 204 and 206. Combustor 200 also includes an annular dome 210 mounted upstream from outer and inner liners 204 and 206 respectively. Dome 210 defines an upstream end of combustion chamber 202 and a plurality of mixer assemblies 212 are spaced circumferentially around dome 210 to deliver a mixture of fuel and air to combustion chamber 202. Each mixer assembly 212 includes a pilot mixer 214 and a main mixer 216. Main mixer 216 is concentrically aligned with respect to pilot mixer 214 and extends circumferentially around pilot mixer 214. A plurality of circumferentially spaced and axially-extending fuel nozzle assemblies 218 are coupled in flow communication with each respective mixer assembly 212. Furthermore, in the exemplary embodiment, combustor 200 includes one or more deflectors 220 that are coupled to and spaced circumferentially around dome 210 at each mixer assembly 212 location. Downstream of mixer assembly 212 and deflector 220 is an igniter 222 that extends through outer casing 208 and into combustion chamber 202 to provide initial ignition of the mixture of compressed air 166 and fuel 168. In various embodiments, igniter 222 may provide continuous or intermittent ignition support to combustion chamber 202.

[0025] In operation, combustor 200 receives compressed air 166 discharged from HP compressor 124 in a diffuser section 224 at flow upstream of combustion chamber 202. A

portion of the flow of compressed air 166 is channeled through mixer assembly 212. At mixer assembly 212 compressed air 166 is mixed with fuel 168 from fuel nozzle assembly 218 and discharged into combustion chamber 202 where the mixture of air 166 and fuel 168 is ignited by igniter 222 creating a flame 224 within combustion chamber 202 that burns the mixture and provides combustion gases 170 that are channeled downstream to HP turbine 128 (shown in FIG. 1). In the exemplary embodiment, combustor 200 is a lean combustor. Specifically, at engine start conditions and engine low power operation, combustor 200 uses only fuel 168 provided to the pilot mixer 214 for generating combustion gases 170. At pilot mixer 214, fuel 168 includes a pilot fuel stream 226 that is mixed with a first portion 228 of compressed air 166 to provide a rich mixture (higher fuel 226 to air 228 ratios within the mixture) that is ignited for a pilot flame 230 within a region 232 that is adjacent to pilot mixer 214. At engine high power operation, combustor 200 uses fuel 168 split between pilot mixer 214 and main mixer 216 for generating combustion gases 170. At main mixer 216, fuel 168 includes a main fuel stream 234 that is mixed with a second portion 236 of compressed air 166 to provide a lean mixture (lower fuel 234 to air 236 ratios within the fuel-air mixture) that is ignited for a main flame 238 within a region 240 that is adjacent to main mixer 216. At engine high power operation most of fuel 168 is injected through main mixer 216 thus providing a lean burn combustion process to generate combustion gases 170 while reducing NO_x emissions.

[0026] Generally, pilot flame 230 burns at a higher temperature than main flame 238 because the fuel 226 air 228 mixtures are richer. As such, during engine start and engine low power operation combustion dynamics are low leading to pilot flame 230/flame 224 that is stable. Main flame 238, however, generally burns at a lower temperature than pilot flame 230 because the fuel 234 air 236 mixtures are leaner. As such, during high power engine operation, when most of fuel 168 is injected through main mixer 216, main flame 238/flame 224 instability may occur due to lower temperatures leading to combustion dynamics. To facilitate reducing NO_x emissions from the combustion process, flame 224 temperatures during high power engine operation are reduced as low as possible and close to a blowout limit by increasing the air 236 to fuel 234 ratio because NO_x is formed at high flame temperatures. As such, cooler temperature regions, such as region 242, are formed within flame stabilization zones that decreases flame 224 stability and increases a likelihood of flame blowout.

