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(54) **Integrated platform, tip, and main body microcircuits for turbine blades**

In Schaufelplattform, Schaufelspitze und Schaufelblatt integrierte Mikrokanäle für Turbinenschaufeln

Microcircuits pour pales de turbine intégrés dans la plate-forme, la pointe, et l'aube

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Description

BACKGROUND

(1) Field of the Invention

[0001] The present invention relates to a turbine engine component having an integrated system for cooling the platform, the tip, and the main body of an airfoil portion of the component.

(2) Prior Art

[0002] FIG. 1 depicts an engine arrangement 10 illustrating the relative location of a high pressure turbine blade 12. FIGS. 2 and 3 depict the main design characteristics of a typical conventionally cooled high-pressure blade 12. In general, cooling flow passes through these blades by means of internal cooling channels 14 that are turbulated with trip strips 16 for enhancing heat transfer inside the blade. The cooling effectiveness of these blades is around 0.50 with a convective efficiency of around 0.40. It should be noted that cooling effectiveness is a dimensionless ratio of metal temperature ranging from zero to unity as the minimum and maximum values. The convective efficiency is also a dimensionless ratio and denotes the ability for heat pick-up by the coolant, with zero and unity denoting no heat pick-up and maximum heat pick-up respectively. The higher these two dimensionless parameters become, the lower the parasitic coolant flow required to cool the high-pressure blade. In other words, if the relative gas peak temperature increases from 2500 degrees Fahrenheit (1371°C) to 2850 degrees Fahrenheit (1566°C), the blade cooling flow should not increase and if possible, even decrease for turbine efficiency improvements. That objective is extremely difficult to achieve with current cooling technology which is shown schematically in FIGS. 2 and 3. In general, for such an increase in gas temperature, the cooling flow would have to increase more than 5% of the engine core flow. The metal temperature in the embodiment of FIG. 3 is about 2180 degrees Fahrenheit (1193°C). This level of temperature is considered above the target limit.

[0003] Another example of current cooling technology is disclosed in document US 5 813 835.

SUMMARY OF THE INVENTION

[0004] To improve the cooling effectiveness and the convective efficiency, several approaches are required. First, coating the airfoil with a thermal barrier coating is a first requirement. The other requirements are: (1) improved film cooling in terms of slots for increased film coverage; (2) improved heat pick--up; and (3) improved heat transfer coefficients in the blade cooling passages. With that in mind, the overall cooling effectiveness will approach 0.8 with a connective efficiency approaching 0.5, allowing for a lower cooling flow of no more than 3.5% of the engine core flow.

[0005] In accordance with the present invention, a turbine engine component according to claim 1 is provided.

[0006] Other details of the integrated platform, tip, and main body microcircuits for blades, as well as other advantages attendant thereto, are set forth in the following detailed description and the accompanying drawings wherein like reference numerals depict like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is a schematic representation of a general high pressure turbine section of an engine;
FIG. 2 is a sectional view of an airfoil portion of a turbine engine component showing existing design characteristics;
FIG. 3 is another sectional view of the airfoil portion of FIG. 2;
FIG. 4 is a sectional view of an airfoil portion of a turbine engine component having cooling microcircuits in accordance with the present invention;
FIG. 5 is a schematic representation of the cooling microcircuit in the suction side of the airfoil portion;
FIG. 6 is a schematic representation of the cooling microcircuit in the pressure side of the airfoil portion;
FIG. 7 is a schematic representation of an airfoil suction side and forward platform microcircuit cooling;
FIG. 8 is a schematic representation of the microcircuit cooling in FIG. 7;
FIG. 9 is a schematic representation of the cooling microcircuit in a pressure side of the airfoil portion and aft plat form microcircuit cooling; and
FIG. 10 is a schematic representation of the microcircuit cooling in FIG. 9

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0008] As noted above, to improve the cooling effectiveness and the convective efficiency, several approaches are required. First, coating the airfoil with a thermal barrier coating is a first requirement. The other requirements are: (1) improved film cooling in terms of slots for increased film coverage; (2) improved heat pick-up; and (3) improved heat transfer coefficients in the blade cooling passages. With that in mind, the overall cooling effectiveness will approach 0.8 with a convective efficiency approaching 0.5, allowing for lower cooling flow of no more than 3.5%. One such design is shown in FIG. 4.

