US 20140072401A1

(19) **United States**

(12) **Patent Application Publication**

Powar et al.

(10) **Pub. No.: US 2014/0072401 A1**

(43) **Pub. Date: Mar. 13, 2014**

(54) **AXIAL DIFFUSER FLOW CONTROL DEVICE**

(75) Inventors: **Shridhar Raghuvir Powar**, Bangalore (IN); **Karthick Kaleeswaran**, Bangalore (IN); **Rajesh Prabhakaran Saraswathi**, Bangalore (IN)

(73) Assignee: **General Electric Company**, Schenectady, NY (US)

(21) Appl. No.: **13/611,223**

(22) Filed: **Sep. 12, 2012**

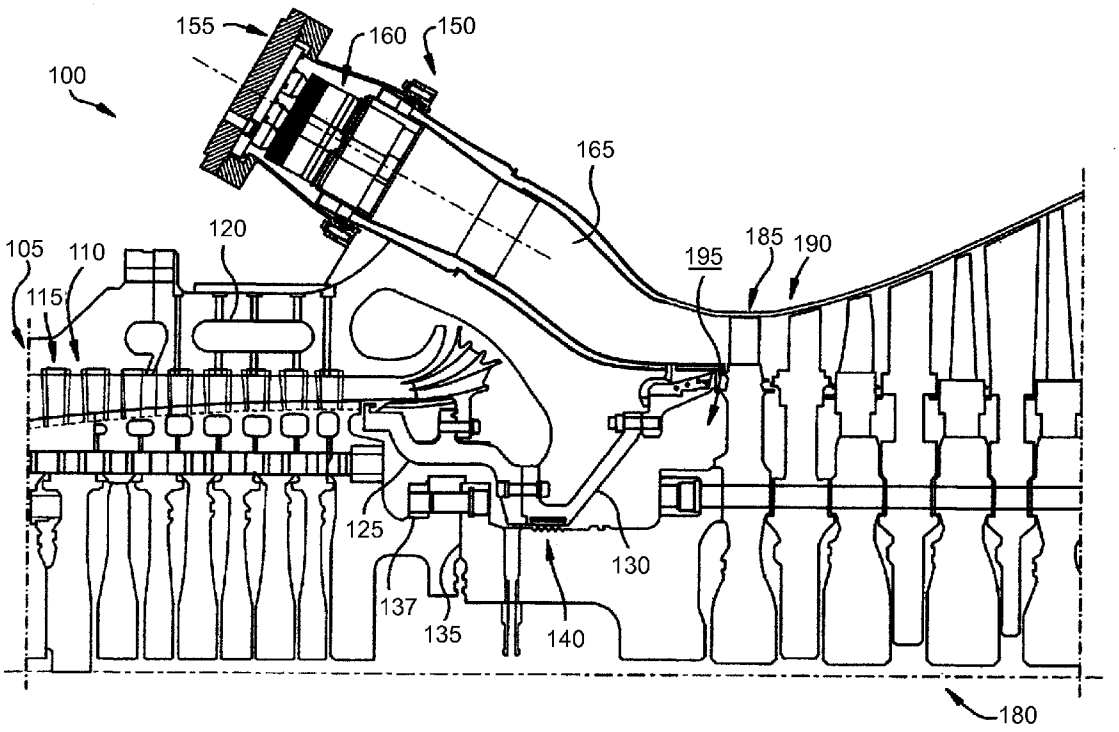
Publication Classification

(51) **Int. Cl.**
F01D 1/04 (2006.01)

(52) **U.S. Cl.**
USPC **415/1**; 415/208.2

(57) **ABSTRACT**

An axial diffuser for a gas turbine includes diffuser walls that define diffuser channels receiving compressor discharge air. The diffuser walls diverge in a flow direction. A flow control device is disposed in the diffuser channels and includes a plasma controller that serves to ionize airflow in the diffuser channels.