[0027] In the exemplary embodiment, deflector 220 facilitates increasing flame 224 stability and decreases combustion dynamics and a likelihood of flame blowout during engine operation

at high power levels while using the lean burn combustion process. Specifically, deflector 220 reflects 244 thermal radiation and infrared radiation generated by flame 224 within combustion chamber 202 to a predetermined focal area 246 within cooler temperature region 242 to increase the temperature of region 242. Flame 224 generates thermal radiation by burning the fuel 168 and air 166 mixture which typically heats up the surrounding combustor components, such as outer and inner liners 204 and 206 and dome 210. By reflecting 244 the thermal radiation back into flame 224, the temperature of region 242 increases. The temperature of region 242 increases by heating up entrained carbon dioxide and water vapor therein. Thus, reducing combustion dynamics and a likelihood of flame blowout, and increasing flame 224 stability.

[0028] It should be appreciated, that the exemplary combustor 200 illustrated in FIG. 2 is by way of example only, and that in other exemplary embodiments, combustor 200 may have any other suitable configuration for lean based combustion. It should further be appreciated, that in still other exemplary embodiments, aspects of the present disclosure may be incorporated into any other suitable gas turbine engine including land-based aero-derivative engine combustion systems.

[0029] FIG. 3 is a perspective view of an exemplary deflector 220 that may be used with combustor 200 (shown in FIG. 2). In the exemplary embodiment, deflector 220 is substantially circular and includes a body 300 formed with an aperture 302 sized to at least partially receive mixer assembly 212 (shown in FIG. 2). Body 300 is coupled to dome 210 (shown in FIG. 2), for example, by brazing. Body 300 includes an upstream surface 304 and a downstream surface 306. Downstream surface 306 facilitates reflecting thermal radiation from combustor flame 224 (shown in FIG. 2) to predetermined focal area 246 (shown in FIG. 2). For example, downstream surface 306 is parabolic such that downstream surface 306 reflects thermal radiation from combustor flame 224 to predetermined focal area 246.

[0030] Parabolic shape 308 of deflector 220 receives thermal radiation on the curved downstream surface 306 and reflects the thermal radiation to predetermined focal area 246. Parabolic curvature 308 of downstream surface 306 may be sized to position focal area 246 at any location that facilitates increasing temperature of combustor flame 224. Thus, reducing combustion dynamics and a likelihood of flame blowout, and increasing flame 224 stability. In alternative embodiments, downstream surface 306 may have any other shape/contour that enables deflector 220 to function as described herein. Additionally, in alternative embodiments, the substantially circular deflector body 300 may be trimmed to form a polygonal periphery.

[0031] In the exemplary embodiment, body 300 is fabricated from a superalloy substrate 310 and coated with a thermal barrier coating 312 to reduce thermal exposure when combustor 200 is operating. Physical vapor deposition thermal barrier coating, TBC 312, is applied to deflector 220 and provides thermal protection thereto. Furthermore, TBC 312 facilitates reflecting thermal radiation of flame 224 as described above.

[0032] During operation of combustor 200, deflector 220 protects dome 210 and mixer assembly 212 from hot gases and thermal flame radiation generated with combustion chamber 202. Furthermore, parabolic curvature 308 and TBC 312 reflect the thermal flame radiation back into flame 224 to increase flame stability during lean combustor operation.

[0033] The above-described embodiments of a deflector for a gas turbine engine combustor provide an apparatus for lean combustion systems that facilitates increasing combustor flame stability and reducing emissions thereof. Specifically, the deflector includes a body with a downstream surface that reflects thermal radiation of a combustor flame within the combustor to a predetermined focal area. The downstream surface is formed in a predetermined shape, such as, but not limited to, a parabolic shape to facilitate thermal radiation reflection from the downstream surface to the predetermined focal area. Furthermore, the deflector may also include a reflective thermal barrier coating that further facilitates reflecting thermal radiation of the combustion flame. By reflecting thermal radiation from the deflector and back into the combustion flame, reactants and products within cooler areas of the combustion flame may increase in temperature to facilitate stabilizing the combustion flame while maintaining a lean fuel/air mixture. Stabilizing the combustion flame reduces combustion dynamics and allows for the combustor to operate closer to a lean blowout limit to reduce NO_x emissions.

[0034] An exemplary technical effect of the methods, systems, and apparatus described herein includes at least one of: (a) reducing combustion dynamics in a gas turbine combustion system; (b) increasing lean combustion flame temperature; (c) increasing combustor flame stability; (d) reducing lean blowout limit of combustor; and (e) reducing combustion emissions.

