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(54) Turbine airfoil and method for controlling a temperature of a turbine airfoil

(57) According to one aspect of the invention, a turbine airfoil (200) includes a platform (202) and a blade (204) extending from the platform (202). The airfoil (200) also includes a slot (208) formed in a slashface (210) of the platform (202), the slot (208) being configured to receive a pressurized fluid via passages (212) and config-

ured to direct the pressurized fluid to a selected region of the turbine airfoil (200). The pressurized fluid forms a barrier to restrict the flow of hot gas across the slashface (210), thus improving the airfoil life.

And corresponding method for controlling the temperature of the airfoil.

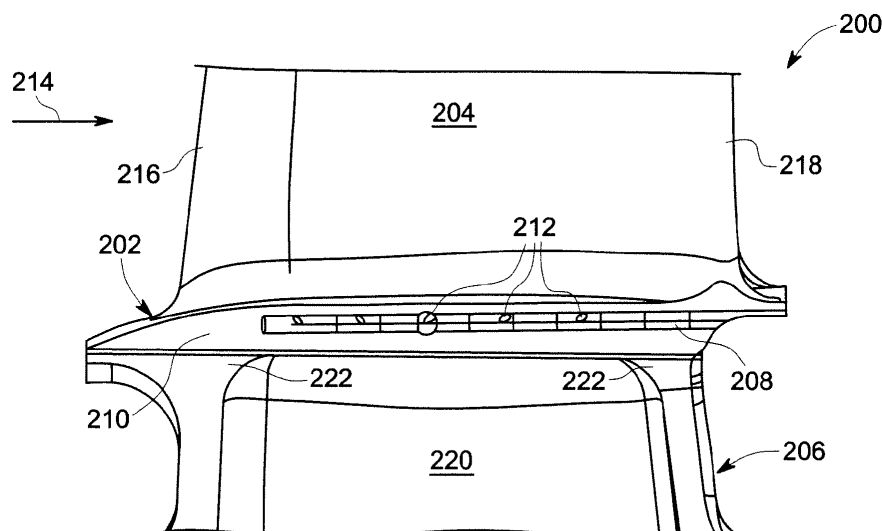


FIG. 2

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Description

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to turbines. More particularly, the subject matter relates to an airfoil to be positioned in a turbine.

[0002] In a gas turbine engine, a combustor converts chemical energy of a fuel or an air-fuel mixture into thermal energy. The thermal energy is conveyed by a fluid, often air from a compressor, to a turbine where the thermal energy is converted to mechanical energy. Several factors influence the efficiency of the conversion of thermal energy to mechanical energy. The factors may include blade passing frequencies, fuel supply fluctuations, fuel type and reactivity, combustor head-on volume, fuel nozzle design, air-fuel profiles, flame shape, air-fuel mixing, flame holding, combustion temperature, turbine component design, hot-gas-path temperature dilution, and exhaust temperature. For example, high combustion temperatures in selected locations, such as the combustor and turbine nozzle areas, may enable improved combustion efficiency and power production. In some cases, high temperatures in certain combustor and turbine regions may shorten the life and increase wear and tear of certain components. Accordingly, it is desirable to control temperatures in the turbine to reduce wear and increase the life of turbine components.

BRIEF DESCRIPTION OF THE INVENTION

[0003] According to one aspect of the invention, a turbine airfoil includes a platform and a blade extending from the platform. The airfoil also includes a slot formed in a slashface of the platform, the slot being configured to receive a pressurized fluid via passages and configured to direct the pressurized fluid to a selected region of the turbine airfoil to improve airfoil life.

[0004] According to another aspect of the invention, a method for cooling a turbine airfoil is provided, wherein the method includes flowing a pressurized fluid into a passage formed in a platform of the turbine airfoil. The method also includes flowing the pressurized fluid from the passage into a slot formed in a slashface of the platform, the slot being configured to direct the pressurized fluid to a selected region of the turbine airfoil to improve airfoil life.