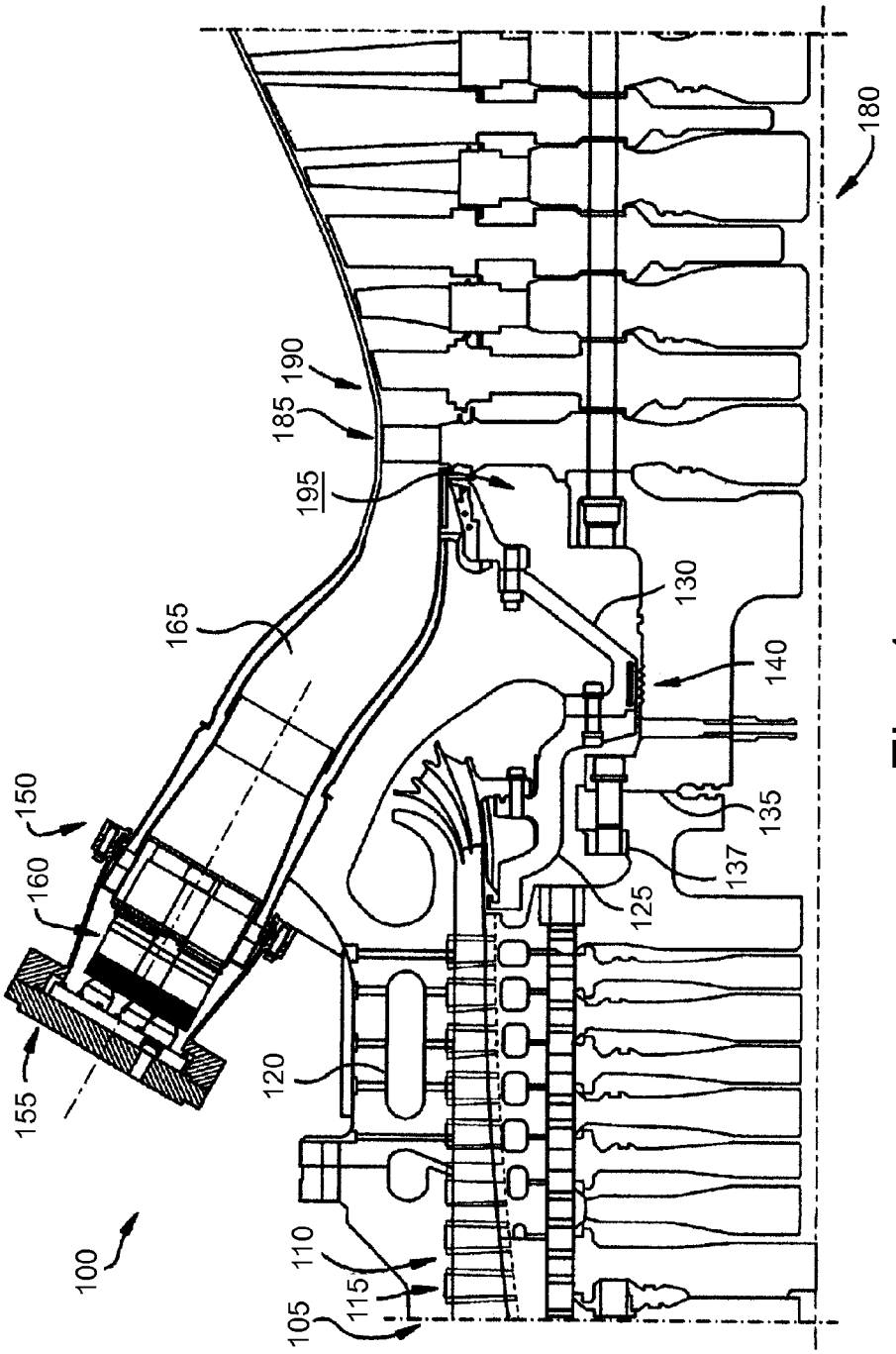

100
105
110
115
120
125
130
135
137
140
150
155
160
165
180
185
190
195

Fig. 1

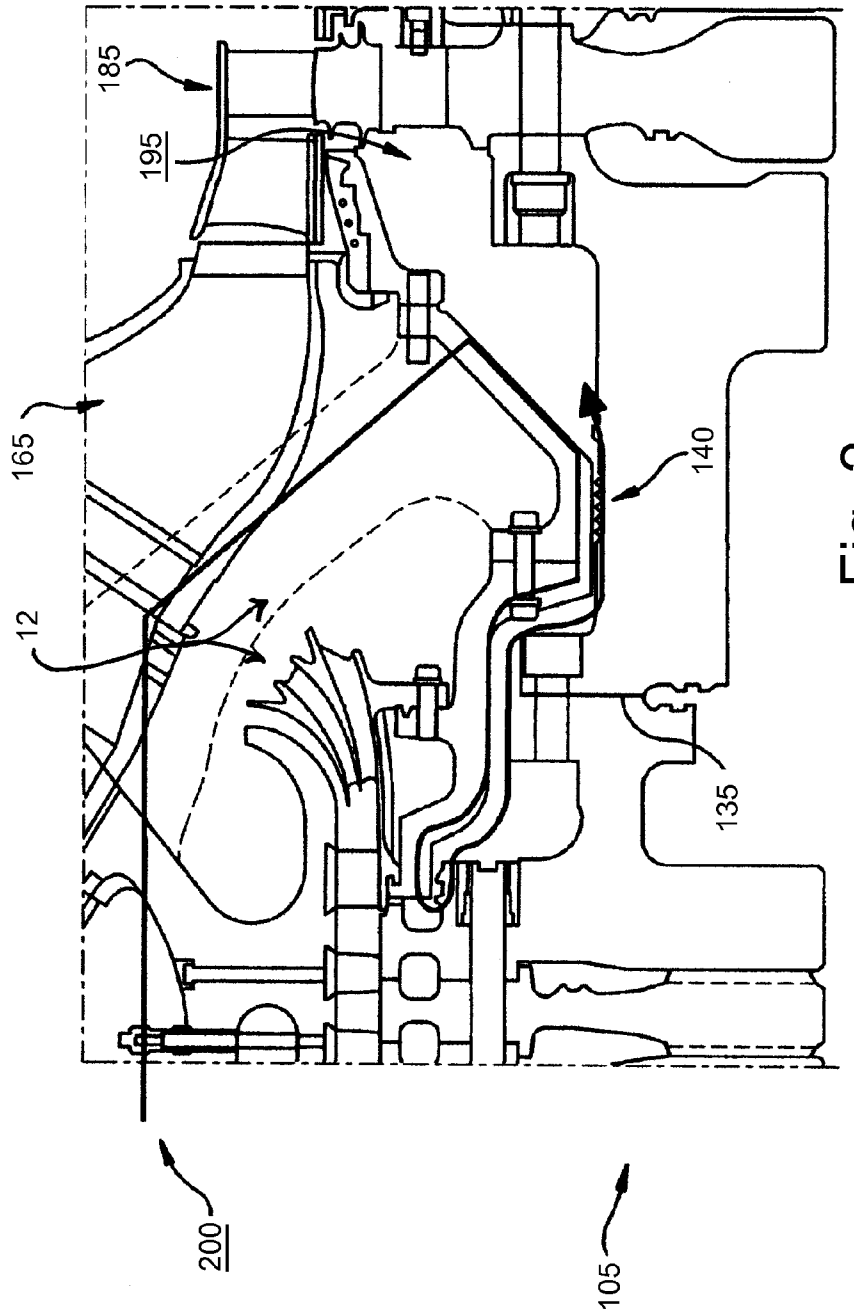


Fig. 2

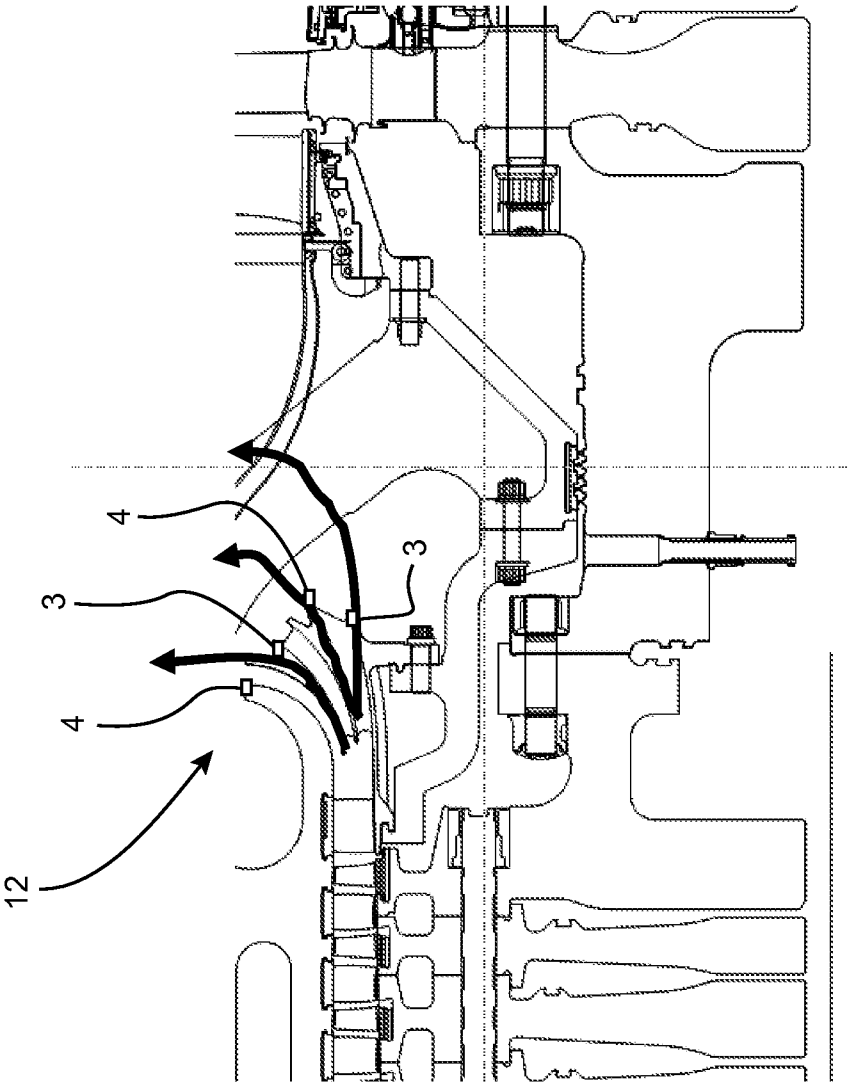


Fig. 3

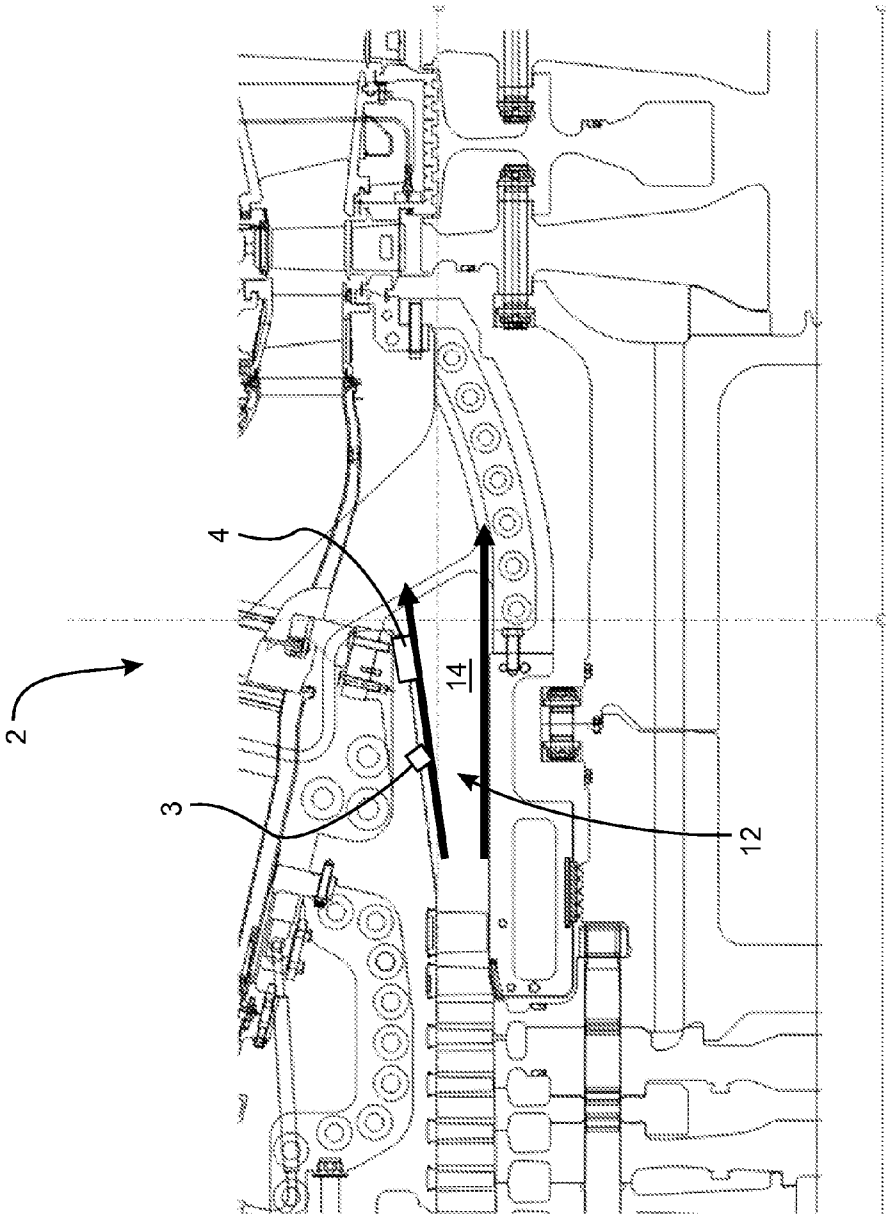


Fig. 4

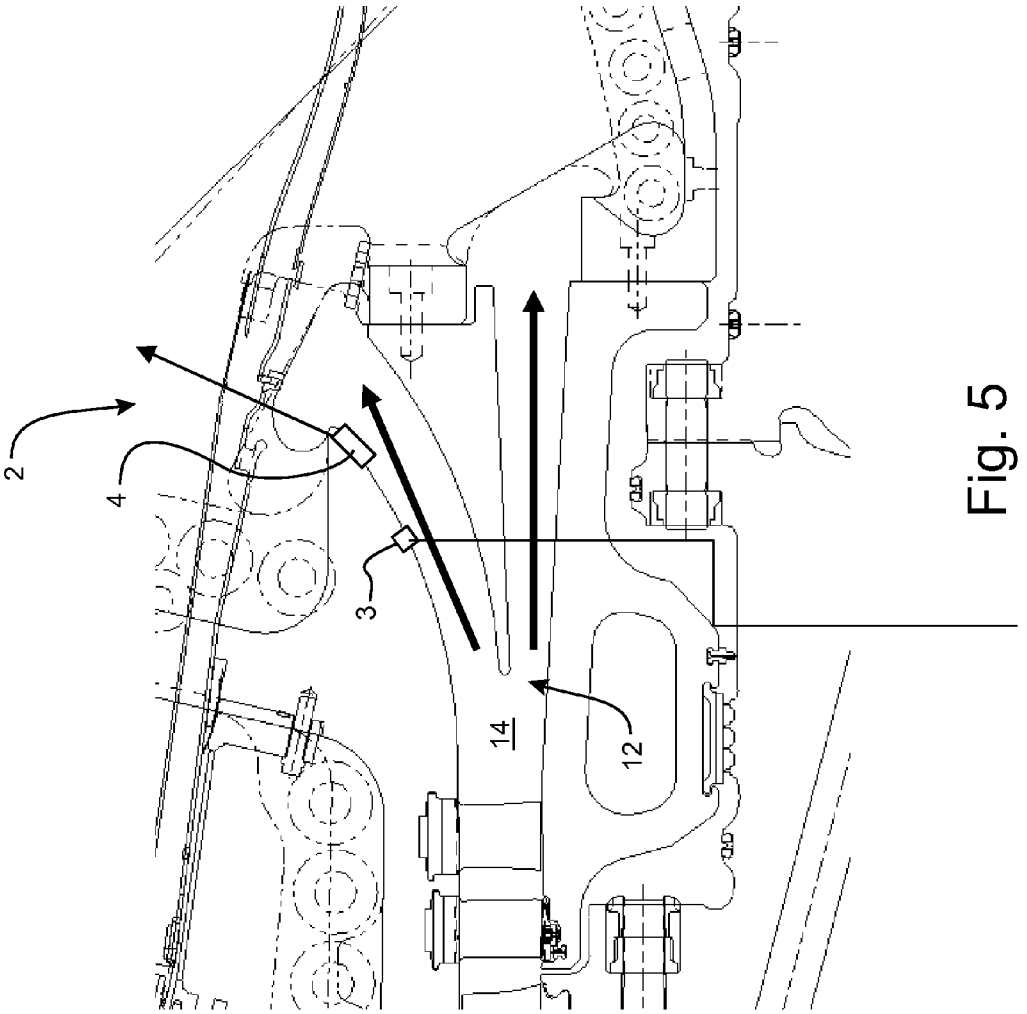


Fig. 5

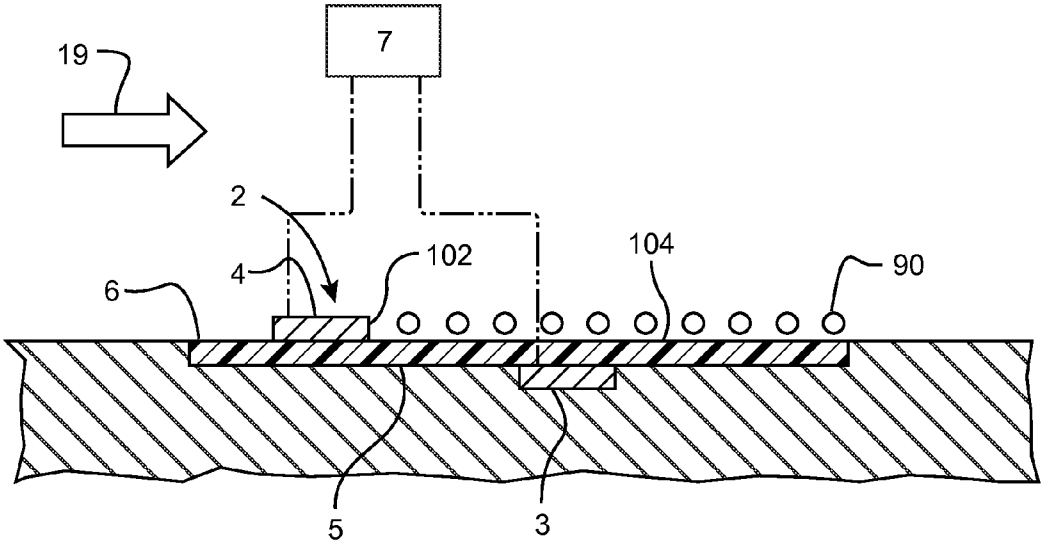


Fig. 6

AXIAL DIFFUSER FLOW CONTROL DEVICE

BACKGROUND OF THE INVENTION

[0001] The invention relates generally to gas turbines and, more specifically, to an axial diffuser in a gas turbine including a plasma controller to control air flow.

[0002] Conventional gas turbine combustion systems employ multiple combustion chamber assemblies to achieve reliable