[0035] Exemplary embodiments of methods, systems, and apparatus for combustor flame stabilization are not limited to the specific embodiments described herein, but rather, components of the systems and/or steps of the methods may be utilized independently and separately from other components and/or steps described herein. For example, the methods may also be used in combination with other systems requiring flame stabilization, and the associated

methods, and are not limited to practice with only the systems and methods as described herein. Rather, the exemplary embodiment can be implemented and utilized in connection with many other applications, equipment, and systems that may benefit from thermal control.

[0036] Although specific features of various embodiments of the disclosure may be shown in some drawings and not in others, this is for convenience only. In accordance with the principles of the disclosure, any feature of a drawing may be referenced and/or claimed in combination with any feature of any other drawing.

[0037] This written description uses examples to disclose the embodiments, including the best mode, and also to enable any person skilled in the art to practice the embodiments, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the disclosure 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.

WHAT IS CLAIMED IS:

1. A deflector for a gas turbine engine combustor, the combustor includes a liner defining a combustion zone and a mixer assembly configured to supply the combustion zone with a predetermined mixture of fuel and air, said deflector comprising:

a deflector body configured to couple to the liner and comprising a first surface configured to reflect thermal radiation to a predetermined focal area, wherein said deflector body defines an aperture extending therethrough, the aperture configured to receive the mixer assembly therethrough.

2. The deflector in accordance with Claim 1, wherein said first surface comprises a parabolic shape.

3. The deflector in accordance with Claim 1, wherein the predetermined focal area is positioned within the combustion zone.

4. The deflector in accordance with Claim 1, wherein the predetermined focal area is configured to heat relatively cool areas of the combustion zone to stabilize a flame during lean combustion within the combustor.

5. The deflector in accordance with Claim 1 further comprising a thermal barrier coating formed on at least a portion of said deflector body.

6. The deflector in accordance with Claim 5, wherein said thermal barrier coating is configured to reflect thermal radiation of a flame to the predetermined focal area.

7. The deflector in accordance with Claim 1, wherein said deflector body comprises a superalloy substrate configured to reduce thermal exposure to combustor components upstream of said deflector body.

8. A combustor for a gas turbine engine comprising:

a liner defining a combustion zone;

a mixer assembly configured to supply the combustion zone with a predetermined mixture of fuel and air; and

a deflector coupled to said liner and comprising:

a deflector body configured to couple to the liner and comprising a first surface configured to reflect incident thermal radiation to a predetermined focal area, wherein said deflector body defines an aperture extending therethrough, the aperture configured to receive said mixer assembly therethrough.

9. The combustor in accordance with Claim 8, wherein said first surface comprises a parabolic shape.

10. The combustor in accordance with Claim 8, wherein said predetermined focal area is positioned within the combustion zone.

11. The combustor in accordance with Claim 8, wherein the predetermined focal area is configured to heat relatively cool areas of the combustion zone to stabilize a combustion flame during lean combustion within the combustor.

12. The combustor in accordance with Claim 8 further comprising a thermal barrier coating formed on at least a portion of said deflector body.

13. The combustor in accordance with Claim 12, wherein said thermal barrier coating is configured to reflect thermal radiation of a combustion flame to the predetermined focal area.

14. The combustor in accordance with Claim 8, wherein said deflector body comprises a superalloy substrate configured to reduce thermal exposure to combustor components upstream of said deflector.

15. A method for stabilizing a flame within a gas turbine engine combustor, the combustor including a liner defining a combustion zone, a mixer assembly, and a deflector coupled to the liner, the deflector including a deflector body configured to couple to the liner, the deflector body including a first surface and defining an aperture extending therethrough, the aperture configured to receive the mixer assembly therethrough, said method comprising:

generating the flame within the combustion zone using a predetermined mixture of fuel and air supplied by the mixture assembly; and

reflecting thermal radiation of the flame to a predetermined focal area.