[0009] Referring now to the drawings, a turbine engine component 90, such as a high pressure turbine blade, is cooled using the cooling design scheme of the present invention. The cooling design scheme, as shown in FIG. 4, encompasses two serpentine microcircuits 100 and 102 located peripherally in the airfoil walls 104 and 106 respectively for cooling the main body 108 of the airfoil portion 110 of the turbine engine component. Separate cooling microcircuits 96 and 98, as shown in FIGS. 5 and 6, may be used to cool the leading and trailing edges 112 and 114 respectively of the airfoil main body 108. One of the benefits of the approach of the present invention is that the coolant inside the turbine engine component may be used to feed the leading and trailing edge regions 112 and 114. This is preferably done by isolating the microcircuits 96 and 98 from the external thermal load from either the pressure side 116 or the suction side 118 of the airfoil portion 110. In this way, both impingement jets before the leading and trailing edges become very effective. In the leading and trailing edge cooling microcircuits 96 and 98 respectively, the coolant may be ejected out of the turbine engine component by means of film cooling.

[0010] Referring now to FIG. 5, there is shown a serpentine cooling microcircuit 102 that may be used on the suction side 118 of the turbine engine component. As can be seen from this figure, the microcircuit 102 has a fluid inlet 126 for supplying cooling fluid to a first leg 128. The inlet 126 receives the cooling fluid from one of the feed cavities 142 in the turbine engine component. Fluid flowing through the first leg 128 travels to an intermediate leg 130 and from there to an outlet leg 132. Fluid supplied by one of the feed cavities 142 may also be introduced into the cooling microcircuit 96 and used to cool the leading edge 112 of the airfoil portion 110. Tne cooling microcircuit 96 may include fluid passageway 131 having fluid outlets 133. Still further, if desired, fluid from the outlet leg 132 may be used to cool the leading edge 112 via an outlet passage 135. As can be seen, the thermal load to the turbine engine component may not require film cooling from each of the legs that form the serpentine peripheral cooling microcircuit 102. In such an event, the flow of cooling fluid may be allowed to exit from the outlet leg 132 at the tip 134 by means of film blowing from the pressure side 116 to the suction side 118 of the turbine engine component. As shown in FIG. 5, the outlet leg 132 may communicate with a passageway 136 in the tip 134 having fluid outlets 138.

[0011] Referring now to FIG. 6, there is shown the serpentine cooling microcircuit 100 for the pressure side 116 of the airfoil portion 110. As can be seen from this figure, the microcircuit 100 has an inlet 141 which communicates with one of the feed cavities 142 and a first leg 144 which receives cooling fluid from the inlet 141. The cooling fluid in the first leg 144 flows through the intermediate leg 146 and through the outlet leg 148. As can be seen, from this figure, fluid from the feed cavity 142 may also be supplied to the trailing edge cooling microcircuit 98. The cooling microcircuit 98 may have a plurality of fluid passageways 150 which have outlets 152 for distributing cooling fluid over the trailing edge 114 of the airfoil portion 110. The outlet leg 148 may have one or more fluid outlets 153 for supplying a film of cooling fluid over the pressure side 116 of the airfoil portion 110 in the region of the trailing edge 114.

[0012] It should be noted that the cooling microcircuit scheme of FIGS. 4 - 6 is completely different from existing designs where a dedicated cooling passage, denoted as a tip flag is employed for cooling the tip 134.

[0013] Also as shown in FIGS. 4 - 6, the pressure side 116 of the airfoil main body 108 is cooled with a serpentine microcircuit 100 located peripherally in the airfoil wall 104. In this case, a flow exits in a series of film cooling slots 153 close to the aft side of the airfoil 110 to protect the airfoil trailing edge 114.

[0014] If desired, each leg 128, 130, 132, 144, 146, and 148 of the serpentine cooling microcircuits 100 and 102 may be provided with one or more internal features (not shown), such as pedestals and/or trip strips, to enhance the heat pick-up and increase the heat transfer coefficients characteristics inside the cooling blade passage(s).

[0015] Referring now to FIGS. 7 and 8, cooling microcircuits may be located around and imbedded in a platform portion 170 of the turbine blade. The cooling microcircuits may include a leading edge or forward cooling microcircuit 172 having an inlet portion A and an outlet portion B. As shown in FIG. 8, the inlet portion A may receive fluid from one of the feed cavities 142. Fluid from the outlet portion B flows back into the cooling microcircuit 96.

