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(54) **Systems and methods involving variable vanes**

Systeme und Verfahren mit variablen Schaufeln

Systèmes et procédés incorporant des vannes variables

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(56) References cited:
EP-A1- 0 164 539
FR-A- 1 499 216
US-A- 2 825 532

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EP 2 014 871 B1

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Description

BACKGROUND

Technical Field

[0001] The invention relates to gas turbine engines.

Description of the Related Art

[0002] Gas turbine engines use compressors to compress gas for combustion. In particular, a compressor typically uses alternating sets of rotating blades and stationary vanes to compress gas. Gas flowing through such a compressor is forced between the sets and between adjacent blades and vanes of a given set. Similarly, after combustion, hot expanding gas drives a turbine that has sets of rotating blades and stationary vanes.

[0003] EP 0164539 A1 discloses a passage through which a gas flow path passes, and an aerodynamically shaped winglet which separates the gas flow into first and second streams. During operating conditions requiring reduced effective throat areas, air is injected into the passage at high pressure through the guide vanes that define the passage, thereby forcing the gas flow around to the suction side of the winglet. The area of the throat is thus reduced by closing one of the streams.

SUMMARY

[0004] Systems and methods involving vanes are provided. The present invention provides a gas turbine engine defining a gas flow path, the gas turbine engine comprising: a first vane extending into the gas flow path and having: an interior operative to receive pressurized air; an outer surface; and outlet ports communicating between the outer surface and the interior of the first vane, the outlet ports being operative to receive the pressurized air from the interior and emit the pressurized air into the gas flow path such that a throat area defined, at least in part, by the first vane is moved upstream within said gas flow path.

[0005] There is also disclosed an exemplary embodiment of a vane assembly comprising: a first vane having: an outer surface; an interior defining a cavity operative to receive pressurized air; and outlet ports communicating between the outer surface and the cavity, the outlet ports being operative to receive the pressurized air from the cavity and emit the pressurized air through the outer surface; and a valve assembly operative to regulate the pressurized air emitted by the first vane.

[0006] The present invention also provides a method for modifying the throat area between vanes of a gas turbine engine comprising: directing a gas flow path of the gas turbine engine between a first vane and a second vane, wherein each of the first vane and the second vane has an outer surface and an interior; and emitting pressurized air from outlet ports communicating between the outer surface and the interior of the first vane, wherein the emitted pressurized air from the first vane moves a throat area between the first vane and the second vane upstream within said gas flow path.

[0007] Other systems, features, and/or advantages will be or may become apparent to one with skill in the art upon examination of the following drawings and detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a schematic side cutaway view illustrating an exemplary embodiment of a turbine section of a gas turbine engine.

FIG. 2 is a side cutaway view of an exemplary embodiment of a vane.

FIG. 3 is a top cutaway view of an exemplary embodiment of vanes in a gas flow path.

FIG. 4 is a top cutaway view of another exemplary embodiment of vanes in a gas flow path.

FIG. 5 is a top cutaway view of another exemplary embodiment of vanes in a gas flow path.

DETAILED DESCRIPTION

[0009] Systems and method involving vanes of gas turbine engines are provided. In this regard, several exemplary embodiments will be described. Notably, gas passing through a gas turbine engine enters a turbine that includes rotating blades and stationary vanes. The gas, following the gas flow path, is forced between adjacent vanes. The vanes are often shaped like airfoils and, therefore, have aerodynamic properties similar to airfoils. The flow of gas between adjacent vanes results in a throat area determined by, for example, the shape and relative position of the vanes. Often, the angle of the vanes relative to the gas flow path may be mechanically changed to vary the location and/or size of the throat area and alter the efficiency of the engine. However, it may be desirable, either additionally or alternatively, to alter the location and/or size of the throat area aerodynamically. In some embodiments, the gas turbine engine is configured as a turbofan.

[0010] Referring now in detail to the drawings, FIG. 1 is a schematic side view illustrating an exemplary embodiment of a turbine section 100 of a gas turbine engine. In turbine section 100, rotating blades 104 are attached to a disk that is rotated by a shaft 106. Stationary vanes 108 are attached to the casing of the engine between the blades 104. In operation, gas enters the turbine section along gas flow path 102 and drives the blades 104. The gas exits the turbine section 100 along gas flow path 102.

