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(54) **Combustor and method for supplying fuel to a combustor**

Brennkammer und Verfahren zur Versorgung einer Brennkammer mit Brennstoff

Chambre de combustion et procédé pour fournir du carburant à une chambre de combustion

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Description

FIELD OF THE INVENTION

[0001] The present invention generally involves a combustor and method for supplying fuel to a combustor.

BACKGROUND OF THE INVENTION

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

[0003] Various design and operating parameters influence the design and operation of combustors. For example, higher combustion gas temperatures generally improve the thermodynamic efficiency of the combustor. However, higher combustion gas temperatures also promote flashback or flame holding conditions in which the combustion flame migrates towards the fuel being supplied by the nozzles, possibly causing severe damage to the nozzles in a relatively short amount of time. In addition, localized hot streaks in the combustion chamber may increase the disassociation rate of diatomic nitrogen, increasing the production of nitrogen oxides (NO_X) at higher combustion gas temperatures. Conversely, lower combustion gas temperatures associated with reduced fuel flow and/or part load operation (turndown) generally reduce the chemical reaction rates of the combustion gases, increasing the production of carbon monoxide and unburned hydrocarbons.

[0004] GB 2197714 describes a combustor for use in the chemical or gas industry for the vapour/oxygen conversion of natural gas. The gas is fed to inlet and mixes with oxygen exiting through pipes at the mouth of the combustor. To avoid the risk that the burner mouth is burnt away by reaction with industrial oxygen, an outer cooling jacket terminates in a coolable base spaced apart from the housing base to provide a gap. Water fed from an inlet passes around gas pipes to the base and exits at an outlet. Oxygen gas outlet pipes pass through both bases.

[0005] US 201/031662 describes an injection nozzle for a turbomachine including a main body having a first end portion that extends to a second end portion defining an exterior wall having an outer surface. A plurality of fluid delivery tubes extend through the main body. Each of the plurality of fluid delivery tubes includes a first fluid inlet for receiving a first fluid, a second fluid inlet for receiving a second fluid and an outlet. The injection nozzle further includes a coolant delivery system arranged within the main body. The coolant delivery system guides a coolant along at least one of a portion of the exterior wall and around the plurality of fluid delivery tubes.

[0006] In a particular combustor design, a plurality of tubes may be radially arranged in an end cap to provide fluid communication for the working fluid to flow through the end cap and into the combustion chamber. A fuel and/or a diluent may be supplied to the end cap and injected into the tubes to enhance mixing between the working fluid and fuel prior to combustion. The enhanced mixing between the working fluid and fuel prior to combustion reduces hot streaks in the combustion chamber that can be problematic with higher combustion gas temperatures. As a result, the tubes are effective at preventing flashback or flame holding and/or reducing NO_X production, particularly at higher operating levels. However, an improved combustor and method for supplying fuel to the combustor that allows for staged fueling, multiple fuels, and/or diluents to be supplied to the tubes without obstructing the tubes would be useful.

BRIEF DESCRIPTION OF THE INVENTION

[0007] The present invention resides in a combustor and in a method for supplying fuel to a combustor as defined in the appended claims.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

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

Fig. 2 is a downstream cross-section view of the combustor shown in Fig. 1 taken along line A-A.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Reference will now be made in detail to present embodiments of the invention, one or more examples of which are illustrated in the accompanying drawings.

[0011] Various embodiments of the present invention

provide a combustor and method for supplying fuel to a combustor. The various embodiments may reduce flow disturbances through the tubes, increase structural support provided to the end cap, reduce manufacturing costs of the combustor, and/or enable staged fueling and/or multiple fuels and/or diluents to be supplied to the tubes over a wide range of operating conditions without exceeding design margins associated with flashback, flame holding, and/or emissions limits.

[0012] Fig. 1 provides a simplified cross-section view of an exemplary combustor 10 according to one embodiment of the present invention, and Fig. 2 provides a downstream cross-section view of the combustor shown in Fig. 1 taken along line A-A. As shown, a casing 12 generally surrounds the combustor 10 to contain a working fluid 14 flowing to the combustor 10, and an end cover 16 provides an interface for supplying fuel, diluent, and/or other additives to the combustor 10. Possible diluents may include, for example, water, steam, working fluid, air, fuel additives, various inert gases such as nitrogen, and/or various non-flammable gases such as carbon dioxide or combustion exhaust gases supplied to the combustor 10.

