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(54) **Late lean injection system**

(57) A late lean injection system (10) includes at least one fuel injector (18) disposed proximate a combustion zone. Also included is at least one guide (22) for directing an airflow (20) from a region proximate a compressor discharge exit (32) to the at least one fuel injector (18).

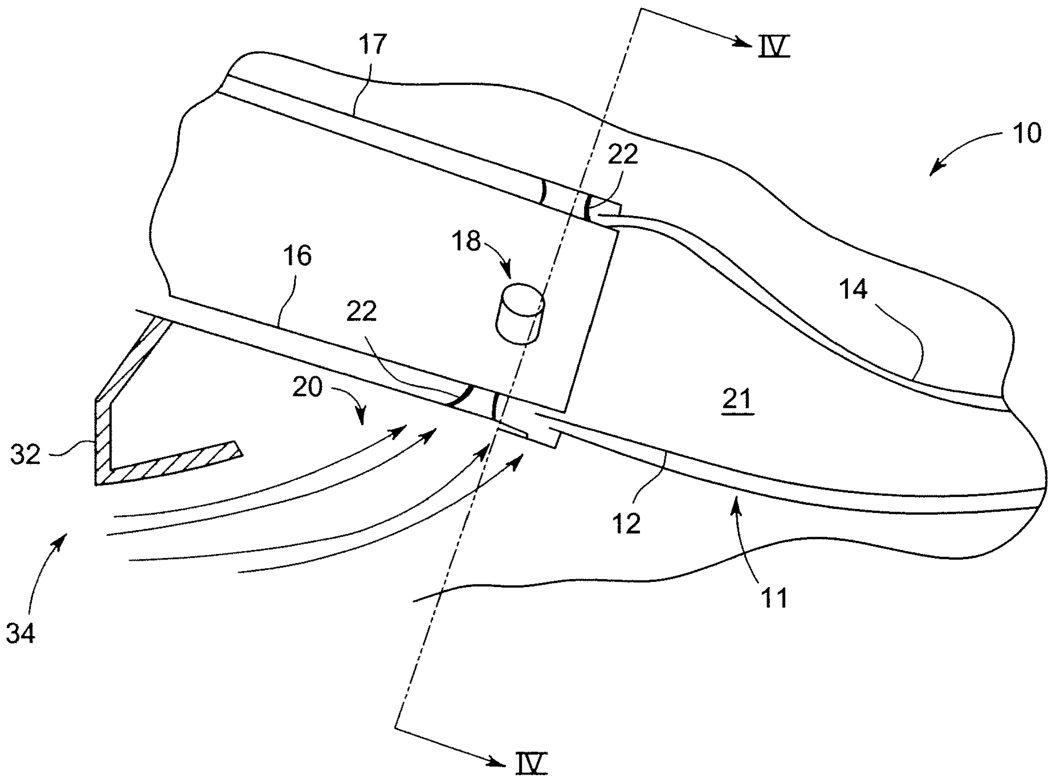

FIG. 1

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Description

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to turbines, and more particularly to late lean injection systems.

BRIEF DESCRIPTION OF THE INVENTION

[0002] According to one aspect of the invention, a late lean injection system includes at least one fuel injector disposed proximate a combustion zone. Also included is at least one guide for directing an airflow from a region proximate a compressor discharge exit to the at least one fuel injector.

[0003] According to another aspect of the invention, a late lean injection system includes a transition duct defining a transition interior, the transition duct having an end adapted for connection to a first turbine zone, and an opposite end. Also included is a sleeve spaced radially outward of the transition duct and extending circumferentially around the transition duct. Further included is at least one fuel injector configured to inject fuel into the transition interior. Yet further included is at least one guide for directing an airflow to the at least one fuel injector.

[0004] According to yet another aspect of the invention, a late lean injection system includes a transition duct having an upstream end and a downstream end. Also included is a liner duct disposed proximate the upstream end of the transition duct. Further included is a flowsleeve spaced radially outward of the liner duct and extending circumferentially around the liner duct. Yet further included is at least one fuel injector disposed proximate at least one of the transition duct and the liner duct. Also included is at least one guide for directing an airflow from a region proximate a compressor discharge exit to the at least one fuel injector.

