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(54) **FUEL NOZZLE CAP**

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**ABSTRACT**

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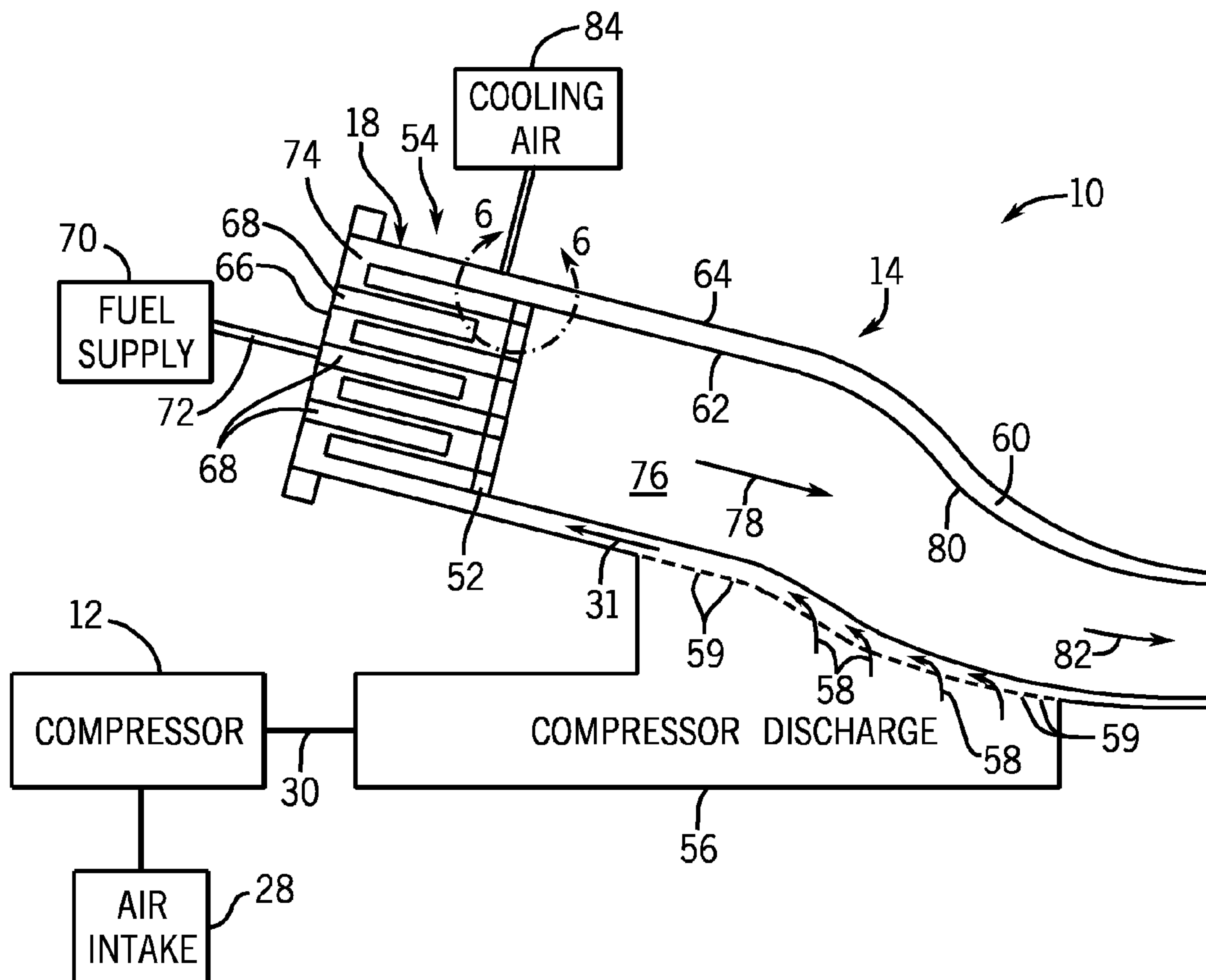
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Certain embodiments include a first individual sector having a first outer perimeter configured to fit together with outer perimeters of a plurality of individual sectors to form a combustor cap assembly of a turbine combustor, wherein the first individual sector comprises a first inner perimeter configured to fit about a nozzle outer perimeter of a first fuel nozzle, and the first individual sector is configured to fixedly attach to the first fuel nozzle.