[0011] FIG. 2 is a simplified, side cutaway view of vane assembly 200 that includes a vane airfoil 202 and a valve assembly 208. Note that vane airfoil 202 typically is mounted to and spans between an outer diameter vane

platform and an inner diameter vane platform, neither of which is depicted in FIG. 2.

[0012] In the embodiment of FIG. 2, valve assembly 208 includes a piston 204 and solenoid 220, which is used to actuate the piston. Inlet ports 218 provide gas to the valve assembly so that actuation of the piston pressurizes the received gas.

[0013] Vane airfoil 202 includes an interior cavity 214 that receives pressurized air from the inlet ports via the piston, and outlet ports 216 that are used to emit the pressurized air into the gas flow path. In particular, the gas emitted by the outlet ports 216 affects the throat area formed between vane airfoil 202 and an adjacent vane airfoil. This is in contrast to emission of pressurized gas from ports of a vane airfoil for performing film cooling. Notably, the pressure of the pressurized gas emitted from the outlet ports 216 is greater than that used for performing film cooling. As such, the pressurized gas from the outlet ports 216 urges the gas flow path, which flows about the vane airfoil during operation of the gas turbine engine, away from the exterior surface of the vane airfoil to a greater extent than that caused by pressurized gas involved in film cooling. In fact, in those embodiments that additionally include film cooling, the boundary layer formed by the film-cooling air also is urged away from the exterior of the vane airfoil. Typically, the pressure of the gas required to alter the throat is not available from the compressor alone. Thus, piston 204 is used in the embodiment of FIG. 2 to increase the pressure of the gas provided to the outlet ports. In other embodiments, various other mechanisms could be used to increase the gas pressure.

[0014] The shape of the vane assembly 200 illustrated in FIG. 2 is merely an illustration of but one possible embodiment. The shape of the vane assembly 200 may vary depending on a variety of factors including, but not limited to, the component to which the vane assembly 200 is attached, the location of the vane assembly 200 in the gas turbine engine, the gas flow path around the vane assembly 200 at particular gas flow velocities, desired design characteristics of the gas turbine engine, and materials used in the fabrication of the gas turbine engine.

[0015] In FIG. 2, a controller 212 also is provided. The controller 212 is used to open and close the valve assembly 208. In one mode of operation, the valve assembly 208 is left open such that the outlet ports 216 emit a constant flow of pressurized air. Additionally, or alternatively, the valve assembly 208 may be opened and closed intermittently. In this mode of operation, the pressurized air may be emitted from the outlet ports 216 in pulses. Notably, operation in a pulsed mode allows the pressure of the pressurized air to increase prior to being emitted into a gas flow path. In some of these embodiments, the controller 212 may be set to control the frequency of the pulses of emitted pressurized air. Controlling the frequency of the pulses may be desirable because a change in the throat area based on a frequency of pulses may allow the aerodynamic characteristics of the engine to be adjusted.

[0016] Specifically, the frequencies of the pulses may be controlled to modify one or more throat areas in a specific region of an engine to control local pressure ratios and/or local temperatures. The pulse frequencies may also be timed to adjust for resonance in the engine that may result in vane and blade vibrations. These pulses may be used to add a canceling frequency that may effectively cancel engine resonance, for example.

[0017] FIG. 3 is a top cutaway view of a pair of vanes in an embodiment of a gas turbine engine. As shown in FIG. 3, gas is forced between the vanes 300 along gas flow path 302, forming a throat area 304. The shape of the adjacent vanes 300, their proximity to each other, and the angle of incidence to the gas flow path 302 are possible factors that can influence the location and size of the throat area 304.

[0018] FIG. 4 depicts a top cutaway view of another embodiment of a vane assembly. In this embodiment, vanes 406 and 412 are adjacent vanes. Vane 406 has an interior cavity 404 that is connected to a pressurized air source (not shown). Outlet ports 410 are located on the surface of vane 406 and are in communication with interior cavity 404.

[0019] Pressurized air emitted from the outlet ports 410 in vane 406 defines a boundary layer 408 that has an aerodynamic effect on the gas flow path 402. Notably, the boundary layer 408 associated with the pressurized air from the outlet ports modifies the location and/or size of the throat area 416, and may, for example, move it upstream. Also note that the outlet ports of this embodiment are oriented such that the flow from the outlet ports is generally in a direction of the gas flow path. In other embodiments, however, the orientation can be different, such as by providing a perpendicular (see FIG. 5) or counter flow (not shown).

