US010385699B2

(12) United States Patent
Quach et al.

(10) Patent No.: US 10,385,699 B2
(45) Date of Patent: Aug. 20, 2019

(54) **GAS TURBINE ENGINE AIRFOIL COOLING CONFIGURATION WITH PRESSURE GRADIENT SEPARATORS**

(71) Applicant: **United Technologies Corporation**, Hartford, CT (US)

(72) Inventors: **San Quach**, East Hartford, CT (US); **Ryan Alan Waite**, South Windsor, CT (US); **Christopher King**, Bristol, CT (US); **Steven Bruce Gautschi**, Naugatuck, CT (US)

(73) Assignee: **United Technologies Corporation**, Farmington, CT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 935 days.

(21) Appl. No.: **14/632,485**

(22) Filed: **Feb. 26, 2015**

(65) **Prior Publication Data**

US 2016/0251968 A1 Sep. 1, 2016

(51) **Int. Cl.**
F01D 5/14 (2006.01)
F01D 5/18 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F01D 5/187*** (2013.01); ***F01D 5/147*** (2013.01); ***F01D 9/041*** (2013.01); ***F01D 11/08*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC F01D 5/187; F01D 5/147; F01D 9/041; F01D 11/08; F01D 525/30; F01D 5/18;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,176,499 A 1/1993 Damlis et al.
5,511,946 A 4/1996 Lee et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 2568119 3/2013
EP 2942485 11/2015

OTHER PUBLICATIONS

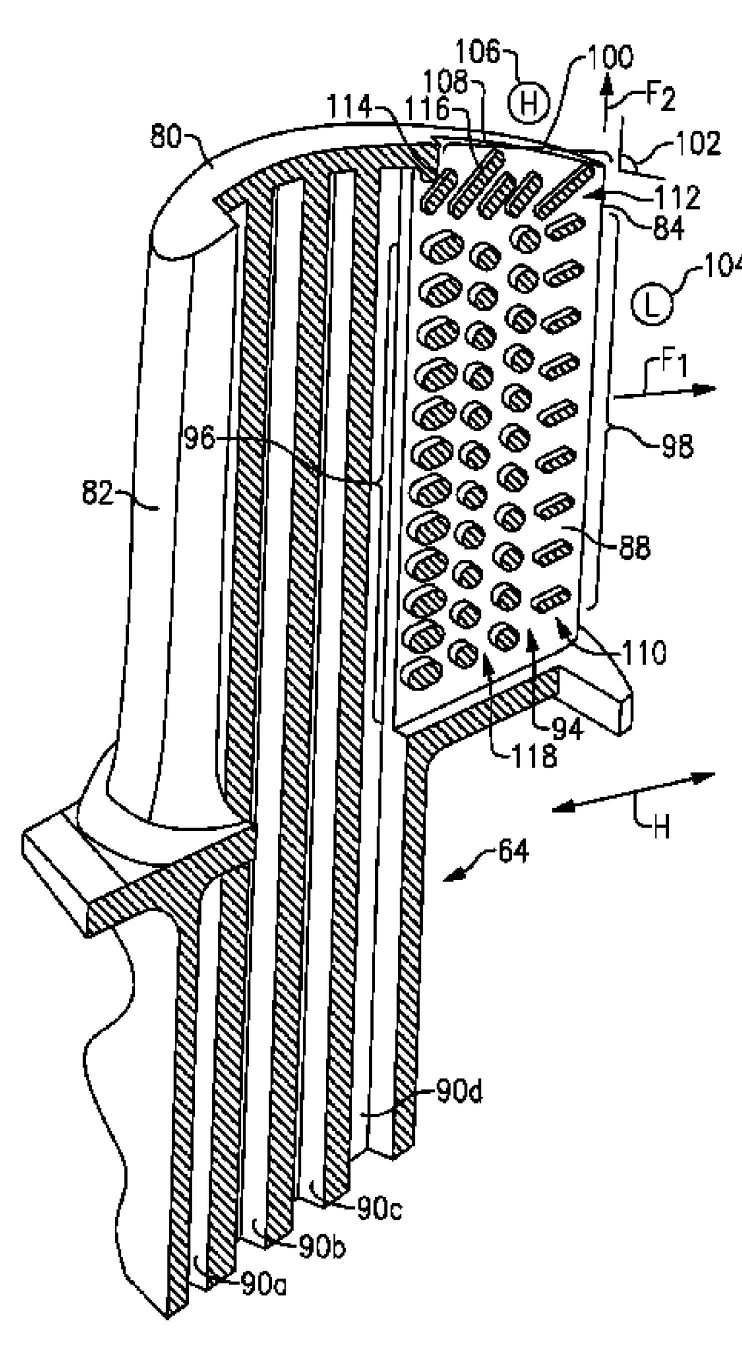
Extended European Search Report for European Application No. 16157740.8 dated Jul. 18, 2016.
(Continued)

Primary Examiner — Justin D Seabe
Assistant Examiner — Justin A Pruitt
(74) *Attorney, Agent, or Firm* — Carlson, Gaskey & Olds, P.C.

(57) **ABSTRACT**

An airfoil for a gas turbine engine includes an airfoil including spaced apart pressure and suction side walls joined at leading and trailing edges to provide an exterior airfoil surface that extends in a radial direction from a platform to a tip. A cavity is provided between the pressure and suction side walls near the trailing edge. The cavity includes an interior region bounded by first and second exit regions arranged at angle relative to one another. The first and second exit regions are respectively in low and high pressure regions relative to one another. First and second pedestal groups respectively are arranged at the first and second exit regions. The second pedestal group has first and second pedestals each terminating in an end. The ends of the second pedestals extend beyond the ends of first pedestals.

19 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

F01D 9/04	(2006.01)
F23R 3/00	(2006.01)
F01D 11/08	(2006.01)
F01D 25/30	(2006.01)

(52) **U.S. Cl.**
CPC ***F01D 25/30*** (2013.01); ***F23R 3/002*** (2013.01); *F05D 2220/32* (2013.01); *F05D 2240/122* (2013.01); *F05D 2240/127* (2013.01); *F05D 2240/304* (2013.01); *F05D 2240/307* (2013.01); *F05D 2240/35* (2013.01); *F05D 2240/55* (2013.01); *F05D 2260/221* (2013.01); *F05D 2260/2212* (2013.01); *F05D 2260/2214* (2013.01); *Y02T 50/673* (2013.01); *Y02T 50/676* (2013.01)

(58) **Field of Classification Search**
CPC F23R 3/002; F05D 2220/32; F05D 2240/122; F05D 2240/127; F05D 2240/304; F05D 2240/307; F05D 2240/32; F05D 2240/55; F05D 2260/221; F05D 2260/2212; F05D 2260/2214; Y02T 50/673; Y02T 50/676
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,257,831	B1 *	7/2001	Papple	B22C 9/10 416/97 R
2004/0151586	A1	8/2004	Chlus et al.	
2005/0281671	A1 *	12/2005	Liang	F01D 5/20 416/1
2013/0064639	A1 *	3/2013	Morris	F01D 5/187 415/1
2013/0280080	A1 *	10/2013	Levine	F01D 5/187 416/223 R
2014/0044555	A1 *	2/2014	Lewis	F01D 5/18 416/96 R
2014/0147287	A1	5/2014	Xu	

OTHER PUBLICATIONS

U.S. Appl. No. 76/078,941, filed Oct. 27, 2009, Cherolis et al.
U.S. Appl. No. 61/986,951, filed May 1, 2014.
U.S. Appl. No. 61/986,951, filed May 1, 2014 titled Splayed Tip Features for Gas Turbine Engine Airfoil.

