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(54) **Combustor**

(57) A combustor (10) includes a combustion chamber (12) and at least one group (26) of at least two burner jets (28) disposed circumferentially about the combustor (10). The at least two burner jets (28) within a group (26) are generally coplanar and are spaced about equal dis-

tances circumferentially. Each of the at least two burner jets (28) within a group (26) is oriented to direct a flow of a fluid at a corresponding tangential point (26-39) of an associated imaginary circle (40) within the combustion chamber (12) to induce a generally cyclonic flow (44) pattern within the combustion chamber (12).

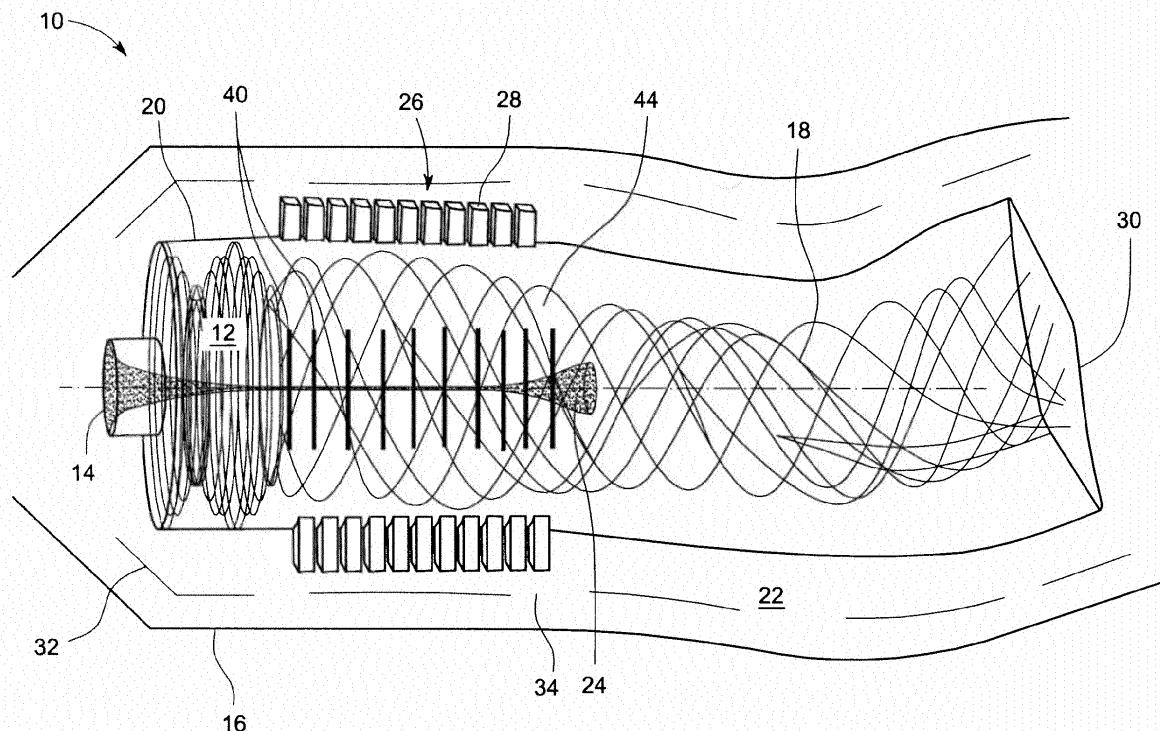


FIG. 1

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Description

BACKGROUND OF THE INVENTION

[0001] The invention is directed to a combustor of a turbine, and, more particularly, to air flow within a combustor resulting from a configuration of burner jets that inject a fuel and air mixture into the combustor in a generally radial orientation.