[0005] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING

[0006] 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 an elevational, side view of a first embodiment of a late lean injection system having at least one fuel injector;

FIG. 2. is an elevational, side view of a second embodiment of the late lean injection;

FIG. 3 is an elevational, side view of a third embodiment of the late lean injection system;

FIG. 4 is a cross-sectional view of the late lean injection system having at least one guide;

FIG. 5 is a simplified view of an airflow penetration profile resulting from the at least one guide of FIG. 4;

FIG. 6 is a cross-sectional view of the late lean injection system having at least one guide of another embodiment; and

FIG. 7 is a simplified view of an airflow penetration profile resulting from the at least one guide of FIG. 6.

[0007] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0008] Referring to FIG. 1, a late lean injection system 10 of a first embodiment is illustrated. The late lean injection system 10 includes a transition piece assembly 11 of a gas turbine system that is operably connected between a combustor (not labeled) and a first turbine stage (not illustrated) and includes an interior 21 defined by a transition duct 12. The transition duct 12 carries hot combustion gases from the combustor, which is typically upstream of the transition duct 12, to an inlet of the turbine. At least a portion of the transition duct 12 may be surroundingly enclosed by an impingement sleeve 14 that is spaced radially outward of the transition duct 12. Upstream of the transition piece assembly 11 is a liner duct 16. The interior region of the liner duct 16 and the transition duct 12 comprises a combustion zone, wherein combustion of the hot gases occurs and is directed toward the turbine. At least a portion of the liner duct 16 is surroundingly enclosed by a flowsleeve 17 that is spaced radially outward of the liner duct 16. A compressor discharge casing 32 is illustrated and includes a compressor discharge exit 34.

[0009] The combustor of the gas turbine is late lean injection (LLI) compatible. An LLI compatible combustor is any combustor with either an exit temperature that exceeds 2500°F or handles fuels with components that are more reactive than methane with a hot side residence time greater than 10 milliseconds (ms).

[0010] Referring to FIG. 2, the late lean injection system 10 of a second embodiment is illustrated. The late lean injection system 10 of the second embodiment is similar to that of the first embodiment, however, does not include an impingement sleeve 14 that surroundingly encloses the transition duct 12.

[0011] Referring to FIG. 3, the late lean injection system 10 of a third embodiment is illustrated. The late lean injection system 10 of the third embodiment comprises merely a single duct, that being the transition duct 12 that extends upstream to a region that included the liner duct 16 in the first and second embodiments. Furthermore, a single sleeve, referred to generally as a sleeve 19 surroundingly encloses the transition duct 12 at a location radially outward of the transition duct 12.

[0012] Irrespective of the embodiment employed in the gas turbine system, a plurality of fuel injectors 18 are each integrated with or structurally supported by a plurality of housings that extend radially into at least one of the transition duct 12 or the liner duct 16. The plurality of fuel injectors 18 extend through the respective duct, i.e., the transition duct 12 or the liner duct 16, to varying depths. That is, the fuel injectors 18 are each configured to supply a second fuel (i.e., LLI fuel) to the combustion zone through fuel injection in a direction that is generally transverse to a predominant flow direction through the transition duct 12 and/or the liner duct 16. For each of the above-described embodiments, it is emphasized that the plurality of fuel injectors 18 may be disposed proximate the transition duct 12 or the liner duct 16, in spite of the illustrated embodiments showing disposal of the plurality of fuel injectors 18 disposed in connection with only one of the transition duct 12 and the liner duct 16. Furthermore, the plurality of fuel injectors 18 may be disposed in connection with both the transition duct 12 and the liner duct 16. The plurality of fuel injectors 18 may be disposed in a single axial circumferential stage that includes multiple currently operating fuel injectors 18 respectively disposed around a circumference of a single axial location of the transition duct 12 and/or the liner duct 16. It is also conceivable that the plurality of fuel injectors 18 may be situated in a single axial stage, multiple axial stages, or multiple axial circumferential stages. A single axial stage includes a currently operating single fuel injector 18. A multiple axial stage includes multiple currently operating fuel injectors 18 that are respectively disposed at multiple axial locations. A multiple axial circumferential stage includes multiple currently operating fuel injectors 18, which are disposed around a circumference of the transition duct 12 and/or the liner duct 16 at multiple axial locations thereof.