[0016] Referring now to FIGS. 9 and 10, the platform cooling microcircuits may include a trailing edge or aft cooling microcircuit 180 having an inlet portion C and an outlet portion D. The inlet portion C may receive fluid from one of the feed cavities 142. Fluid from the outlet portion D flows into the cooling microcircuit 98.

[0017] As can be seen, the platform cooling is independent of the serpentine cooling microcircuits 100 and 102 used for the airfoil portion 100. The inlet coolant flow to either of the leading and trailing edge cooling microcircuits 172 and 180 comes from a lower radii. This coolant flow is allowed to pass through the platform walls before discharging into the cooling microcircuit 96 or 98 at a higher radii. The rotational pumping which is created, along with the ejector-type action of the main flow, will ensure circulation in the peripheral platform cooling microcircuits 172 and 180. In this way, an integrated cooling system has been devised to cool the platform 170, the main body 108 of the airfoil portion 110, and the tip 134 of the airfoil portion 110 by taking advantage of the microcircuit cooling characteristics.

[0018] If desired, the platform cooling microcircuits 172 and 180 may be provided with one or more internal features (not shown), such as pedestals, to enhance heat pick-up and increase the heat transfer coefficient characteristics inside the cooling passage(s) of the cooling microcircuits.

Claims

1. A turbine engine component (90) having an airfoil portion (110) with a pressure side (116) and a suction

side (118) comprising:

a first cooling microcircuit (102) embedded within a first wall (106) forming said suction side (118), said first cooling microcircuit (102) having a serpentine arrangement with a first outlet leg (132) and having means for allowing a cooling fluid in said first cooling microcircuit (102) to exit at a tip (134) of said airfoil portion;
a second cooling microcircuit (100) embedded within a second wall (104) forming said pressure side (116), said second cooling microcircuit (100) having a serpentine arrangement with a second outlet leg (148);
means for creating a flow of cooling fluid over a trailing edge (114) of said.airfoil portion (110);
means for creating a flow of cooling fluid over a leading edge (112) of said airfoil portion (110); and **characterised in that** said first cooling microcircuit (102) has an outlet passage (135) for cooling the leading edge (112) of the airfoil portion; and **in that** said second cooling microcircuit (100) has an inlet (141) and said second outlet leg (148) has a plurality of film cooling outlets to supply cooling fluid over the pressure side of the airfoil portion in the region of the trailing edge of the airfoil portion.

2. The turbine engine component according to claim 1, wherein said cooling fluid exits at said tip (134) by means of film blowing from the pressure side (116) to the suction side (118) of the airfoil portion (110).

3. The turbine engine component according to claim 1 or 2, wherein said means for creating a flow of cooling fluid over a trailing edge (114) of said airfoil portion (110) is isolated from an external thermal load from either the pressure side (116) or the suction side (118) of the airfoil portion (110).

4. The turbine engine component according to claim 1, 2 or 3, wherein said means for creating a flow of cooling fluid over said leading edge (112) of said airfoil portion (110) is isolated from an external thermal load from either the pressure side (116) or the suction side (118) of the airfoil portion (110).

5. The turbine engine component according to any preceding claim, further comprising a platform (170) and means for cooling said platform (170).

6. The turbine engine component according to claim 5, wherein said platform cooling means is independent of said, first and second cooling microcircuits (100, 102).

7. The turbine engine component according to claim 5 or 6, wherein said platform cooling means comprises a third cooling microcircuit (172) embedded within a forward portion of said platform (170).

8. The turbine engine component according to claim 7, wherein said platform cooling means further comprises a fourth cooling microcircuit (180) embedded within an aft portion of said platform (170).

9. The turbine engine component according to claim 8, wherein each of said third and fourth cooling microcircuits (172, 180) has an inlet at a first level and an outlet at a second level different from said first level.