[0002] A combustor typically includes a combustion chamber, a swirler, and a shell. The combustion chamber is generally cylindrical in shape about a centerline. The combustion chamber is defined by a liner, which is disposed within the shell. A path or opening for air flow from a turbine compressor is provided between the liner and the shell. The swirler is located at an upstream end of the combustion chamber, typically about the centerline. Air flow from the turbine compressor is passed through the swirler, where it is rotated to form a vortex flow pattern within the combustion chamber. Burner jets are positioned at the upstream end of the combustion chamber to inject a fuel and air mixture into a combustion chamber. The burner jets directed a fuel and air mixture longitudinally into the combustion chamber. The fuel and air mixture then combusts within the combustion chamber with heat exiting at a downstream or exhaust end of the combustion chamber to an exhaust. To enhance heat transfer of the liner, an impingement cooling configuration is often employed. This cooling dissipates the heat load for more uniform temperature distribution in the combustion region, and thusly more efficient combustion. It would be advantageous to further improve the operating efficiency and to further reduce the emissions of the combustor.

BRIEF DESCRIPTION OF THE INVENTION

[0003] According to one aspect of the invention, a combustor comprising a combustion chamber and a group of at least two burner jets disposed circumferentially about the combustor is presented. The at least two burner jets are generally coplanar and are spaced about equal distances circumferentially. Each of the at least two burner jets is oriented to direct a flow of a fluid at a corresponding tangential point of an imaginary circle within the combustion chamber to induce a generally cyclonic flow pattern within the combustion chamber.

[0004] According to another aspect of the invention, a method of inducing a generally cyclonic flow pattern within a combustion chamber of a combustor is presented. The method comprising directing a first flow of a fluid at a first tangential point of a first imaginary circle within the combustion chamber and directing a second flow of a fluid at a second tangential point of the first imaginary circle within the combustion chamber. The first and second tangential points of the first imaginary circle are spaced about equal distances circumferentially. The first and second flows cooperate to induce the generally cyclonic flow pattern within the combustion chamber.

[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 a diagrammatic view of a combustor of the present invention;

FIG. 2 is a diagrammatic view of the direction of flow from a group of burner jets into a combustor chamber of the combustor of FIG. 1; and

FIG. 3 is a diagrammatic view of the combustor of FIG. 1 including additional groups of burner jets.

[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 combustor 10 is generally shown. The combustor 10 includes a combustion chamber 12, a swirler 14, and a shell 16. The combustion chamber 12 is generally cylindrical in shape about a centerline 18. The combustion chamber 12 is defined by a liner 20, which is disposed within the shell 16. A path or opening 22 for a portion of air flow from a turbine compressor (not shown) is provided between the liner 20 and the shell 16. The swirler 14 is located at an upstream end of the combustion chamber 12, typically about the centerline 18. Air flow from the turbine compressor (not shown) is passed through the swirler 14, where it is rotated to form a vortex flow pattern 24 within the combustion chamber 12. In the prior art, burner jets were positioned at the upstream end of the combustion chamber to inject a fuel and air mixture into a combustion chamber, such being well known. These prior art burner jets directed a fuel and air mixture longitudinally into the combustion chamber. The disclosure hereof includes a departure from this prior art practice by employing groups 26 of burner jets 28 disposed circumferentially about the combustion chamber 12 to inject a fuel and air mixture generally radially, as is described more fully below. The fuel and air mixture then combusts within the combustion chamber 12 with heat exiting at a downstream or exhaust end of the combustion chamber 12 to an exhaust 30. To enhance heat transfer of the liner 20 an impingement sleeve 32 is affixed between the liner 20 and the shell 16. The impingement plate 32 has a plurality of openings or passages 34 that inject the turbine air (or a cooling fluid) about the backside of the liner 20. Cooling can also be directed towards the burner jets 28. The cooling fluid

dissipates the heat load for more uniform temperature distribution in the combustion region, and thusly more efficient combustion. This use of impingement cooling generates a more uniform thermal loading reducing thermal strain on the combustor 10.