[0013] Airflow from a compressor enters into a compressor discharge casing 32. A high pressure dynamic airflow 20 exits the compressor discharge casing 32 proximate a compressor discharge exit 34 and rushes downstream toward the transition duct 12 and/or the liner duct 16 to locations proximate the fuel injectors 18. To reduce the pressure drop of airflow within the fuel injectors 18, where mixing of the air and LLI fuel occurs and penetrates into the transition duct 12 and/or the liner duct 16, it is advantageous to harness the high pressure dynamic airflow 20 into the fuel injectors 18.

[0014] Referring to FIG. 4, a cross-sectional view of an axial location of the late lean injection system 10 is illustrated. The impingement sleeve 14 and/or the flowsleeve 17, or the transition duct 12 in the case of the embodiment illustrated in FIG. 2, includes one or more guides 22 to redirect the high pressure dynamic airflow 20 into the fuel injectors 18. In the illustrated example, the guides 22 are in the form of scoops that are positioned to correspond to the fuel injectors 18. Based on this correspondence to the fuel injectors 18, the guides may be disposed in a single axial circumferential stage, a single axial stage, a multiple axial stage, or a multiple axial circumferential stage, as is the case with the fuel injectors 18. The impingement sleeve 14 and/or the flowsleeve 17 include apertures 24 that correspond to the fuel injectors 18 and the guides 22 are positioned proximate the apertures 24. A typical scoop can either fully or partially surround each aperture 24 or partially or fully cover the aperture 24 and be generally part-spherical in shape. For example, the scoop may be in the shape of a half cylinder with or without a top. Alternatively, the guides 22 may take the form of various other shapes that provide a similar functionality, specifically harnessing of the high pressure dynamic airflow 20. Furthermore, the guides 22 may be disposed radially inward of the impingement sleeve 14 and/or the flowsleeve 17 and may be in direct connection with the plurality of fuel injectors 18 in embodiments where a sleeve is not present.

[0015] Irrespective of the exact shape of the guide 22, the guides 22 may be attached individually proximate the impingement sleeve 14 and/or flowsleeve 17, or the transition duct 12 in the case of the embodiment illustrated in FIG. 2, so as to direct the compressor discharge air radially inboard, through the guides 22, apertures 24, into the fuel injectors 18, and projecting into the transition duct 12 and/or the liner duct 16. As the high pressure dynamic airflow 20 rushes into the guides 22, the airflow 20 is quickly turned and redirected inboard. Such a redirection may lead to turning vortices within the airflow, thereby hindering the flow into the fuel injector 18. To reduce the formation of such turning vortices, each guide 22 may include one or more straightening vanes 26 proximate a bend 28 in the guide 22.

[0016] Referring to FIG. 5, a penetration profile of the mixed airflow and LLI fuel is illustrated. The harnessing of the high pressure dynamic airflow 20 allows deeper penetration of the late lean injection into the combustion zone.

[0017] In operation, airflow is channeled toward the fuel injectors 18 by the guides 22 that project out into the high pressure dynamic airflow 20 passing the impingement sleeve 14 and/or the flowsleeve 17 of the transition duct 12 and/or the liner duct 16. The guides 22, by a combination of stagnation and redirection, catch air that would previously have passed the apertures 24 aligned with the fuel injectors 18 due to the lack of static pressure differential to drive the flow through them, and directs the airflow 20 inward into the fuel injectors 18 to mix with LLI fuel, and into the transition duct 12 and/or the liner duct 16, thus producing deeper penetration into the combustion zone.

[0018] Referring now to FIG. 6, another embodiment of the guides 122 is illustrated. The guides 122 are substantially longer than the above-described guides 22 in the form of scoops or the like. The guides 122 function similarly to guides 22, such that high pressure dynamic airflow 120 is directed from a compressor discharge exit 133 to one or more fuel injectors 118. The guides 122 include a first end 130 disposed proximate the compressor discharge exit 133 and a second end 132 disposed proximate an aperture 124 of an impingement sleeve 114 and/or a flowsleeve 117, where the aperture 124 is relatively aligned with an inlet 134 of each fuel injector 118. The guides 122 function as passages that take the high pressure dynamic airflow 120 to the fuel injectors 118. Each guide 122 may be mounted to numerous components within the gas turbine assembly including, but not limited to, a compressor discharge casing 131 or various other combustion hardware components.