[0013] An end cap 18 extends radially across at least a portion of the combustor 10, and the casing 12 circumferentially surrounds at least a portion of the end cap 18 to define an annular passage 20 between the end cap 18 and the casing 12. The end cap 18 and a liner 22 defines at least a portion of a combustion chamber 24 downstream from the end cap 18. In this manner, the working fluid 14 flows through the annular passage 20 along the outside of the liner 22 to provide convective cooling to the liner 22. When the working fluid 14 reaches the end cover 16, the working fluid 14 may reverse direction to flow through the end cap 18 and into the combustion chamber 24.

[0014] The end cap 18 includes an upstream surface 26 axially separated from a downstream surface 28, and a shroud 29 surrounds the upstream and downstream surfaces 26, 28. A plurality of tubes 30 extend axially from the upstream surface 26 to the downstream surface 28 to provide fluid communication through the end cap 18. The particular shape, size, number, and arrangement of the tubes 30 may vary according to particular embodiments. For example, the tubes 30 are generally illustrated as having a cylindrical shape; however, alternate embodiments within the scope of the present invention may include tubes having virtually any geometric cross-section. In addition, the tubes 30 may be radially arranged across the end cap 18 in one or more sets or groups of various shapes and sizes, with each set of tubes 30 having one or more separate fuel supplies. For example, multiple tubes 30 may be radially arranged around a fuel nozzle, or multiple sets of tubes 30 may be radially arranged across the end cap 18. One or more fluid conduits may provide one or more fuels, diluents, and/or other additives to each set of tubes 30, and the type, fuel content, and reactivity of the fuel and/or diluent may vary for each fluid conduit or set of tubes. In this manner, different types, flow rates, and/or additives may be supplied to one or more sets of tubes to enhance staged fueling of the tubes 30 over a wide range of operating conditions.

[0015] The combustor 10 includes one or more structures that extend downstream from the end cover 16 to support the end cap 18 and/or provide various fluid passages between the end cover 16 and the end cap 18. For example, as shown in Fig. 1, the combustor 10 includes an inner support tube 40 and an outer support tube 42 that extend downstream from the end cover 16. The inner support tube 40 connects to the downstream surface 28 of the end cap 18 to partially support the end cap 18 axially inside the combustor 10. In particular embodiments, the inner support tube 40 also functions as or include a fuel conduit 40 that extends downstream from the end cover 16 to define a fuel plenum 44 inside the inner support tube 40. In this manner, the inner support tube/fuel conduit 40 provides fluid communication from the end cover 16 to the end cap 18 to supply fuel to the end cap 18 and/or combustion chamber 24.

[0016] The outer support tube 42 circumferentially surrounds the inner support tube 40 and connect to the upstream surface 26 of the end cap 18 to partially support the end cap 18 axially inside the combustor 10. In addition, the outer support tube 42 defines one or more fluid passages between the end cover 16 and the end cap 18. For example, as shown in Fig. 1, a barrier 46 extends axially between the inner and outer support tubes 40, 42 upstream from the upstream surface 26 to partially define first and second plenums 50, 52 between the inner and outer support tubes 40, 42. Downstream from the upstream surface 26, the barrier 46 extends radially between the first and second plenums 50, 52 to further separate the first and second plenums 50, 52 inside the end cap 18. As a result, the first plenum 50 circumferentially surrounds the inner support tube/fuel conduit 40 between the end cover 16 and the upstream surface 26 before extending radially inside the end cap 18 between the upstream and downstream surfaces 26, 28. Similarly, the second plenum 52 may circumferentially surround the first plenum 50 between the end cover 16 and the upstream surface 26 before extending radially inside the end cap 18 between the upstream and downstream surfaces 26, 28. In the particular embodiment shown in Fig. 1, the first plenum 50 thus extends radially inside the end cap 18 downstream from the second plenum 52 with respect to the direction of the working fluid 14 through the end cap 18.