[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 schematic drawing of an embodiment of

a gas turbine engine, including a combustor, fuel nozzle, compressor and turbine;

FIG. 2 is a side view of an embodiment of an airfoil;

FIG. 3 is an end view of an embodiment of an assembly of airfoils;

FIG. 4 is a perspective view of another embodiment of an airfoil;

FIG. 5 is a detailed end view of an embodiment of an airfoil; and

FIG. 6 is a detailed end view of yet another embodiment of an airfoil.

[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] FIG. 1 is a schematic diagram of an embodiment of a gas turbine system 100. The system 100 includes a compressor 102, a combustor 104, a turbine 106, a shaft 108 and a fuel nozzle 110. In an embodiment, the system 100 may include a plurality of compressors 102, combustors 104, turbines 106, shafts 108 and fuel nozzles 110. As depicted, the compressor 102 and turbine 106 are coupled by the shaft 108. The shaft 108 may be a single shaft or a plurality of shaft segments coupled together to form shaft 108.

[0009] In an aspect, the combustor 104 uses liquid and/or gas fuel, such as natural gas or a hydrogen rich synthetic gas, to run the turbine engine. For example, fuel nozzles 110 are in fluid communication with a fuel supply and pressurized air from the compressor 102. The fuel nozzles 110 create an air-fuel mix, and discharge the air-fuel mix into the combustor 104, thereby causing a combustion that creates a hot pressurized exhaust gas. The combustor 104 directs the hot pressurized exhaust gas through a transition piece into a turbine nozzle (or "stage one nozzle"), causing turbine 106 rotation as the gas exits the nozzle or vane and gets directed to the turbine bucket or blade. The rotation of turbine 106 causes the shaft 108 to rotate, thereby compressing the air as it flows into the compressor 102. In an embodiment, airfoils (also nozzles or buckets) are located in various portions of the turbine, such as in the compressor 102 or the turbine 106, where hot gas flow across the airfoils causes wear and thermal fatigue of turbine parts, due to non-uniform temperatures. Controlling the temperature of parts of the turbine airfoil can reduce wear and enable higher combustion temperatures in the combustor, thereby improving performance. Controlling the temperature of regions of and proximate to parts, such as airfoils, to improve component life is discussed in detail below with

reference to FIGS. 2-6. Although the following discussion primarily focuses on gas turbines, the concepts discussed are not limited to gas turbines.

[0010] FIG. 2 is a side view of a portion of an exemplary airfoil 200. The airfoil 200 includes a platform 202 and a blade 204 extending from the platform 202. A lower portion 206 extends below the platform 202 and may be used to secure the airfoil to a part of a rotor or stator, such as a turbine wheel. A slot 208 is formed in a slashface 210 of the platform 202. The slashface 210 is a surface of the platform configured to be placed adjacent to a similar surface, or slashface, of an adjacent airfoil. A plurality of passages 212 are located in the slot and are configured to communicate a fluid, such as a pressurized cooling fluid or pressurized temperature controlling fluid, into the slot 208. Embodiments of the slashface 210 may include a single passage 212 to communicate the fluid. In an embodiment, the slashface 210 is joined to an adjacent slashface and the pressurized fluid flows into the slot 208 to form a fluid barrier configured to restrict fluid flow across the slashfaces. In addition, the flow of pressurized fluid along the slot 208 provides a distributing cooling of the platform slashface 202, thereby reducing wear and thermal fatigue while also improving and extending airfoil life.

[0011] As depicted, a hot gas path 214 flows from a leading edge 216 to a trailing edge 218 of the blade 204. The pressurized fluid barrier formed within the slot 208 restricts flow of the hot gas across the slashface 210 to a cavity 220 (also called a "shank cavity") in the lower portion 206. A recess 222 to receive a pin is located below the platform 202. In embodiments, the pressurized fluid is also configured to cool the recess 222 and pin region. By restricting the hot gas flow across the slashface 210, the cooling fluid within the slot 208 reduces wear and tear on the lower portion 206. In an embodiment, the pressurized fluid is pressurized air used to cool selected portions of the airfoil 200, wherein passages are used to direct the cooling fluid to the selected portions. Further, the passages may include passages 212, wherein the pressurized fluid is distributed by the slot 208 to cool the platform 202. In the embodiment, the slot 208 comprises a substantially semicircular cross section geometry. As depicted, the pressurized fluid is configured to flow in the direction of the hot gas path 214 flow, wherein the fluid exits the open trailing edge side of the slot 208. In other embodiments, both ends of the slot 208 may be closed. The slot 208 with closed ends may be configured to direct the pressurized fluid to other regions of the airfoil 200. In embodiments, the slot 208 in the slashface 210 may also provide stress relief for high stress regions of the airfoil 200, such as the trailing edge 218 and platform 202, wherein the slot 208 weakens the slashface to divert a load from the high stress region. As depicted, the cross sectional geometry of the slot 208 is a portion of a circle, ellipse or oval. In other embodiments, the cross sectional geometry will include any suitable shape, such as triangles, rectangles or trapezoids. Further, the slot 208 may