* cited by examiner

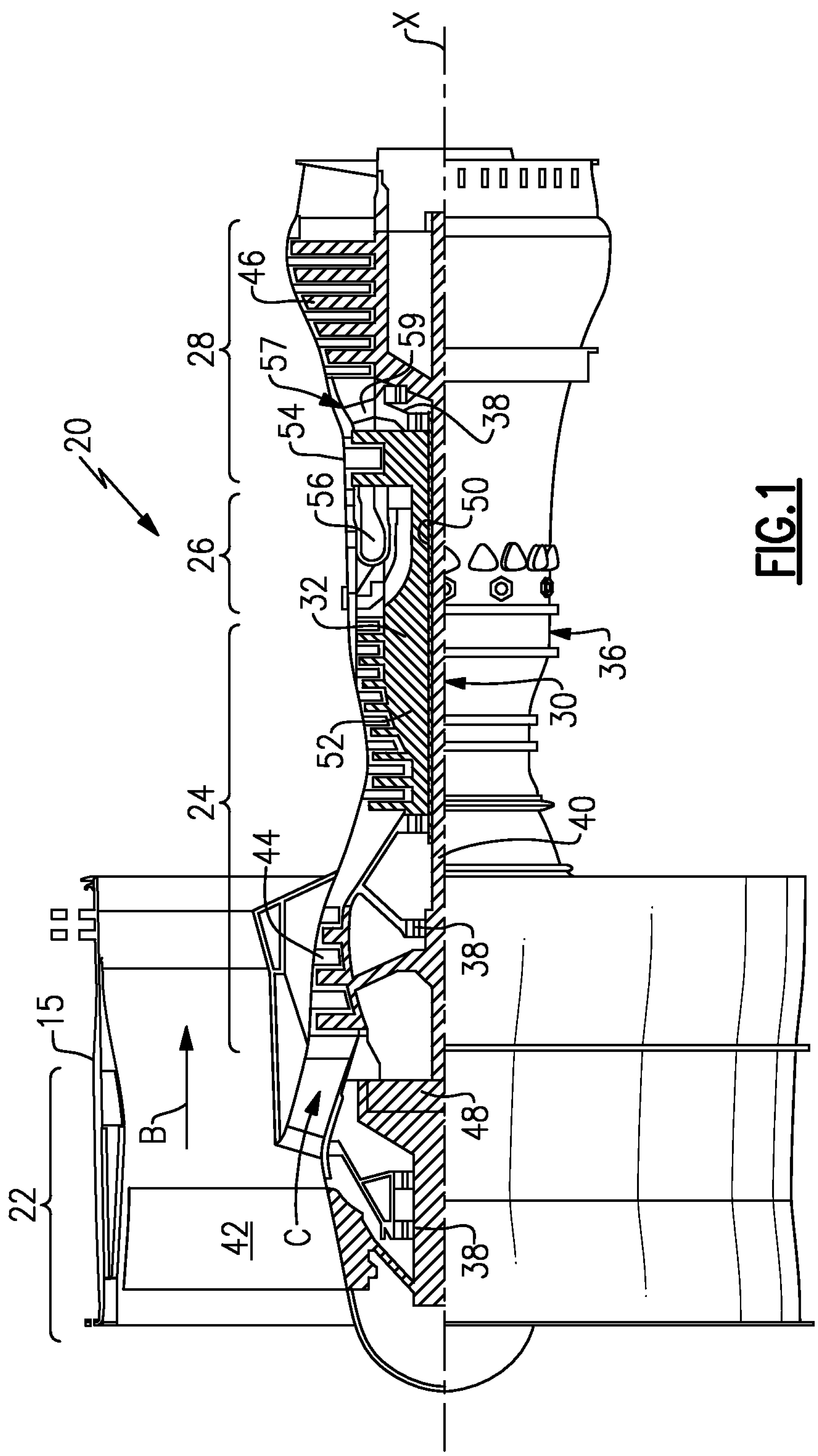


FIG.1

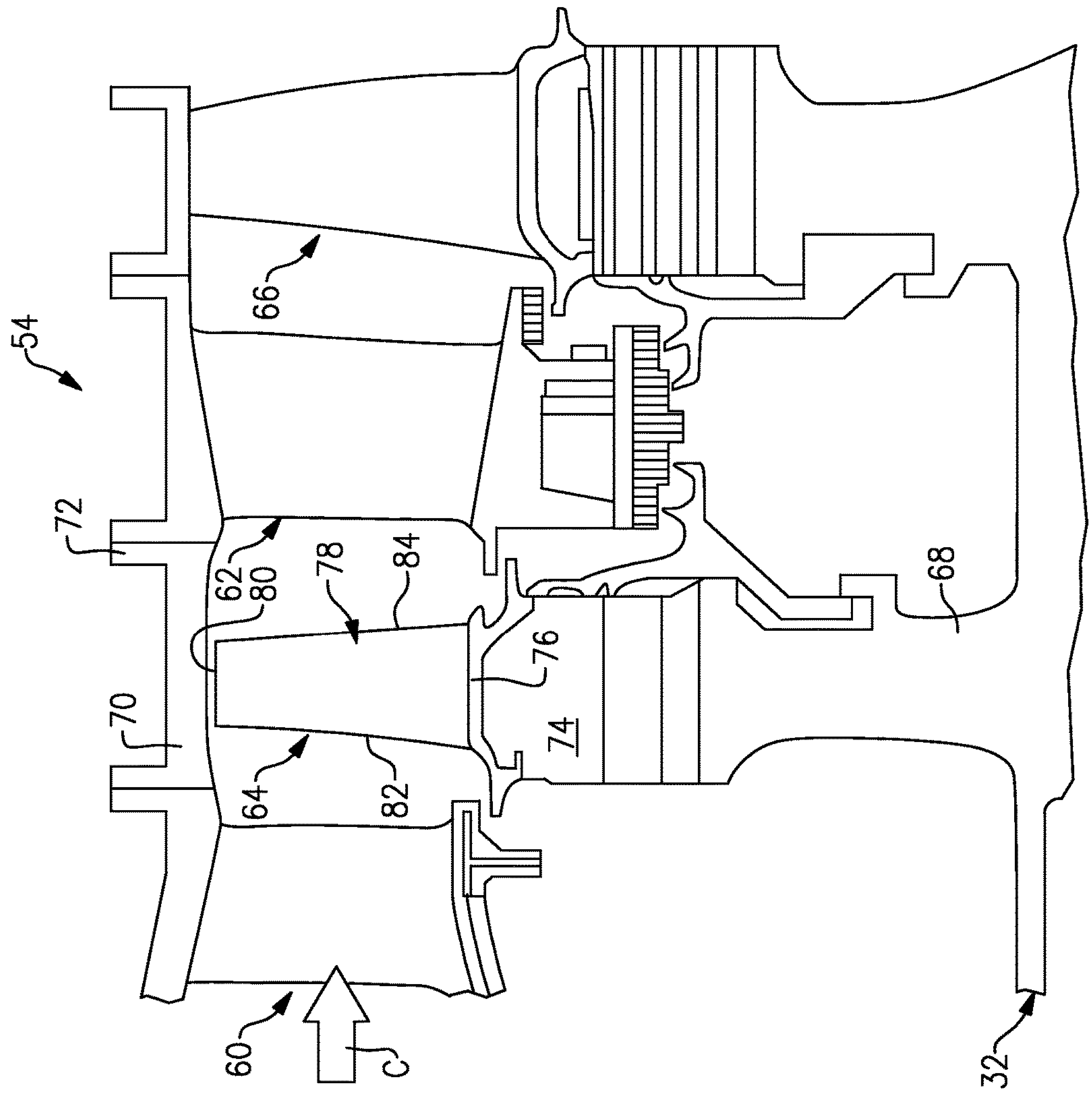
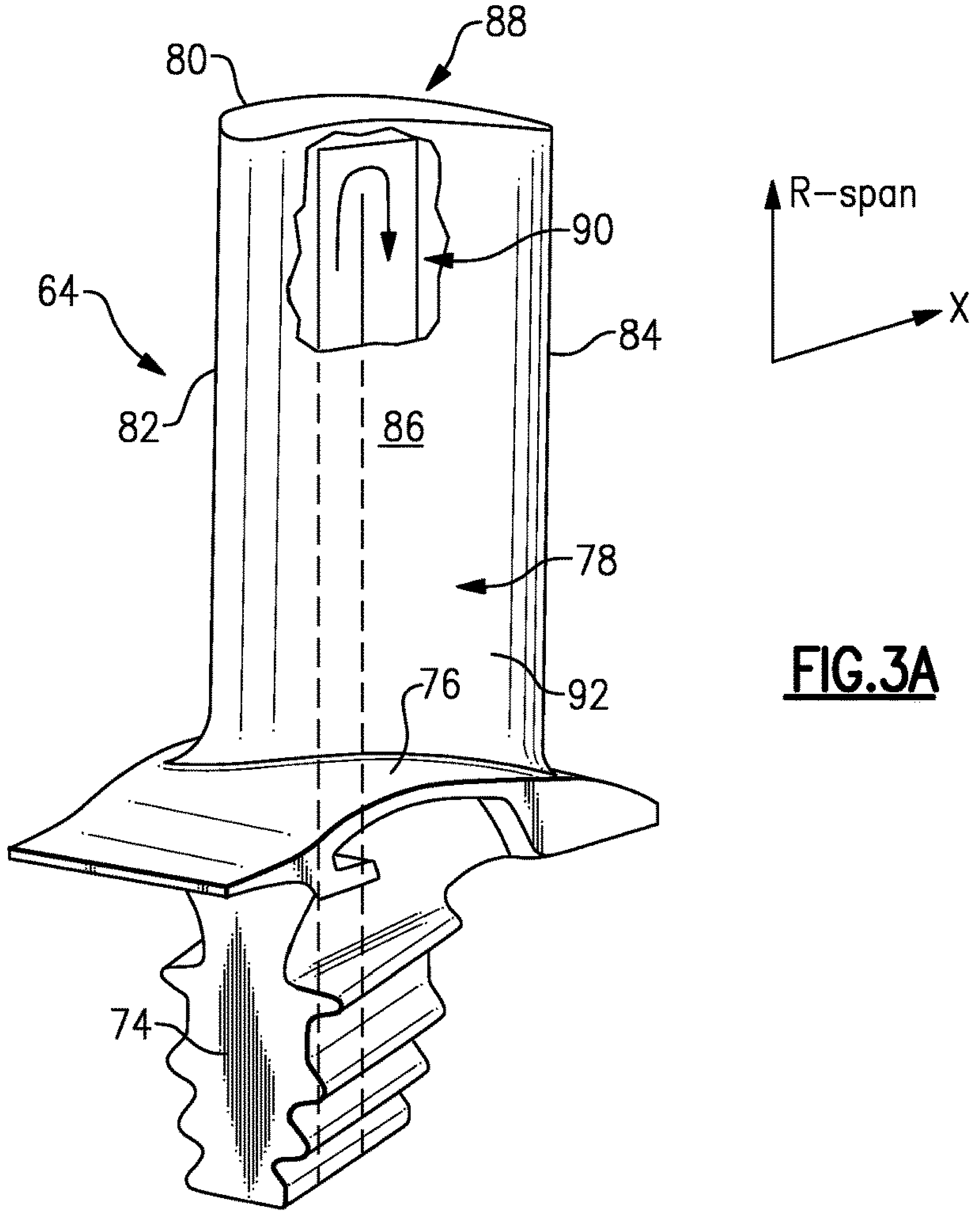
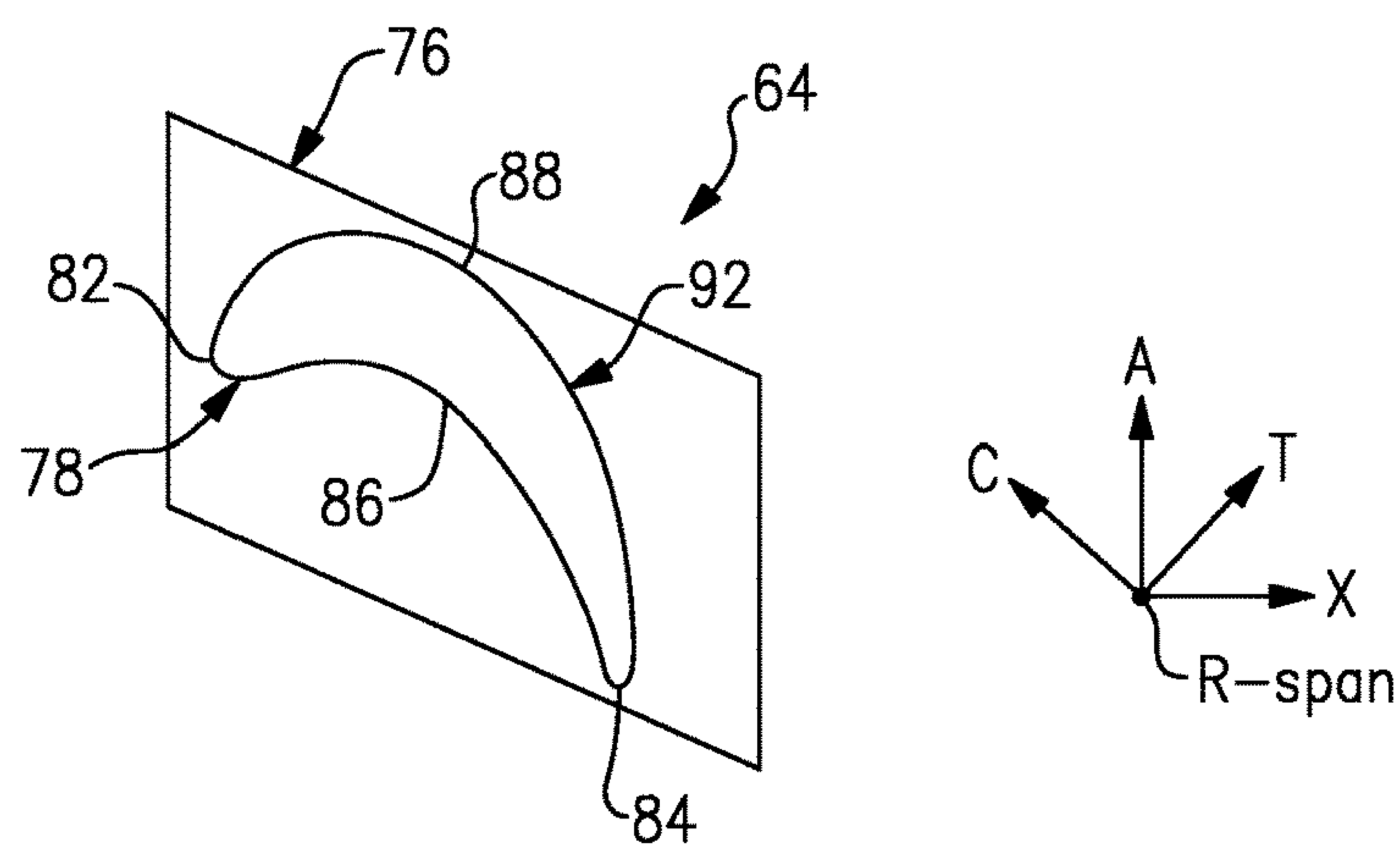