10. The turbine engine component according to claim 9, wherein said first level is lower than said second level.

11. The turbine engine component according to any preceding claim, wherein said component (90) comprises a blade.

12. The turbine engine component according to claim 11, wherein said component (90) comprises a high-pressure blade.

Patentansprüche

1. Turbinenmaschinenkomponente (90), welche einen Strömungsprofilbereich (110) aufweist mit einer Druckseite (116) und einer Saugseite (118) umfassend:

einen ersten Kühlungsmikrokreislauf (102), der innerhalb einer ersten Wand (106), welche die Saugseite (118) ausbildet, eingeschlossen ist, wobei der erste Kühlungsmikrokreislauf (102) eine gewundene Anordnung aufweist mit einem ersten Auslassabschnitt (132) und Mittel aufweist, die es einem Kühlfluid in dem ersten Kühlungsmikrokreislauf (102) ermöglichen, an einem Ende (134) des Strömungsprofilbereichs auszutreten;
einen zweiten Kühlungsmikrokreislauf (100), der innerhalb einer zweiten Wand (104), welche die Druckseite (116) ausbildet, eingeschlossen ist, wobei der zweite Kühlungsmikrokreislauf (100) eine gewundene Anordnung aufweist mit einem zweiten Auslassbereich (148);
Mittel zur Erzeugung eines Stroms von Kühlfluid über eine Hinterkante (114) des Strömungsprofilbereichs (110);
Mittel zur Erzeugung eines Stroms von Kühlfluid über eine Vorderkante (112) des Strömungsprofilbereichs (110); und **dadurch gekennzeichnet dass** der erste Kühlungsmikrokreislauf (102) einen Auslassdurchgang (135) aufweist, um die Vorderkante (112) des Strömungsprofil-

bereichs zu kühlen; und dadurch dass der zweite Kühlungsmikrokreislauf (100) einen Einlass (141) aufweist und der zweite Auslassbereich (148) eine Mehrzahl von Filmkühlungsauslässen aufweist, um Kühlfluid über die Druckseite des Strömungsprofilbereichs in den Bereich der Hinterkante des Strömungsprofilbereichs zu liefern.

2. Turbinenmaschinenkomponente nach Anspruch 1, wobei das Kühlfluid an dem Ende (134) mittels Filmblasen von der Druckseite (116) zu der Saugseite (118) des Strömungsprofilbereichs (110) austritt.

3. Turbinenmaschinenkomponente nach Anspruch 1 oder 2, wobei das Mittel zur Erzeugung eines Stroms von Kühlfluid über eine Hinterkante (114) des Strömungsprofilbereichs (110) isoliert ist von einer externen thermischen Last von entweder der Druckseite (116) oder der Saugseite (118) des Strömungsprofilbereichs (110).

4. Turbinenmaschinenkomponente nach Anspruch 1, 2 oder 3, wobei das Mittel zur Erzeugung eines Stroms von Kühlfluid über die Vorderkante (112) des Strömungsprofilbereichs (110) isoliert ist von einer externen thermalen Last von entweder der Druckseite (116) oder der Saugseite (118) des Strömungsprofilbereichs (110).

5. Turbinenmaschinenkomponente nach einem der vorangehenden Ansprüche, des Weiteren umfassend eine Plattform (170) und Mittel zur Kühlung dieser Plattform (170).

6. Turbinenmaschinenkomponente nach Anspruch 5, wobei das Plattformkühlungsmittel unabhängig von dem ersten und zweiten Kühlungsmikrokreislauf (100, 102) ist.

7. Turbinenmaschinenkomponente nach Anspruch 5 oder 6, wobei das Plattformkühlungsmittel einen dritten Kühlungsmikrokreislauf (172) umfasst, welcher innerhalb eines vorderen Bereichs der Plattform (170) eingeschlossen ist.

8. Turbinenmaschinenkomponente nach Anspruch 7, wobei das Plattformkühlungsmittel des Weiteren einen vierten Kühlungsmikrokreislauf (180) umfasst, welcher innerhalb eines hinteren Bereichs der Plattform (170) eingeschlossen ist.

9. Turbinenmaschinenkomponente nach Anspruch 8, wobei sowohl der dritte als auch der vierte Kühlungsmikrokreislauf (172, 180) einen Einlass in einer ersten Ebene und einen Auslass in einer zweiten Ebene, die unterschiedlich von der ersten Ebene ist, aufweist.

10. Turbinenmaschinenkomponente nach Anspruch 9, wobei die erste Ebene tiefer als die zweite Ebene ist.

11. Turbinenmaschinenkomponente nach einem der vorangehenden Ansprüche, wobei die Komponente (90) eine Laufschaufel umfasst.