[0020] Modifying the throat area of an engine may affect the flow of gases through the engine. For instance, such modifying can affect the pressure ratio of the compressor and change the relationship between the flow and the pressure ratio. For example, a lower flow rate can increase the pressure ratio.

[0021] FIG. 5 depicts a top cutaway view of another embodiment of a vane assembly. In the illustrated embodiment, vane assembly 500 incorporates two adjacent vanes, a first vane 501 and a second vane 503. The first vane 501 and the second vane 503 are spaced from each other to define a gas flow path 502. The first vane 501 includes three chambers - a film-cooling chamber 504, a suction side chamber 505 and a pressure side chamber 507. The film-cooling chamber 504, suction side chamber 505 and the pressure side chamber 507 include ports, such as ports 506, 509 and 511, respectively.

[0022] In operation, the film-cooling chamber 504 receives cooling pressurized air that is emitted from the associated ports, e.g., port 506. This air creates a relatively thin boundary layer 530 that is located adjacent to the exterior of the vane 501 to serve as a barrier against

the hot gas flowpath 502. The suction side chamber 505 and the pressure side chamber 507 also receive pressurized air, which is at a higher pressure than that provided to chamber 504, that is emitted from associated ports, e.g., ports 509 and 511. The pressurized air emitted from chamber 507 creates a boundary layer 513 along the pressure surface 515 of the first vane 501 that affects the throat area 550. Notably, the boundary layer 513 tends to urge the boundary layer 530 away from the pressure surface 515, thereby causing the boundary layer 530 to dissipate and mix with the gas of the gas flow path 502.

[0023] The second vane 503 also includes three chambers - a film-cooling chamber 532, a suction side chamber 510 and a pressure side chamber 512. The film-cooling chamber 532, suction side chamber 510 and the pressure side chamber 512 include ports, such as ports 534, 522 and 514, respectively.

[0024] In operation, the film-cooling chamber 532 receives cooling pressurized air that is emitted from the associated ports, e.g., port 534. This air creates a relatively thin boundary layer 536 that is located adjacent to the exterior of the vane 503. The suction side chamber 510 and the pressure side chamber 512 also receive pressurized air, which is at a higher pressure than that provided to chamber 534, that is emitted from associated ports, e.g., ports 522 and 514. The pressurized air emitted from chamber 510 creates a boundary layer 525 along the suction surface 508 of the vane 503 that affects the throat area 550. Notably, the boundary layer 525 tends to urge the boundary layer 536 away from the suction surface 508, thereby causing the boundary layer 536 to dissipate and mix with the gas of the gas flow path 502.

[0025] The suction side chambers 505 and 510 and the pressure side chambers 507 and 512 may be separate and unconnected to each other so that the air emitted from each of the chambers may be controlled independently. Alternatively, the suction side chambers 505 and 510 and the pressure side chambers 507 and 512 may be in communication, and therefore, dependently controlled.

[0026] It should be emphasized that the above-described embodiments are merely possible examples of implementations. Many variations and modifications may be made to the above-described embodiments. By way of example, although a solenoid is described with respect to the embodiment of FIG. 2, other types of actuation could be used. As another example, a pressurized line could be used to provide gas to a valve assembly. All such modifications and variations are intended to be included herein within the scope of the invention, which is defined by the accompanying claims and their equivalents.

Claims

1. A gas turbine engine defining a gas flow path (102; 402;502), the gas turbine engine comprising:

a first vane (202;406;501;503) extending into the gas flow path and having:

an interior (214;404;505;507;510;512) operative to receive pressurized air;
an outer surface (515;508); and
outlet ports (216;410;509;511;522;514) communicating between the outer surface and the interior of the first vane, the outlet ports being operative to receive the pressurized air from the interior and emit the pressurized air into the gas flow path such that a throat area (416;550) defined, at least in part, by the first vane is moved upstream within said gas flow path.

2. The turbine engine of claim 1, wherein the first vane (501 ;503) further comprises film cooling ports (506; 534) operative to receive cooling pressurized air at a pressure lower than that provided to the outlet ports (509;511;522;514) and to emit the cooling pressurized air from the first vane such that the first vane is film cooled.

