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(54) **Turbine exhaust diffuser**

(57) A turbine exhaust diffuser (26) includes a diffuser component disposed within the turbine exhaust diffuser and having an outer surface. Also included is a suction path (52) extending between the outer surface and an interior compartment of the diffuser component, wherein the suction path is configured to ingest a fluid. Further

included is an actuating path (58) extending between the outer surface and the interior compartment of the diffuser component, wherein the actuating path (58) is configured to expel the fluid. Yet further included is a flow manipulating device (54) disposed within the interior compartment of the diffuser component.

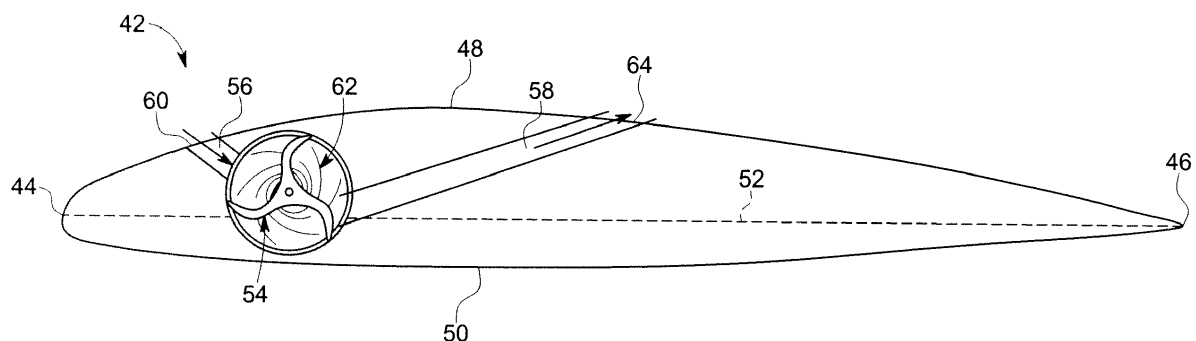


FIG. 3

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Description

[0001] The subject matter disclosed herein relates to turbine systems, and more particularly to boundary layer flow control of turbine exhaust diffuser components.

[0002] Typical turbine systems, such as gas turbine systems, for example, include an exhaust diffuser coupled to a turbine section of the turbine system to increase efficiency of a last stage bucket of the turbine section. The exhaust diffuser is geometrically configured to rapidly decrease the kinetic energy of flow and increase static pressure recovery within the exhaust diffuser.

[0003] Commonly, the exhaust diffuser is designed for full load operation, however, the turbine system is often operated at part load. Therefore, part load performance efficiency is sacrificed, based on the full load design. Such inefficiency is due, at least in part, to flow separation on exhaust diffuser components, such as an inner barrel and radially extending struts, for example. Flow separation often is caused, in part, by swirling of the flow upon exit of the last bucket stage of the turbine section and entry into the exhaust diffuser. The magnitude of swirl may be quantified as a "tangential flow angle," and such an angle may be up to about 40 degrees, which leads to a higher angle of attack on the exhaust diffuser components, such as the radially extending struts, for example. Such a flow characteristic leads to boundary layer growth and flow separation and eventually reduced pressure recovery.

[0004] According to one aspect of the invention, a turbine exhaust diffuser includes a diffuser component disposed within the turbine exhaust diffuser and having an outer surface. Also included is a suction path extending between the outer surface and an interior compartment of the diffuser component, wherein the suction path is configured to ingest a fluid. Further included is an actuating path extending between the outer surface and the interior compartment of the diffuser component, wherein the actuating path is configured to expel the fluid. Yet further included is a flow manipulating device disposed within the interior compartment of the diffuser component. According to another aspect of the invention, a turbine exhaust diffuser includes a strut extending between, and operably coupled to, an annular inner barrel extending in a longitudinal direction of the turbine exhaust diffuser and an outer wall disposed radially outwardly from the inner barrel, the strut comprising a leading edge, a trailing edge and a suction side. Also included is a suction path extending from a first aperture in the suction side to an interior compartment of the strut. Further included is an actuating path extending from a second aperture in the suction side to the interior compartment of the strut. Yet further included is a flow manipulating device disposed within the interior compartment of the strut.