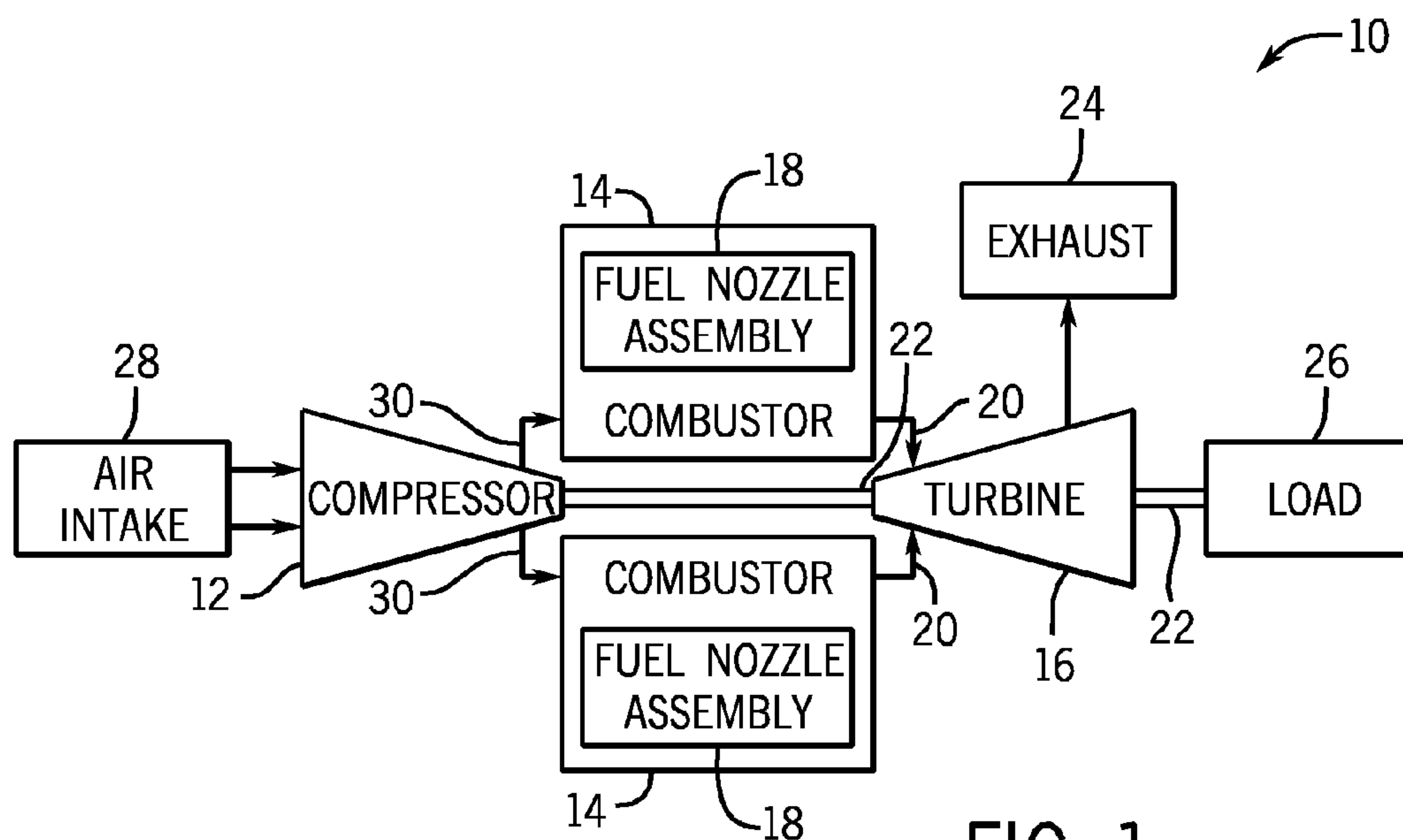


FIG. 1

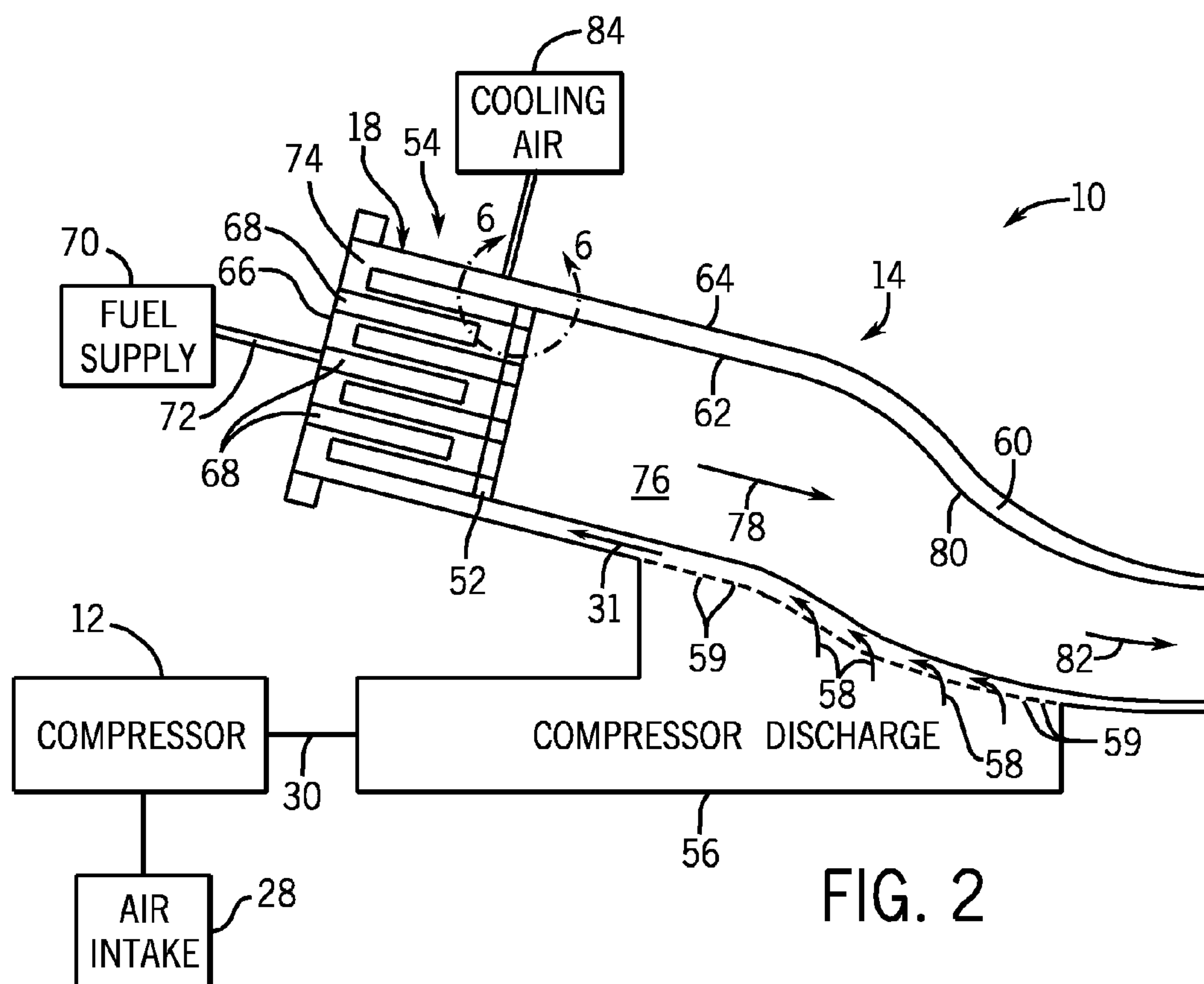
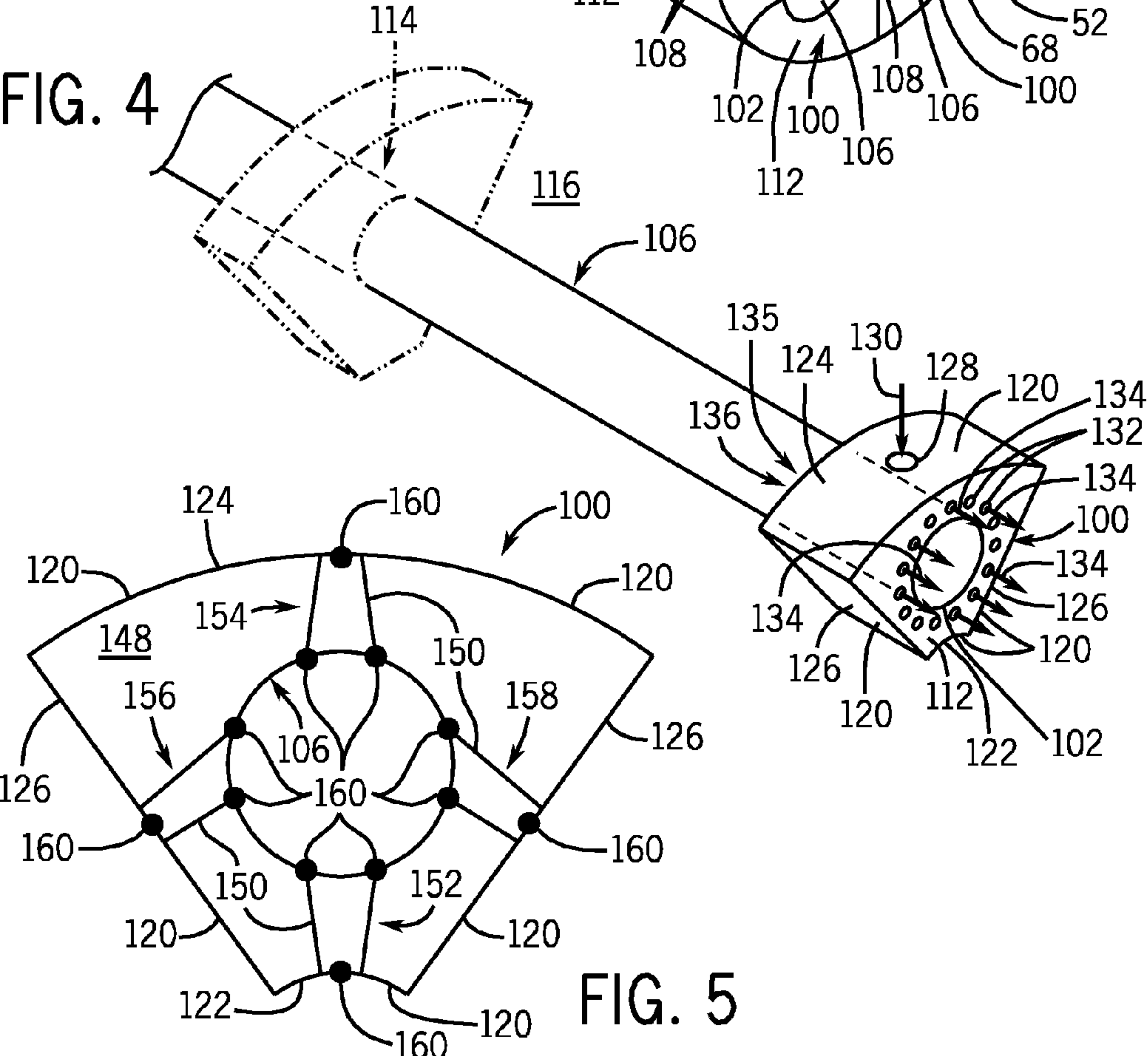
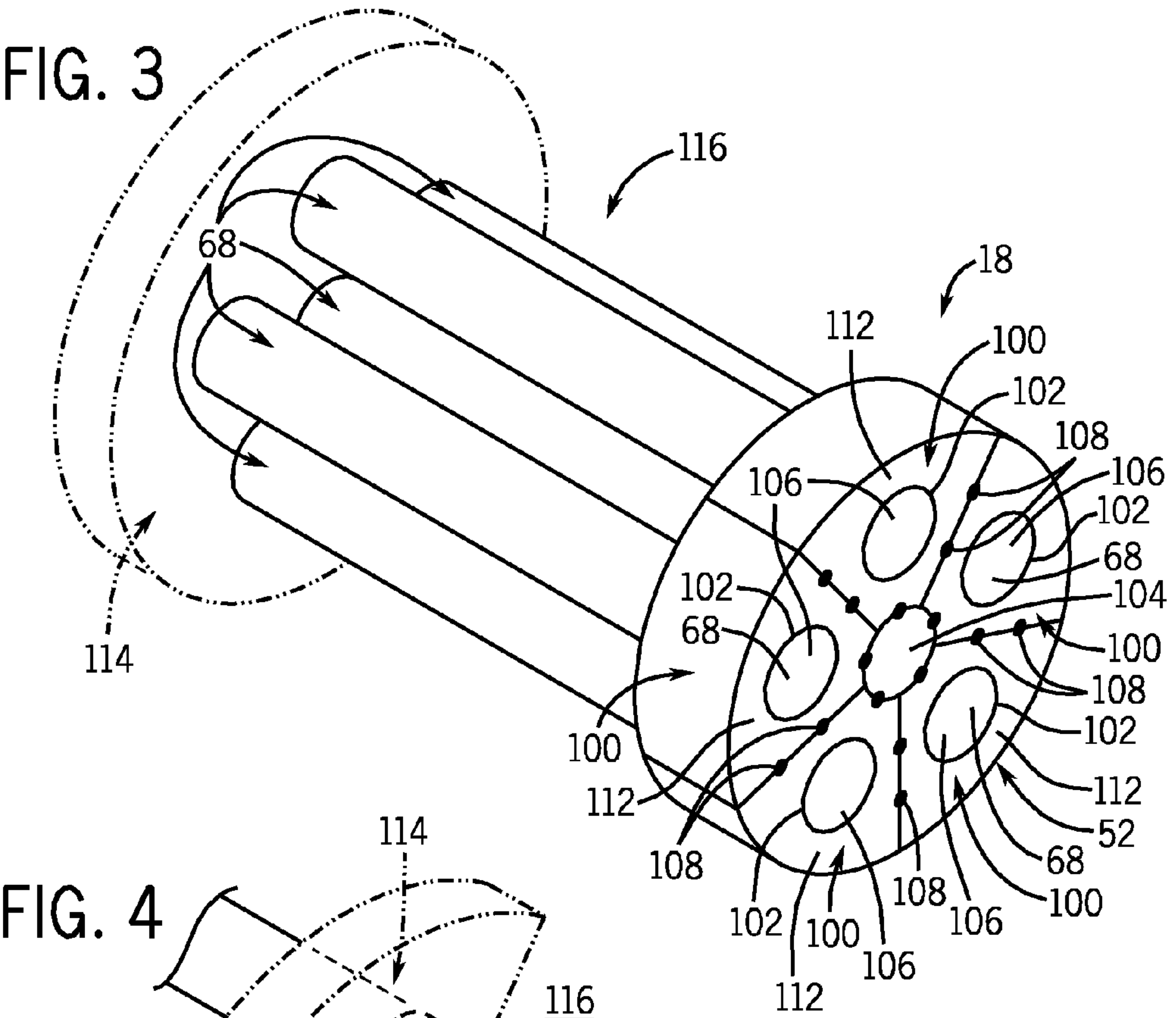