[0019] The contour of the guides 122 as they extend from the first end 130 to the second end 132 may vary based on the specific application of use. One typical contour comprises a substantially elongated straight portion 136 extending from a region proximate the first end 130 and a bend portion 128 that functions to transition the airflow 120 from the substantially elongated straight portion 136 to the inlet 134 of the fuel injector 118. As with the scoop guides 22, such a bend portion 128 may impose turning vortices on the airflow. To reduce the occurrence of such vortices, the bend portion 128 may include one or more straightening vanes 126.

[0020] Referring to FIG. 7, a penetration profile of the mixed airflow and LLI fuel is illustrated. The harnessing of the high pressure dynamic airflow 120 allows deeper penetration of the late lean injection into the combustion zone.

[0021] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

Claims

1. A late lean injection system (10) comprising:

> at least one fuel injector (18) disposed proximate a combustion zone; and
> at least one guide (22) for directing an airflow (20) from a region proximate a compressor discharge exit (34) to the at least one fuel injector (18).

2. The late lean injection system of claim 1, further comprising a transition duct (12).

3. The late lean injection system of claim 2, wherein the at least one fuel injector (18) is disposed proximate the transition duct (12) and is configured to inject a fuel into the combustion zone.

4. The late lean injection system of any of claims 1 to 3, further comprising a liner duct (16), wherein the at least one fuel injector (18) is disposed proximate the liner duct (16) and is configured to inject a fuel into the combustion zone.

5. The late lean injection system of any of claims 1 to 4, wherein the at least one guide (122) includes a first end (130) disposed proximate the compressor discharge exit (34) and a second end (132) disposed proximate the at least one fuel injector (118).

6. The late lean injection system of any of claims 1 to 5, wherein the at least one guide (122) comprises a bend (128) proximate the at least one fuel injector (118).

7. The late lean injection system of claim 6, wherein the at least one guide (122) comprises at least one straightening vane (126) proximate the bend (128).

8. The late lean injection system of any of claims 1 to 7, wherein the at least one guide (122) is operably connected to a compressor discharge casing (32).

9. The late lean injection system of any of claims 1 to 8, further comprising a plurality of fuel injectors (118), wherein the plurality of fuel injectors (118) are circumferentially spaced at a single axial location.

10. The late lean injection system of any of claims 1 to 8, further comprising a plurality of fuel injectors (118), wherein the plurality of fuel injectors (118) are circumferentially spaced a plurality of axial locations.

11. The late lean injection system comprising of any of claims 2 to 10, wherein the transition duct (12) defines a transition interior (21), the transition duct (12) having an end adapted for connection to a first turbine zone, and an opposite end; and further comprising:

> a sleeve (14) spaced radially outward of the transition duct (12) and extending circumferentially around the transition duct (12), wherein the least one fuel injector (18) is configured to inject fuel into the transition interior.