[0005] According to yet another aspect of the invention, a turbine system includes a turbine casing that surrounds a portion of a turbine section of the turbine system. Also included is an exhaust diffuser that includes an inner bar-

rel extending from proximate a diffuser inlet to a location downstream of the diffuser inlet. The exhaust diffuser also includes an outer wall disposed radially outwardly from the inner barrel. The exhaust diffuser further includes a strut extending between, and operably coupled to, the inner barrel and the outer wall, the strut comprising a leading edge, a trailing edge and a suction side. The exhaust diffuser yet further includes a suction path extending from the suction side to an interior compartment of the strut and an actuating path extending from the suction side to the interior compartment of the strut. The exhaust diffuser also includes a flow manipulating device disposed within the interior compartment of the strut.

[0006] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

[0007] The subject matter, which is regarded as the invention, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic illustration of a turbine system;

FIG. 2 is a cross-sectional view of a turbine exhaust diffuser of the turbine system; and

FIG. 3 is a schematic, side view of a strut of the turbine exhaust diffuser.

[0008] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

[0009] Referring to FIG. 1, a turbine system, such as a gas turbine system, for example, is schematically illustrated with reference numeral 10. The gas turbine system 10 includes a compressor section 12, a combustor section 14, a turbine section 16, a shaft 18 and a fuel nozzle 20. It is to be appreciated that one embodiment of the gas turbine system 10 may include a plurality of compressors 12, combustors 14, turbines 16, shafts 18 and fuel nozzles 20. The compressor section 12 and the turbine section 16 are coupled by the shaft 18. The shaft 18 may be a single shaft or a plurality of shaft segments coupled together to form the shaft 18.

[0010] The combustor section 14 uses a combustible liquid and/or gas fuel, such as natural gas or a hydrogen rich synthetic gas, to run the gas turbine system 10. For example, fuel nozzles 20 are in fluid communication with an air supply and a fuel supply 22. The fuel nozzles 20 create an air-fuel mixture, and discharge the air-fuel mixture into the combustor section 14, thereby causing a combustion that creates a hot pressurized exhaust gas. The combustor section 14 directs the hot pressurized gas through a transition piece into a turbine nozzle (or "stage one nozzle"), and other stages of buckets and

nozzles causing rotation of turbine blades within an outer casing 24 of the turbine section 16. Subsequently, the hot pressurized gas is sent from the turbine section 16 to an exhaust diffuser 26 that is operably coupled to a portion of the turbine section, such as the outer casing 24, for example.

[0011] Referring now to FIG. 2, a side, cross-sectional view of the exhaust diffuser 26 is illustrated. The exhaust diffuser 26 includes an inlet 28 configured to receive an exhaust fluid 30 from the turbine section 16. An outlet 32 is disposed at a downstream location relative to the inlet 28. Extending relatively axially along a longitudinal direction of the exhaust diffuser 26 at least partially between the inlet 28 and the outlet 32 is an inner barrel 34 that includes an outer surface 36. Spaced radially outwardly from the inner barrel 34, and more specifically radially outwardly from the outer surface 36, is an outer wall 38 having an inner surface 40. The outer wall 38 is arranged in a relatively diverging configuration, such that kinetic energy of the exhaust fluid 30 is lessened subsequent to entering the inlet 28 of the exhaust diffuser 26. More particularly, a transfer of dynamic pressure to static pressure occurs within the exhaust diffuser 26 due to the diverging configuration of the outer wall 38. The exhaust fluid 30 flows through the area defined by the outer surface 36 of the inner barrel 34 and the inner surface 40 of the outer wall 38.