FIG. 2



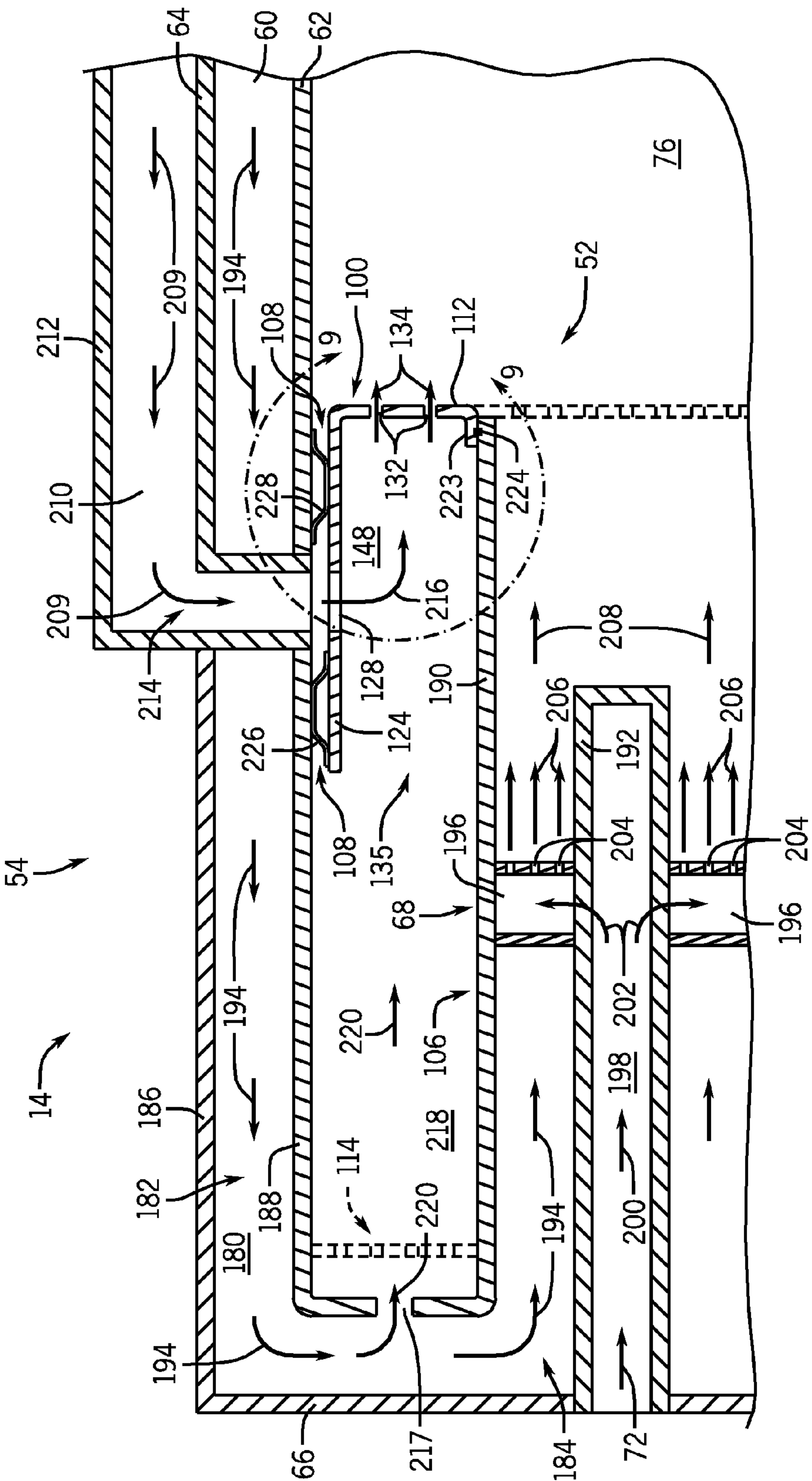


FIG. 6



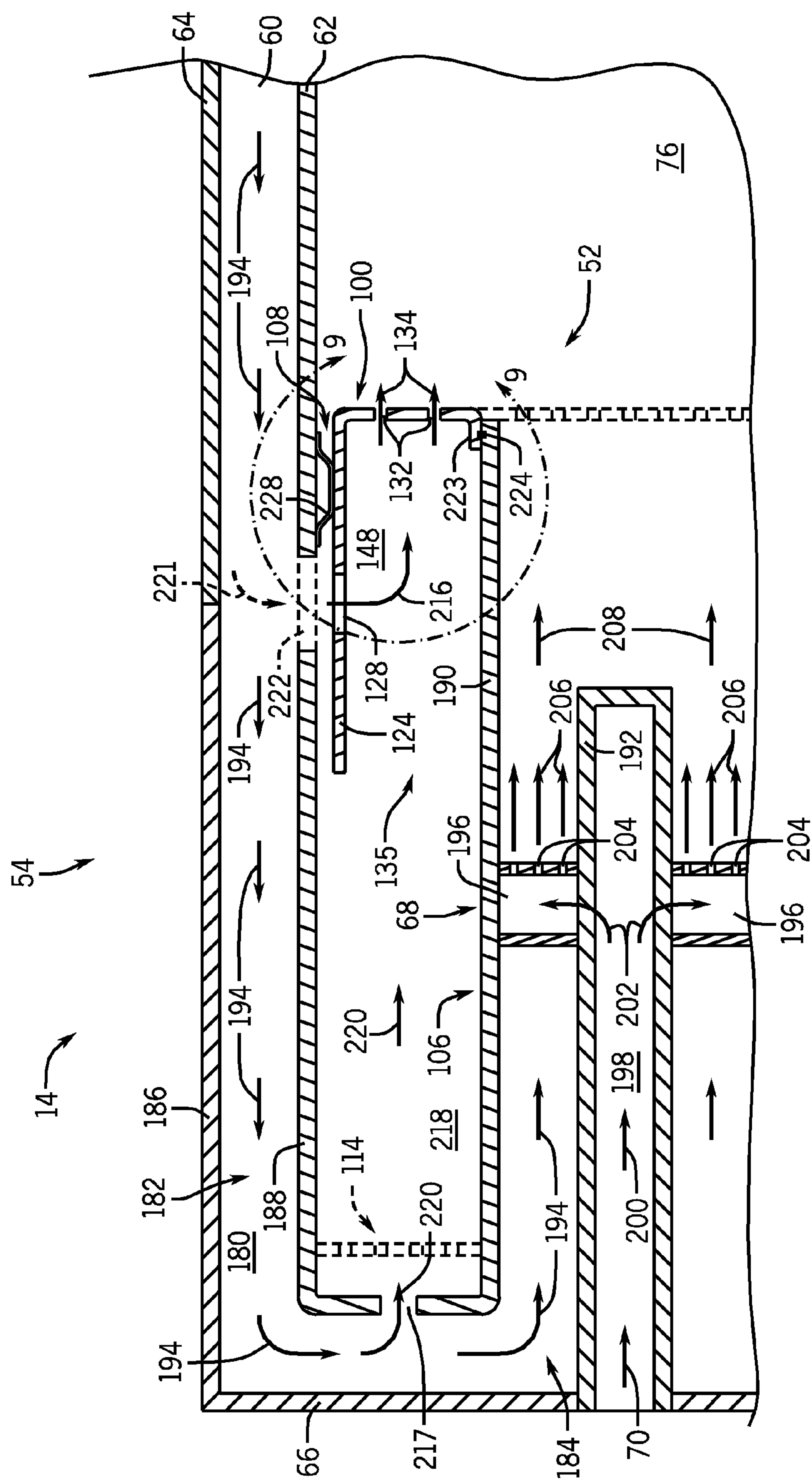


FIG. 7

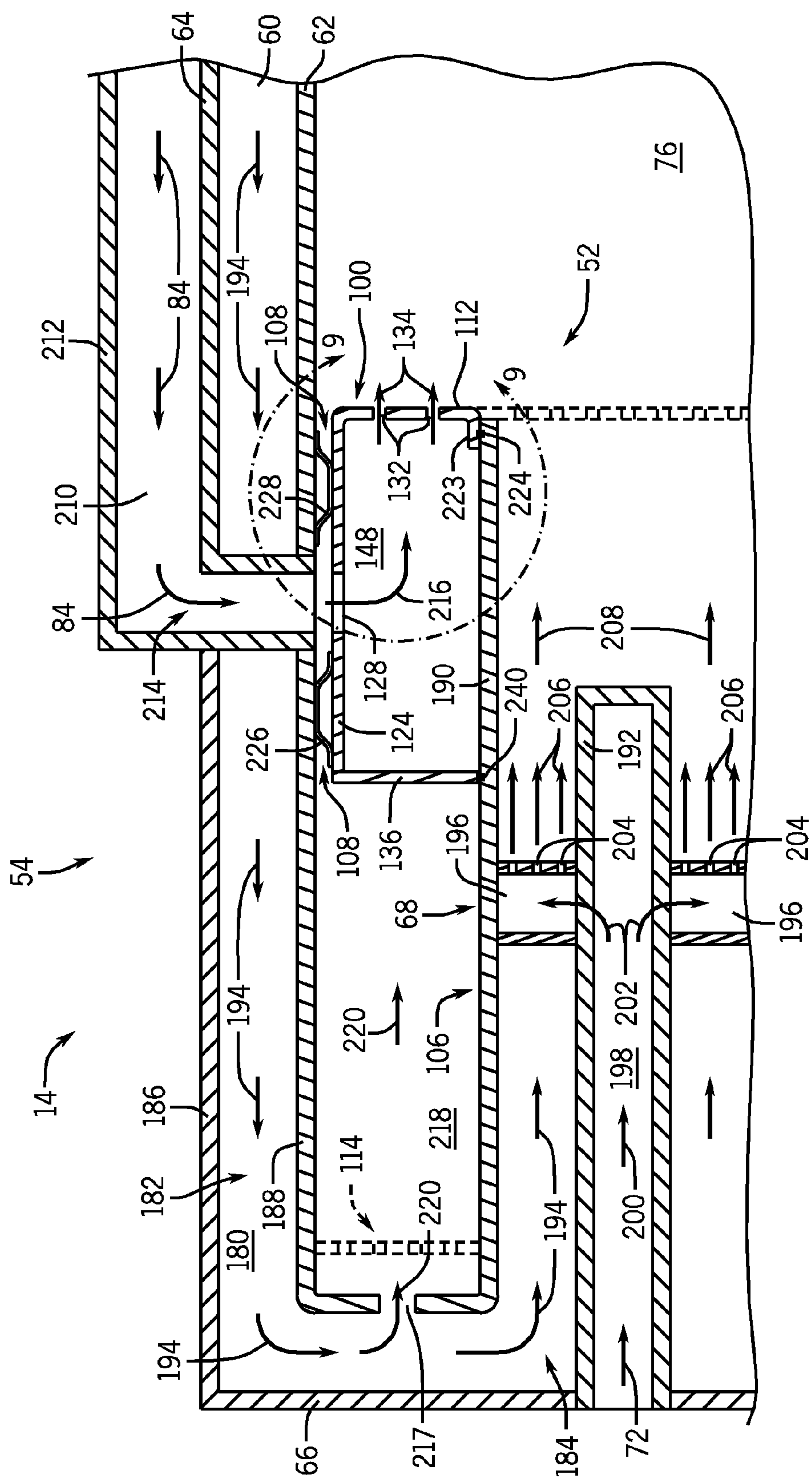


FIG. 8





## FUEL NOZZLE CAP

### BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to gas turbine engines, and, more particularly, to a fuel nozzle in a turbine combustor.

[0002] A gas turbine engine combusts a fuel-air mixture in a combustor, and then drives one or more turbines with the resulting hot combustion gases. In general, fuel and air are mixed and ignited within one or more fuel nozzles of the combustor. Conventional combustion assemblies may include a single cap having a face exposed to a combustion chamber of the combustor. The single cap includes large circular openings to support multiple circular-shaped fuel nozzles. Unfortunately, existing cap design may be susceptible to various weaknesses. For example, combustion dynamics (e.g., flow disturbances, pressure waves, etc.) and high thermal gradients across the single cap can cause cracking and undesirable oscillations within the head end of the combustor.

### BRIEF DESCRIPTION OF THE INVENTION

[0003] Certain embodiments commensurate in scope with the originally claimed invention are summarized below. These embodiments are not intended to limit the scope of the claimed invention, but rather these embodiments are intended only to provide a brief summary of possible forms of the invention. Indeed, the invention may encompass a variety of forms that may be similar to or different from the embodiments set forth below.

[0004] In a first embodiment, a system includes a turbine combustor having a plurality of fuel nozzles and a combustor cap assembly having a plurality of individual sectors supporting the plurality of fuel nozzles, wherein each sector of the plurality of individual sectors is fixedly attached to a respective fuel nozzle of the plurality of fuel nozzles.

[0005] In a second embodiment, a system a first fuel nozzle and a first individual sector having a first outer perimeter configured to fit together with outer perimeters a plurality of individual sectors to form a combustor cap assembly of a turbine combustor, wherein the first individual sector comprises a first inner perimeter that fits about a nozzle outer perimeter of the first fuel nozzle, and the first individual sector is fixedly attached to the first fuel nozzle.

[0006] In a third embodiment, a system includes a first individual sector having a first outer perimeter configured to fit together with outer perimeters of a plurality of individual sectors to form a combustor cap assembly of a turbine combustor, wherein the first individual sector comprises a first inner perimeter configured to fit about a nozzle outer perimeter of a first fuel nozzle, and the first individual sector is configured to fixedly attach to the first fuel nozzle.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0007] 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:

[0008] FIG. 1 is a schematic of an embodiment of a gas turbine system with a plurality of turbine combustors;

[0009] FIG. 2 is a cross-sectional side view schematic of an embodiment of one of the turbine combustors of FIG. 1;

[0010] FIG. 3 is a perspective view of an embodiment of a turbine combustor fuel nozzle assembly having fuel nozzles with individual sector cap assemblies;

[0011] FIG. 4 is a perspective view of an embodiment of a peripheral fuel nozzle having an individual sector cap assembly;