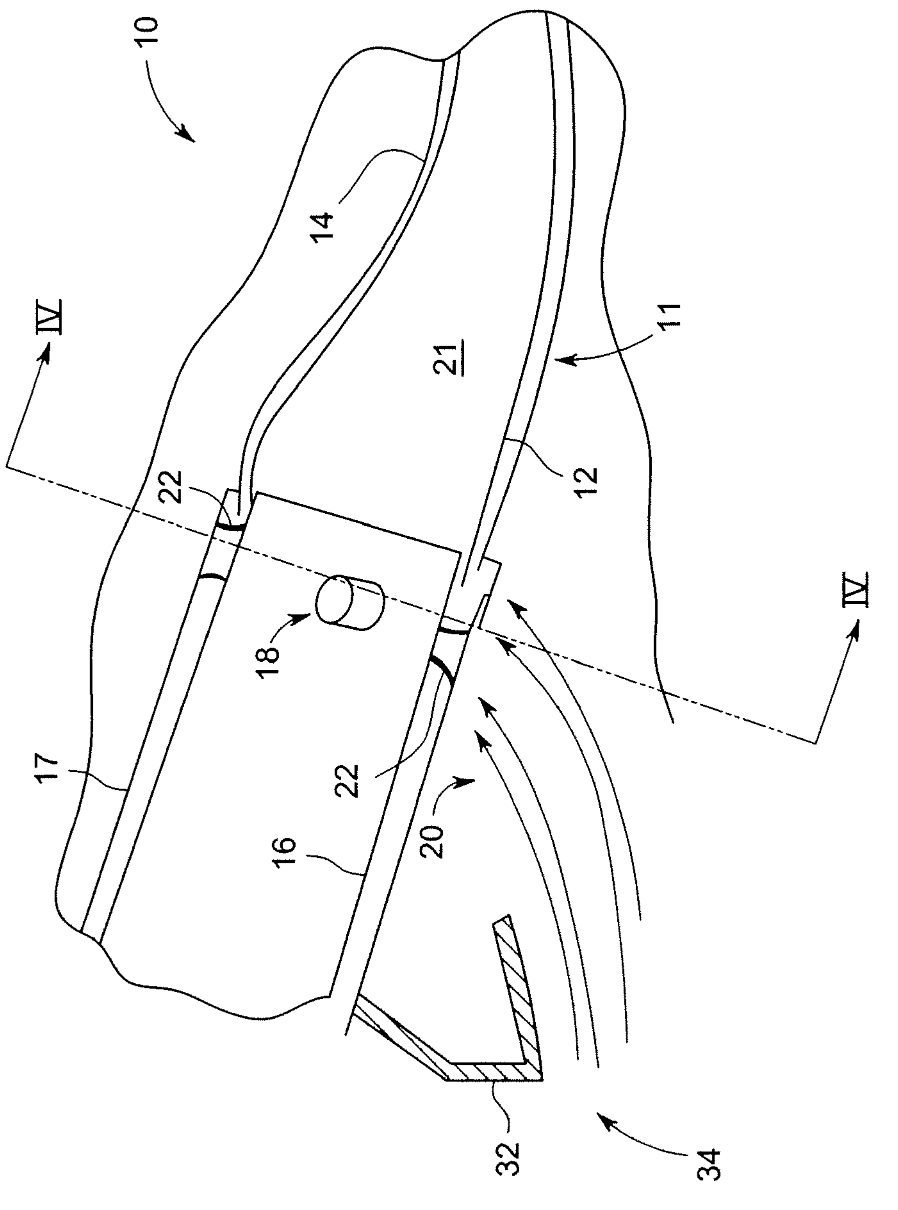

FIG. 1

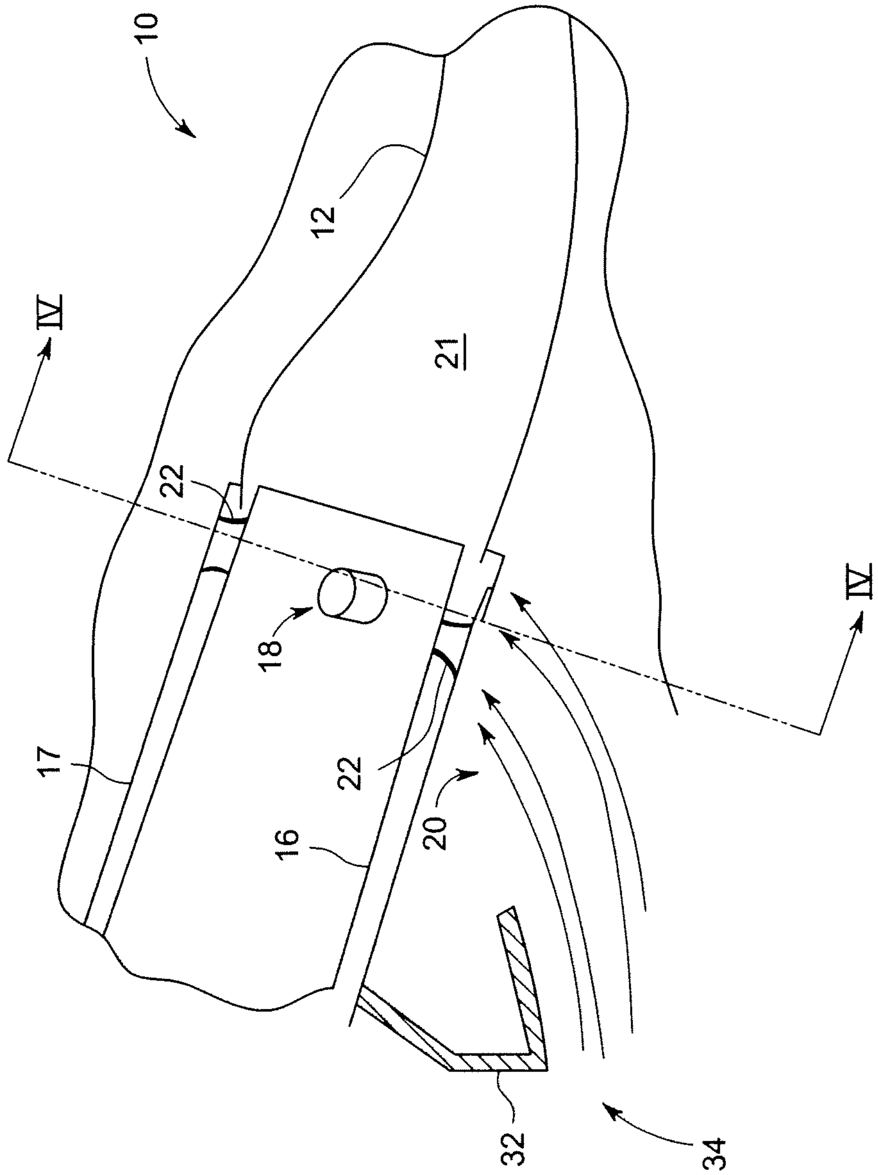

FIG. 2

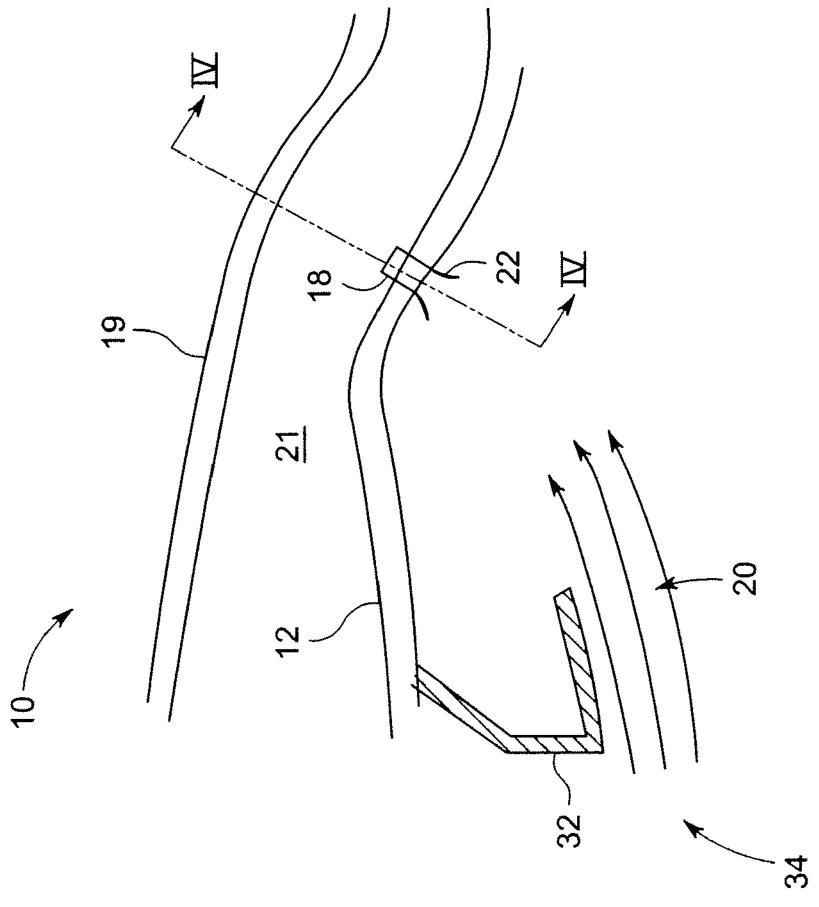

FIG. 3