[0009] Each group 26 of burner jets 28 is mounted at the liner 20 of the combustion chamber 12, with each burner jet 28 from a group 26 being coplanar and spaced circumferentially generally equal distant about the combustion chamber 12 from burner jets 28 in adjacent groups 26. Each group 26 of burner jets 28 comprises four (or more) burner jets 28 equally spaced circumferentially about the combustion chamber 12 and form an X pattern when view cross-sectionally.

[0010] Referring also to FIG. 2, with respect to any one group 26 of burner jets 28 equally spaced circumferentially about the combustion chamber 12, they are oriented to direct the fuel and air mixture at tangential points 36 - 39 on an imaginary circle 40 within the combustion chamber 12. The imaginary circle 40 is located about the vortex 24 generated by the swirler 14, discussed above. From a cross-sectional view, FIG. 3, the tangential points 36 - 39 are located in an X configuration such being indicated by the broken line X 42. The imaginary circle 40 is shown in the present example as being centered on the centerline 18 of the combustion chamber 12. For each such group there is a corresponding imaginary circle 40. These circles 40 can have the same diameter or varying diameters, for example, the circles 40 can increase or decrease in diameter as they move longitudinally downstream (toward the exhaust end) in the combustion chamber 12. Also, the diameters of the circles 40 and/or the volume of the fuel and mixture injected by individual burner jets 28 can be set or controlled to improve performance. This includes acoustic dynamics (e.g., frequency locking), emission reduction, power, fuel economy, and others.

[0011] Injecting the fuel and air mixture into the combustion chambers with this configuration of burner jets 28 generates a generally cyclonic flow pattern 44 longitudinally within the combustion chamber 12. Further, the burner jets 28 can be configured to provide a leaner fuel air mixture about an outer portion of the spray and a richer fuel air mixture towards the center of the spray, also to achieve a desired performance. Groups 26 of burner jets 28 can be aligned, such that corresponding burner jets 28 from adjacent groups 26 for a line of burner jets longitudinally. Alternatively, groups 26 of burner jets 28 can be shifted or rotated relative to adjacent groups 28, to achieve a desired performance or flow pattern.

[0012] While a group 26 of burner jets 28 has been described in the above exemplary embodiment as four or more burner jets 28, it is within the scope of the invention that a group 26 of burner jets 28 includes at least two burner jets 28. By way of example, a group 26 may include burner jets 36 and 38 or burner jets 37 and 39 to generate the generally cyclonic flow pattern 44.

[0013] The generally cyclonic flow pattern 44 is around

the vortex flow pattern 24 generated by the swirler 14, which results in a reduction in vortex breakdown within the combustion chamber 12. Maintaining the vortex flow pattern 24 improves the stability of flow and combustion within the combustion chamber 12. Also, the use of impingement cooling as discussed above further aids in maintaining the integrity of the combustor 10. Impingement cooling is preferred in this exemplary embodiment, instead of ingesting additional air into the combustion chamber 12, which may disturb the desired flow patterns. Further, the generally cyclonic flow pattern 44 generates a larger swirling flame that is easier to control and less dynamic than the flame generated with the vortex flow pattern 24 alone. The generally cyclonic flow pattern 44 reduces the vortex flow pattern 24 breakdown, thereby increasing flame stability. Greater flame stability reduces lean blowout and increases the turn down of the combustor 10. Also, aerothermal acoustics will be reduced, the operation window increased, and result in a wide Wobbe index.

[0014] Also, the cyclonic introduction of the fuel and air mixture of the invention allows exhaust fuel gases to interact more intensely with the fresh fuel and air mixture, by creating a gas recirculation effect within the combustion chamber 12. The recirculation directs combusted gases from the combustor 10 exit back upstream towards generally the center of the combustor, which then flow outward radially along the combustor 10 downstream. When combusted gases meet the fresh fuel and air mixture, they ignite the mixture streams and increase residence time for burnt out fuel. A portion of the burnt gases are then discharged to the exhaust and a portion of the gases will continue circle back toward the upstream. This recirculation provides a steady ignition source for the fresh fuel and air mixture from the burner jets 28 and carries NOx (nitric oxides) from the combustion when it mixes with the fresh fuel and air mixture. The concentration of NOx in the mixture moves the chemical reactions toward the reduction of NOx; therefore, the recirculation produces lower air emissions. This recirculation results in lower combustion temperatures, which reduces NOx emissions that form during combustion. It is well known that NOx emissions increase exponentially as inlet temperatures of the combustor increases. It has become important to reduce NOx emissions, as the potential for pollution has become an increasing governmental concern.