FIG.2



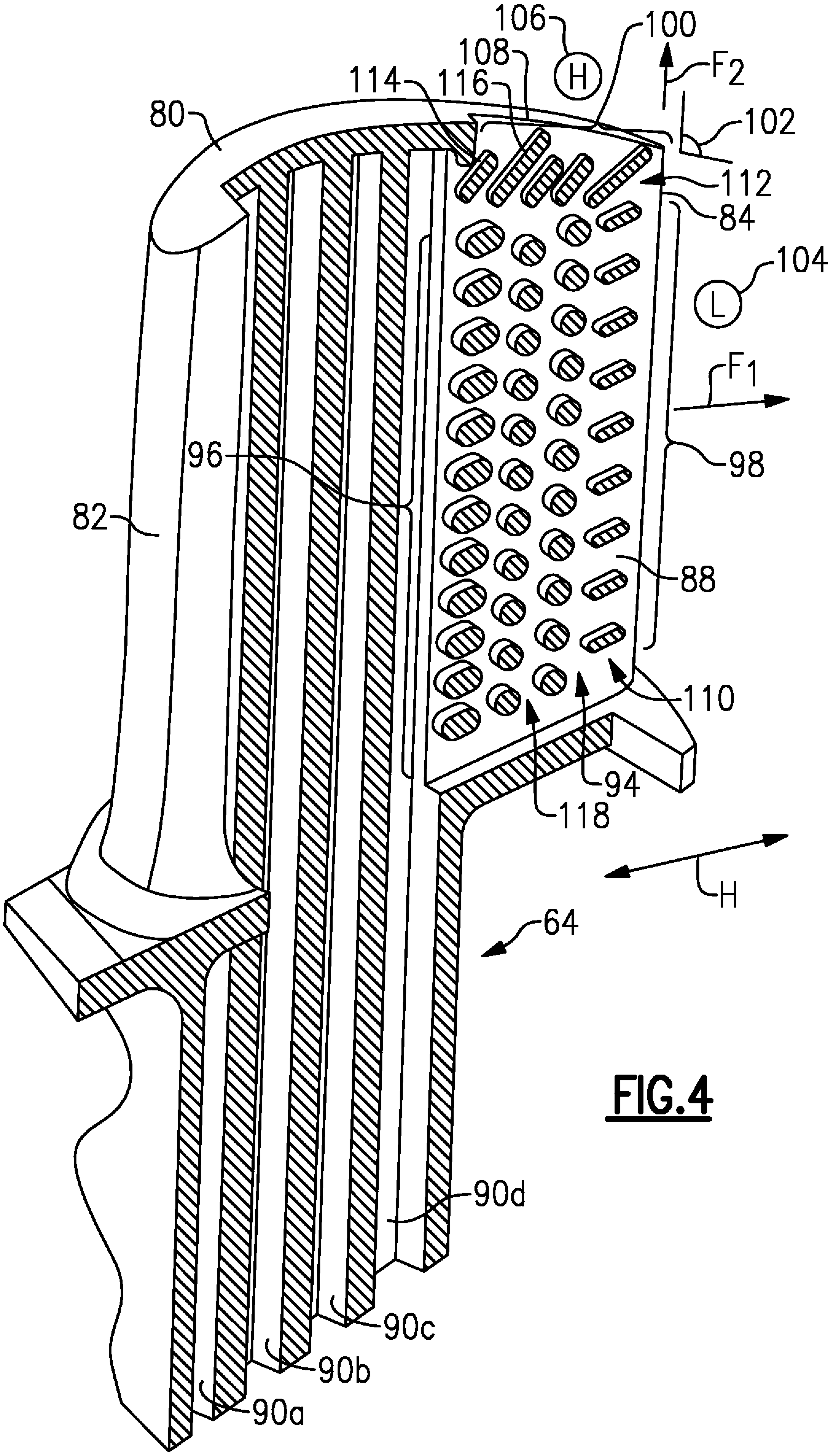
88
80
R-span
90
64
84
X
82
86
78
92
76
74