12. Turbinenmaschinenkomponente nach Anspruch 11, wobei die Komponente (90) eine Hochdrucklaufschaufel umfasst.

Revendications

1. Composant de moteur à turbine (90) comportant une portion de surface portante (110) avec un côté pression (116) et un côté aspiration (118) comprenant :

un premier microcircuit de refroidissement (102) noyé dans une première paroi (106) formant ledit côté aspiration (118), ledit premier microcircuit de refroidissement (102) présentant une disposition en serpentin avec une première jambe de train de refoulement (132) et comportant un moyen pour permettre à un fluide de refroidissement dans ledit premier microcircuit de refroidissement (102) de sortir au niveau d'un embout (134) de ladite portion de surface portante ;
un deuxième microcircuit de refroidissement (100) noyé dans une seconde paroi (104) formant ledit côté pression (116), ledit deuxième microcircuit de refroidissement (100) présentant une disposition en serpentin avec une seconde jambe de train de refoulement (148) ;
un moyen pour créer un flux de fluide de refroidissement sur un bord de fuite (114) de ladite portion de surface portante (110) ;
un moyen pour créer un flux de fluide de refroidissement sur un bord d'attaque (112) de ladite portion de surface portante (110) ; et
caractérisé en ce que ledit premier microcircuit de refroidissement (102) comporte un passage de refoulement (135) pour refroidir le bord d'attaque (112) de la portion de surface portante ; et **en ce que** ledit deuxième microcircuit de refroidissement (100) comporte une admission (141) et ladite seconde jambe de train de refoulement (148) comporte une pluralité de refoulements de refroidissement de film pour fournir un fluide de refroidissement sur le côté pression de la portion de surface portante dans la région du bord de fuite de la portion de surface portante.

2. Composant de moteur à turbine selon la revendication 1, dans lequel ledit fluide de refroidissement sort au niveau dudit embout (134) au moyen d'un soufflage de film du côté pression (116) au côté aspiration (118) de la portion de surface portante (110).

3. Composant de moteur à turbine selon la revendication 1 ou 2, dans lequel ledit moyen pour créer un flux de fluide de refroidissement sur un bord de fuite (114) de ladite portion de surface portante (110) est isolé d'une charge thermique externe soit du côté pression (116), soit du côté aspiration (118) de la portion de surface portante (110).

4. Composant de moteur à turbine selon la revendication 1, 2 ou 3, dans lequel ledit moyen pour créer un flux de fluide de refroidissement sur ledit bord d'attaque (112) de ladite portion de surface portante (110) est isolé d'une charge thermique externe soit du côté pression (116), soit du côté aspiration (118) de la portion de surface portante (110).

5. Composant de moteur à turbine selon l'une quelconque des revendications précédentes, comprenant en outre une plate-forme (170) et un moyen pour refroidir ladite plate-forme (170).

6. Composant de moteur à turbine selon la revendication 5, dans lequel ledit moyen de refroidissement de plate-forme est indépendant desdits premier et deuxième microcircuits de refroidissement (100, 102).

7. Composant de moteur à turbine selon la revendication 5 ou 6, dans lequel ledit moyen de refroidissement de plate-forme comprend un troisième microcircuit de refroidissement (172) noyé dans une portion avant de ladite plate-forme (170).

8. Composant de moteur à turbine selon la revendication 7, dans lequel ledit moyen de refroidissement de plate-forme comprend en outre un quatrième microcircuit de refroidissement (180) noyé dans une portion arrière de ladite plate-forme (170).

9. Composant de moteur à turbine selon la revendication 8, dans lequel chacun des troisième et quatrième microcircuits de refroidissement (172, 180) comporte une admission à un premier niveau et un refoulement à un second niveau différent dudit premier niveau.

10. Composant de moteur à turbine selon la revendication 9, dans lequel ledit premier niveau est inférieur audit second niveau.

11. Composant de moteur à turbine selon l'une quelconque des revendications précédentes, dans lequel ledit composant (90) comprend une pale.

12. Composant de moteur à turbine selon la revendication 11, dans lequel ledit composant (90) comprend une pale haute pression.