have a substantially uniform cross-section across the slashface 210. Other embodiments may have a variable cross-section for the slot 208, such as a slot 208 that varies in cross section shape or size along its length. For example, the slot 208 may have a decreasing cross-section size in one direction to force flow out of the slot 208, or with increasing size to reduce flow velocity at the slot exit. In another example, the slot 208 could transition from a shape optimized for heat transfer at one part of the slash face 210 to one that is optimized for stress relief at another part of the slash face 210.

[0012] In aspects, turbine parts, including airfoils, are formed of stainless steel or an alloy, where the parts may experience thermal fatigue if not properly cooled during engine operation. It should be noted that the apparatus and method for controlling temperature in turbine parts may apply to cooling of turbine buckets, as shown in FIGS. 2-6, as well as nozzles, compressor vanes or any other airfoil or hot gas path component within a turbine engine.

[0013] FIG. 3 is an end view of an exemplary assembly of an airfoil 300 and airfoil 200. The airfoil 300 is substantially similar to airfoil 200 and includes a platform 302, a blade 304 and a lower portion 306. The platform 302 is part of the airfoil body and includes a slot 308 formed in a slashface 310. The slashfaces 210 and 310 are joined as the airfoils 200, 300 are assembled in a turbine, such as on a rotor or stator. The slots 208 and 308 form a cavity 312 that receives the pressurized fluid flow. The cavity 312 enables flow of the pressurized fluid to control the temperature of the platforms 202 and 302. Further, the cooling fluid barrier is formed in the cavity 312 to restrict a hot gas flow 314 across the slashfaces 210 and 310. In the embodiment, the airfoils 200 and 300 include additional slots 316 and 318 formed in slashfaces 320 and 322, respectively. The slashfaces 320 and 322 may be joined to slashfaces of adjacent airfoils. In an exemplary embodiment, a passage 324 (also referred to as "channel") is located in the airfoil 200 body and provides the pressurized fluid to the slot 208 and supplies cooling fluid flow into the slot 308 and a passage 326. Thus, the body of airfoil 200 may receive the pressurized fluid from a source and supply the pressurized fluid to the airfoil 300 via passages 324 and 326, thereby cooling selected regions of the airfoil 300.

[0014] FIG. 4 is a perspective view of a portion of an exemplary airfoil 400 that includes a platform 402, a blade 404 and a lower portion 406. The platform 402 includes a slot 408 formed in a slashface 410 for receiving pressurized fluid from passages 412. The platform 402 also includes features, such as notches 414, to flow the pressurized fluid along a surface 416 of the platform 402. Accordingly, the pressurized fluid flows 418 toward an open end of the slot 408 and through notches 414. The pressurized fluid in the slot 408 provides distributed cooling of the platform 402 and forms a barrier to restrict fluid flow across the slashface 410. By flowing the pressurized fluid through the notches 414 and to selected regions,

such as the surface 416, the slot 408 and notches 414 reduce thermal fatigue and wear. The slot 408 may include any suitable cooling features, such as the exemplary notches 414, which utilize structures, geometries and/or passages to direct fluid flow onto and/or through selected portions of the airfoil, such as the platform 402. Accordingly, by directing fluid onto the surface 416 via the notches 414, the temperature of the surface 416 region is controlled to reduce wear and thermal fatigue. In embodiments, cooling features may include passages and/or notches configured to cool regions such as the blade 204, 304, 404 and/or lower portion 206, 306, 406.