[0012] Also disposed between the outer surface 36 of the inner barrel 34 and the inner surface 40 of the outer wall 38 is a strut 42. Although only a single strut will be described herein, it is to be appreciated that the exhaust diffuser 26 typically includes a plurality of struts, with exemplary embodiments including a number of struts ranging from four (4) to twelve (12) struts. The strut 42 serves to hold the inner barrel 34 and the outer wall 38 in a fixed relationship to one another, as well as providing bearing support. As the strut 42 is disposed within the area between the inner barrel 34 and the outer wall 38, the exhaust fluid 30 passes over the strut 42. Therefore, the strut 42 influences the flow characteristics of the exhaust fluid 30, and hence the overall exhaust diffuser performance.

[0013] Referring now to FIG. 3, the strut 42 is shaped as a cambered airfoil, and it is to be appreciated that the precise geometry and dimensions of the strut 42 may vary from that illustrated, based on the application. The strut 42 includes a leading edge 44, a trailing edge 46, a suction side 48 and a pressure side 50. Extending from the leading edge 44 to the trailing edge 46 is an imaginary line referred to as a chord length 52. Although described as having a cambered airfoil shape, it is to be understood that a generally symmetrical configuration may be employed.

[0014] As the exhaust fluid 30 exits the turbine section 16, the last stage bucket exit tangential flow angle (referred to herein as "swirl") of the exhaust fluid 30 increases based on the diverging configuration of the outer wall 38 of the exhaust diffuser 26, thereby leading to flow separation in regions proximate the outer surface 36 of the

inner barrel 34, as well as regions proximate the various outer surfaces of the strut 42, such as the suction side 48 and the pressure side 50, for example. To reduce flow separation and the increase in swirl, a flow manipulating device 54, such as a rotating impeller, is disposed within the strut 42 to promote ingestion, or suction, of a portion of the exhaust fluid 30 passing over the suction side 48 of the strut 42 through a suction path 56. Subsequently, a portion of the exhaust fluid 30 is expelled, or blown, to a region proximate the suction side 48 of the strut 42 through an actuating path 58. The flow manipulating device 54 is generally fully enclosed by surrounding surfaces of the strut 42, with the exception of the suction path 56 and the actuating path 58. The flow manipulating device 54 may be driven by various actuation structures, such as one or more motors. The one or more motors may be mounted proximate the outer wall 38, the inner barrel 34, and/or the strut 42.

[0015] The suction path 56 extends from a first aperture 60 disposed within the suction side 48 of the strut 42 to an interior compartment 62 of the strut 42, where the flow manipulating device 54 is located. The suction path 56 may be arranged at numerous angles, as the embodiment shown is merely for illustrative purposes only. The first aperture 60, and therefore at least a portion of the suction path 56, is disposed proximate the leading edge 44 of the strut 42, however, it is contemplated that the first aperture 60 may be located substantially downstream of the leading edge 44. Similarly, the actuating path 58 extends from a second aperture 64 disposed within the suction side 48 of the strut 42 to the interior compartment 62. As with the suction path 56, the actuating path 58 may be arranged at numerous angles other than that illustrated. The second aperture 64, and therefore at least a portion of the actuating path 58, may be disposed at various locations downstream of the first aperture 60. In an exemplary embodiment, the second aperture 64 is located about 60% downstream of the leading edge 44, with respect to the chord length 52 extending from the leading edge 44 to the trailing edge 46, however, the precise location may vary based on overall characteristics of the exhaust diffuser 26. Similarly, the first aperture 60 may be located proximate the trailing edge 46, rather than proximate the leading edge 44, as illustrated.

[0016] It should be understood that although the preceding description has referred to an embodiment having a suction path 56 disposed at an upstream location of the actuating path 58, it is contemplated that the actuating path 58 is disposed upstream of the suction path 56, such that the exhaust fluid 30 is ingested downstream and blown through the actuating path 58 to an upstream location. Furthermore, it is to be appreciated that although the suction path 56 and the actuating path 58 are illustrated and described above as being disposed at locations between the suction side 48 and the interior compartment 62, it is also contemplated that the suction path 56 and the actuating path 58 may be disposed at loca-

tions between the pressure side 50 and the interior compartment 62 in other embodiments. Alternatively, a plurality of suction paths 56 and actuating paths 58 may be employed proximate both the suction side 48 and the pressure side 50.