and efficient turbine operation. Each combustion chamber includes a cylindrical combustor, a fuel injection system, and a transition piece that guides the flow of the hot gas from the combustor to the inlet of the turbine. Generally, a portion of the compressor discharge air is introduced directly into the combustor reaction zone to be mixed with the fuel and burned. The balance of the airflow serves either to quench the flame prior to the combustor discharge entering the turbine, or to cool the wall of the combustor and, in some cases, the transition piece.

[0003] In systems incorporating impingement cooled transition pieces, a hollow sleeve surrounds the transition piece, and the sleeve wall is perforated so that compressor discharge air will flow through the cooling apertures in the sleeve wall and impinge upon (and thus cool) the transition piece.

[0004] Because the transition piece is a structural member, it is desirable to have lower temperatures where the stresses are highest. This has proven difficult to achieve, but an acceptable compromise is to have uniform temperatures (at which the stresses are within allowable limits) all along the length of the transition piece. Thus, uniform flow pressures along the impingement sleeve are desirable to achieve the desired uniform temperatures.

[0005] Substantially straight axial diffusers are typically utilized in gas turbines at the compressor discharge location.

[0006] A typical problem associated with existing diffuser configurations is flow separation. The flow gets detached from the surface creating losses and reducing pressure recovery. Efforts have been made to have an aggressive design of the diffuser for reducing its length of providing a steeper angle and by diverging the annulus in two stages. The steeper angle, however, creates more flow separation, thereby reducing the pressure recovery. Current methods of flow control are achieved by mechanical means, which are complicated, add weight, have volume and are sources of noise and vibration. Also, existing devices are typically composed of mechanical parts that wear away and that may break down.

[0007] It would be desirable to eliminate the problems with existing devices while effectively controlling the flow profile.

BRIEF DESCRIPTION OF THE INVENTION

[0008] In an exemplary embodiment, an axial diffuser for a gas turbine includes diffuser walls that define diffuser channels receiving compressor discharge air. The diffuser walls diverge in a flow direction. A flow control device is disposed in the diffuser channels. The flow control device includes a plasma controller that serves to ionize airflow in the diffuser channels.

[0009] In another exemplary embodiment, a flow control device is cooperable with an axial diffuser in a gas turbine and includes the plasma controller that serves to ionize airflow through the axial diffuser.