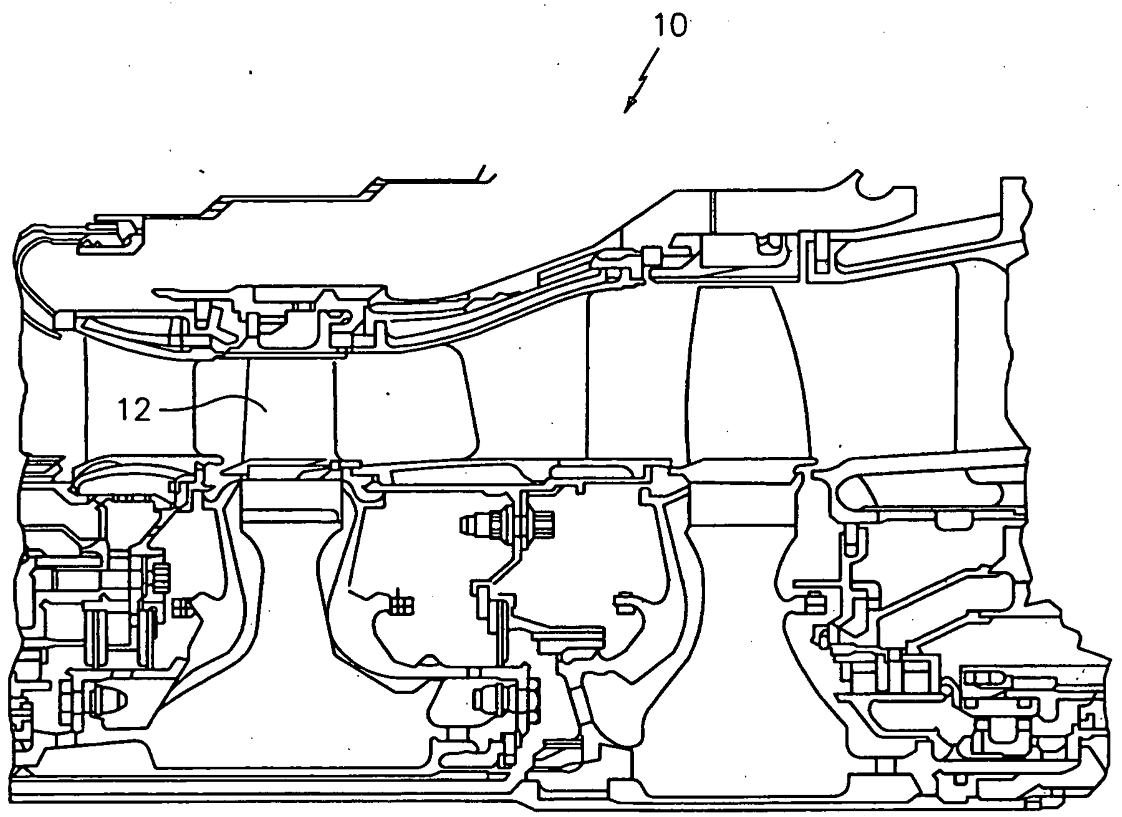


FIG. 1

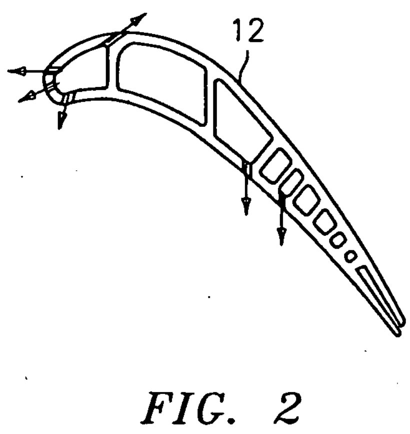


FIG. 2

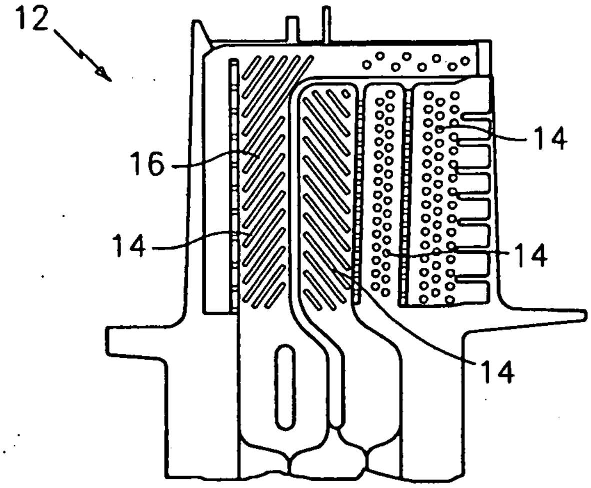
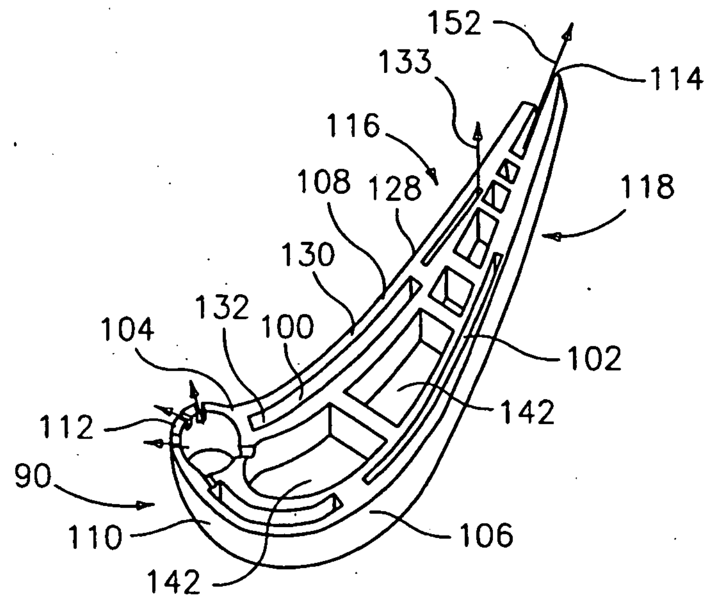

12
16
14
14
14
14

FIG. 3


152
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118
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128
130
132
100
104
102
142
112
90
110
106
142