[0017] The first and second plenums 50, 52 provide fluid communication between the end cover 16 and the end cap 18 to allow various fuels, diluents, or other fluid additives to be supplied to the tubes 30. Each tube 30 in turn includes one or more ports 54 that provide fluid communication through the tube 30 from the first and/or second fuel plenums 50, 52. The ports 54 may be angled radially, axially, and/or azimuthally to project and/or impart swirl to the fluid flowing through the ports 54 and into

the tubes 30. In addition, the particular number, size, and location of the ports 54 in the tubes 30 may be varied to allow staged fluid flow to the tubes 30. For example, as shown in Fig. 1, a first set of tubes 60 include ports 54 that provide fluid communication with only the first plenum 50, and a second set of tubes 62 include ports 54 that provide fluid communication with only the second plenum 52. In this manner, the working fluid 14 flows outside of the end cap 18 through the annular passage 20 until it reaches the end cover 16 and reverses direction to flow through the tubes 30. In addition, a first fuel or diluent may flow around the tubes 30 in the first plenum 50 to provide convective cooling to the tubes 30 before flowing through the ports 54 and into the first set of tubes 60 to mix with the working fluid 14. Similarly, a second fuel or diluent may flow around the tubes 30 in the second plenum 52 to provide convective cooling to the tubes 30 before flowing through the ports 54 and into the second set of tubes 60 to mix with the working fluid 14. The mixture from each set of tubes 60, 62 may then flow into the combustion chamber 24.

[0018] The combustor 10 may also include additional structures for supporting the end cap 18 and/or allowing thermal expansion between the various components. For example, as shown in the particular embodiment illustrated in Figs. 1 and 2, the combustor 10 includes a flexible coupling 64 between the end cover 16 and the inner support tube/fuel conduit 40 and/or the barrier 46. The flexible coupling 64 may include an expansion joint, bellows, or other device that allows for axial displacement of the inner support tube/fuel conduit 40 and/or barrier 46 caused by thermal expansion and contraction of the outer support tube 42 and/or tubes 30.

[0019] One of ordinary skill in the art will readily appreciate that alternate locations and/or combinations of flexible couplings 64 are within the scope of various embodiments of the present invention.

[0020] As further shown in Figs. 1 and 2, the combustor 10 also includes a support 66 that extends radially between the end cap 18 and the casing 12 in the annular passage 20. The support 66 may have an airfoil shape to reduce flow resistance of the working fluid 14 flowing across the support 66 in the annular passage 20. In particular embodiments, the support 66 may be angled to impart swirl to the working fluid 14 flowing through the annular passage 20. Alternately or in addition, the combustor 10 may include a cap shield 68 that circumferentially surrounds the end cap 18 and/or a sliding engagement 70 between the end cap 18 and the cap shield 68.

[0021] The cap shield 68 is connected to the support 66 and/or the shroud 29 that surrounds the end cap 18. The sliding engagement 70 includes a spring washer, a hula seal, or similar device and may extend continuously around the end cap 18 or in segments around the end cap 18, as shown in Fig. 2, to allow axial movement of the end cap 18 with respect to the cap shield 68 and/or support 66. In particular embodiments, the sliding engagement 70 may also provide a variable radial stiffness to the end cap 18 to allow slight modifications to the natural or resonant frequency of the end cap 18.

[0022] The various embodiments shown in Figs. 1 and 2 provide multiple combinations of methods for supplying fuel to the combustor 10. For example, the working fluid 14 may be supplied through the annular passage 20 and tubes 30 radially arranged in the end cap 18. A first fuel or a first diluent may be supplied through the first plenum 50 to the first set of tubes 60, and a second fuel or a second diluent may be supplied through the second plenum 52 to the second set of tubes 62. Alternately, or in addition, a third fuel or third diluent may be supplied through the fuel plenum 44 to the combustion chamber 24. The first, second, and third fuels and diluents may be the same or different, thus providing very flexible methods for providing staged fueling to various locations across the combustor 10 to enable the combustor 10 to operate over a wide range of operating conditions without exceeding design margins associated with flashback, flame holding, and/or emissions limits.