[0015] Referring to FIG. 3, in an alternative embodiment an additional group 26 of burner jets 28 can be provided downstream to achieve later lean, fuel staging, or air staging for further abating emissions.

[0016] 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 com-

mensurate 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 combustor (10) comprising:

a combustion chamber (12); and
a first group (26) of at least two burner jets (28) disposed circumferentially about the combustor (10) and being generally coplanar, the at least two burner jets (28) being spaced about equal distances circumferentially, each of the at least two burner jets (28) oriented to direct a flow of a fluid at a corresponding tangential point (36-39) of a first imaginary circle (40) within the combustion chamber (12) to induce a generally cyclonic flow pattern (44) within the combustion chamber (12).

2. The combustor of claim 1 further comprising:

a second group (26) of at least two burner jets (28) disposed circumferentially about the combustor (10) downstream from the first group (26) of at least two burner jets (28), the at least two burner jets (28) of the second group being generally coplanar, the at least two burner jets (28) of the second group being spaced about equal distances circumferentially, each of the at least two burner jets (28) of the second group being oriented to direct a flow of a fluid at a corresponding tangential point (36-39) of a second imaginary circle within the combustion chamber (12) to further induce the generally cyclonic flow pattern (44) within the combustion chamber (12).

3. The combustor of claim 2, wherein each of the at least two burner jets (28) of the first group (26) is collinear with a corresponding one of each of the at least two burner jets (28) of the second group (26).

4. The combustor of any of claims 1 to 3, wherein the combustor (10) has a center-line (18) and the first and/or second imaginary circles (40) are generally centered on the center-line (18).

5. The combustor of any of claims 2 to 4 wherein the first and second imaginary circles (40) have generally the same diameter.

6. The combustor of any of claims 2 to 4, wherein the

diameter of the first imaginary circle (40) is greater than or less than the diameter of the second imaginary circle (40).

7. The combustor of any preceding claim, further comprising:

an impingement sleeve (32) disposed within the combustor (10), the impingement sleeve (32) including passages (34) to provide cooling for the combustor (10).

8. The combustor of any preceding claim, wherein the first group (26) of at least two burner jets (28) comprises four burner jets.

9. The combustor of any of claims 2 to 8, wherein the first group (26) of at least two burner jets (28) comprises four burner jets and the second group (26) of at least two burner jets (28) comprises four burner jets.

10. The combustor of any preceding claim, further comprising:

a swirler (14) disposed at one end of the combustor (10) for inducing a generally vortex flow pattern (24) within the combustion chamber (12), and
wherein the generally cyclonic flow pattern (44) is generally about the generally vortex flow pattern (24) and interacts therewith.

11. A method of inducing a generally cyclonic flow pattern (44) within a combustion chamber (12) of a combustor (10), the method comprising:

directing a first flow of a fluid at a first tangential point (36-39) of a first imaginary circle (40) within the combustion chamber (12); and
directing a second flow of a fluid at a second tangential point (36-39) of the first imaginary circle (40) within the combustion chamber (12), the first and second tangential points (36-39) of the first imaginary circle (40) are spaced about equal distances circumferentially; wherein the first and second flows cooperate to induce the generally cyclonic flow pattern (44) within the combustion chamber (12).