[0017] In addition or alternatively to disposition of the flow manipulating device 54 within the strut 42, the flow manipulating device 54 may be included within the inner barrel 34 to reduce flow separation and swirl proximate regions along the outer surface 36 of the inner barrel 34. Such an embodiment is similar in structure and operation as that of an embodiment comprising the flow manipulating device 54 in the strut 42. Irrespective of whether the flow manipulating device 54 is included in the strut 42 or the inner barrel 34, or both, the flow manipulating device 54, used in conjunction with the suction path 56 and the actuating path 58, reduces flow separation proximate the outer surface 36 of the inner barrel 34 and the suction side 48 of the strut 42.

[0018] 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.

[0019] Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. A turbine exhaust diffuser comprising:

a diffuser component disposed within the turbine exhaust diffuser and having an outer surface;
a suction path extending between the outer surface and an interior compartment of the diffuser component, wherein the suction path is configured to ingest a fluid;
an actuating path extending between the outer surface and the interior compartment of the diffuser component, wherein the actuating path is configured to expel the fluid; and
a flow manipulating device disposed within the interior compartment of the diffuser component.

2. The turbine exhaust diffuser of clause 1, wherein the diffuser component comprises an annular inner barrel extending in a longitudinal direction of the turbine exhaust diffuser.

3. The turbine exhaust diffuser of any preceding

clause, wherein the diffuser component comprises a strut extending between, and operably coupled to, an inner barrel extending in a longitudinal direction of the turbine exhaust diffuser and an outer wall disposed radially outwardly of the inner barrel, wherein the strut comprises a leading edge, a trailing edge and a suction side.

4. The turbine exhaust diffuser of any preceding clause, wherein the suction path is disposed proximate the leading edge of the strut.

5. The turbine exhaust diffuser of any preceding clause, further comprising a chord length extending between, and defined by, the leading edge and the trailing edge, wherein the actuating path is disposed at a location along the chord length about 60% downstream of the leading edge.

6. The turbine exhaust diffuser of any preceding clause, wherein the suction path is disposed upstream of the actuating path.

7. The turbine exhaust diffuser of any preceding clause, wherein the suction path is disposed downstream of the actuating path.

8. The turbine exhaust diffuser of any preceding clause, wherein the flow manipulating device comprises a rotating impeller.

9. The turbine exhaust diffuser of any preceding clause, wherein the flow manipulating device is fully enclosed within the diffuser component.

10. A turbine exhaust diffuser comprising:

a strut extending between, and operably coupled to, an annular inner barrel extending in a longitudinal direction of the turbine exhaust diffuser and an outer wall disposed radially outwardly from the inner barrel, the strut comprising a leading edge, a trailing edge and a suction side;
a suction path extending from a first aperture in the suction side to an interior compartment of the strut;
an actuating path extending from a second aperture in the suction side to the interior compartment of the strut; and
a rotating impeller disposed within the interior compartment of the strut.

11. The turbine exhaust diffuser of any preceding clause, further comprising at least one motor mounted proximate the outer wall.

12. The turbine exhaust diffuser of any preceding

clause, further comprising a chord length extending between, and defined by, the leading edge and the trailing edge, wherein the actuating path is disposed at a location along the chord length about 60% downstream of the leading edge.

13. The turbine exhaust diffuser of any preceding clause, wherein the suction path is disposed upstream of the actuating path.

14. The turbine exhaust diffuser of any preceding clause, wherein the suction path is disposed downstream of the actuating path.

15. The turbine exhaust diffuser of any preceding clause, wherein the rotating impeller is fully enclosed within the strut.