[0012] FIG. 5 is a cross-sectional axial view of an embodiment of a peripheral fuel nozzle having an individual sector cap assembly, illustrating a mounting arrangement of the individual sector cap assembly to the fuel nozzle;

[0013] FIG. 6 is a schematic, taken within line 6-6 of FIG. 2, of an embodiment of a turbine combustor, illustrating a peripheral fuel nozzle having an individual sector cap assembly;

[0014] FIG. 7 is a schematic, taken within line 6-6 of FIG. 2 of an embodiment of a turbine combustor, illustrating a peripheral fuel nozzle having an individual sector cap assembly;

[0015] FIG. 8 is a schematic, taken within line 6-6 of FIG. 2, of an embodiment of a turbine combustor, illustrating a peripheral fuel nozzle having an individual sector cap assembly;

[0016] FIG. 9 is a schematic, taken within line 9-9 of FIG. 6, of an embodiment of a peripheral fuel nozzle having an individual sector cap assembly; and

[0017] FIG. 10 is a schematic, taken within line 9-9 of FIG. 6, of an embodiment of a peripheral fuel nozzle having an individual sector cap assembly.

### DETAILED DESCRIPTION OF THE INVENTION

[0018] One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0019] When introducing elements of various embodiments of the present invention, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

[0020] The disclosed embodiments are directed toward a combustor cap assembly for a turbine combustor. More specifically, the disclosed embodiments may include a plurality of individual sector assemblies mounted to respective fuel nozzles of a fuel nozzle assembly. For example, in certain embodiments, the fuel nozzle assembly may have a plurality of peripheral fuel nozzles arranged about a central fuel nozzle. The plurality of peripheral fuel nozzles may each include an individual sector assembly mounted to the respective peripheral fuel nozzle. Further, the individual sector assemblies may have a geometry that enables the individual sector assemblies to abut one another (e.g., adjacent individual sector assemblies), the central fuel nozzle, and a tur-



bine combustor liner surrounding the fuel nozzle assembly. In certain embodiments, the individual sector assemblies may include seals, such as hula seals, to improve the interface (e.g., seal while enabling some movement) between the individual sector assemblies and surrounding components (e.g., adjacent individual sector assemblies, the central fuel nozzle, and the liner of the turbine combustor). In this manner, the individual sector assemblies may form the substantially continuous combustor cap assembly between the fuel nozzle assembly and a combustion chamber of the turbine combustor.

[0021] Additionally, as discussed in detail below, the seals may be configured to provide damping, account for tolerances within the head end of the turbine combustor, and/or reduce air leakage across the combustor cap assembly. Furthermore, the individual sector assemblies may be configured to receive an air flow, such as a high pressure cooling air flow. In this manner, the combustor cap assembly of turbine combustor may achieve improved cooling and reduce undesired effects of combustion dynamics. Additionally, in certain embodiments, the individual sector assemblies may be substantially enclosed, thereby increasing the pressure of the air flow received by each individual sector assembly and further improving the cooling of the combustor cap assembly.