12. The method of claim 11 further comprising:

directing a third flow of a fluid at a first tangential point (36-39) of a second imaginary circle (40) within the combustion chamber (12), the second imaginary circle (40) being downstream of the first imaginary circle (40);
directing a fourth flow of a fluid at a second tan-

gential point (36-39) of the second imaginary circle (40) within the combustion chamber (12), the first and second tangential points (36-39) of the second imaginary circle (40) are spaced about equal distances circumferentially; and wherein the third and fourth flows cooperate to further induce the generally cyclonic flow pattern (44) within the combustion chamber (12).

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13. The method of claim 12, wherein each of the first and second tangential points (36-39) of the first imaginary circle (40) are collinear with a corresponding one of each of the first and second tangential points (3-39) of the second imaginary circle (40).

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14. The method of claim 12 or 13, wherein the first and second imaginary circles (40) have generally the same diameter, the diameter of the first imaginary circle is greater than the diameter of the second imaginary circle, or the diameter of the first imaginary circle is less than the diameter of the second imaginary circle.

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15. The method of any of claim 11 to 14, further comprising impingement cooling the combustor (10).

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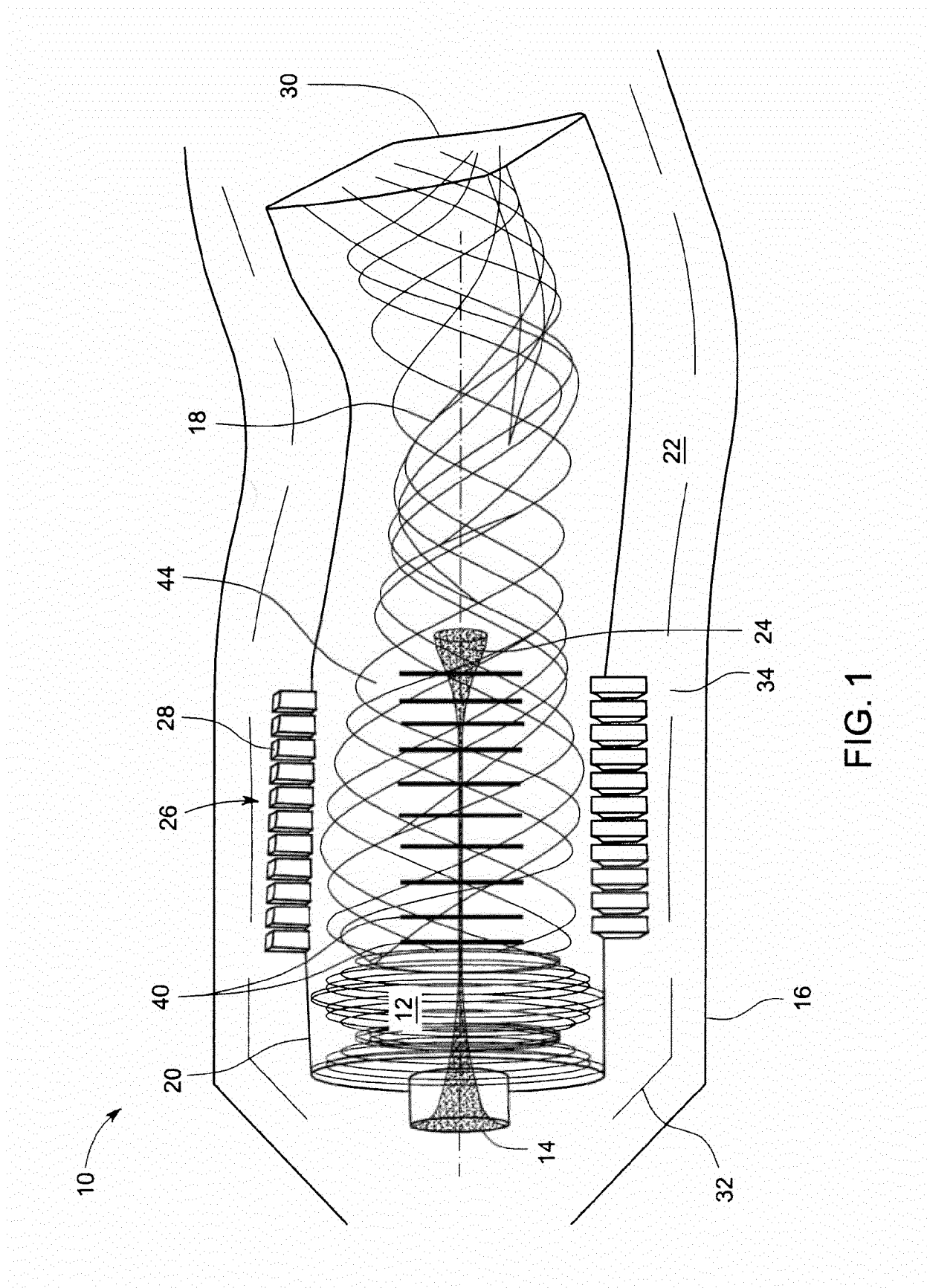
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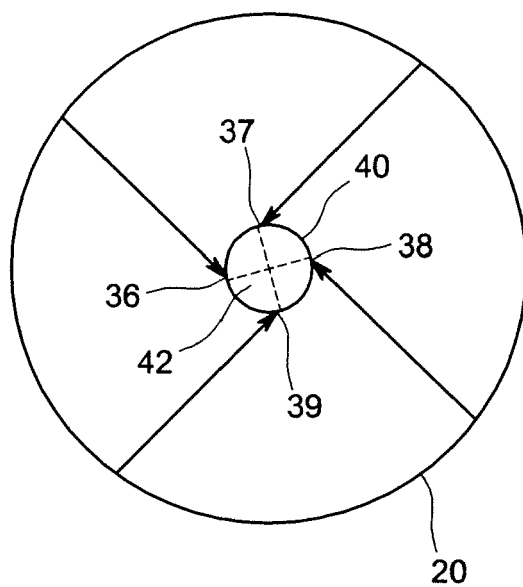