3. The turbine engine of claim 1 or 2, further comprising a valve assembly (208) operative to regulate the pressurized air emitted by the ports.

4. The turbine engine of claim 1, 2 or 3 further comprising a second vane (503), the throat area being defined by the first vane (501) and the second vane (503).

5. The turbine engine of claim 4, further comprising a valve assembly (208) operative to control the pressurized air emitted by the first vane (501) and the second vane (503).

6. The turbine engine of claim 5, further comprising a second throat area defined, at least in part, by the second vane (503), wherein the throat area and the second throat area are moved upstream independently by the valve assembly (208).

7. The turbine engine of claim 3, 5 or 6, wherein the valve assembly (208) is operative to intermittently provide the pressurized air to the ports.

8. The turbine engine of any preceding claim, wherein the engine is a turbofan.

9. A method for modifying the throat area between vanes of a gas turbine engine comprising:

directing a gas flow path of the gas turbine engine between a first vane and a second vane,

wherein each of the first vane and the second vane has an outer surface and an interior; and emitting pressurized air from outlet ports communicating between the outer surface and the interior of the first vane, wherein the emitted pressurized air from the first vane moves a throat area between the first vane and the second vane upstream within said gas flow path.

10. The method of claim 9, further comprising film cooling the first vane using lower pressure air than the emitted pressurized air used to move the throat area.

11. The method of claim 9 or 10, wherein the step of emitting the pressurized air from outlet ports further comprises emitting the pressurized air in pulses.

12. The method of claim 9, 10 or 11, further comprising emitting pressurized air from outlet ports communicating between the outer surface of the second vane and the interior of the second vane such that the emitted pressurized air from the second vane also moves the throat area between the first vane and the second vane.

13. The method of claim 9, 10, 11 or 12, wherein the step of emitting the pressurized air from outlet ports further comprises emitting the pressurized air in a direction corresponding to the flow of the gas flow path.

14. The method of any of claims 9 to 13, wherein the step of emitting the pressurized air from ports further comprises emitting the pressurized air to reduce engine resonance.

Patentansprüche

1. Gasturbinenmaschine, die einen Gas-Strömungsweg (102; 402; 502) definiert, wobei die Gasturbinenmaschine umfasst:

eine erste Leitschaufel (202; 406; 501; 503), die sich in den Gas-Strömungsweg erstreckt und aufweist:

ein Inneres (214; 404; 505; 507; 510; 512), das in der Lage ist, druckbeaufschlagte Luft zu empfangen;
eine Außenfläche (515; 508); und
Auslassanschlüsse (216; 410; 509; 511; 522; 514), die die Außenfläche und das Innere der ersten Leitschaufel verbinden, wobei die Auslassanschlüsse in der Lage sind, druckbeaufschlagte Luft von dem Inneren zu empfangen, und die druckbeaufschlagte Luft in den Gas-Strömungsweg zu entlassen, sodass ein Einschnürungsbereich (416; 550), der zumindest teilweise durch die erste Leitschaufel definiert ist, innerhalb des Gas-Strömungsweges stromaufwärts bewegt wird.

2. Turbinenmaschine nach Anspruch 1, wobei die erste Leitschaufel (501; 503) des Weiteren Filmkühlungsanschlüsse (506; 534) umfasst, die in der Lage sind, druckbeaufschlagte Kühlungsluft bei einem Druck zu empfangen, der geringer ist als derjenige, der an den Auslassanschlüssen (509; 511; 522; 514) bereitgestellt ist, und die druckbeaufschlagte Kühlungsluft von der ersten Leitschaufel zu entlassen, sodass die erste Leitschaufel filmgekühlt ist.

3. Turbinenmaschine nach Anspruch 1 oder 2, des Weiteren umfassend eine Ventilanordnung (208), die dazu in der Lage ist, die druckbeaufschlagte, von den Anschlüssen entlassene Luft zu regulieren.

4. Turbinenmaschine nach Anspruch 1, 2 oder 3, des Weiteren umfassend eine zweite Leitschaufel (503), wobei der Einschnürungsbereich durch die erste Leitschaufel (501) und die zweite Leitschaufel (503) definiert ist.

5. Turbinenmaschine nach Anspruch 4, des Weiteren umfassend eine Ventilanordnung (208), die dazu in der Lage ist, die druckbeaufschlagte, von der ersten Leitschaufel (501) und der zweiten Leitschaufel (503) entlassene Luft zu steuern/zu regeln.