FIG.3A



76
64
88
82
92
A
78
86
C
T
X
R-span
84

FIG.3B



106
100
108
H
F2
114
116
102
80
112
84
104
L
F1
96
98
82
88
110
94
118
H
64
90d
90c
90b
90a

FIG.4

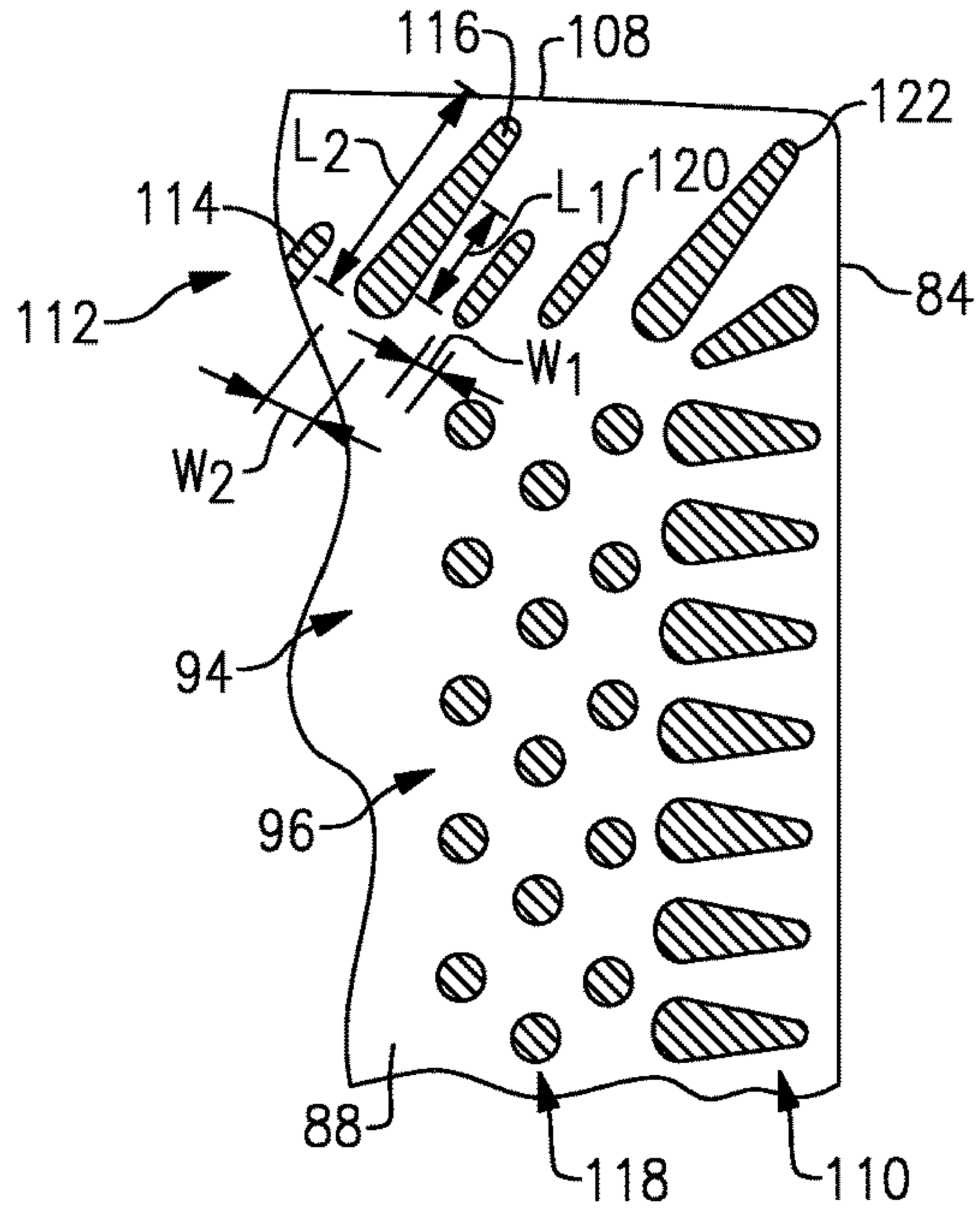

116
108
122
L2
L1
120
114
84
112
W1
W2
94
96
88
118
110

FIG.5A

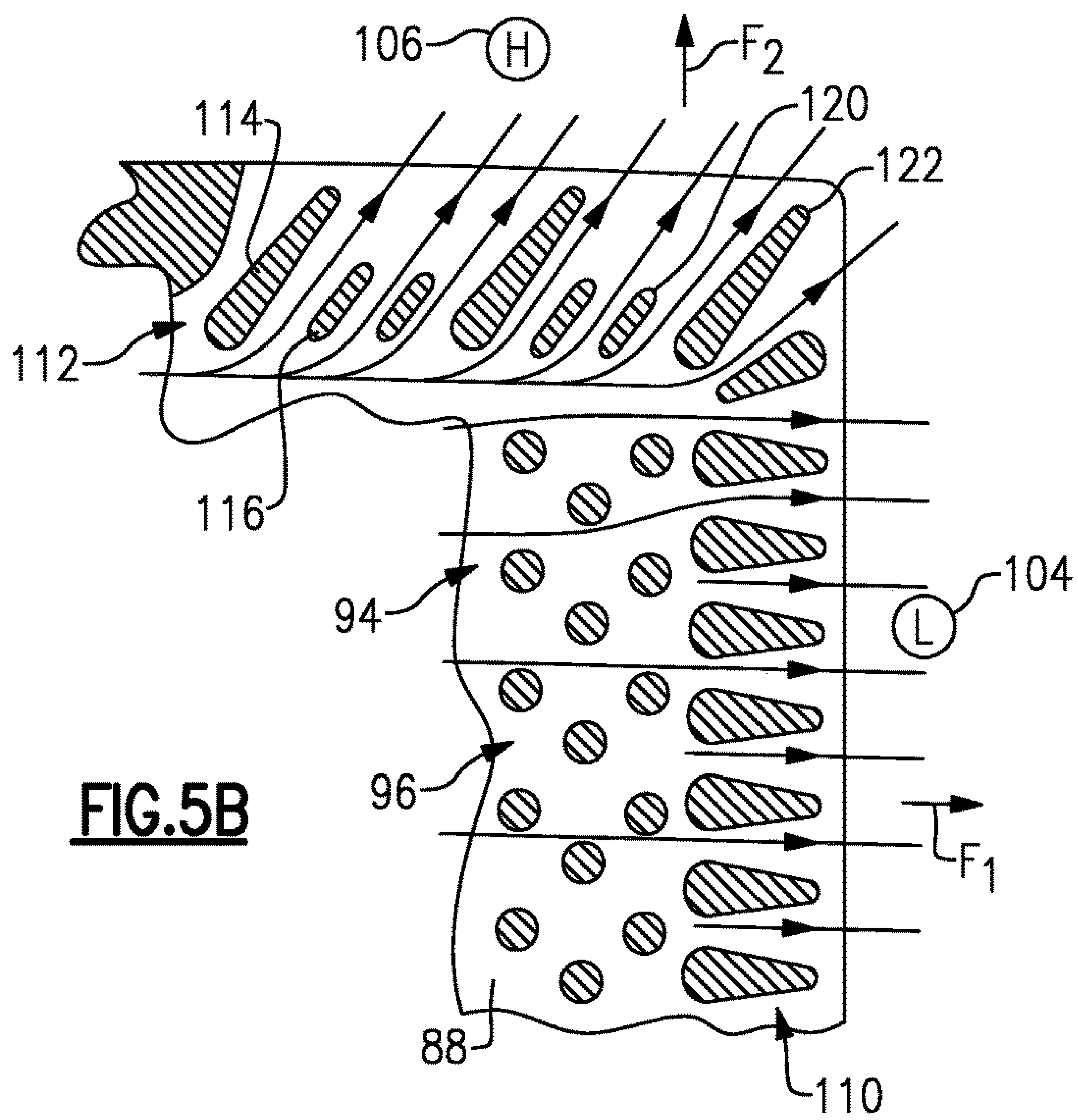

106
H
F2
120
114
122
112
116
104
L
94
96
F1
88
110

FIG.5B

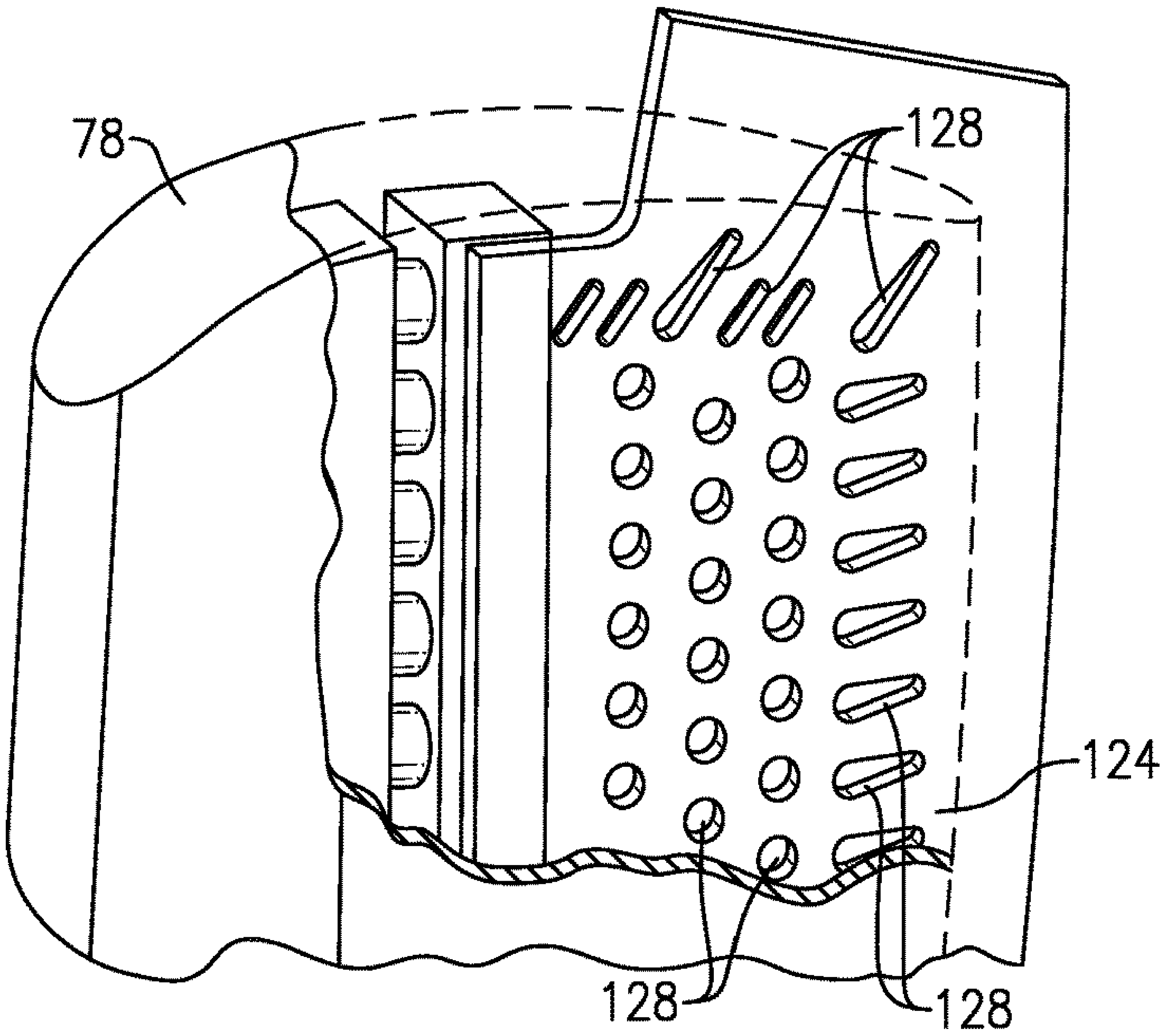


FIG.6

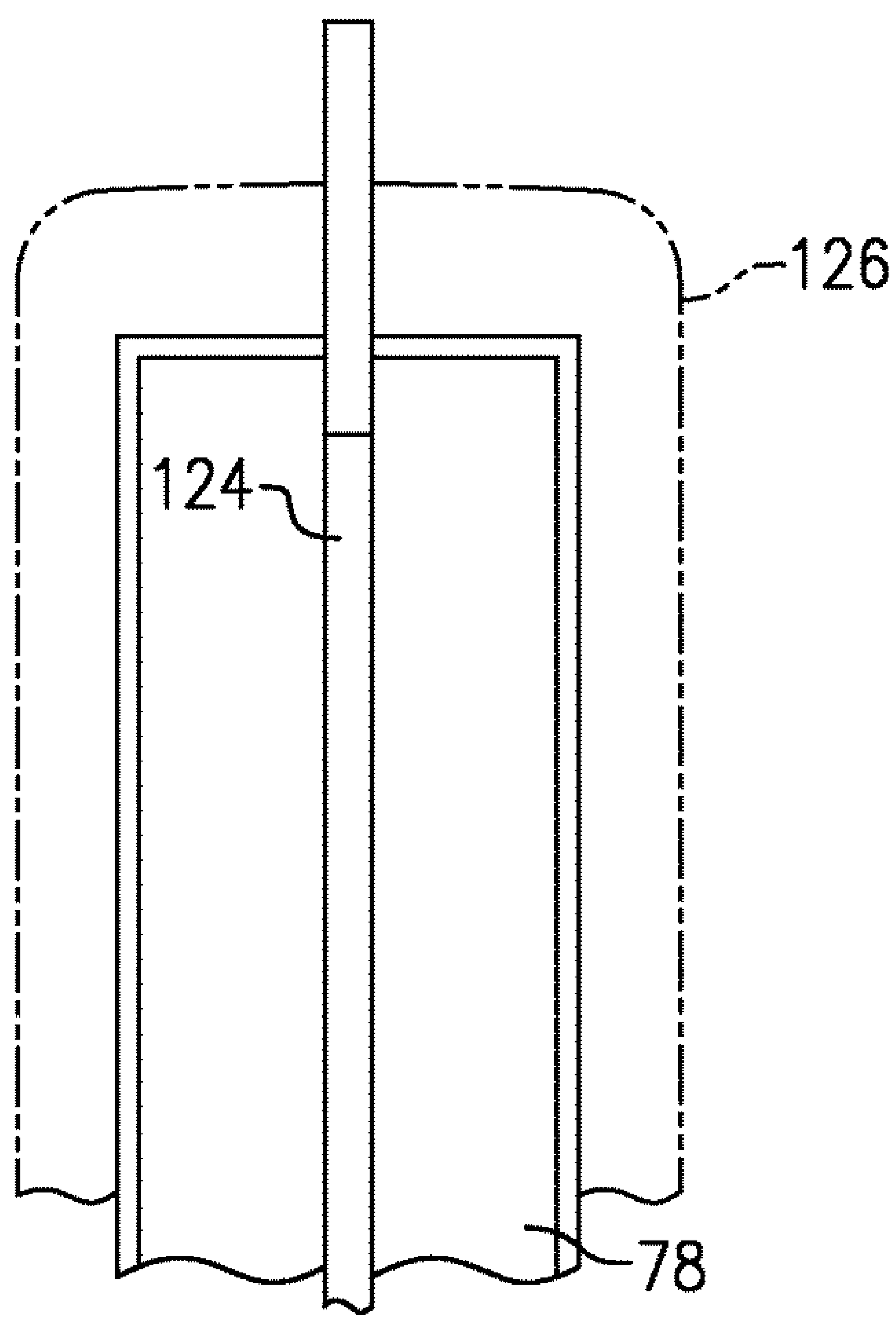


FIG.7

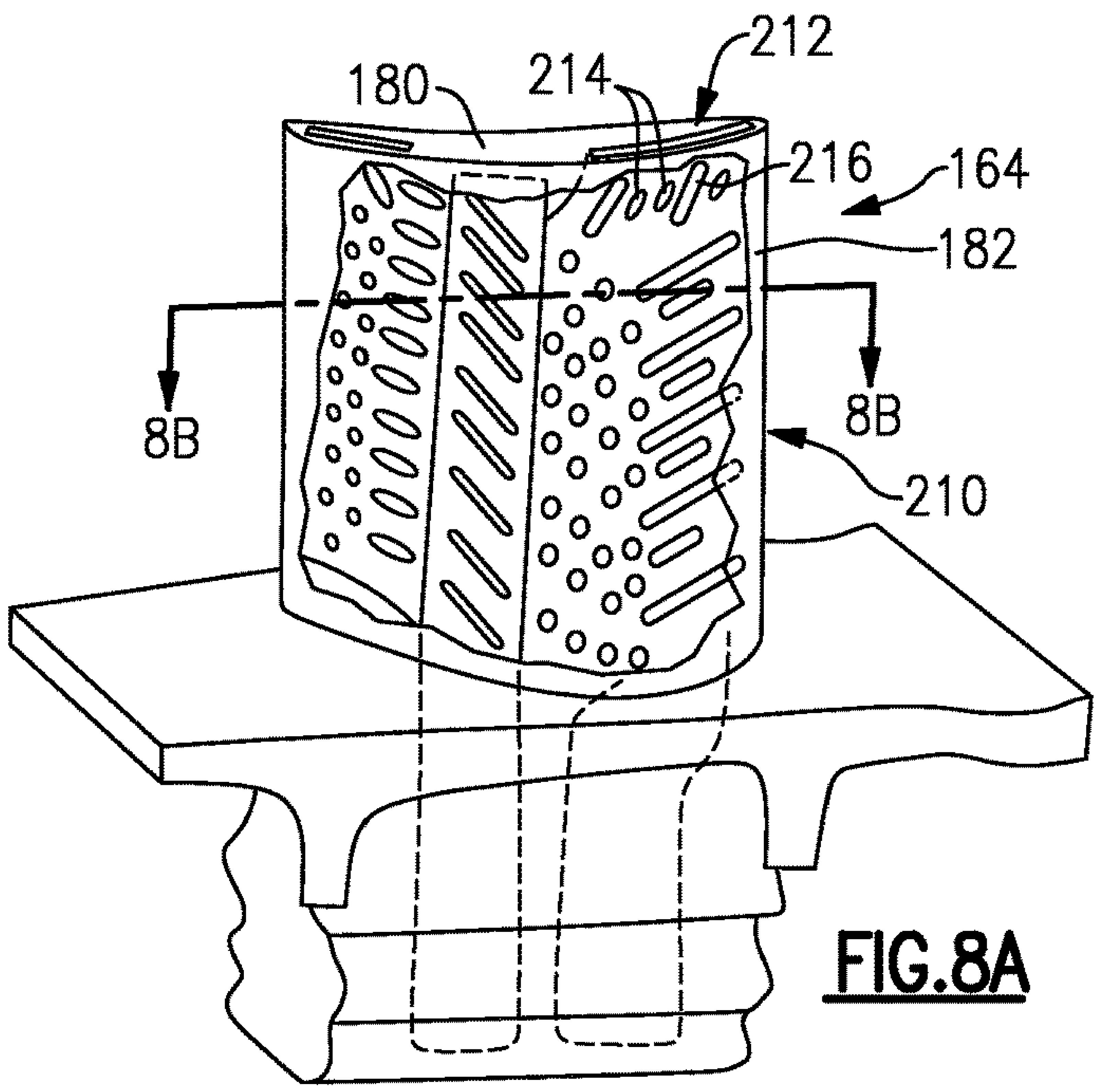


FIG.8A

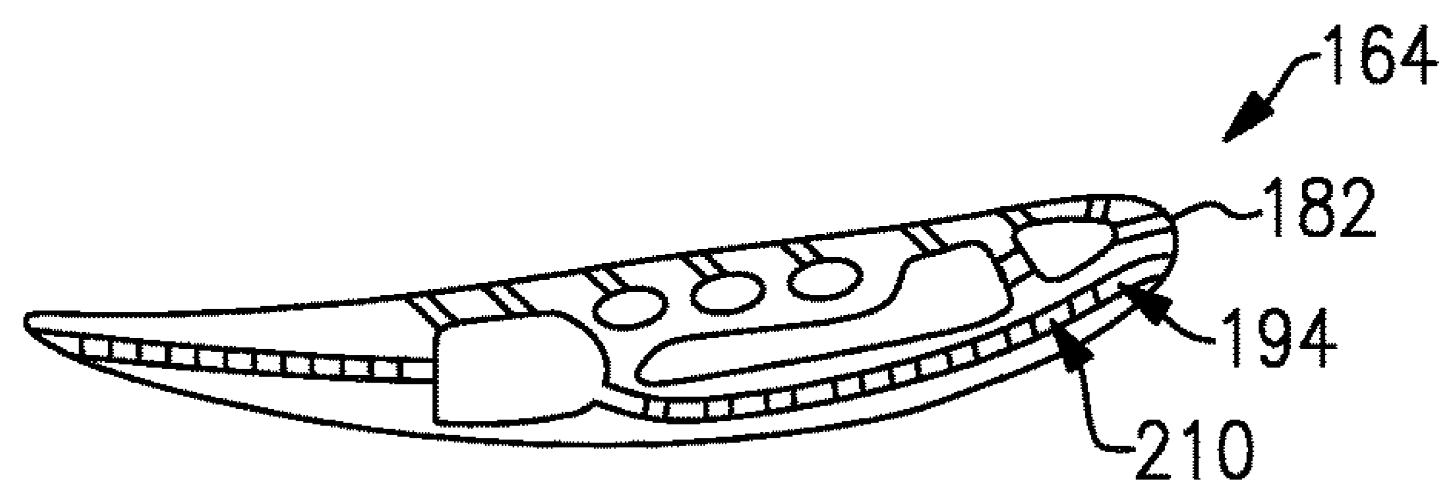


FIG.8B

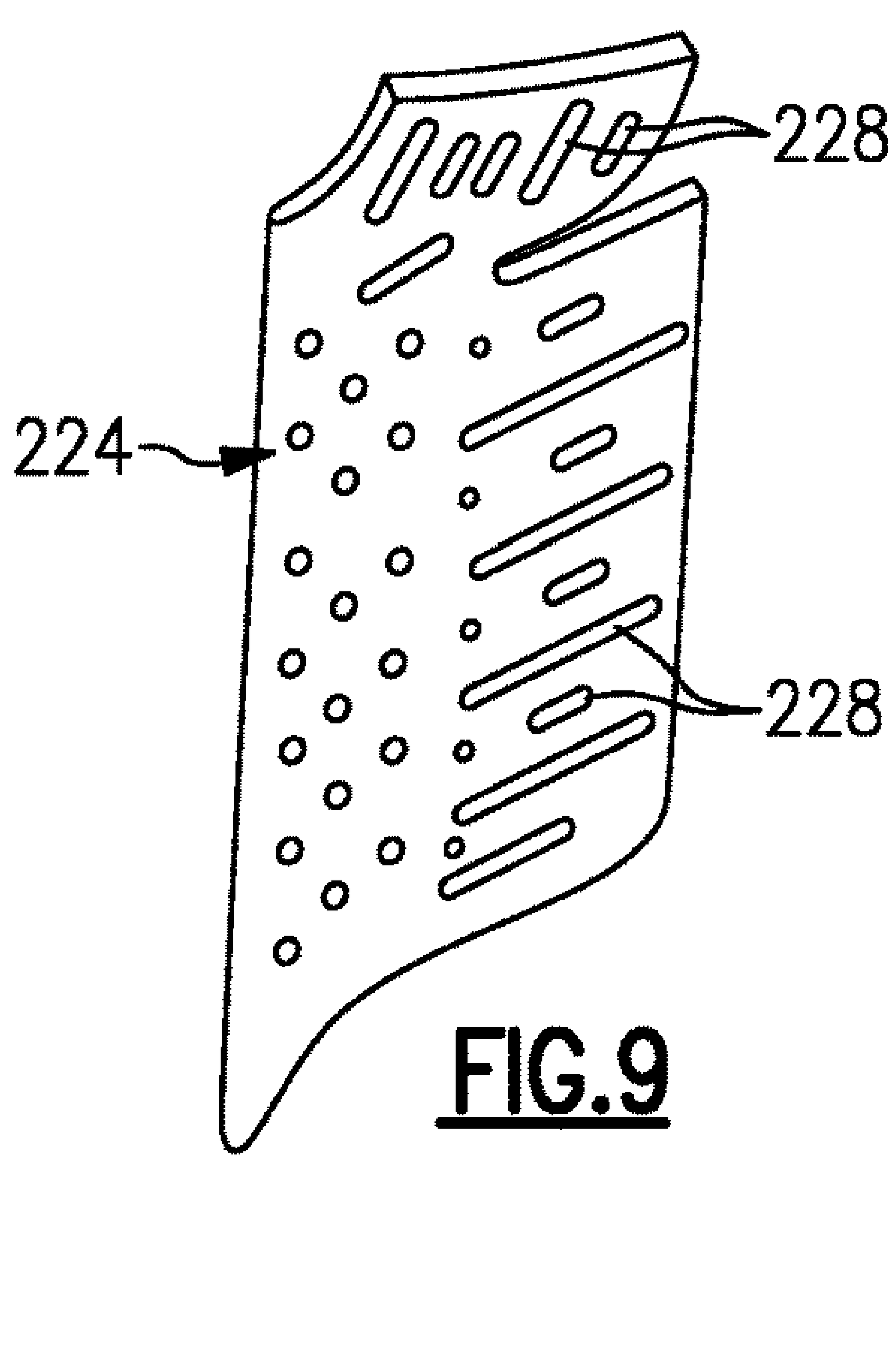


FIG.9

GAS TURBINE ENGINE AIRFOIL COOLING CONFIGURATION WITH PRESSURE GRADIENT SEPARATORS

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

This invention was made with government support under Contract No. N68335-13-C-0005 awarded by the United States Navy. The Government has certain rights in this invention.

BACKGROUND

This disclosure relates to a gas turbine engine component, such as an airfoil. More particularly, the disclosure relates to a cooling configuration used to effectively turn the cooling fluid at two adjacent cooling fluid exits.

Gas turbine engines typically include a compressor section, a combustor section and a turbine section. During operation, air is pressurized in the compressor section and is mixed with fuel and burned in the combustor section to generate hot combustion gases. The hot combustion gases are communicated through the turbine section, which extracts energy from the hot combustion gases to power the compressor section and other gas turbine engine loads.

Both the compressor and turbine sections may include alternating series of rotating blades and stationary vanes that extend into the core flow path of the gas turbine engine. For example, in the turbine section, turbine blades rotate and extract energy from the hot combustion gases that are communicated along the core flow path of the gas turbine engine. The turbine vanes, which generally do not rotate, guide the airflow and prepare it for the next set of blades.

Many blades and vanes, blade outer air seals, turbine platforms, and other components include internal cooling passages. Blade trailing edge tips are typically susceptible to high temperature damage such as thermal mechanical fatigue, and/or oxidation. Current airfoil designs tend to leave the trailing edge tip without convective cooling.

To address this concern, one example airfoil design adds flow features at the tip, which enables the entire trailing edge to be convectively cooled. Discrete slots or a large continuous slot is provided the length of the trailing edge all the way to the tip.