FIG. 2

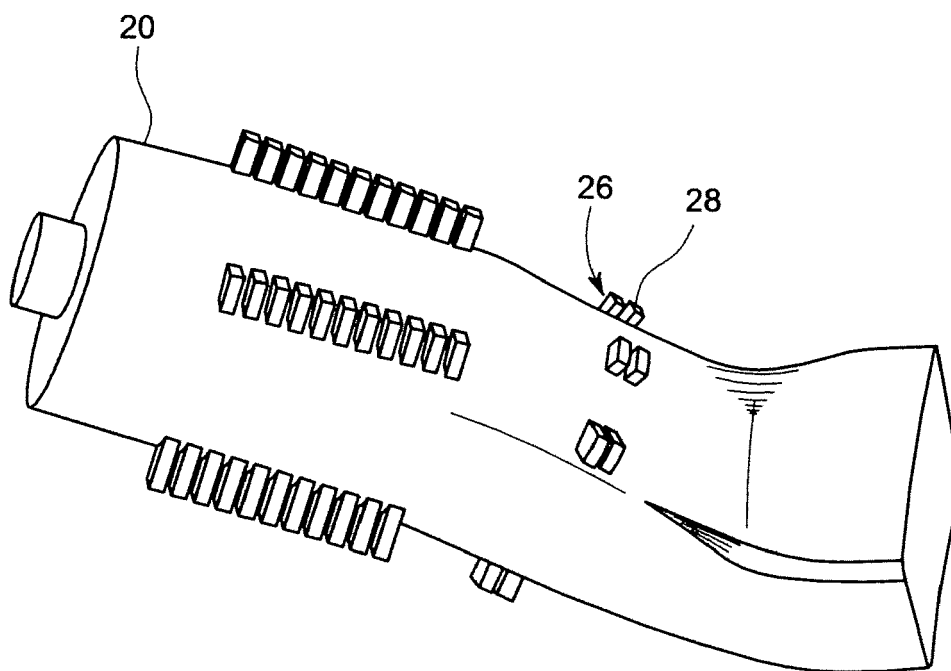


FIG. 3