[0015] FIGS. 5 and 6 are detailed end views of exemplary platforms 500 and 600 utilizing different cross sectional geometries for slots 502 and 602, respectively. Exemplary geometries include semi-circles, ovals, trapezoids and rectangles. The slot 502 comprises a rectangular cross sectional geometry in a slashface 504, wherein the geometry is configured to provide flow of pressurized fluid to selected regions of the platform 500. Similarly, the slot 602 comprises a trapezoidal cross sectional geometry in a slashface 604. Thus, the cross sectional geometries of the slots 208, 308, 408, 502, 602 are configured to provide cooling to selected portions of the airfoils and/or form fluid barriers of selected volumes to restrict fluid flow. The slots may be formed by any suitable method, such as casting and/or machining the platform. Further, the pressurized fluid may be provided from an external and dedicated source, such as a coolant tank, or may be cool air provided internally by other portions of the turbine. The slot and suitable cross sectional geometry may be utilized for cooling any turbine hot gas path component, wherein the slot provides cooling and or restricts fluid flow for the component. In an embodiment, the slot is configured to direct the pressurized fluid to lower mixing loss regions of the airfoil to improve aerodynamic performance. For example, the cooling fluid may be directed to an area of the airfoil that, when it encounters other fluid flow, such as hot gas, does not produce substantial amounts of turbulence. In embodiments, the cooling fluid is directed to regions of the airfoil to enable energy from the cooling fluid. Such regions may include regions proximate the throat of the airfoil.

[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 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 turbine airfoil (200) comprising:
 - a platform (202);
 - a blade (204) extending from the platform (202); and
 - a slot (208) formed in a slashface (210) of the platform (202), the slot (208) being configured to receive a pressurized fluid (418) via passages (212) and configured to direct the pressurized fluid (418) to a selected region of the turbine airfoil (200) improve airfoil (200) life.
2. The turbine airfoil (200) of claim 1, wherein the slot (208) is configured to direct the pressurized fluid (418) to lower mixing loss regions to improve aerodynamic performance.
3. The turbine airfoil (200) of claim 1 or 2, wherein the blade (204) is configured to extend into a hot gas path (214) and the slot (208) is configured to form a barrier with the pressurized fluid (418) to restrict flow of hot gas across the slashface (210) to a shank cavity.
4. The turbine airfoil (200) of any of claims 1 to 3, wherein the slot (208) is configured to be joined to an adjacent slashface (310) of an adjacent airfoil and wherein the adjacent slashface (310) comprises an adjacent slot (308) to receive the pressurized fluid (418) from the passages (212) in the slashface (210).
5. The turbine airfoil (200) of any of claims 1 to 3, wherein the slot (208) is configured to be joined to an adjacent slashface (310) of an adjacent airfoil (300) and wherein the passages (212) in the slashface (210) are configured to provide the pressurized fluid (418) to the adjacent airfoil (300) via the adjacent slashface (310).
6. The turbine airfoil (200) of claim 5, wherein the adjacent slashface (210) comprises an adjacent slot (208) with a passage (326) to receive the pressurized fluid (418).
7. The turbine airfoil (200) of any preceding claim, wherein the slot (208) comprises a cross sectional geometry of one selected from the group consisting of: a semicircle, a trapezoid and a rectangle.
8. The turbine airfoil (200) of any preceding claim, wherein the slot (208) comprises one open end to allow the pressurized fluid (418) to flow out from the turbine airfoil (200).
9. The turbine airfoil (200) of any preceding claim, comprising features in the slashface (210) to enable flow

of the pressurized fluid (418) on an upper surface of the platform (202).