Claims

1. A combustor (10), comprising:

an end cover (16);
an end cap (18) downstream from the end cover (16) that extends radially across at least a portion of the combustor (10), wherein the end cap (18) comprises an upstream surface (26) axially separated from a downstream surface (28);
a plurality of tubes (30) that extends from the upstream surface (26) through the downstream surface (28) to provide fluid communication through the end cap (18);
an outer support tube (42) that extends downstream from the end cover (16) and connects to the upstream surface (28) of the end cap (18);
an inner support tube (40) that extends downstream from the end cover (16) and connects to the downstream surface (28) of the end cap (18);
a first plenum (50) that surrounds the inner support tube (40) between the end cover (16) and the upstream surface (26) before extending radially between the upstream and downstream surfaces (26, 28);
a second plenum (52) that surrounds the first plenum (50) between the end cover (16) and the upstream surface (26) before extending radially between the upstream and downstream surfaces (26, 28); and
characterized in that the first plenum (50) is in fluid communication with a first set of tubes (60) and the second plenum (52) is in fluid communication with a second set of tubes (62).

2. The combustor as in claim 1, wherein the first plenum

(50) extends radially inside the end cap (18) downstream from the second plenum (52).

3. The combustor as in claim 1 or 2, further comprising a barrier (46) that extends between the first and second plenums (50,52), wherein the barrier (46) extends axially between the first and second plenums (50,52) upstream from the upstream surface (26).

4. The combustor as in claim 3, wherein the barrier (46) extends radially between the first and second plenums (50,52) downstream from the upstream surface (26).

5. The combustor as in any of claims 1 to 4, further comprising a fuel plenum (44) inside the inner support tube (40).

6. The combustor as in any preceding claim, further comprising a casing (12) that circumferentially surrounds at least a portion of the end cap (18) to define an annular passage (20) between the end cap (18) and the casing (12) and a support extends (66) radially between the end cap (18) and the casing (12) in the annular passage (20).

7. The combustor as in any preceding claim, further comprising a cap shield (68) that circumferentially surrounds the end cap (18).

8. The combustor as in claim 7, further comprising a sliding engagement (70) between the end cap (18) and the cap shield (68).

9. A method for supplying fuel to a combustor (10), comprising:

flowing a working fluid (14) through a plurality of tubes (30) radially arranged in an end cap (18), wherein the end cap (18) extends radially across at least a portion of the combustor (10);
flowing at least one of a first fuel or a first diluent through a first plenum (50), wherein the first plenum (50) is at least partially defined by an inner support tube (40) that connects to a downstream surface (28) of the end cap (18); and
flowing at least one of a second fuel or a second diluent through a second plenum (52) that circumferentially surrounds at least a portion of the first plenum (50), wherein the second plenum (52) is at least partially defined by an outer support tube (42) that connects to an upstream surface (26) of the end cap (18);
characterized in that the first plenum (50) is in fluid communication with the first set (60) a tubes (30) and the second plenum (52) is in fluid communication with a second set (62) of tubes (30).

10. The method as in claim 9, further comprising flowing a third fuel inside the inner support tube (40).

11. The method as in claim 10, further comprising flowing at least one of the first fuel or first diluent radially inside the end cap (18) downstream from the second plenum (52).

Patentansprüche

1. Brennkammer (10), die umfasst:

eine Abschlussabdeckung (16);
eine Abschlusskappe (18) stromabwärts von der Abschlussabdeckung (16), die sich radial quer über mindestens einen Abschnitt der Brennkammer (10) erstreckt, wobei die Abschlusskappe (18) eine Oberfläche (26) stromaufwärts umfasst, die axial von einer Oberfläche (28) stromabwärts getrennt ist;
mehrere Rohre (30), die sich von der Oberfläche (26) stromaufwärts durch die Oberfläche (28) stromabwärts erstrecken, um eine Fluidkommunikation durch die Abschlusskappe (18) bereitzustellen;
ein äußeres Trägerrohr (42), das sich stromabwärts von der Abschlussabdeckung (16) erstreckt und mit der Oberfläche (28) stromaufwärts der Abschlusskappe (18) verbunden ist;
ein inneres Trägerrohr (40), das sich stromabwärts von der Abschlussabdeckung (16) erstreckt und mit der Oberfläche (28) stromabwärts der Abschlusskappe (18) verbunden ist;
eine erste Kammer (50), die das innere Trägerrohr (40) zwischen der Abschlussabdeckung (16) und der Oberfläche (26) stromaufwärts umgibt, bevor sie sich radial zwischen der Oberfläche stromaufwärts und stromabwärts (26, 28) erstreckt;
eine zweite Kammer (52), die die erste Kammer (50) zwischen der Abschlussabdeckung (16) und der Oberfläche (26) stromaufwärts umgibt, bevor sie sich radial zwischen der Oberfläche stromaufwärts und stromabwärts (26, 28) erstreckt; und
dadurch gekennzeichnet, dass die erste Kammer (50) in einer Fluidkommunikation mit einem ersten Satz von Rohren (60) und die zweite Kammer (52) in einer Fluidkommunikation mit einem zweiten Satz von Rohren (62) in Verbindung steht.