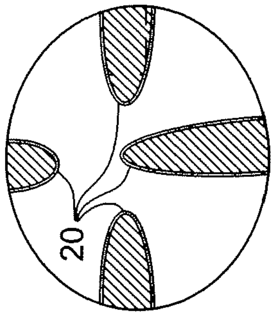

FIG. 5

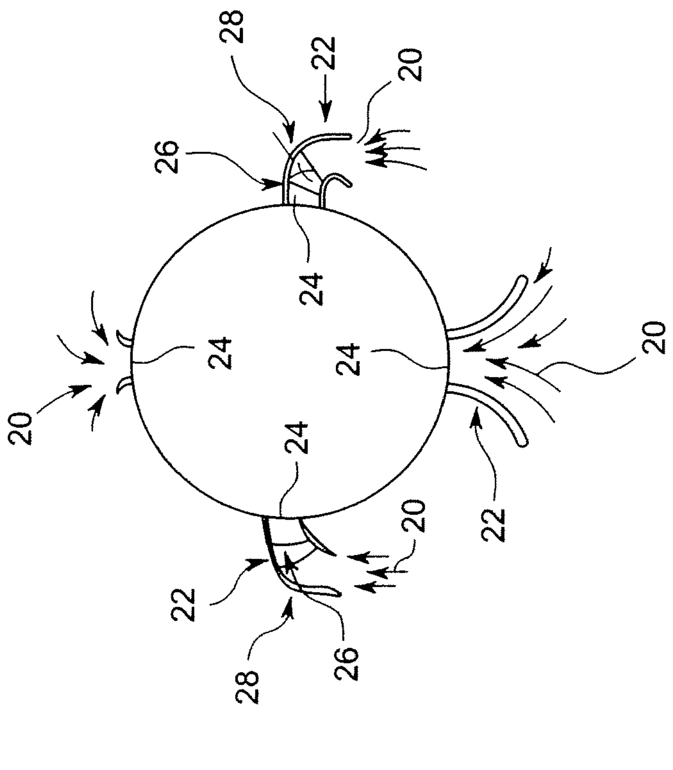

FIG. 4

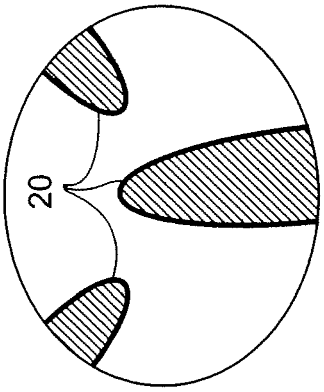