[0010] In still another exemplary embodiment, a method of controlling flow in a gas turbine axial diffuser includes the steps of positioning a flow control device in diffuser channels of the axial diffuser, where the flow control device includes a plasma controller; and applying a current to the plasma controller to ionize airflow in the diffuser channels.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is a schematic cross-sectional view of a gas turbine;

[0012] FIG. **2** is an enlarged view of a portion of the gas turbine illustrated in FIG. **1**;

[0013] FIGS. **3-5** show exemplary turbine configurations including an axial diffuser with a plasma controller; and

[0014] FIG. **6** is a schematic illustration including an energized plasma controller and a boundary layer.

DETAILED DESCRIPTION OF THE INVENTION

[0015] FIG. **1** is a schematic view, in cross-section, of a portion of a gas turbine, illustrating the environment in which an embodiment of the present invention operates. The gas turbine **100** includes a compressor section **105**, a combustion section **150**, and a turbine section **180**. Generally, the compressor section **105** includes a plurality of rotating blades **110** and stationary vanes **115** structured to compress a fluid. The compressor section **105** may also include at least one extraction port **120**, an inner barrel **125**, a compressor discharge casing **130**, a marriage joint **135**, and a marriage joint bolt **137**.

[0016] Generally, the combustion section **150** includes a plurality of combustion cans **155** (only one is illustrated), a plurality of fuel nozzles **160**, and a plurality of transition sections **165** (only one is illustrated). The plurality of combustion cans **155** may be coupled to a fuel source (not illustrated). Within each combustion can **155**, compressed air is received from the compressor section **105** and mixed with fuel received from the fuel source. The air and fuel mixture is ignited and creates a working fluid. The working fluid generally proceeds from the aft end of the plurality of fuel nozzles **160** downstream through the transition section **165** into the turbine section **180**.

[0017] Generally, the turbine section **180** includes a plurality of rotating components **185**, a plurality of stationary components **190**, and a plurality of wheelspace areas **195**. The turbine section **180** converts the working fluid to a mechanical torque.

[0018] Typically, during the operation of the gas turbine **100**, a plurality of components experience high temperatures and may require cooling or purging. These components may include a portion of the compressor section **105**, the marriage joint **135**, and the plurality of wheelspace areas **195**.

[0019] The extraction port **120** draws cooling fluid from the compressor section **105**. The cooling fluid bypasses the combustion section **150**, and flows through a cooling circuit **200** (illustrated in FIG. **2**), for cooling or purging various components, including the marriage joint **135**, and at least one of the plurality of wheelspace areas **195**.

[0020] FIG. **2** is a close-up view of a section of the gas turbine illustrated in FIG. **1**. The flow path of the cooling circuit **200** may start at the extraction port **120** (illustrated in FIG. **1**), flow through a portion of the compressor discharge casing **130** and the inner barrel casing **125**, through to a cavity at the aft end of the compressor section **105**. Next, the cooling circuit **200** may reverse direction, flowing past the marriage joint **135**, past the seal system components **140**, to the wheelspace area **195**.

[0021] An axial diffuser **12** is provided at the compressor discharge location to distribute compressor discharge air along the impingement sleeve surrounding the transition piece. The axial diffuser **12** includes diffuser walls that define diffuser channels **14** that receive the compressor discharge air. As shown, the diffuser walls diverge in a flow direction (shown by arrows in FIGS. **3-5**). A flow control device such as a plasma controller **2** is disposed in the diffuser channels. The plasma controller **2** serves to ionize air flow in the diffuser channels. The plasma controller **2** is provided with an anode **3** and a cathode **4** or other suitable electrodes, and an energy source **7** (FIG. **6**) provides a current between the electrodes **3**, **4**. In one arrangement, the electrodes consist of two low-diameter wires flush-mounted on the surface in the diffuser channels.

[0022] In use, the fluid/air in the diffuser will get ionized, and in ambient air, an electric wind is created tangentially to the diffuser wall. The effect is used to reduce the flow separation, providing effective flow control and reduced pressure drop. As shown, the electrodes can be mounted to the inner surface of the axial diffuser casing.

[0023] The air flow direction can be altered in different channels based on the aerodynamic shape of the diffuser, hence making the airflow conform to the shape of the diffuser. Moreover, a decreased amount of air during reduced load on the turbine can be made to accelerate through the diffuser to thereby further control turbine performance. Additionally, redirecting the amount and the nature of the flow may serve to control the impingement of air on the combustion hardware.