SUMMARY

In one exemplary embodiment, an airfoil for a gas turbine engine includes an airfoil including spaced apart pressure and suction side walls joined at leading and trailing edges to provide an exterior airfoil surface that extends in a radial direction from a platform to a tip. A cavity is provided between the pressure and suction side walls near the trailing edge. The cavity includes an interior region bounded by first and second exit regions arranged at angle relative to one another. The first and second exit regions are respectively in low and high pressure regions relative to one another. First and second pedestal groups respectively are arranged at the first and second exit regions. The second pedestal group has first and second pedestals each terminating in an end. The ends of the second pedestals extend beyond the ends of first pedestals.

In a further embodiment of the above, the airfoil is a blade.

In a further embodiment of any of the above, the airfoil extends from the leading edge to the trailing edge in a chord-wise direction. The cavity is provided in at least the last 20% of the airfoil near the trailing edge in the chord-wise direction.

In a further embodiment of any of the above, the interior region includes a third pedestal group that interconnects the pressure and suction sidewalls.

In a further embodiment of any of the above, the first exit region is provided at the trailing edge.

In a further embodiment of any of the above, the first pedestal group is recessed from the trailing edge or extending to the trailing edge.

In a further embodiment of any of the above, the second exit region is provided at the tip.

In a further embodiment of any of the above, the second pedestal group is recessed from the tip.

In a further embodiment of any of the above, a natural flow direction extends from the interior region to the first exit region. A desired flow direction extends from the interior region to the second exit region. The ends of the second pedestals extend beyond the ends of first pedestals in the desired flow direction.

In a further embodiment of any of the above, the natural flow direction corresponds to an aft direction in the chord-wise direction.

In a further embodiment of any of the above, the desired flow direction corresponds to the radial direction.

In a further embodiment of any of the above, the first and second pedestals include first and second lengths respectively and first and second widths respectively. The first and second lengths are greater than their corresponding first and second widths.