16. A turbine system comprising:

a turbine casing that surrounds a portion of a turbine section of the turbine system; and an exhaust diffuser comprising:

an inner barrel extending from proximate a diffuser inlet to a location downstream of the diffuser inlet;

an outer wall disposed radially outwardly from the inner barrel;

a strut extending between, and operably coupled to, the inner barrel and the outer wall, the strut comprising a leading edge, a trailing edge and a suction side;

a suction path extending from the suction side to an interior compartment of the strut; an actuating path extending from the suction side to the interior compartment of the strut; and

a flow manipulating device disposed within the interior compartment of the strut.

17. The turbine system of any preceding clause, wherein the flow manipulating device comprises a rotating impeller.

18. The turbine system of any preceding clause, wherein the rotating impeller is fully enclosed within the strut.

19. The turbine system of any preceding clause, further comprising a chord length extending between, and defined by, the leading edge and the trailing edge, wherein the actuating path is disposed at a location along the chord length about 60% downstream of the leading edge.

20. The turbine system of any preceding clause, wherein the suction path is disposed proximate the

leading edge of the strut.

Claims

1. A turbine exhaust diffuser (26) comprising:

a diffuser component (34) disposed within the turbine exhaust diffuser and having an outer surface (36);

a suction path (56) extending between the outer surface (36) and an interior compartment of the diffuser component, wherein the suction path (56) is configured to ingest a fluid;

an actuating path (58) extending between the outer surface and the interior compartment of the diffuser component, wherein the actuating path (58) is configured to expel the fluid; and a flow manipulating device (54) disposed within the interior compartment of the diffuser component.

2. The turbine exhaust diffuser of claim 1, wherein the diffuser component comprises an annular inner barrel extending in a longitudinal direction of the turbine exhaust diffuser.

3. The turbine exhaust diffuser of claim 1 or claim 2, wherein the diffuser component comprises a strut (42) extending between, and operably coupled to, an inner barrel (34) extending in a longitudinal direction of the turbine exhaust diffuser and an outer wall (38) disposed radially outwardly of the inner barrel, wherein the strut (42) comprises a leading edge, a trailing edge and a suction side.

4. The turbine exhaust diffuser of claim 3, wherein the suction path (56) is disposed proximate the leading edge of the strut (42).

5. The turbine exhaust diffuser of claim 3 or claim 4, further comprising a chord length extending between, and defined by, the leading edge and the trailing edge, wherein the actuating path (58) is disposed at a location along the chord length about 60% downstream of the leading edge.

6. The turbine exhaust diffuser of any preceding claim, wherein:

the suction path (56) is disposed upstream of the actuating path (58), or
the suction path (56) is disposed downstream of the actuating path (58).

7. The turbine exhaust diffuser of any preceding claim, wherein:

the flow manipulating device (54) comprises a rotating impeller, and/or
the flow manipulating device (54) is fully enclosed within the diffuser component.

8. A turbine exhaust diffuser comprising:

a strut (42) extending between, and operably coupled to, an annular inner barrel (34) extending in a longitudinal direction of the turbine exhaust diffuser and an outer wall (38) disposed radially outwardly from the inner barrel (34), the strut comprising a leading edge, a trailing edge and a suction side;
a suction path (56) extending from a first aperture in the suction side to an interior compartment of the strut (42);
an actuating path (58) extending from a second aperture in the suction side to the interior compartment of the strut (42); and
a rotating impeller (54) disposed within the interior compartment of the strut (42).

9. The turbine exhaust diffuser of claim 8, further comprising at least one motor mounted proximate the outer wall (38).

10. The turbine exhaust diffuser of claim 8 or claim 9, further comprising a chord length extending between, and defined by, the leading edge and the trailing edge, wherein the actuating path (58) is disposed at a location along the chord length about 60% downstream of the leading edge.

11. The turbine exhaust diffuser of claim 8, 9 or 10, wherein:

the suction path (56) is disposed upstream of the actuating path (58), or
the suction path (56) is disposed downstream of the actuating path (58), and/or
the rotating impeller is fully enclosed within the strut (42).