[0022] Turning now to the drawings, FIG. 1 illustrates a block diagram of an embodiment of a gas turbine system 10. The system 10 includes a compressor 12, turbine combustors 14, and a turbine 16. The turbine combustors 14 each include a fuel nozzle assembly 18. The fuel nozzle assembly 18 of each turbine combustor 14 includes fuel nozzles which route a liquid fuel and/or gas fuel, such as natural gas or syngas, into the turbine combustors 14. As described in detail below, each turbine combustor 14 may include a combustor cap assembly with individual sector assemblies. More specifically, the individual sector assemblies may be mounted to a respective fuel nozzle of the fuel nozzle assembly 18, and the individual sector assemblies may collectively form the combustor cap assembly. Furthermore, the individual sector assemblies may be configured to receive an air flow to cool the combustor cap assembly.

[0023] The turbine combustors 14 ignite and combust an air-fuel mixture, and then pass hot pressurized combustion gasses 20 (e.g., exhaust) into the turbine 16. Turbine blades are coupled to a shaft 22, which is also coupled to several other components throughout the turbine system 10. As the combustion gases 20 pass through the turbine blades in the turbine 16, the turbine 16 is driven into rotation, which causes the shaft 22 to rotate. Eventually, the combustion gases 20 exit the turbine system 10 via an exhaust outlet 24. Further, the shaft 22 may be coupled to a load 26, which is powered via rotation of the shaft 22. For example, the load 26 may be any suitable device that may generate power via the rotational output of the turbine system 10, such as an electrical generator, a propeller of an airplane, and so forth.

[0024] Compressor blades are included as components of the compressor 12. The blades within the compressor 12 are coupled to the shaft 22, and will rotate as the shaft 22 is driven to rotate by the turbine 16, as described above. The rotation of the blades within the compressor 12 compress air from an air intake 28 into pressurized air 30. The pressurized air 30 is then fed into the fuel nozzle assembly 18 (e.g., fuel nozzles) of the turbine combustors 14. The fuel nozzles of the fuel nozzle assemblies 18 mix the pressurized air 30 and fuel to produce a suitable mixture ratio for combustion (e.g., a com-

bustion that causes the fuel to more completely burn) so as not to waste fuel or cause excess emissions. As discussed below, in certain embodiments, the pressurized air 30 may also flow to the individual sector assemblies of the combustor cap assembly of each combustor 14 to cool the combustor cap assembly.

[0025] FIG. 2 is a schematic of an embodiment of one of the turbine combustors 14 of FIG. 1, illustrating the fuel nozzle assembly 18 having a combustor cap assembly 52 within a head end 54 of the turbine combustor 14. As described above, the compressor 12 receives air from the air intake 28, compresses the air, and produces a flow of pressurized air 30 for use in the combustion process within the turbine combustor 14. As shown in the illustrated embodiment, the pressurized air 30 is received by a compressor discharge 56 that is operatively coupled to the turbine combustor 14. As indicated by arrows 58, the pressurized air 30 flows from the compressor discharge 56 towards the head end 54 of the turbine combustor 14. More specifically, the pressurized air 30 flows through an annulus 60 between a liner 62 and a flow sleeve 64 of the turbine combustor 14 to reach the head end 54. The pressurized air 30 may reach the head end 54 at a reduced pressure air 31 (e.g., air 31 has a lower pressure than the pressurized air 30). As will be appreciated, the pressure of the pressurized air 30 is reduced as it cools (e.g., via impingement) the combustor 14 via impingement holes 59.

[0026] In certain embodiments, the head end 54 includes an end plate 66 that may support the fuel nozzle assembly 18 depicted in FIG. 1. In the illustrated embodiment, the fuel nozzle assembly 18 has multiple fuel nozzles 68, which may include individual sector assemblies of the combustor cap assembly 52. A fuel supply 70 provides fuel 72 to the fuel nozzles 68. Additionally, an air flow path 74 (e.g., air flow path 180 shown in FIG. 6) delivers the pressurized air 30 from the annulus 60 of the turbine combustor 14 to the fuel nozzles 68. The fuel nozzles 68 combine the pressurized air 30 with the fuel 72 provided by the fuel supply 70 to form an air/fuel mixture. For example, the fuel 72 may be injected into the air flow path 74 by swirl vanes. The air/fuel mixture flows from the air flow path 74 through the combustor cap assembly 52 and into a combustion chamber 76 where the air/fuel mixture is ignited and combusted to form combustion gases (e.g., exhaust). As shown, the combustor cap assembly 52 creates a boundary between the combustion chamber 76 and the fuel nozzles 68. The combustion gases flow in a direction 78 toward a transition piece 80 of the turbine combustor 14. The combustion gases pass through the transition piece 80, as indicated by arrow 82, toward the turbine 16, where the combustion gases drive the rotation of the blades within the turbine 16.

[0027] During the combustion process, the combustor cap assembly 52 may experience stress as combustion occurs. In particular, the pressurized air 30 may be at a temperature, around 300-700° C., which causes thermal expansion of combustor cap assembly 52. Fuel may be at around 10 to 175° C., thereby causing a thermal expansion of fuel nozzles 68 that is of a lesser magnitude, relative to the thermal expansion of the combustor cap assembly 52. The fuel nozzles 68 and the combustor cap assembly 52 may be composed of similar or different materials, such as stainless steel, an alloy, or other suitable material. Furthermore, combustion may expose the combustor cap assembly 52 to temperatures ranging from approximately 1000° to 1700° or more Celsius. As a result of exposure to these various temperatures, the combustor cap



assembly **52** may experience considerable thermal stresses. As discussed in detail below, segmentation of the combustor cap assembly **52** may provide stress relief that may be caused, for example, by thermal expansion of the different components of the combustor cap assembly **52**. More particularly, the combustor cap assembly **52** may include multiple individual sector assemblies attached or fixed to the fuel nozzles **68** that are configured to receive a cooling air flow **84**, which may be a higher pressure than the pressurized air **31**. As a result, the combustor cap assembly **52** may not include piston rings and/or floating collars. In other embodiments, the cooling air flow **84** may be the pressurized air **31** from the annulus **60** or an air flow from another source. Additionally, the multiple individual sector assemblies may abut one another and the liner **62** of the turbine combustor **14** with hula seals, thereby improving sealing and vibration damping between adjacent fuel nozzles **68** in the fuel nozzle assembly **18** and reducing undesired leakage of pressurized air **30** across the combustor cap assembly **52**. The hula seals between the individual sector assemblies may also allow for misalignment and improved tolerances between the fuel nozzles **68**.

[0028] FIG. 3 is a perspective view of the fuel nozzle assembly **18** and the combustor cap assembly **52**, where the combustor cap assembly **52** includes individual sector assemblies **100**. As mentioned above, the combustor cap assembly **52** is disposed on ends **102** of the fuel nozzles **68**, thereby separating the fuel nozzles **68** from the combustion chamber **76** of the turbine combustor **14**. In the illustrated embodiment, the fuel nozzle assembly **18** includes six fuel nozzles **68**. More specifically, the fuel nozzle assembly **18** includes a central fuel nozzle **104** and five peripheral fuel nozzles **106** disposed about the central fuel nozzle **104**. However, other embodiments of the fuel nozzle assembly **18** may include other numbers of fuel nozzles **68** (e.g., 4, 5, 7, 8, or more), with peripheral fuel nozzles **106** surrounding the central fuel nozzle **104**.

[0029] As shown, each of the peripheral fuel nozzles **106** of the fuel nozzle assembly **18** includes a respective individual sector assembly **100** disposed about the respective end **102** of each of the peripheral fuel nozzles **106**. Additionally, each of the individual sector assemblies **100** has a similar “pie-shaped” or “wedge-shaped” configuration. In this manner, the individual sector assemblies **100** may collectively form the combustor cap assembly **52**. More specifically, each individual sector assembly **100** disposed about each peripheral fuel nozzle **106** abuts the individual sector assemblies **100** of the peripheral fuel nozzles **106** to which it is adjacent. Additionally, each individual sector assembly **100** abuts the central fuel nozzle **104**. As mentioned above, each individual sector assembly **100** also abuts the liner **62** of the turbine combustor **14**. In this manner, the entire perimeter of each individual sector assembly **100** abuts another surface. Furthermore, the interfaces between each of the individual sector assemblies **100** may include hula seals **108**. That is, the individual sector assemblies **100** may include hula seals **108** to improve the interfaces and contacts between one another. Similarly, the individual sector assemblies **100** may include hula seals **108** to improve the interfaces and contacts with the central fuel nozzle **104**. The hula seals **108** may also provide improved damping and alignment among the fuel nozzles **68** in the fuel nozzle assembly **18**. The hula seals **108** may also allow some movement, thermal expansion, contraction, etc., among the fuel nozzles **68**. Additionally, while the illustrated embodiments show hula seals **108**, other embodiments of the com-

bustor cap assembly **52** may include other types of seals, such as leaf seals, brush seals, metal cloth seals, spring seals, and so forth.