In a further embodiment of any of the above, the first and second pedestals are in an alternating relationship with one another.

In a further embodiment of any of the above, least one first pedestal is arranged between adjacent second pedestals.

In a further embodiment of any of the above, the first length has a ratio relative to the first width of $1<L\mathbf{1}/W\mathbf{1}<20$ and the second length has a ratio relative to the second width of $1<L\mathbf{2}/W\mathbf{2}<20$.

In another exemplary embodiment, a component for a gas turbine engine includes a structure including spaced apart walls that provide an exterior surface that extends in first and second directions to first and second edges, respectively. A cavity is provided between the walls near the first and second edges. The cavity includes an interior region bounded by first and second exit regions and is arranged at angle relative to one another that terminate at the first and second edges arranged at an angle in a range of 60°-120°. The first and second exit regions respectively are in low and high pressure regions relative to one another. First and second pedestal groups respectively are arranged at the first and second exit regions. The second pedestal group has first and second pedestals that each terminate in an end. The ends of the second pedestals extend beyond the ends of first pedestals. The first and second pedestals include first and second lengths respectively and first and second widths respectively. The first and second lengths are greater than their corresponding first and second widths. The first and second pedestals are in an alternating relationship with one another.

In a further embodiment of any of the above, first and second edge are arranged at about 90° relative to one another.

In a further embodiment of any of the above, at least one first pedestals is arranged between adjacent second pedestals.

In a further embodiment of any of the above, the first and second pedestal groups are recessed respectively from the first and second edges.

In a further embodiment of any of the above, the structure is one of a vane, a blade, a blade outer air seal, a combustor liner or an exhaust liner.

In a further embodiment of any of the above, the structure is an airfoil of a blade.

In a further embodiment of any of the above, a natural flow direction extends from the interior region to the first exit region. A desired flow direction extends from the interior region to the second exit region. The ends of the second pedestals extend beyond the ends of first pedestals in the desired flow direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure can be further understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. **1** schematically illustrates a gas turbine engine embodiment.