[0024] An exemplary plasma controller **2** is illustrated in FIG. **6**. The plasma controller **2** is secured to the diffuser walls, preferably mounted to an inner surface of the axial diffuser casing. The plasma controller **2** includes first and second electrodes **3**, **4** separated by a dielectric material **5**. The dielectric material **5** is disposed within spanwise extending grooves **6** in the diffuser walls. A power supply **7** is connected to the electrodes **3**, **4** to supply a high voltage potential to the electrodes. Preferably, the power supply **7** is a direct current power supply.

[0025] When the current amplitude is large enough, the gas flow **19** ionizes in a region of largest electric potential forming the plasma **90**. The plasma controller **2** produces an outer surface conforming plasma **90** which covers a substantial portion of the diffuser channels. The plasma **90** generally begins at an edge **102** of the first electrode **3**, which is exposed to the gas flow **19**, and spreads out over an area **104** projected by the second electrode **4**, which is covered by the dielectric material **5**. The plasma **90** in the presence of an electric field gradient produces a force on the gas flow **19** located between the diffuser surface and the plasma **90** inducing a virtual aerodynamic shape that causes a change in the pressure distribution over the diffuser surface.

[0026] The use of plasma flow control in an axial diffuser serves to reduce flow separation without complicated mechanical devices that add weight and can be sources of noise and vibration. Effective flow control and a reduced pressure drop can be advantageously achieved by the application of current between the plasma controller electrodes. The improved pressure recovery results in higher and more efficient power generation. Additionally, the device is suitable for retrofitting on existing turbines.

[0027] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. An axial diffuser for a gas turbine, the axial diffuser comprising:

diffuser walls that define diffuser channels receiving compressor discharge air, the diffuser walls diverging in a flow direction; and

a flow control device disposed in the diffuser channels, the flow control device including a plasma controller that serves to ionize airflow in the diffuser channels.

2. An axial diffuser according to claim **1**, wherein the plasma controller comprises two wires secured to the diffuser walls and an energy source providing a current between the two wires.

3. An axial diffuser according to claim **2**, wherein the energy source comprises a direct current power supply.

4. An axial diffuser according to claim **1**, wherein the plasma controller comprises first and second electrodes secured to the diffuser walls and separated by a dielectric material, and an energy source connected to the electrodes.

5. An axial diffuser according to claim **1**, wherein the plasma controller comprises an anode and a cathode secured to one of the diffuser walls, and wherein the cathode is disposed downstream of the anode.

6. A flow control device cooperable with an axial diffuser in a gas turbine, the flow control device comprising a plasma controller that serves to ionize airflow through the axial diffuser.

7. A flow control device according to claim **6**, wherein the plasma controller comprises two wires secured to walls of the diffuser and an energy source providing a current between the two wires.

8. A flow control device according to claim **7**, wherein the energy source comprises a direct current power supply.

9. A flow control device according to claim **6**, wherein the plasma controller comprises first and second electrodes secured to walls of the diffuser and separated by a dielectric material, and an energy source connected to the electrodes.

10. A flow control device according to claim **6**, wherein the plasma controller comprises an anode and a cathode secured to one of the diffuser walls, and wherein the cathode is disposed downstream of the anode.

11. A method of controlling flow in a gas turbine axial diffuser, the method comprising:

positioning a flow control device in diffuser channels of the axial diffuser, the flow control device including a plasma controller; and

applying a current to the plasma controller to ionize airflow in the diffuser channels.

12. A method according to claim **11**, wherein the plasma controller includes first and second electrodes secured in the diffuser channels and separated by a dielectric material, and an energy source connected to the electrodes, the method further comprising creating an electric wind.

13. A method according to claim **12**, wherein the applying step is practiced by applying a direct current between the first and second electrodes.

14. A method according to claim **11**, wherein the positioning step is practiced by securing two wires to walls of the diffuser.

15. A method according to claim **11**, comprising altering an air flow direction in different channels based on an aerodynamic shape of the diffuser, thereby making the air flow conform to the shape of the diffuser.

16. A method according to claim **11**, comprising accelerating a decreased amount of air during reduced load on the turbine through the diffuser to thereby further control turbine performance.

17. A method according to claim **16**, comprising redirecting an amount and nature of the flow to control impingement of air on the combustion hardware.

* * * * *