[0030] As discussed in further detail below, each individual sector assembly **100** is configured to receive the cooling air flow **84**. For example, the cooling air flow **84** may be the pressurized air **31** from the air flow path **74** or cooling air from another source, which may be a different (e.g., higher) pressure than the pressurized air **31**. For example, the cooling air flow **84** may be the pressurized air **30** from the compressor discharge **56**. As each individual sector assembly **100** receives the cooling air flow **84**, the cooling air flow **84** passes through respective front plates **112** of the individual sector assemblies **100**. In this manner, the cooling air flow **84** may cool the individual sector assemblies **100** and the combustor cap assembly **52**. By cooling the individual sector assemblies **100** and the combustor cap assembly **52**, the thermal gradient between the combustion chamber **76** and the head end **54** of the turbine combustor **14** may be reduced, which may reduce low cycle fatigue and wear on the fuel nozzle assembly **18** and the fuel nozzles **68**. Additionally, certain embodiments of the fuel nozzle assembly **18** may include a dynamics plate **114**. The dynamics plate **114** is disposed about the fuel nozzle assembly **18** upstream of the combustor cap assembly **52**. As will be appreciated, the dynamics plate **114** may be adjusted along the fuel nozzle assembly **18** to regulate a volume **116** between dynamics plate **114**, the combustor cap assembly **52**, and the liner **62** surrounding the dynamics plate **114**, the combustor cap assembly **52** and the fuel nozzle assembly **18**. As the volume **116** is increased or decreased, the frequencies of combustion dynamics damped or attenuated in the head end **54** of the turbine combustor **14** may be adjusted.

[0031] FIG. 4 is a perspective view of an embodiment of the individual sector assembly **100** mounted to, and disposed about, the end **102** of one of the peripheral fuel nozzles **106**. In certain embodiments, the individual sector assembly **100** may be mounted to the peripheral fuel nozzle **106** by welding joints or other fixed joints. As a result, the individual sector assembly **100** is fixed to the peripheral fuel nozzle **106**. Additionally, when the individual sector assembly **100** and the peripheral fuel nozzle **106** are installed within the turbine combustor **14**, the individual sector assembly **100** may not move relative to the peripheral fuel nozzle **106**.

[0032] As mentioned above, the individual sector assembly **100** has the front plate **112**, which is exposed to the combustion chamber **76** of the turbine combustor **14**. Additionally, the individual sector assembly **100** has sides **120**, which form an outer perimeter of the individual sector assembly **100**. For example, the individual sector assembly **100** includes an inner radial side or surface **122** (e.g., arcuate surface), an outer radial side or surface **124** (e.g., arcuate surface) and lateral sides or surfaces **126** (e.g., converging or diverging surfaces). When the fuel nozzle assembly **18** (e.g., the central fuel nozzle **104** and the peripheral fuel nozzles **106**) and the combustor cap assembly **52** (e.g., the individual sector assemblies **100**) are assembled, the respective inner radial surface **122** of each individual sector assembly **100** abuts the central fuel nozzle **104**. Additionally, the lateral surfaces **126** abut respective lateral surfaces **126** of adjacent individual sector assemblies **100**, and the outer radial surface **124** abuts the liner **62** of the turbine combustor **14**. As mentioned above, the sides **120** (e.g., the inner radial surface **122**, the outer radial surface **124**, and the lateral surfaces **126**) may each include one or more hula seals **108**. The hula seals **108** serve to



improve the interface between the sides **120** and the respective surfaces, which abut the sides **120**. In particular, the hula seals **108** provide an improved seal while enabling some movement, such as thermal expansion or contraction. Additionally, the hula seals **108** may provide improved alignment among the fuel nozzles **68** in the fuel nozzle assembly **18**, while also helping to damp vibration associated with combustion dynamics or other sources.

[0033] As mentioned above, the individual sector assembly **100** is configured to receive the cooling air flow **84**, which may be the pressurized air **31** from the air flow path, the pressurized air **30** from the compressor discharge **56**, or other high pressure air flow (e.g., higher pressure than the pressurized air **30**). More specifically, the outer radial surface **124** of the individual sector assembly **100** may include one or more apertures **128** configured to receive the cooling air flow **84**, in the manner described below. In one embodiment, the cooling air flow **84** flows into a cavity (e.g., cavity **148** shown in FIG. 5) of the individual sector assembly **100** formed by the sides **120**, the front plate **112**, and the peripheral fuel nozzle **106**, as indicated by arrow **130**. Thereafter, the cooling air flow **84** passes through apertures **132** formed in the front plate **112**, as indicated by arrows **134**. In this manner, the cooling air flow **84** may cool the individual sector assemblies **100** and the combustor cap assembly **52**. Additionally, the cooling air flow **84** may flow through the air flow path **74** and into the volume **116**, from where the cooling air flow **84** may enter the cavity of the individual sector assembly **100** from a back side **135** (e.g., a side opposite the front plate **112**) of the individual sector assembly **100**. By cooling the individual sector assemblies **100** and the combustor cap assembly **52**, the thermal gradient between the combustion chamber **76** and the head end **54** of the turbine combustor **14** may be reduced, which may reduce thermal stress and wear on the fuel nozzle assembly **18** and the fuel nozzles **68**.

[0034] Furthermore, in certain embodiments, the individual sector assembly **100** may include a back plate **136** (e.g., opposite the front plate **112**). The addition of the back plate **136** may substantially enclose the cavity of the individual sector assembly **100**. In this manner, the pressure of the cooling air flow **84** passing through the apertures **132** of the front plate **112** may increase, thereby increasing the pressure drop across the front plate **112**. As will be appreciated, elevated pressure of the cooling air flow **84** passing through the apertures **132** of the front plate **112** may help reduce the effects of combustion dynamics produced within the combustion chamber **76** of the turbine combustor **14**. Additionally, the elevated pressure of the cooling air flow **84** within the individual sector assembly **100** may increase the flow rate of the cooling air flow **84** through the apertures **132** of the front plate **112**, thereby increasing the cooling and reducing thermal stress of the individual sector assemblies **100** and the combustor cap assembly **52**.

[0035] FIG. 5 is a cross-sectional axial view of an embodiment of the peripheral fuel nozzle **106** with the individual sector assembly **100**, illustrating a mounting arrangement of the individual sector assembly **100** to the peripheral fuel nozzle **106**. Additionally, the illustrated embodiment show a cavity **148** formed by the individual sector assembly **100** and the peripheral fuel nozzle **106** into which the cooling air flow **84** may flow (e.g., from the air flow path **74**). The individual sector assembly **100** is mounted to the peripheral fuel nozzle **106** by several brackets **150**. In the illustrated embodiment,

the brackets **150** have an A-shaped configuration. However, other embodiments may include brackets **150** having other configurations.

[0036] As shown, a first bracket **152** couples the inner radial surface **122** of the individual sector assembly **100** to the peripheral fuel nozzle **106**. Similarly, a second bracket **154** couples the outer radial surface **124** of the individual sector assembly **100** to the peripheral fuel nozzle **106**, a third bracket **156** couples one of the lateral surfaces **126** of the individual sector assembly **100** to the peripheral fuel nozzle **106**, and a fourth bracket **158** couples another lateral surface **126** of the individual sector assembly **100** to the peripheral fuel nozzle **106**. As mentioned above, the individual sector assembly **100** is fixedly attached to the peripheral fuel nozzle **106**. For example, each of the brackets **150** may be secured to the peripheral fuel nozzle **106** and the respective side **120** of the individual sector assembly **100** by weld joints **160**. In other embodiments, the brackets **150** may be secured to the peripheral fuel nozzle **106** by other methods such as brazed joints, bolts, rivets, and so forth. Because the individual sector assembly **100** is fixedly attached to the peripheral fuel nozzle **106**, the combustor cap assembly **52** may not include piston rings and/or floating collars. In other words, the individual sector assembly **100** does not move or float relative to its supported fuel nozzle **106**.

[0037] FIG. 6 is a schematic of an embodiment of the individual sector assembly **100** mounted to the peripheral fuel nozzle **106** and installed within the head end **54** of the turbine combustor **14**. Specifically, the illustrated embodiment shows the front plate **112** of the individual sector assembly **100** coupled to the peripheral fuel nozzle **106** and the outer radial surface **124** interfacing with the liner **62** of the turbine combustor **14**. As mentioned above, the cooling air flow **84** (e.g., pressurized air **30**, pressurized air **31**, or other air flow) flows into the cavity **148** of the individual sector assembly **100** and subsequently passes through the apertures **132** of the front plate **112**, thereby cooling the individual sector assembly **100**, the combustor cap assembly **52**, and the peripheral fuel nozzle **106**. As described below, the cooling air flow **84** may flow into the cavity **148** of the individual sector assembly **100** through various paths (e.g., through air flow path **180**, gap **217**, and volume **218**, through the air inlet **214**, and so forth).