FIG. **2** schematically illustrates a high turbine of the gas turbine engine shown in FIG. **1**.

FIG. **3**A is a perspective view of the airfoil having the disclosed cooling passage.

FIG. **3**B is a plan view of the airfoil illustrating directional references.

FIG. **4** is a cross-sectional view of an example airfoil cooling configuration.

FIG. **5**A is an enlarged view of an airfoil cooling cavity with pedestals.

FIG. **5**B illustrates the flow through the cavity shown in FIG. **5**A.

FIG. **6** shows a core used to make the cavity shown in FIGS. **4** and **5**A in a partially broken view of the airfoil.

FIG. **7** is an trailing edge view of the core extending from the airfoil.

FIG. **8**A is a partially broken airfoil illustrating another example cooling configuration.

FIG. **8**B is a cross-sectional view of the airfoil shown in FIG. **8**A taken along line **8**B-**8**B.

FIG. **9** shows a core used to make the cavity shown in FIGS. **8**A and **8**B.

The embodiments, examples and alternatives of the preceding paragraphs, the claims, or the following description and drawings, including any of their various aspects or respective individual features, may be taken independently or in any combination. Features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

DETAILED DESCRIPTION

FIG. **1** schematically illustrates a gas turbine engine **20**. The gas turbine engine **20** is disclosed herein as a two-spool turbofan that generally incorporates a fan section **22**, a compressor section **24**, a combustor section **26** and a turbine section **28**. Alternative engines might include an augmenter section (not shown) among other systems or features. The fan section **22** drives air along a bypass flow path B in a bypass duct at least partially defined within a fan case **15**, while the compressor section **24** drives air along a core flow path C for compression and communication into the combustor section **26** then expansion through the turbine section **28**. Although depicted as a two-spool turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with two-spool turbofans as the teachings may be applied to other types of turbine engines including three-spool architectures.

Moreover, although a commercial gas turbine engine embodiment is illustrated, it should be understood that the disclosed component cooling configuration can be used in other types of engines, such as military and/or industrial engines.