FIG. 4

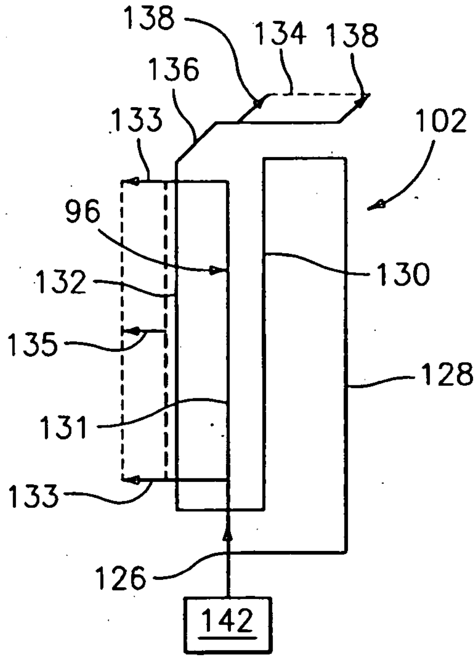


FIG. 5

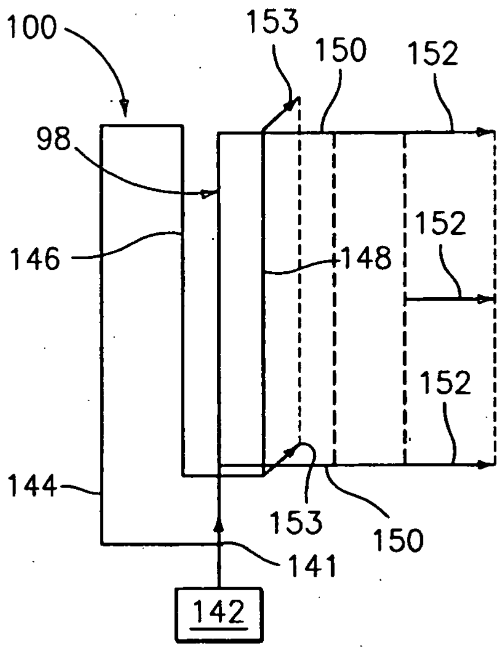


FIG. 6

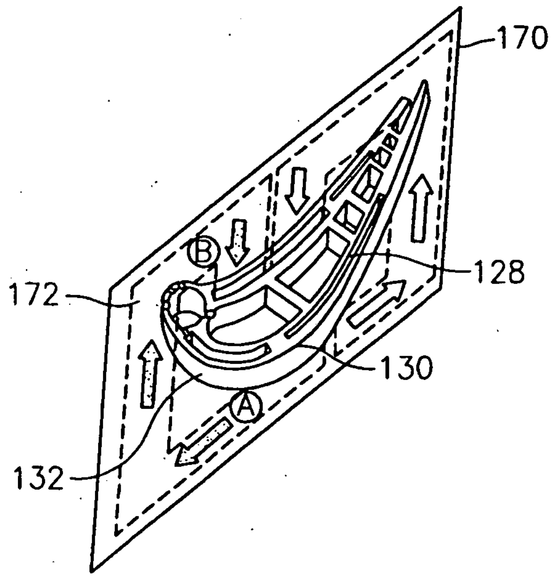


FIG. 7

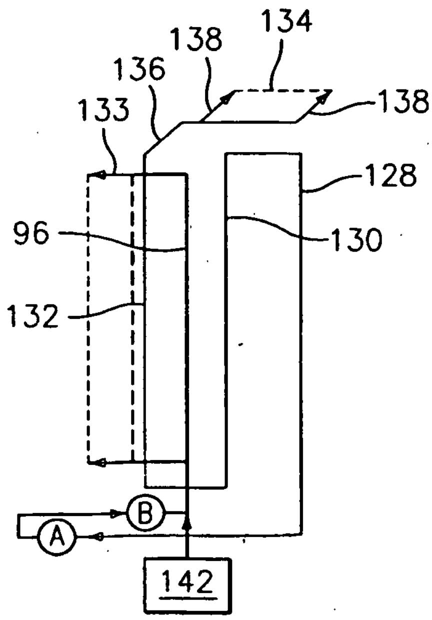


FIG. 8

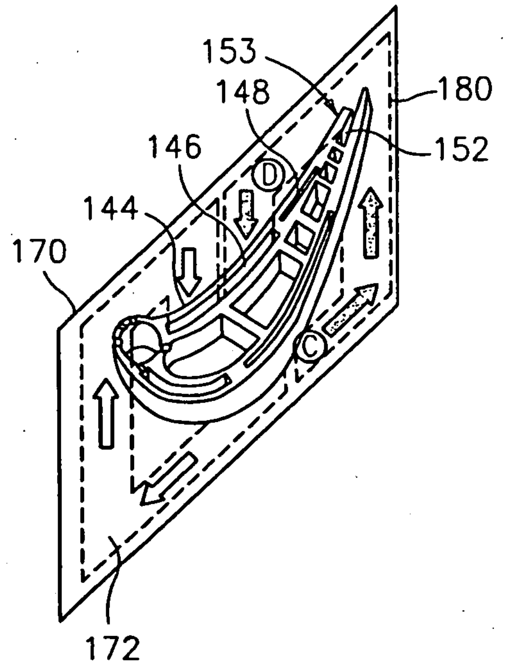