6. Turbinenmaschine nach Anspruch 5, des Weiteren umfassend einen zweiten Einschnürungsbereich, der zumindest teilweise durch die zweite Leitschaufel (503) definiert ist, wobei der Einschnürungsbereich und der zweite Einschnürungsbereich unabhängig durch die Ventilanordnung (208) stromaufwärts bewegt werden.

7. Turbinenmaschine nach Anspruch 3, 5 oder 6, wobei die Ventilanordnung (208) in der Lage ist, die druckbeaufschlagte Luft zeitweise an die Anschlüsse bereitzustellen.

8. Turbinenmaschine nach einem der vorangehenden Ansprüche, wobei die Maschine ein Turbobläser ist.

9. Verfahren zum Modifizieren des Halsbereichs zwischen Leitschaufeln einer Gasturbinenmaschine umfassend:

Leiten eines Gas-Strömungswegs der Gasturbinenmaschine zwischen einer ersten Leitschaufel und einer zweiten Leitschaufel, wobei sowohl die erste Leitschaufel als auch die zweite Leitschaufel eine äußere Fläche und ein Inneres

aufweist; und
Entlassen von druckbeaufschlagter Luft von den Auslassanschlüssen, die die Außenfläche und das Innere der ersten Leitschaufel verbinden, wobei die entlassene druckbeaufschlagte Luft von der ersten Leitschaufel einen Einschnürungsbereich zwischen der ersten Leitschaufel und der zweiten Leitschaufel stromaufwärts innerhalb des Gas-Strömungswegs bewegt.

10. Verfahren nach Anspruch 9, des Weiteren umfassend Filmkühlen der ersten Leitschaufel durch das Verwenden von Luft geringeren Drucks als die druckbeaufschlagte, zum Bewegen des Einschnürungsbereichs verwendete Luft.

11. Verfahren nach Anspruch 9 oder 10, wobei der Schritt des Entlassens der druckbeaufschlagten Luft aus den Auslassanschlüssen des Weiteren das Entlassen der druckbeaufschlagten Luft in Pulsen umfasst.

12. Verfahren nach Anspruch 9, 10 oder 11, des Weiteren umfassend Entlassen druckbeaufschlagter Luft aus Auslassanschlüssen, die die Außenfläche der zweiten Leitschaufel mit dem Inneren der zweiten Leitschaufel verbinden, sodass die entlassene druckbeaufschlagte Luft von der zweiten Leitschaufel auch den Einschnürungsbereich zwischen der ersten Leitschaufel und der zweiten Leitschaufel bewegt.

13. Verfahren nach Anspruch 9, 10, 11 oder 12, wobei der Schritt des Entlassens der druckbeaufschlagten Luft von Auslassanschlüssen des Weiteren Entlassen der druckbeaufschlagten Luft in eine Richtung, die der Strömung des Gas-Strömungsweges entspricht, umfasst.

14. Verfahren nach einem der Ansprüche 9 bis 13, wobei der Schritt des Entlassens der druckbeaufschlagten Luft von Anschlüssen des Weiteren Entlassen der druckbeaufschlagten Luft, um Maschinenresonanz zu reduzieren, umfasst

Revendications

1. Turbomoteur, définissant un chemin d'écoulement de gaz (102 ; 402 ; 502), le turbomoteur comprenant :

une première aube (202 ; 406 ; 501 ; 503) s'étendant dans le chemin d'écoulement de gaz et comportant :

un intérieur (214 ; 404 ; 505 ; 507 ; 510 ; 512) apte à recevoir de l'air sous pression ;
une surface extérieure (515 ; 508) ; et
des orifices de sortie (216 ; 410 ; 509 ; 511 ; 522 ; 514) communiquant entre la surface extérieure et l'intérieur de la première aube, les orifices de sortie étant aptes à recevoir l'air sous pression en provenance de l'intérieur et à émettre l'air sous pression dans le chemin d'écoulement de gaz de manière à déplacer vers l'amont dans ledit chemin d'écoulement de gaz une zone d'étranglement (416 ; 550) définie, en partie au moins, par la première aube.