10. A method for controlling a temperature of a turbine airfoil (200), the method comprising: 5
- flowing a pressurized fluid (418) into a passage (212) formed in a platform (202) of the turbine airfoil (200); and
- flowing the pressurized fluid (418) from the pas- 10
 sage (212) into a slot (208) formed in a slashface (210) of the platform (202), the slot (208) being configured to direct the pressurized fluid (418) to a selected region of the turbine airfoil (200) to improve airfoil (200) life. 15
11. The method of claim 10, wherein flowing the pressurized fluid (418) from the passage (212) into the slot (208) comprises forming a barrier with the pressurized fluid (418) to restrict flow of hot gas across the slashface (210). 20
12. The method of claim 10 or 11, comprising joining the slot (208) in the slashface (210) to an adjacent slashface (310) of an adjacent airfoil (300) wherein the adjacent slashface (310) comprises an adjacent slot (308) to receive the pressurized fluid (418) from the passages (212) in the slashface (210). 25

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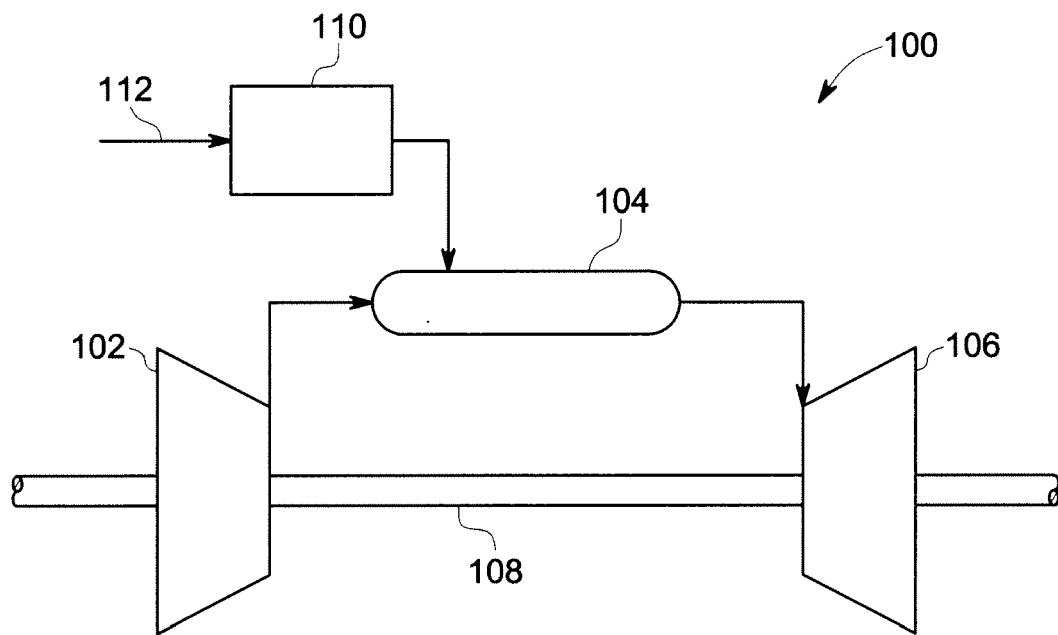