2. Brennkammer nach Anspruch 1, wobei sich die erste Kammer (50) radial innerhalb der Abschlusskappe (18) stromabwärts von der zweiten Kammer (52) erstreckt.

3. Brennkammer nach Anspruch 1 oder 2, die ferner eine Barriere (46) umfasst, die sich zwischen der ersten und der zweiten Kammer (50, 52) erstreckt, wobei sich die Barriere (46) axial zwischen der ersten und der zweiten Kammer (50, 52) stromaufwärts von der Oberfläche (26) stromaufwärts erstreckt.

4. Brennkammer nach Anspruch 3, wobei sich die Barriere (46) radial zwischen der ersten und der zweiten Kammer (50, 52) stromabwärts von der Oberfläche (26) stromaufwärts erstreckt.

5. Brennkammer nach einem der Ansprüche 1 bis 4, die ferner eine Brennstoffkammer (44) innerhalb des inneren Trägerrohrs (40) umfasst.

6. Brennkammer nach einem vorhergehenden Anspruch, die ferner ein Gehäuse (12), das mindestens einen Abschnitt der Abschlusskappe (18) am Umfang umgibt, um einen ringförmigen Durchlass (20) zwischen der Abschlusskappe (18) und dem Gehäuse (12) zu definieren, umfasst, und wobei sich ein Träger (66) radial zwischen der Abschlusskappe (18) und dem Gehäuse (12) in dem ringförmigen Durchlass (20) erstreckt.

7. Brennkammer nach einem vorhergehenden Anspruch, die ferner eine Schutzkappe (68) umfasst, die die Abschlusskappe (18) am Umfang umgibt.

8. Brennkammer nach Anspruch 7, die ferner zwischen der Abschlusskappe (18) und der Schutzkappe (68) einen Gleiteingriff (70) umfasst.

9. Verfahren zur Versorgung einer Brennkammer (10) mit Brennstoff, das umfasst:

Strömen eines Arbeitsfluids (14) durch mehrere Rohre (30), die radial in einer Abschlusskappe (18) angeordnet sind, wobei sich die Abschlusskappe (18) quer über mindestens einen Abschnitt der Brennkammer (10) erstreckt;
Strömen mindestens von einem eines ersten Brennstoffs oder einer ersten Verdünnung durch eine erste Kammer (50), wobei die erste Kammer (50) mindestens teilweise durch ein inneres Trägerrohr (40) definiert ist, das mit einer Oberfläche (28) stromabwärts der Abschlusskappe (18) verbunden ist; und Strömen mindestens von einem eines zweiten Brennstoffs oder einer zweiten Verdünnung durch eine zweite Kammer (52), die mindestens einen Abschnitt der ersten Kammer (50) am Umfang umgibt, wobei die zweite Kammer (52) mindestens teilweise durch ein äußeres Trägerrohr (42) definiert ist, das mit einer Oberfläche (26) stromaufwärts der Abschlusskappe (18) verbunden ist;
dadurch gekennzeichnet, dass die erste Kammer (50) in einer Fluidkommunikation mit dem ersten Satz (60) von Rohren (30) und die zweite Kammer (52) in einer Fluidkommunikation mit einem zweiten Satz (62) von Rohren (30) in Verbindung steht.

10. Verfahren nach Anspruch 9, das ferner ein Strömen eines dritten Brennstoffs innerhalb des inneren Trägerrohrs (40) umfasst.