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FIG. 7

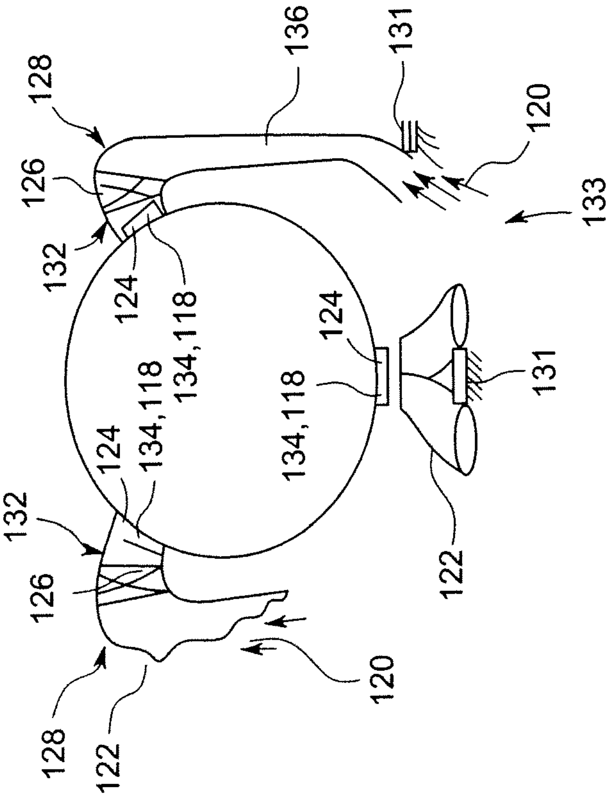
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FIG. 6