16. The method in accordance with Claim 15, wherein the first surface has a parabolic shape.
17. The method in accordance with Claim 16 further comprising reflecting thermal radiation into the predetermined focal area using the parabolic shape of the first surface.
18. The method in accordance with Claim 15 further comprising forming the first surface to focus the thermal radiation to the predetermined focal area positioned within the combustion zone.
19. The method in accordance with Claim 15 further comprising forming a thermal barrier coating on at least a portion of the deflector body.
20. The method in accordance with Claim 15 further comprising forming the body from a superalloy substrate configured to reduce thermal exposure to combustor components upstream of the deflector.

Deflector for gas turbine engine combustors and method of using the same

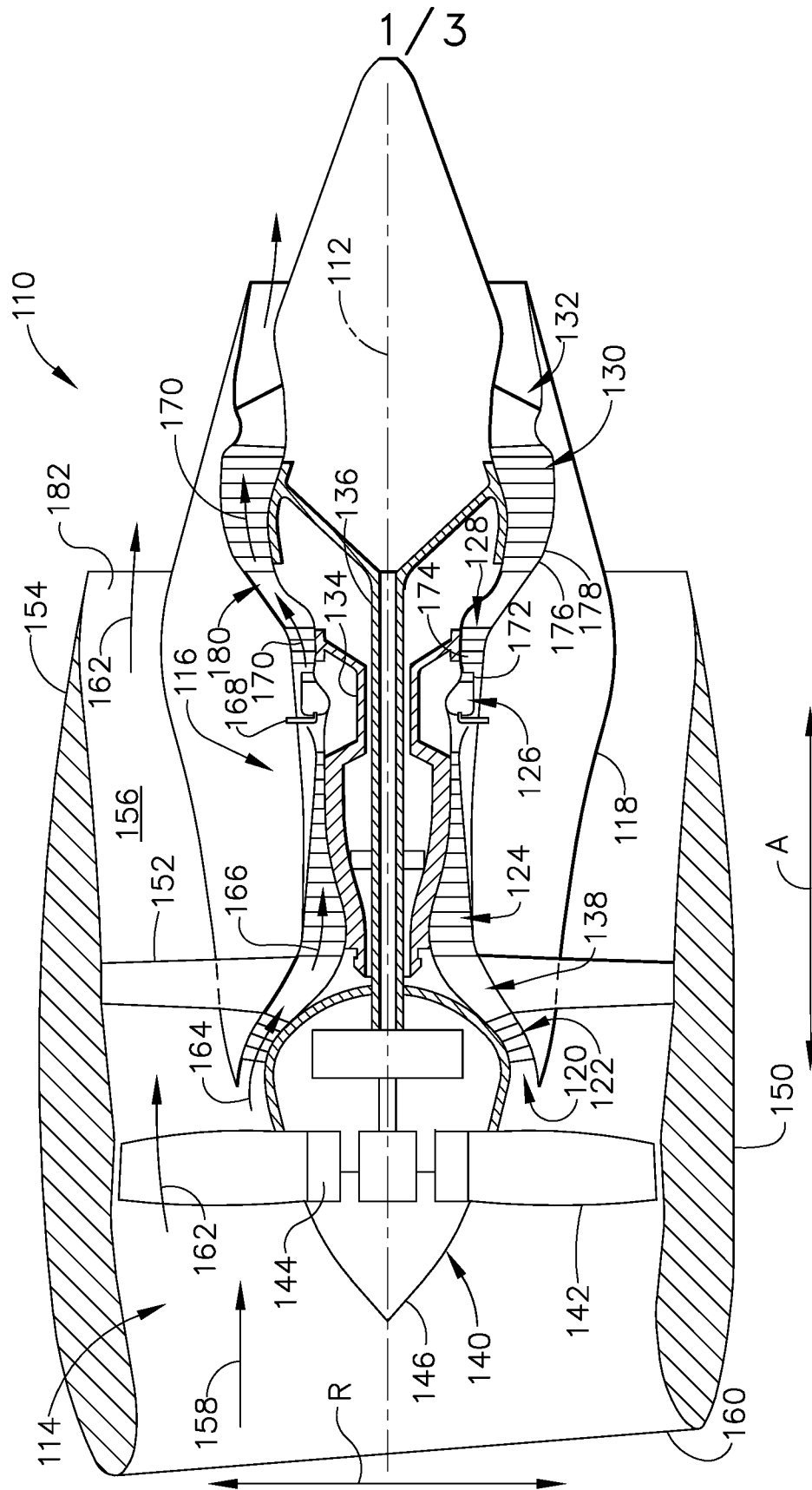


FIG. 1

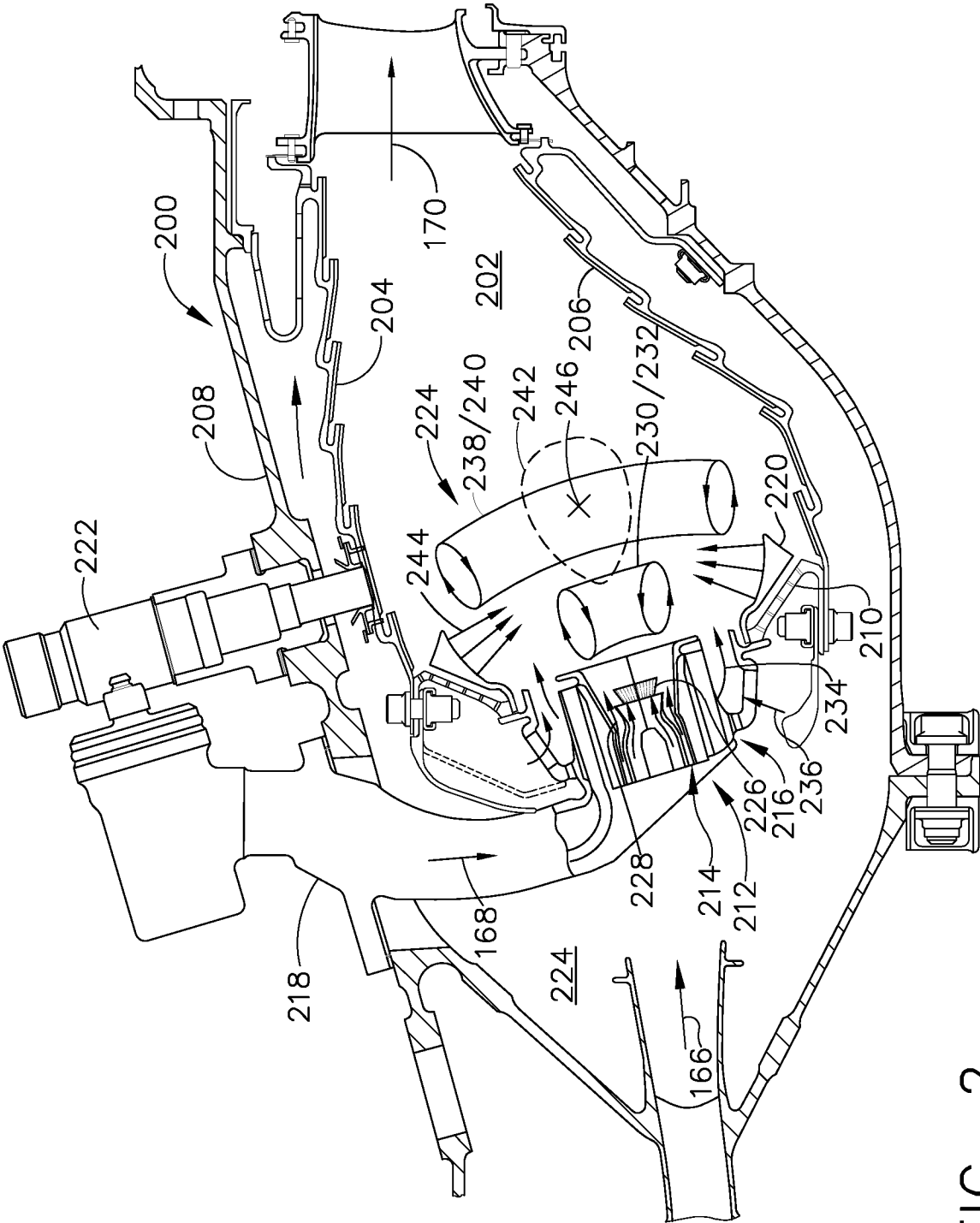


FIG. 2

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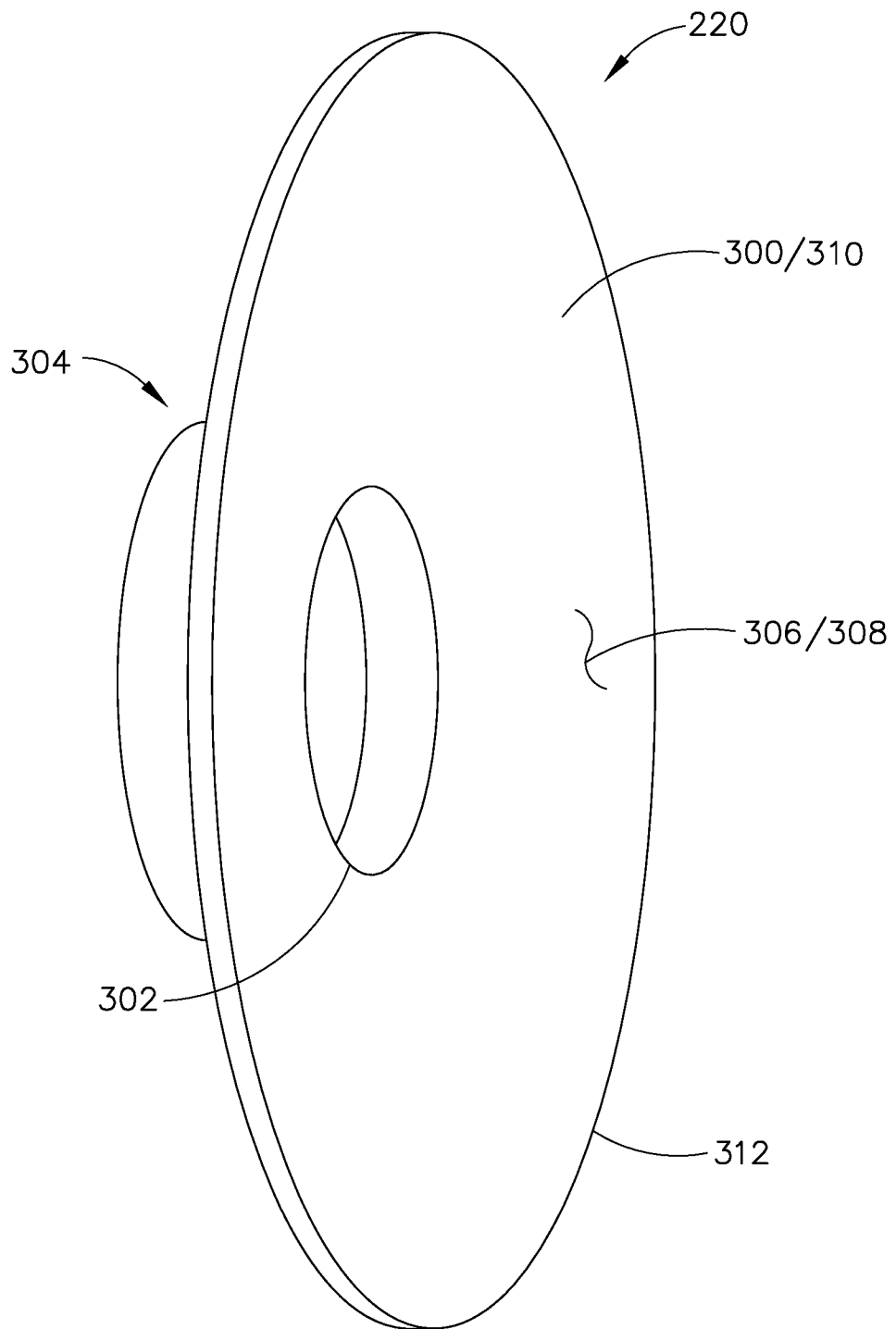


FIG. 3