2. Turbomoteur selon la revendication 1, dans lequel la première aube (501 ; 503) comprend en outre des orifices de refroidissement par film fluide (506 ; 534) aptes à recevoir de l'air de refroidissement sous pression à une pression inférieure à celle de celui fourni aux orifices de sortie (509 ; 511 ; 522 ; 514) et à émettre l'air de refroidissement sous pression depuis la première aube de manière à assurer un refroidissement par film fluide de la première aube.

3. Turbomoteur selon la revendication 1 ou 2, comprenant en outre un ensemble soupape (208) apte à réguler l'air sous pression émis par les orifices.

4. Turbomoteur selon la revendication 1, 2 ou 3, comprenant en outre une deuxième aube (503), la zone d'étranglement étant définie par la première aube (501) et la deuxième aube (503).

5. Turbomoteur selon la revendication 4, comprenant en outre un ensemble soupape (208) apte à réguler l'air sous pression émis par la première aube (501) et la deuxième aube (503).

6. Turbomoteur selon la revendication 5, comprenant en outre une deuxième zone d'étranglement définie, en partie au moins, par la deuxième aube (503), lesquelles zone d'étranglement et deuxième zone d'étranglement sont déplacées indépendamment vers l'amont par l'ensemble soupape (208).

7. Turbomoteur selon la revendication 3, 5 ou 6, dans lequel l'ensemble soupape (208) est apte à fournir par intermittence l'air sous pression aux orifices.

8. Turbomoteur selon l'une quelconque des revendications précédentes, prenant la forme d'un turboréacteur à double flux.

9. Procédé permettant de modifier la zone d'étranglement entre des aubes d'un turbomoteur, le procédé comprenant les étapes consistant à :

diriger un chemin d'écoulement de gaz du turbomoteur entre une première aube et une

deuxième aube, lesquelles première aube et deuxième aube présentent chacune une surface extérieure et un intérieur ; et
émettre de l'air sous pression depuis des orifices de sortie communiquant entre la surface extérieure et l'intérieur de la première aube, lequel air sous pression émis depuis la première aube déplace une zone d'étranglement entre la première aube et la deuxième aube vers l'amont dans ledit chemin d'écoulement de gaz.

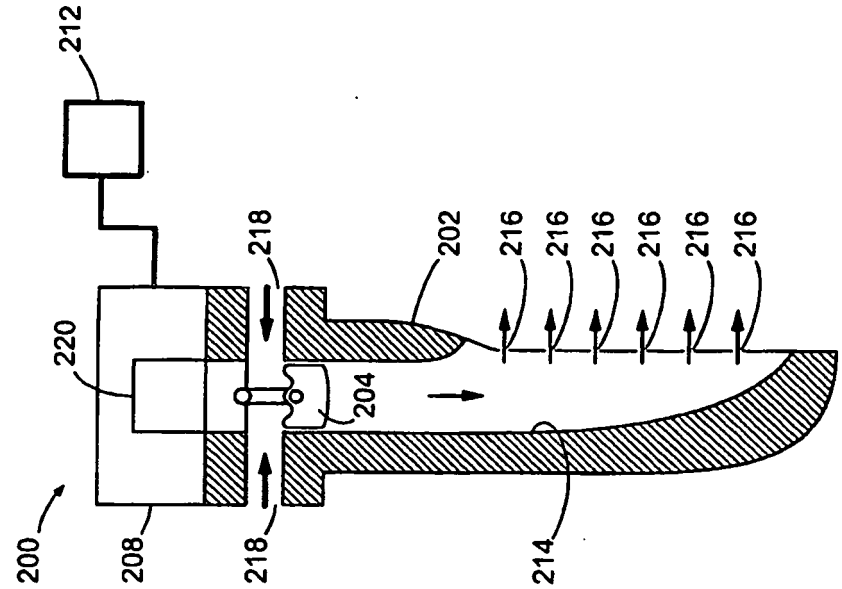
10. Procédé selon la revendication 9, comprenant en outre l'étape consistant à assurer un refroidissement par film fluide de la première aube par de l'air dont la pression est inférieure à celle de l'air sous pression émis utilisé pour déplacer la zone d'étranglement.

11. Procédé selon la revendication 9 ou 10, dans lequel l'étape consistant à émettre l'air sous pression depuis des ports de sortie comprend en outre l'étape consistant à émettre l'air sous pression de manière pulsée.