11. Verfahren nach Anspruch 10, das ferner ein Strömen mindestens von einem des ersten Brennstoffs oder der ersten Verdünnung radial innerhalb der Abschlusskappe (18) stromabwärts von der zweiten Kammer (52) umfasst.

Revendications

1. Chambre de combustion (10), comprenant :

une coiffe terminale (16) ;
un chapeau terminal (18) en aval de ladite coiffe terminale (16) qui s'étend radialement en travers d'au moins une partie de la chambre de combustion (10), dans laquelle le chapeau terminal (18) comprend une surface amont (26) axialement séparée d'une surface aval (28) ;
une pluralité de tubes (30) qui s'étendent de la surface amont (26) à travers la surface aval (28) pour fournir une communication fluidique à travers le chapeau terminal (18) ;
un tube de support externe (42) qui s'étend en aval de la coiffe terminale (16) et se raccorde à la surface amont (28) du chapeau terminal (18) ;
un tube de support interne (40) qui s'étend en aval de la coiffe terminale (16) et se raccorde à la surface aval (28) du chapeau terminal (18) ;
un premier plénum (50) qui entoure le tube de support interne (40) entre la coiffe terminale (16) et la surface amont (26) avant de s'étendre radialement entre les surfaces amont et aval (26, 28) ;
un second plénum (52) qui entoure le premier plénum (50) entre la coiffe terminale (16) et la surface amont (26) avant de s'étendre radialement entre les surfaces amont et aval (26, 28) ; et
caractérisée en ce que le premier plénum (50) est en communication fluidique avec un premier ensemble de tubes (60) et le second plénum (52) est en communication fluidique avec un second ensemble de tubes (62).

2. Chambre de combustion selon la revendication 1, dans laquelle le premier plénum (50) s'étend radialement à l'intérieur du chapeau terminal (18) en aval du second plénum (52).

3. Chambre de combustion selon la revendication 1 ou 2, comprenant en outre une barrière (46) qui s'étend entre le premier et le second plénum (50, 52), dans laquelle la barrière (46) s'étend axialement entre le premier et le second plénum (50, 52) en amont de la surface amont (26).

4. Chambre de combustion selon la revendication 3, dans laquelle la barrière (46) s'étend radialement entre le premier et le second plénum (500, 52) en aval de la surface amont (26).

5. Chambre de combustion selon l'une quelconque des revendications 1 à 4, comprenant en outre un plénum de carburant (44) à l'intérieur du tube de support interne (40).

6. Chambre de combustion selon l'une quelconque des revendications précédentes, comprenant en outre un carter (12) qui entoure circonférentiellement au moins une partie du chapeau terminal (18) pour définir un passage annulaire (20) entre le chapeau terminal (18) et le carter (12) et un support s'étend (66) radialement entre le chapeau terminal (18) et le carter (12) dans le passage annulaire (20).

7. Chambre de combustion selon l'une quelconque des revendications précédentes, comprenant en outre un carénage de chapeau (68) qui entoure circonférentiellement le chapeau terminal (18).

8. Chambre de combustion selon la revendication 7, comprenant en outre un engagement à coulissement (70) entre le chapeau terminal (18) et le carénage de chapeau (68).

9. Procédé de fourniture de carburant à une chambre de combustion (10), comprenant :

l'écoulement d'un fluide de travail (14) à travers une pluralité de tubes (30) agencés radialement dans un chapeau terminal (18), dans lequel le chapeau terminal (18) s'étend radialement en travers d'au moins une partie de la chambre de combustion (10);
l'écoulement d'au moins l'un d'un premier carburant ou d'un premier diluant à travers un premier plénum (50), dans lequel le premier plénum (50) est au moins en partie défini par un tube de support interne (40) qui se raccorde à une surface aval (28) du chapeau terminal (18) ; et
l'écoulement d'au moins l'un d'un second carburant ou d'un second diluant à travers un second plénum (52) qui entoure circonférentiellement au moins une partie du premier plénum (50), dans lequel le second plénum (52) est au moins en partie défini par un tube de support externe (42) qui se raccorde à une surface amont (26) du chapeau terminal (18) ;
caractérisé en ce que le premier plénum (50) est en communication fluidique avec le premier ensemble (60) de tubes (30) et le second plénum (52) est en communication fluidique avec un second ensemble (62) de tubes (30).