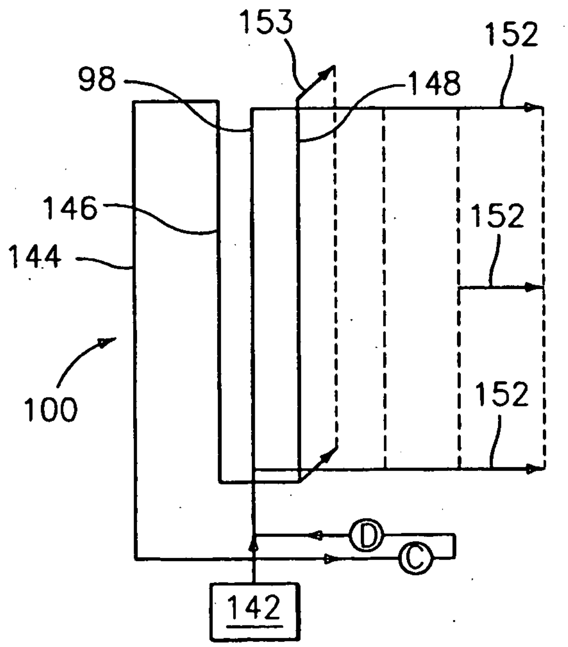

153
148
180
146
152
D
144
170
C
172

FIG. 9


153
152
98
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144
100
152
D
C
142

FIG. 10

REFERENCES CITED IN THE DESCRIPTION

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