12. Procédé selon la revendication 9, 10 ou 11, comprenant en outre l'étape consistant à émettre de l'air sous pression depuis des orifices de sortie communiquant entre la surface extérieure de la deuxième aube et l'intérieur de la deuxième aube de manière à ce que l'air sous pression émis depuis la deuxième aube déplace également la zone d'étranglement entre la première aube et la deuxième aube.

13. Procédé selon la revendication 9, 10, 11 ou 12, dans lequel l'étape consistant à émettre l'air sous pression depuis des orifices de sortie comprend en outre l'étape consistant à émettre l'air sous pression dans une direction correspondant à l'écoulement du chemin d'écoulement de gaz.

14. Procédé selon l'une quelconque des revendications 9 à 13, dans lequel l'étape consistant à émettre l'air sous pression depuis des orifices comprend en outre l'étape consistant à émettre l'air sous pression dans le but de réduire la résonance du turbomoteur.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220
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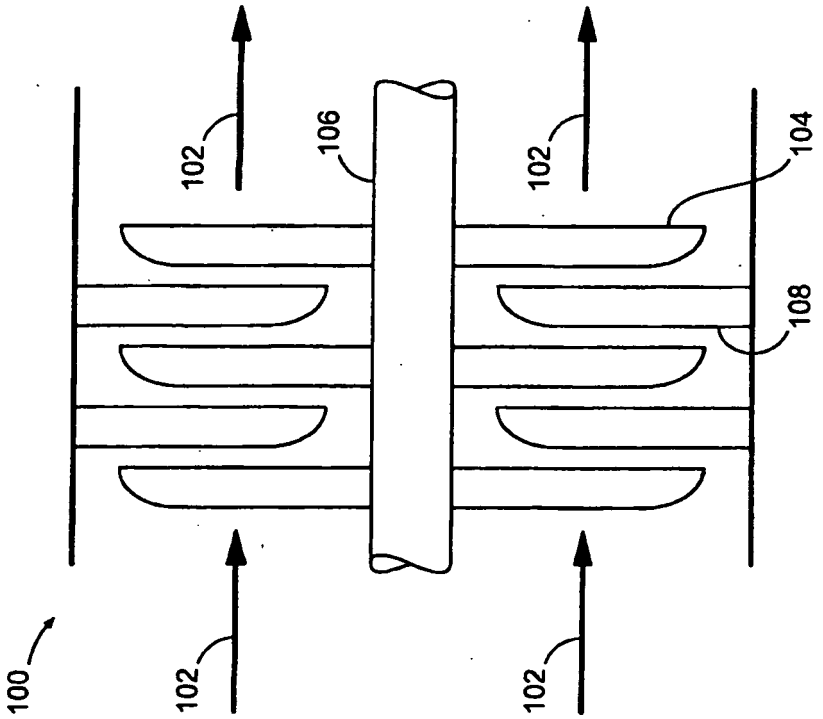
208
218
214