[0038] As mentioned above, in operation, the peripheral fuel nozzle **106** (e.g., fuel nozzle **68**) combines the pressurized air **31** from the annulus **60** with the fuel **72** provided by the fuel supply **70** to form an air/fuel mixture for combustion within the combustion chamber **76** of the turbine combustor **14**. For example, the peripheral fuel nozzle **106** may received the pressurized air **31** from an air flow path **180** operatively coupled to the annulus **60** between the liner **62** and the flow sleeve **64** of the turbine combustor **14**. As shown, the air flow path **180** contains a first portion **182** and a second portion **184**, and the first portion **182** and the second portion **184** are operatively coupled. The first portion **182** of the air flow path **180** is defined by an outer wall **186** (e.g., a head end casing) and an inner wall **188** (e.g., a head end sleeve) of the turbine combustor **14**. The second portion **184** of the air flow path **180** is defined by an outer shell **190** (e.g., a burner tube of the fuel nozzle **68**, **106**) and an inner shell **192** (e.g., a central fuel supply conduit) of the peripheral fuel nozzle **106**. As indicated by arrows **194**, the pressurized air **31** flows from the annulus **60**, first through the first portion **182** of the air flow path **180** in an upstream direction, and then through the second portion **184** of the air flow path **180** in a downstream



direction. Subsequently, the pressurized air **31** flows around swirl vanes **196** of the peripheral fuel nozzle **106**. As mentioned above, the fuel **72** is released into the pressurized air **31** through the swirl vanes **196**. Specifically, the fuel **72** flows down a fuel path **198** within the inner shell **192** (e.g., central fuel supply conduit) of the peripheral fuel nozzle **106**, as represented by arrows **200**. The fuel **72** passes into the swirl vanes **196** from the fuel path **198**, as represented by arrows **202**, and exits the swirl vanes **196** through fuel ports **204** in the swirl vanes **196**, as represented by arrows **206**. The fuel **72** mixes with the pressurized air **31** to create an air/fuel mixture. The air/fuel mixture flows downstream, as indicated by arrows **208**, toward the combustion chamber **76**.

[0039] As mentioned above, the individual sector assembly **106** of the combustor cap assembly **52** is coupled to the peripheral fuel nozzle **106** of the fuel nozzle assembly **18**. As shown, the individual sector assembly **100** may receive the cooling air flow **84**, represented by arrows **209**, from a cooling air flow path **210**. For example, in the illustrated embodiment, the cooling air flow path **210** is formed by the flow sleeve **64** of the turbine combustor **14** and a casing **212** of the turbine combustor **14**. As mentioned above, the cooling air flow **84** may be the pressurized air **30** supplied by the compressor discharge **54**. In other embodiments, the cooling air flow **84** may be supplied by another source. Furthermore, the cooling air flow **84** may have a higher pressure than the pressurized air **31** flowing through the liner **62** and the flow sleeve **64** (e.g., represented by arrows **194**).

[0040] The cooling air flow **84**, represented by arrows **209**, enters the cavity **148** of the individual sector assembly **100** through the aperture **128** in the outer radial surface **124** and from a cooling air inlet **214** operatively coupled to the cooling air flow path **210**. While the illustrated embodiment shows a single cooling air inlet **214**, other embodiments may include more cooling air inlets **214**. For example, the individual sector assembly **100** may have 2, 3, 4, 5, 6, 7, 8, or more cooling air inlets **214**. Similarly, other individual sector assemblies **100** of the combustor cap assembly **52** may include a single or multiple cooling air inlets **214** configured to flow the cooling air flow **84** into the respective cavity **148** of each individual sector assembly **100**. The cavity **148** receives the cooling air flow **84**, represented by arrows **209**, from the cooling air inlet **214** and directs the cooling air flow **84** in an upstream direction towards the front plate **112** of the individual sector assembly **100**, as indicated by arrow **216**. Moreover, the cooling air **84** is directed toward the apertures **132** in the front plate **112**. In the illustrated embodiment, the apertures **132** are straight holes. However, as discussed below, other embodiments of the front plate **112** may have apertures **132** that are angled holes. As the cooling air flow **84** passes through the apertures **132**, the air flow **84** helps to cool the front plate **112**, the individual sector assembly **100** and the combustor cap assembly **52**.

[0041] In the illustrated embodiment, the cavity **148** of the individual sector assembly **100** may also receive the pressurized air **31** flowing through the air flow path **180**, as mentioned above. Specifically, the pressurized air **31** may flow through the gap **217** between the outer shell **190** (e.g., burner tube) of the peripheral fuel nozzle **106** and the inner wall **188** (e.g., a head end sleeve) and into the volume **218**, as represented by arrows **220**. From the volume **218**, the pressurized air **30**, represented by arrow **220**, may pass into the cavity **148** of the individual sector assembly **100**. As mentioned above, the head end **54** of the turbine combustor **14** may include the

dynamics plate **114**. As shown, the dynamics plate **114** is disposed between the outer shell **190** (e.g., burner tube) of the peripheral fuel nozzle **106** and the inner wall **188** (e.g., a head end sleeve), and may be moved to adjust the size of the volume **218**. As the size of the volume **218** is adjusted, the frequencies of vibrations and pressure fluctuations damped within the head end **54** of the turbine combustor **14** may be changed.

[0042] As mentioned above, the individual sector assembly **100** is rigidly attached to the peripheral fuel nozzle **106**. Specifically, an inner perimeter **223** of the individual sector assembly **100** is fixedly attached to the outer shell **190** (e.g., burner tube) of the peripheral fuel nozzle **106**. In the illustrated embodiment, the inner perimeter **223** is secured to the outer shell **190** by a weld joint **224**. As will be appreciated, multiple weld joints **224** may be used to secure the inner perimeter **223** to the outer shell **190**. In other embodiments, the inner perimeter **223** may be fixedly attached to the outer shell **190** of the peripheral fuel nozzle **106** by other methods, such as the brackets **150**, brazing, bolting, riveting, etc.

[0043] Additionally, hula seals **108** are disposed between the individual sector assembly **100** and the liner **62** and the outer wall **188** of the turbine combustor **14**. The hula seals **108** serve multiple functions. For example, the hula seals **108** may substantially block the pressurized air **31** and/or the cooling air flow **84** from leaking between the individual sector assembly **100**, the liner **62**, and the outer wall **186** and into the combustion chamber **76**. Additionally, the hula seals **108** may allow for less stringent tolerances and misalignment of the fuel nozzle assembly **18** and the combustor cap assembly **52** within the head end **54** of the turbine combustor **14**. In other words, the hula seals **108** may enable some movement, such as thermal expansion and/or contraction, of the fuel nozzles **68**. Furthermore, the hula seals **108** may enable improved damping of vibration associated with combustion dynamics among the fuel nozzles **68** and within the head end **54** of the turbine combustor. Indeed, the spring rate of the hula seals **108** may be selected to adjust damping among the fuel nozzles **68** and within the head end **54** of the turbine combustor **14**. Furthermore, the hula seals **108** may simplify the installation of the fuel nozzle assembly **18** and the combustor cap assembly **52**.

[0044] In the illustrated embodiment, the outer radial surface **124** of the individual sector assembly **100** includes a first hula seal **108**, **226**. As shown, the first hula seal **226** is configured to interface with the inner wall **188** (e.g., head end sleeve) of the turbine combustor **14**. Similarly, the liner **62** of the turbine combustor **14** includes a second hula seal **108**, **228** (e.g., an inverted hula seal) configured to interface with the outer radial surface **124** of the individual sector assembly **100**. However, in other embodiments, the inner wall **188** of the turbine combustor **14** may include the hula seal **108**, **226** (e.g., an inverted hula seal) configured to interface with the outer radial surface **124** of the individual sector assembly **100**. Similarly, in certain embodiments, the outer radial surface **124** of the individual sector assembly **100** may include the hula seal **108**, **228** configured to interface with the liner **62** of the turbine combustor **14**.

[0045] FIG. 7 is a schematic of an embodiment of the individual sector assembly **100** mounted to the peripheral fuel nozzle **106** and installed within the head end **54** of the turbine combustor **14**. The illustrated embodiment includes similar elements and element numbers as the embodiment shown in FIG. 6. However, in the illustrated embodiment, the cavity



**148** of the individual sector assembly **100** receives the pressurized air **31**, represented by arrows **194**, as the cooling air flow **84**. In other words, the individual sector assembly **100** does not receive the cooling air flow **84** from the cooling air inlet **214** (e.g., where the cooling air flow **84** is the pressurized air **30** or other air flow). For example, the pressurized air **31** may reach the cavity **148** of the individual sector assembly **100** by flowing from the annulus **60**, through the air flow path **180**, through the gap **217**, through the volume **218**, and into the cavity **148** through the back side **135** of the individual sector assembly **100**, as discussed in detail above.

[0046] Additionally, or alternatively, the pressurized air **31** may flow into the cavity **148** through the aperture **128** of the outer radial surface **124** of the individual sector assembly **100**. That is, the pressurized air **31** may flow into the cavity **148** through the aperture **128** of the outer radial surface **124** instead of, or in addition to, the pressurized air **31** passing through the air flow path **180**, the gap **217**, and the volume **218** to reach the back side **135** of the individual sector assembly **100**. As shown, the pressurized air **31** may pass through an aperture **222** in the liner **62**, as indicated by arrow **221**. In some embodiments, the aperture **222** may be formed in the inner wall **188** (e.g., head end sleeve) of the turbine combustor **14**. However, other embodiments of the turbine combustor **14** may not include the aperture **222**. Furthermore, the illustrated embodiment of the individual sector assembly **100** includes one hula seal **108**. Specifically, the individual sector assembly **100** includes the second hula seal **228**, but not the first hula seal **226** shown in FIG. 6.