FIG. 1

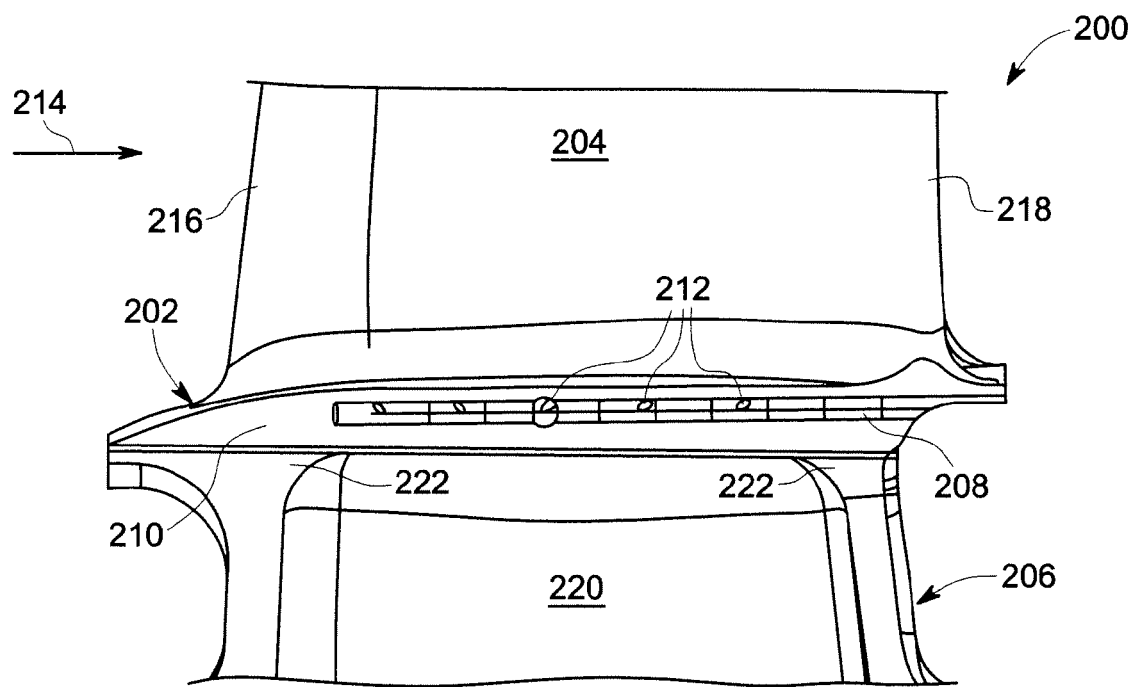


FIG. 2

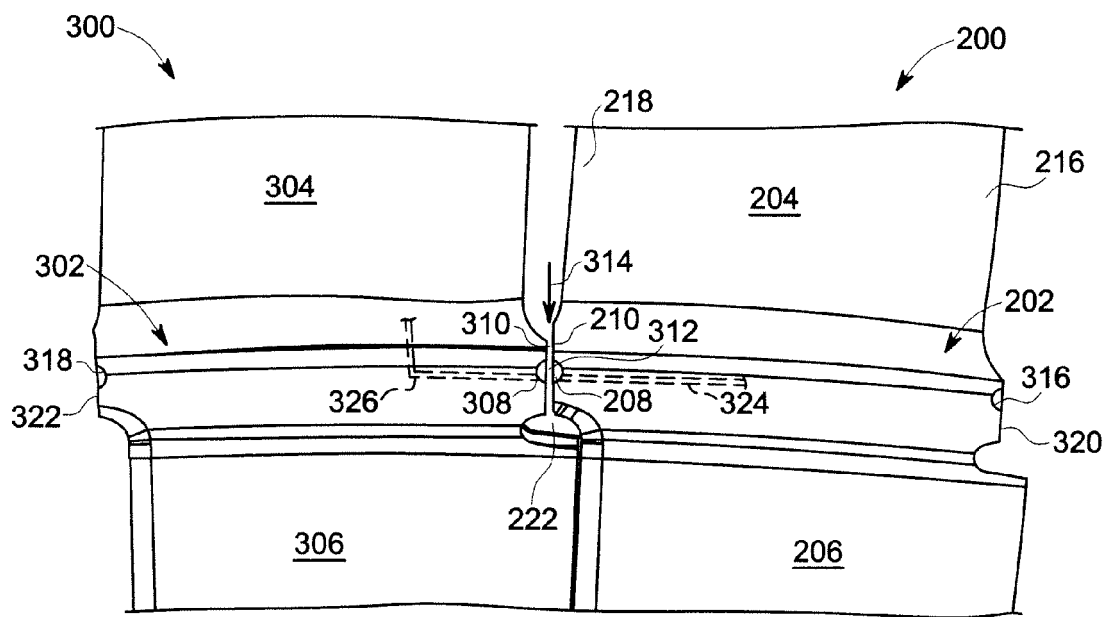


FIG. 3