FIG. 2


102
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108
100
102
102

FIG. 1

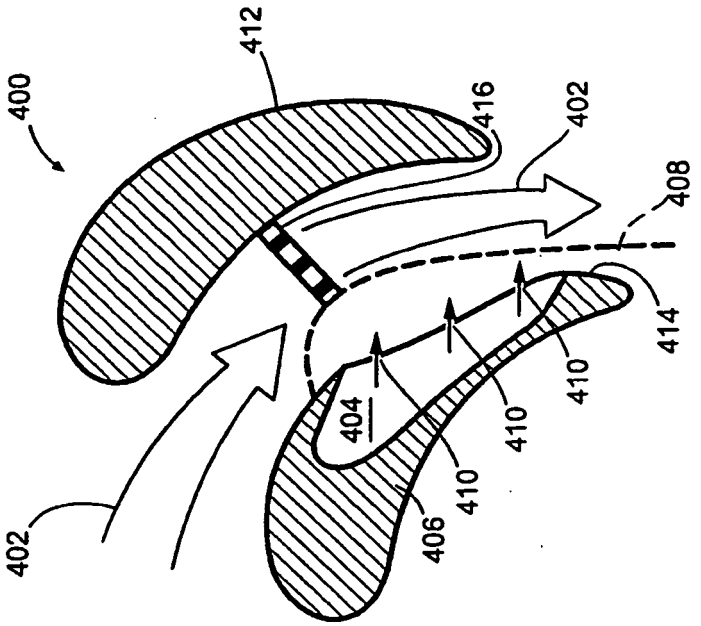

FIG. 4

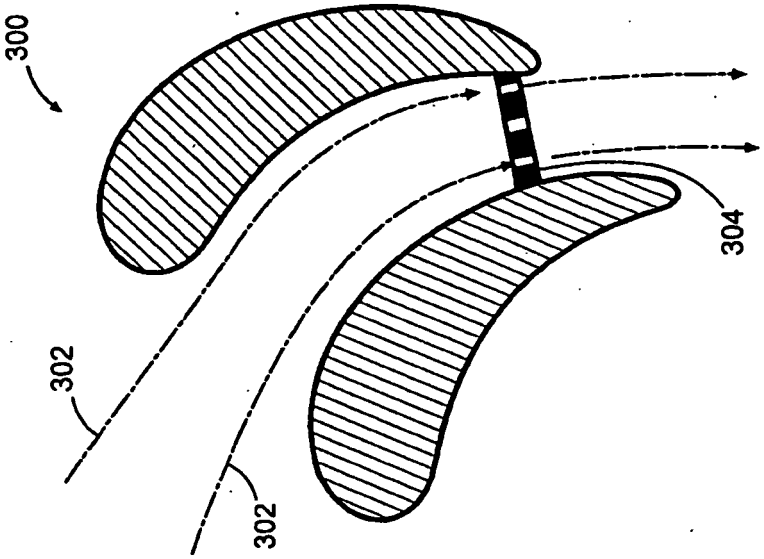

FIG. 3

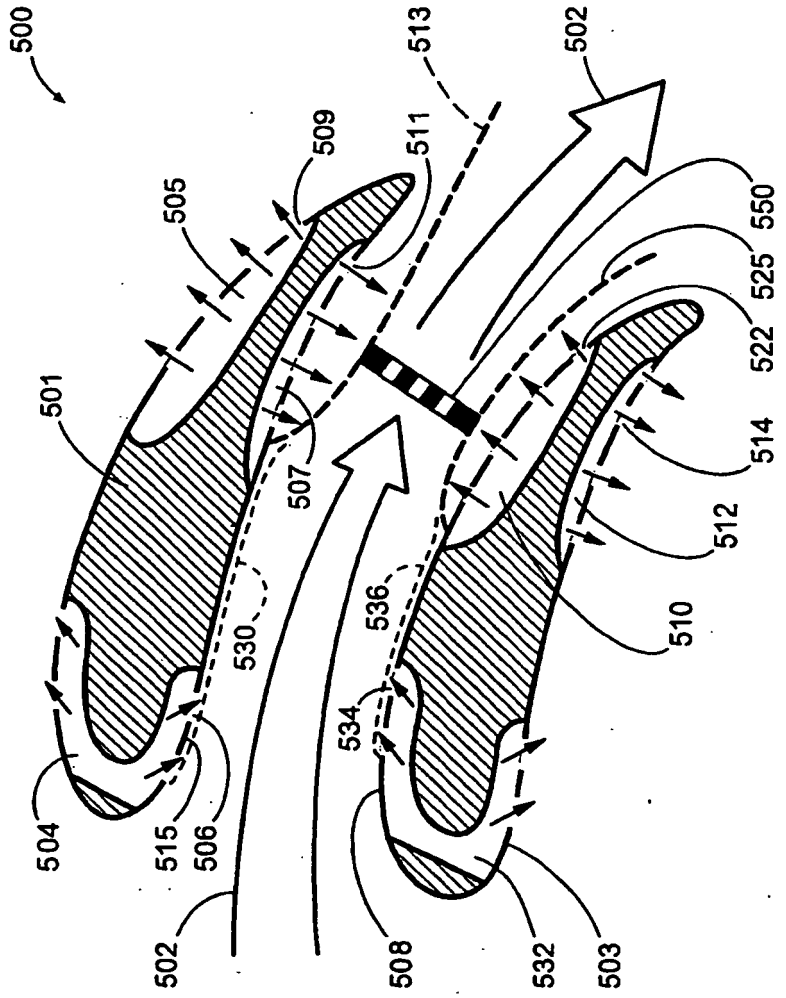
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FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0164539 A1 **[0003]**