12. A turbine system (10) comprising:

a turbine casing (24) that surrounds a portion of a turbine section of the turbine system (10); and
an exhaust diffuser (26) comprising:

an inner barrel (34) extending from proximate a diffuser inlet (28) to a location downstream of the diffuser inlet;
an outer wall (38) disposed radially outwardly from the inner barrel (34);
a strut (42) extending between, and operably coupled to, the inner barrel (34) and the outer wall (38), the strut (42) comprising a

leading edge, a trailing edge and a suction side;

a suction path (56) extending from the suction side to an interior compartment of the strut (42);

an actuating path (58) extending from the suction side to the interior compartment of the strut (42); and

a flow manipulating device (54) disposed within the interior compartment of the strut (42).

13. The turbine system of claim 12, wherein the flow manipulating device (54) comprises a rotating impeller, and wherein preferably the rotating impeller is fully enclosed within the strut (42).

14. The turbine system of claim 12 or claim 13, further comprising a chord length extending between, and defined by, the leading edge and the trailing edge, wherein the actuating path is disposed at a location along the chord length about 60% downstream of the leading edge.

15. The turbine system of claim 12, 13 or 14, wherein the suction path is disposed proximate the leading edge of the strut (42).

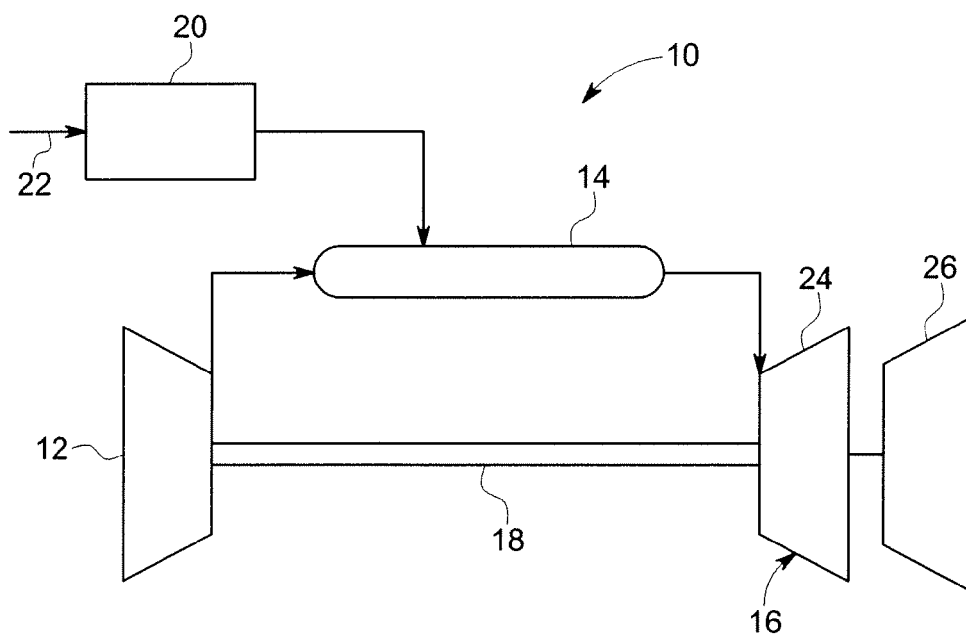


FIG. 1

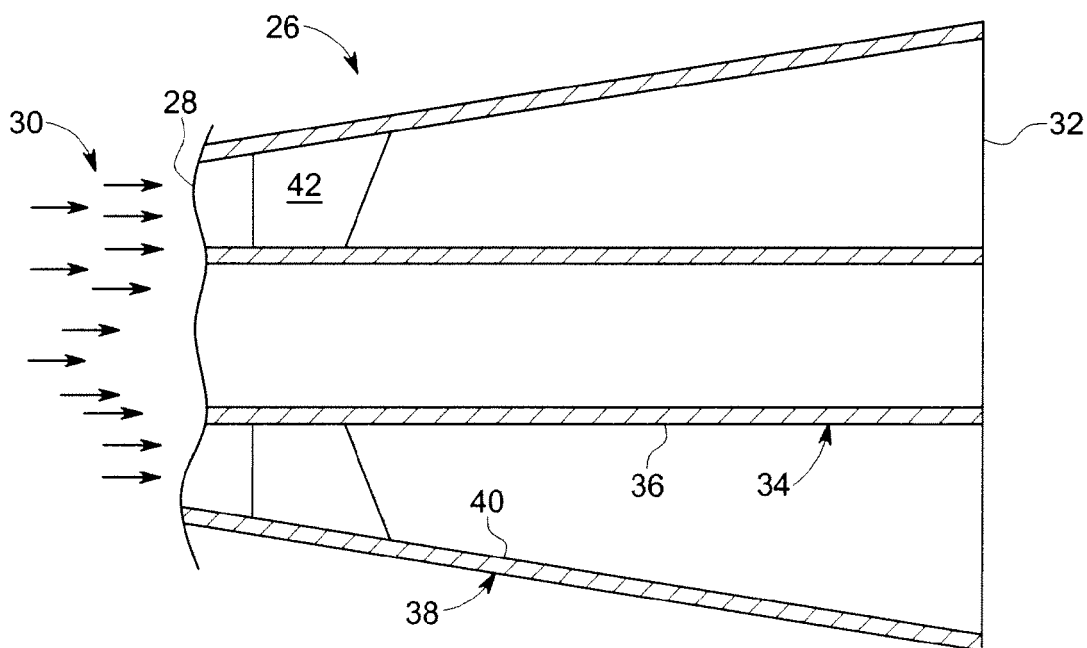


FIG. 2

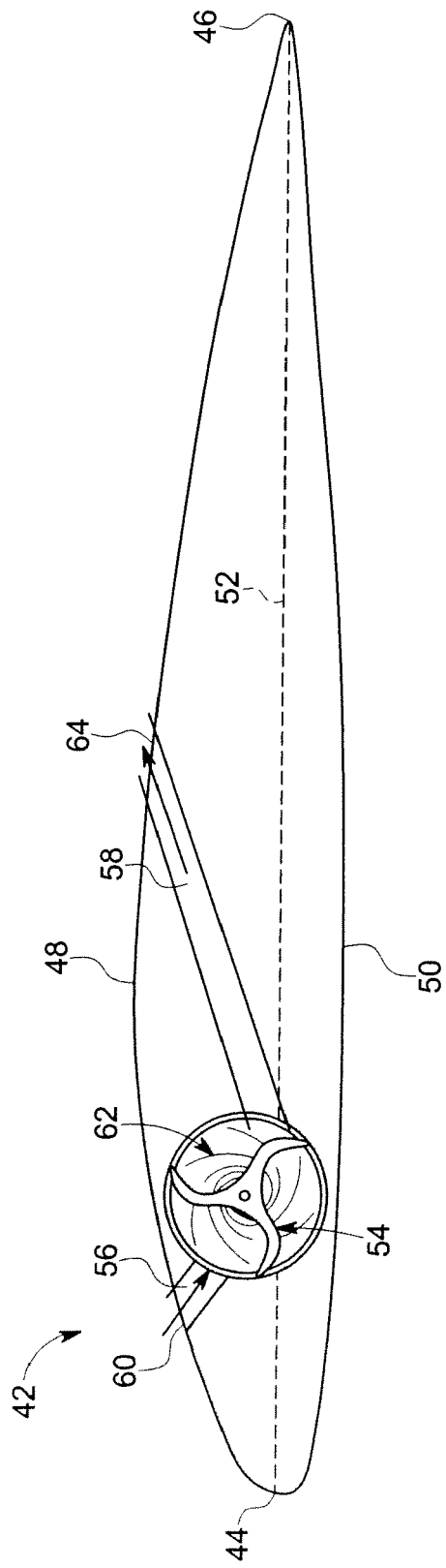


FIG. 3