[0047] FIG. 8 is a schematic of an embodiment of the individual sector assembly **100** mounted to the peripheral fuel nozzle **106** and installed within the head end **54** of the turbine combustor **14**. The illustrated embodiment includes similar elements and element numbers as the embodiment shown in FIG. 6. Additionally, the illustrated embodiment of the individual sector assembly **100** includes the back plate **136**, which may be secured to the outer shell **190** (e.g., burner tube) of the peripheral fuel nozzle **106** by a weld joint **240**. In this manner, the cavity **148** of the individual sector assembly **100** is substantially enclosed and/or sealed relative to the fuel nozzle **68**, **106**. That is, the cavity **148** is substantially enclosed by the front plate **112**, the back plate **136**, the lateral sides **126**, the outer radial surface **124**, the inner radial surface **122**, and the outer shell **190** (e.g., burner tube) of the peripheral fuel nozzle **106**. As a result, the elevated pressure of the cooling air flow **84** may be maintained or increased within the individual sector assembly **100**. As mentioned above, the cooling air flow **84** may have a pressure higher than the pressurized air **30** flowing through the annulus **60** and the air flow path **180**. As a result, the substantially enclosed individual sector assembly **100** may block the pressurized air **30** (e.g., flowing within the volume **218**, as described above) from mixing with the higher pressure cooling air flow **84** within the cavity **148**. In this manner, the cooling air flow **84** may maintain an elevated pressure within the individual sector assembly **100**, thereby providing improved cooling of the combustor cap assembly **52** and the fuel nozzle assembly **18** and increasing the pressure drop across the front plate **112** of the individual sector assembly **100**.

[0048] FIGS. 9 and 10 are schematics of embodiments of the front plate **112** of the individual sector assembly **100** mounted to the peripheral fuel nozzle **106**. For example, FIG. 9 illustrates the front plate **112** of the individual sector assembly **100**, where the apertures **132** in the front plate **112** are

angled holes. In certain embodiments, the front plate **112** having apertures **132**, which are angled holes, may act as an effusion plate. FIG. 10 illustrates an embodiment of the individual sector assembly **100** having two front plates **112** (e.g., a first front plate **280** and a second front plate **282**). As shown, each of the two front plates **112** has the apertures **132** configured to flow the cooling air flow **84**, represented by arrows **270**, from the cavity **148** to the combustion chamber **76**, as indicated by arrows **134**. For example, the first front plate **280** may be an impingement plate and the second front plate **282** may be an effusion plate. That is, the first front plate **280** may impinge the cooling air flow **84**, represented by arrows **270**, on the second front plate **282**.

[0049] As described in detail above, the disclosed embodiments are directed towards the combustor cap assembly **52** for the turbine combustor **14**. More specifically, the disclosed embodiments include a plurality of individual sector assemblies **100** mounted to fuel nozzles **68** of the fuel nozzle assembly **18**. For example, in certain embodiments, the fuel nozzle assembly **18** includes peripheral fuel nozzles **106** arranged about the central fuel nozzle **104**. The peripheral fuel nozzles **106** may each include the individual sector assembly **100** mounted to the respective peripheral fuel nozzle **106**. Further, the individual sector assemblies **100** may have a geometry that enables an entire outer perimeter of the individual sector assemblies **100** to abut one another (e.g., adjacent individual sector assemblies **100**), the central fuel nozzle **106**, and the liner **62** surrounding the fuel nozzle assembly **18**. In certain embodiments, the individual sector assemblies **100** further include hula seals **108** to improve the interface between the individual sector assemblies **100** and surrounding components (e.g., adjacent individual sector assemblies **100**, the central fuel nozzle **106**, and the liner **62** of the turbine combustor **14**). In this manner, the individual sector assemblies **100** may form the substantially continuous combustor cap assembly **52** between the fuel nozzle assembly **18** and the combustion chamber **76** of the turbine combustor **14**. Additionally, the hula seals **108** may be configured to provide damping, account for tolerances within the head end **54** of the turbine combustor **14**, allow movement, e.g., thermal expansion or contraction, of the fuel nozzles **68**, and/or reduce air leakage across the combustor cap assembly **52**. Furthermore, the individual sector assemblies **100** are configured to receive a cooling air flow **84**, which may be a high pressure cooling air flow. For example, the cooling air flow **84** may be pressurized air **31** from an annulus **60** between a liner **62** and flow sleeve **64** of the combustor **14**, or pressurized air **30** from a compressor discharge case **56**. In this manner, the combustor cap assembly **52** of turbine combustor **14** may achieve improved cooling and reduce undesired effects of combustion dynamics. Additionally, in certain embodiments, the individual sector assemblies **100** may be substantially enclosed, thereby increasing the pressure of the cooling air flow **84** received by each individual sector assembly **100** and further improving the cooling of the combustor cap assembly **52**.

[0050] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language



of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

1. A system, comprising:
  - a turbine combustor, comprising:
    - a plurality of fuel nozzles; and
    - a combustor cap assembly comprising a plurality of individual sectors supporting the plurality of fuel nozzles, wherein each sector of the plurality of individual sectors is fixedly attached to a respective fuel nozzle of the plurality of fuel nozzles.
2. The system of claim 1, wherein each sector of the plurality of individual sectors comprises a wedge-shaped outer perimeter.
3. The system of claim 2, wherein each sector of the plurality of individual sectors comprises a circular inner perimeter that extends around a circular outer perimeter of the respective fuel nozzle of the plurality of fuel nozzles.
4. The system of claim 3, wherein each fuel nozzle of the plurality of fuel nozzles comprises an air conduit having at least one swirl vane, and each fuel nozzle comprises at least one fuel outlet configured to output a fuel flow into an air flow passing through the air conduit.
5. The system of claim 1, wherein each sector of the plurality of individual sectors comprises at least one hula seal disposed between each pair of abutting sectors of the plurality of individual sectors, or at least one hula seal disposed between each sector and a liner surrounding the combustor cap assembly, or at least one hula seal disposed between each sector and a central fuel nozzle.
6. The system of claim 5, wherein the at least one hula seal is configured to maintain a seal while damping vibration and/or allowing movement due to thermal expansion or contraction of the plurality of individual sectors.
7. The system of claim 1, wherein the plurality of fuel nozzles comprises a plurality of peripheral fuel nozzles disposed about a central fuel nozzle, and each peripheral fuel nozzle is fixedly attached to one of the plurality of individual sectors.
8. The system of claim 1, wherein each sector of the plurality of individual sectors comprises at least one coolant inlet and at least one coolant outlet configured to pass a cooling air flow.
9. The system of claim 8, wherein the at least one coolant outlet of each sector of the plurality of individual sectors is disposed in a front plate configured to face a combustion chamber of the turbine combustor, and the at least one coolant outlet is configured to pass the cooling air flow through the front plate into the combustion chamber.
10. The system of claim 8, wherein the at least one coolant inlet of each sector of the plurality of individual sectors comprises a first coolant inlet and a second coolant inlet, the first coolant inlet is configured to receive a first cooling air flow from an air flow region between a liner and a flow sleeve of the

turbine combustor, and the second coolant inlet is configured to receive a second cooling air flow that is different than the first cooling air flow.

11. The system of claim 1, wherein each sector of the plurality of individual sectors comprises a first front plate and a second front plate, each sector of the plurality of individual sectors is configured to receive a cooling air flow and direct the cooling air flow through apertures of the first and second front plates, wherein the first front plate is configured to impinge the cooling air flow on the second front plate.

12. The system of claim 1, comprising a turbine engine having the turbine combustor.

13. A system, comprising:
 

- a first fuel nozzle; and
- a first individual sector having a first outer perimeter configured to fit together with outer perimeters a plurality of individual sectors to form a combustor cap assembly of a turbine combustor, wherein the first individual sector comprises a first inner perimeter that fits about a nozzle outer perimeter of the first fuel nozzle, and the first individual sector is fixedly attached to the first fuel nozzle.

14. The system of claim 13, wherein the first outer perimeter comprises a wedge-shaped outer perimeter.

15. The system of claim 13, wherein the first outer perimeter comprises at least one hula seal.

16. The system of claim 13, wherein the nozzle outer perimeter comprises a circular outer perimeter, and the first inner perimeter comprises a circular inner perimeter.

17. The system of claim 13, wherein the first individual sector has a front plate configured to face a combustion chamber of the turbine combustor, and the front plate has a plurality of cooling outlets to pass a cooling air flow into the combustion chamber.

18. The system of claim 13, wherein the first fuel nozzle comprises an air conduit having at least one swirl vane, and the first fuel nozzle comprises at least one fuel outlet configured to output a fuel flow into an air flow passing through the air conduit.

19. A system, comprising:
 

- a first individual sector having a first outer perimeter configured to fit together with outer perimeters of a plurality of individual sectors to form a combustor cap assembly of a turbine combustor, wherein the first individual sector comprises a first inner perimeter configured to fit about a nozzle outer perimeter of a first fuel nozzle, and the first individual sector is configured to fixedly attach to the first fuel nozzle.

20. The system of claim 19, comprising the combustor cap assembly including the plurality of individual sectors, wherein each sector of the plurality of individual sectors comprises a wedge-shaped outer perimeter having at least one hula seal.

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