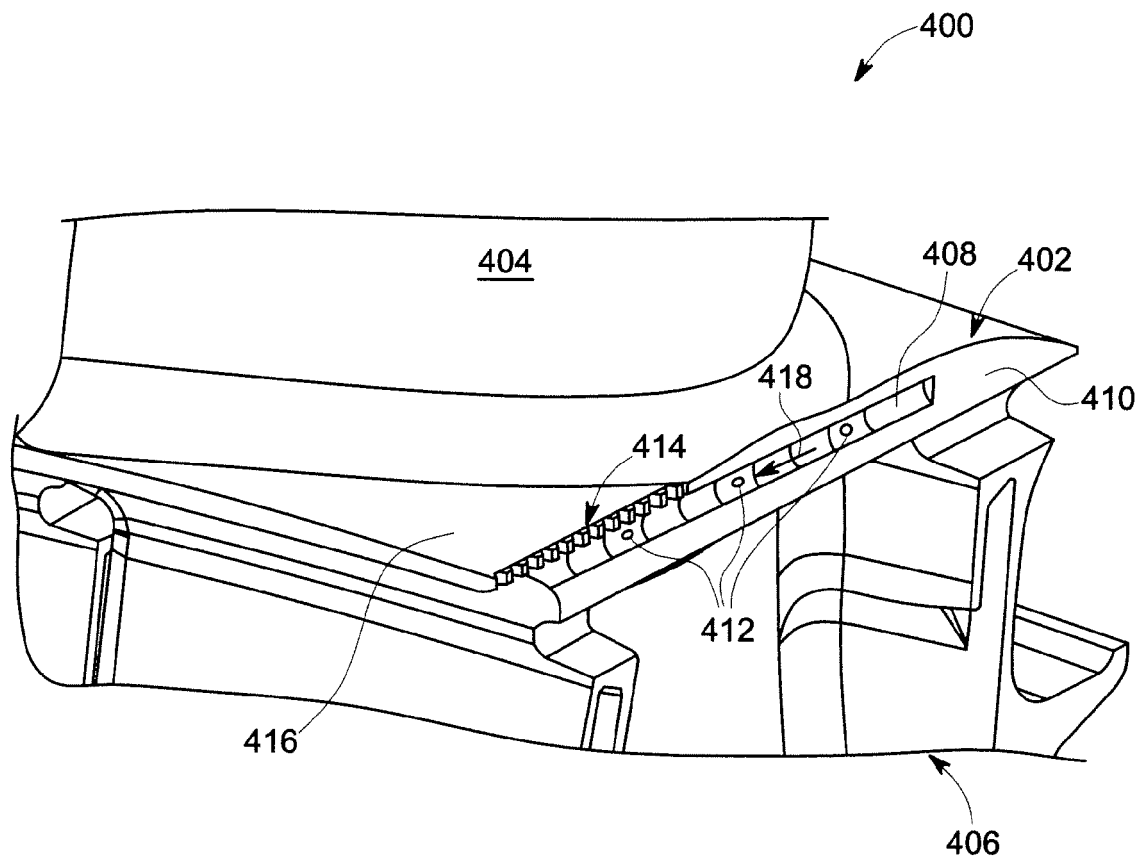


FIG. 4

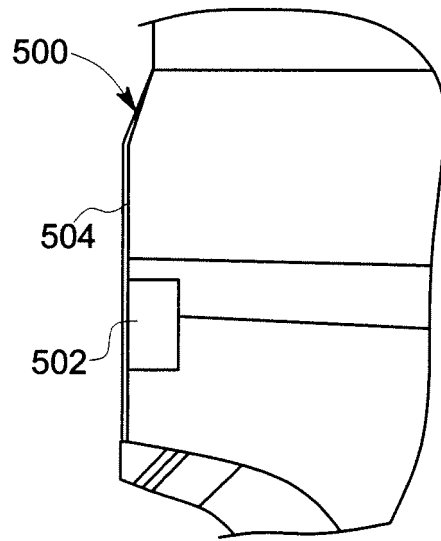


FIG. 5

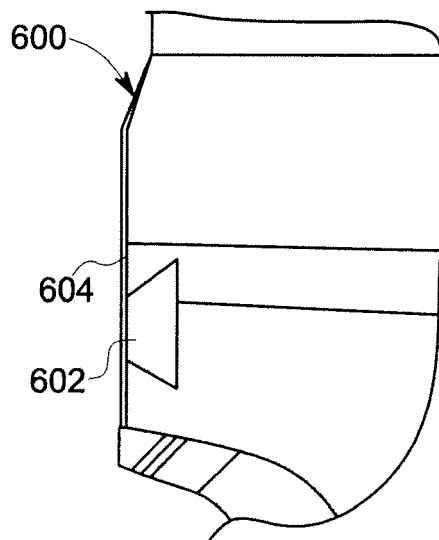


FIG. 6