10. Procédé selon la revendication 9, comprenant en outre l'écoulement d'un troisième carburant dans le tube de support interne (40).

11. Procédé selon la revendication 10, comprenant en outre l'écoulement d'au moins l'un du premier carburant ou du premier diluant radialement à l'intérieur du chapeau terminal (18) en aval du second plénum (52).

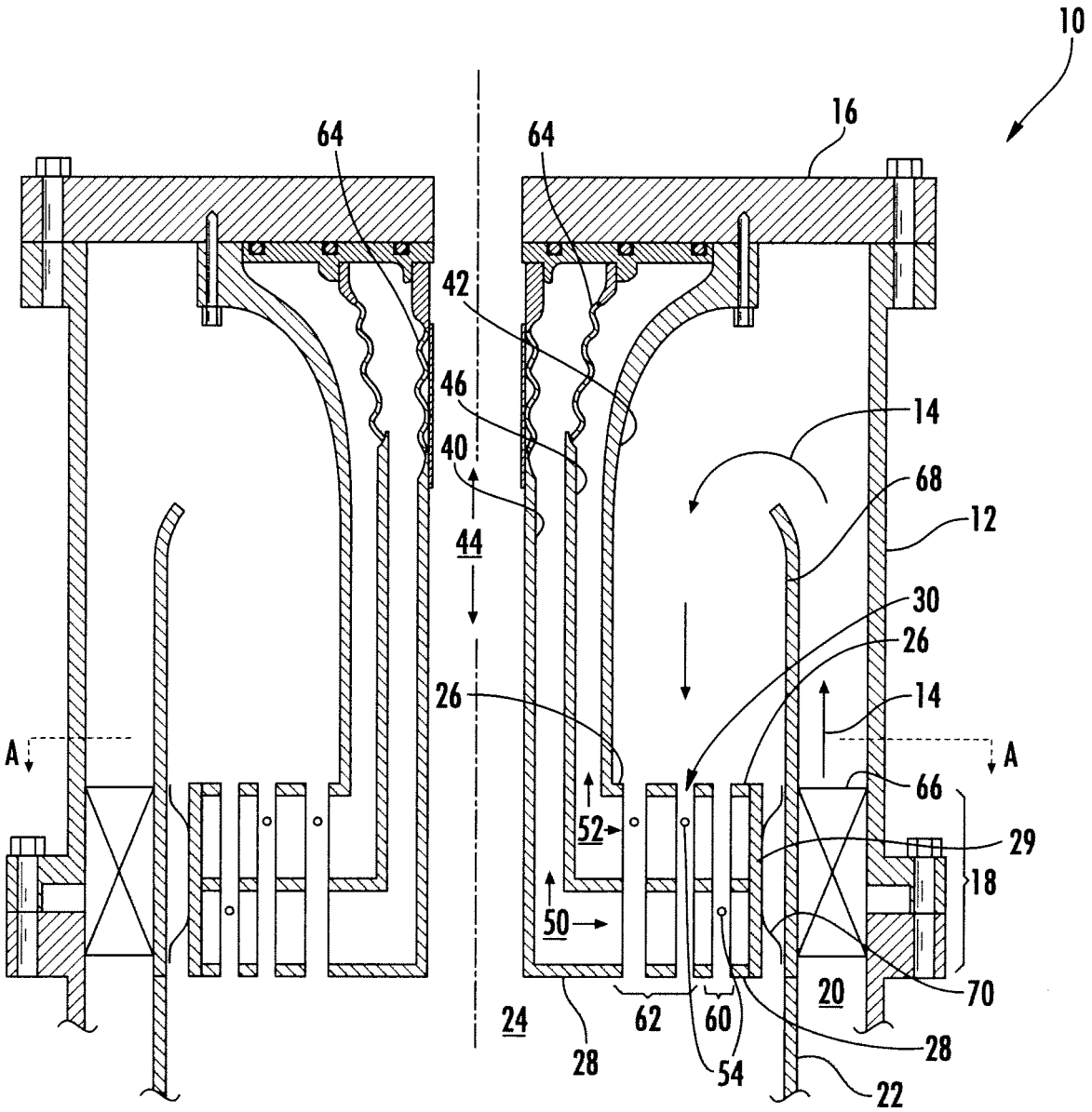

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FIG. 1

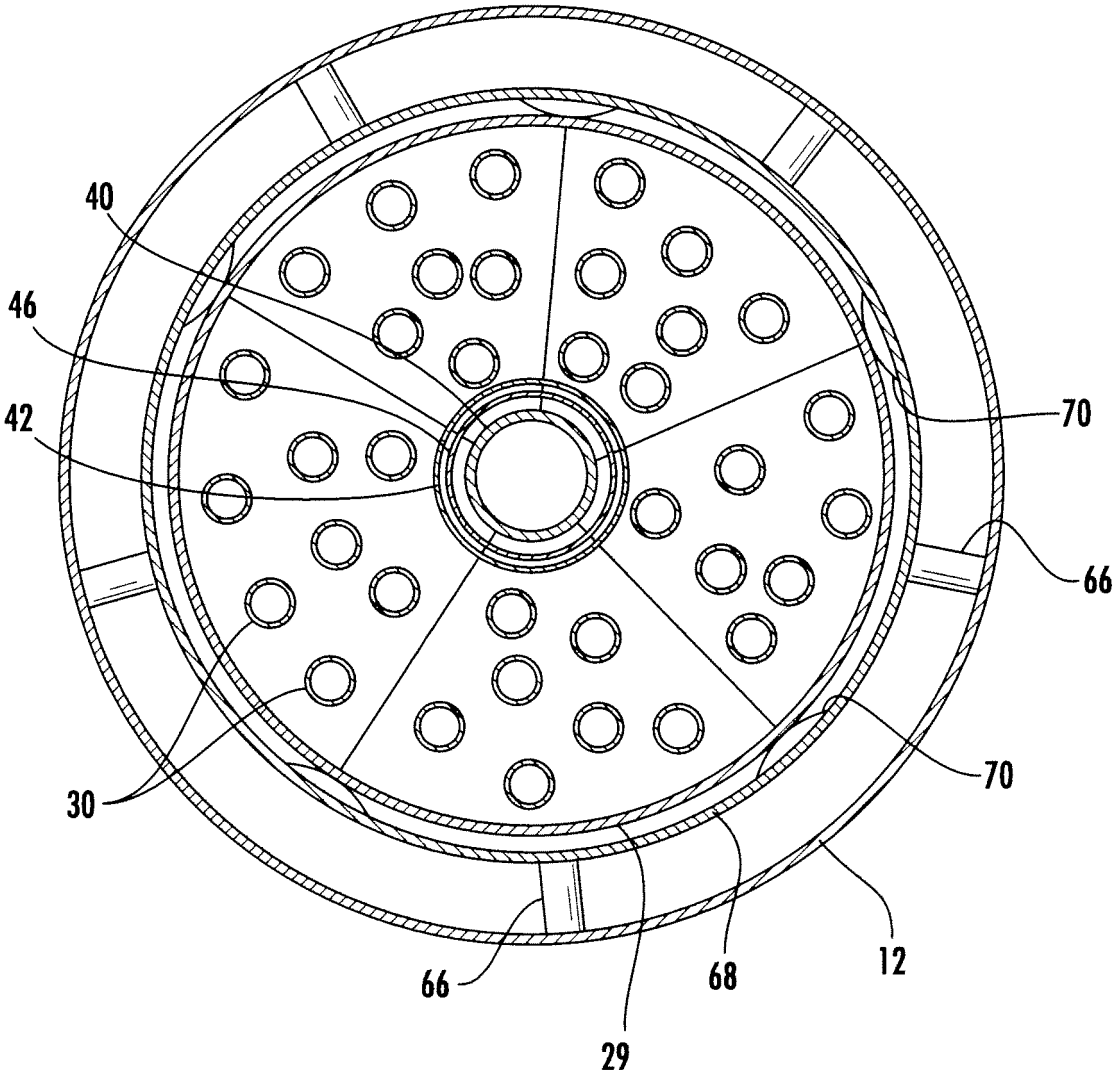


FIG. 2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 2197714 A **[0004]**
- US 201031662 B **[0005]**