The exemplary engine **20** generally includes a low speed spool **30** and a high speed spool **32** mounted for rotation about an engine central longitudinal axis X relative to an engine static structure **36** via several bearing systems **38**. It should be understood that various bearing systems **38** at various locations may alternatively or additionally be provided, and the location of bearing systems **38** may be varied as appropriate to the application.

The low speed spool **30** generally includes an inner shaft **40** that interconnects a fan **42**, a first (or low) pressure compressor **44** and a first (or low) pressure turbine **46**. The inner shaft **40** is connected to the fan **42** through a speed change mechanism, which in exemplary gas turbine engine **20** is illustrated as a geared architecture **48** to drive the fan **42** at a lower speed than the low speed spool **30**. The high speed spool **32** includes an outer shaft **50** that interconnects a second (or high) pressure compressor **52** and a second (or high) pressure turbine **54**. A combustor **56** is arranged in exemplary gas turbine **20** between the high pressure compressor **52** and the high pressure turbine **54**. A mid-turbine frame **57** of the engine static structure **36** is arranged generally between the high pressure turbine **54** and the low pressure turbine **46**. The mid-turbine frame **57** further supports bearing systems **38** in the turbine section **28**. The inner shaft **40** and the outer shaft **50** are concentric and rotate via bearing systems **38** about the engine central longitudinal axis X which is collinear with their longitudinal axes.

The core airflow is compressed by the low pressure compressor **44** then the high pressure compressor **52**, mixed and burned with fuel in the combustor **56**, then expanded over the high pressure turbine **54** and low pressure turbine **46**. The mid-turbine frame **57** includes airfoils **59** which are in the core airflow path C. The turbines **46**, **54** rotationally drive the respective low speed spool **30** and high speed spool **32** in response to the expansion. It will be appreciated that each of the positions of the fan section **22**, compressor section **24**, combustor section **26**, turbine section **28**, and fan drive gear system **48** may be varied. For example, gear system **48** may be located aft of combustor section **26** or even aft of turbine section **28**, and fan section **22** may be positioned forward or aft of the location of gear system **48**.

The engine **20** in one example is a high-bypass geared aircraft engine. In a further example, the engine **20** bypass ratio is greater than about six (6), with an example embodiment being greater than about ten (10), the geared architecture **48** is an epicyclic gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3 and the low pressure turbine **46** has a pressure ratio that is greater than about five. In one disclosed embodiment, the engine **20** bypass ratio is greater than about ten (10:1), the fan diameter is significantly larger than that of the low pressure compressor **44**, and the low pressure turbine **46** has a pressure ratio that is greater than about five 5:1. Low pressure turbine **46** pressure ratio is pressure measured prior to inlet of low pressure turbine **46** as related to the pressure at the outlet of the low pressure turbine **46** prior to an exhaust nozzle. The geared architecture **48** may be an epicycle gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3:1. It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine and that the present invention is applicable to other gas turbine engines including direct drive turbofans.

A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section **22** of the engine **20** is designed for a particular flight condition—typically cruise at about 0.8 Mach and about 35,000 feet (10,668 meters). The flight condition of 0.8 Mach and 35,000 ft (10,668 meters), with the engine at its best fuel consumption—also known as "bucket cruise Thrust Specific Fuel Consumption ('TSFC')"—is the industry standard parameter of lbm of fuel being burned divided by lbf of thrust the engine produces at that minimum point. "Low fan pressure ratio" is the pressure ratio across the fan blade alone, without a Fan Exit Guide Vane ("FEGV") system. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.45. "Low corrected fan tip speed" is the actual fan tip speed in ft/sec divided by an industry standard temperature correction of $[(\text{Tram } °\text{R})/(518.7°\text{R})]^{0.5}$. The "Low corrected fan tip speed" as disclosed herein according to one non-limiting embodiment is less than about 1150 ft/second (350.5 meters/second).

The disclosed cooling configuration may be used in various gas turbine engine components. For exemplary purposes, a turbine blade **64** is described. It should be understood that the cooling passage may also be used in vanes, blade outer air seals, and combustor or exhaust liners, for example.

Referring to FIG. **2**, a cross-sectional view through a high pressure turbine section **54** is illustrated. In the example high pressure turbine section **54**, first and second arrays of circumferentially spaced fixed vanes **60**, **62** are axially spaced apart from one another. A first stage array of circumferentially spaced turbine blades **64**, mounted to a rotor disk **68**, is arranged axially between the first and second fixed vane arrays. A second stage array of circumferentially spaced turbine blades **66** is arranged aft of the second array of fixed vanes **62**.

The turbine blades each include a tip **80** adjacent to a blade outer air seal **70** of a case structure **72**. The first and second stage arrays of turbine vanes and first and second stage arrays of turbine blades are arranged within a core flow path C and are operatively connected to a spool **32**.

Referring to FIGS. **3**A and **3**B, a root **74** of each turbine blade **64** is mounted to the rotor disk. The turbine blade **64** includes a platform **76**, which provides the inner flow path, supported by the root **74**. An airfoil **78** extends in a radial direction R from the platform **76** to the tip **80**. It should be understood that the turbine blades may be integrally formed with the rotor such that the roots are eliminated. In such a configuration, the platform is provided by the outer diameter of the rotor. The airfoil **78** provides leading and trailing edges **82**, **84**.

The airfoil **78** of FIG. **3**B somewhat schematically illustrates exterior airfoil surface **92** extending in a chord-wise direction H from a leading edge **82** to a trailing edge **84**. The airfoil **78** is provided between pressure (typically concave) and suction (typically convex) side walls **86**, **88** spaced apart in an airfoil thickness direction T, which is generally perpendicular to the chord-wise direction C, and joined at the leading and trailing edges **82**, **84**. Multiple turbine blades **64** are arranged circumferentially in a circumferential direction A. The airfoil **78** extends from the platform **76** in the radial direction R, or spanwise, to the tip **80**.

The airfoil **78** includes a cooling passage **90** provided between the pressure and suction walls **86**, **88**. The cooling passage **90** may be one or more discrete passages arranged in a configuration suitable for the given application. Referring to FIG. **4**, the cooling passage **90** is provided by passages **90***a*-**90***d*. The exterior airfoil surface may include multiple film cooling holes (not shown) in fluid communication with the cooling passage **90**.

With continuing reference to FIG. **4**, the cooling passage **90***d* feed a cavity **94** provided between the pressure and suction side walls **86**, **88** near the trailing edge **84**. In the example, the cavity **94** is provided in at least the last 20% of the airfoil **78** near the trailing edge **84** in the chord-wise direction H.

The cavity **94** includes an interior region **96** bounded by first and second exit regions **98**, **100** arranged at angle relative to one another. The first exit region **98** is provided at the trailing edge **84**, and the second exit region **100** is provided at a tip edge **108** of the tip **80**. Thus, the fluid exit of the cavity **94** runs to the tip **80** to cool this hot corner of the airfoil. The tip **80** and the trailing edge **84** are arranged at an angle **102** in a range of 60°-120°, and in another example, about 90° relative to one another (90°+/−5°).

The first and second exit regions **98**, **100** are arranged respectively in low and high pressure regions **104**, **106**. The high pressure region **106** is at a greater pressure than the low pressure regions **104**. A natural flow direction F**1** extends from the interior region **96** to the first exit region **98**, which corresponds to an aftward direction along the chord-wise direction H in the example blade. The "natural flow direction" is the direction the fluid would tend to flow from the component, here an airfoil, due to the various pressure gradients. A desired flow direction F**2** extends from the interior region **96** to the second exit region **100** and generally corresponds to the radial direction R. The "desired flow direction" is a direction that is different than the natural flow direction. That is, the fluid would not flow substantially in the desired flow direction but for the first pedestals **114**, discussed below, but would instead tend to flow in the natural flow direction.

Pedestals interconnect the pressure and suction side walls **86**, **88**. First and second pedestal groups **110**, **112** are respectively arranged at the first and second exit regions **98**, **100**. In the example, the first pedestal group **110** includes a column of pedestals recessed from the trailing edge **84** and elongated in the chord-wise direction H. The first pedestal group **110** may extend all the way to the trailing edge **84**, if desired. The second pedestal group **112** is recessed from the tip **80**. Recessing the pedestals into the cavity **94** can avoid coat down issues when applying a thermal barrier coating to the exterior airfoil surface.

Referring to FIGS. **4**, **5**A and **5**B, the second pedestal group **112** has first and second pedestals **114**, **116** each terminating in an end **120**, **122**. The ends **122** of the second pedestals **116** extend beyond the ends **120** of first pedestals **114** in the desired flow direction F**2**. In the example, the elongated pedestals of the second pedestal group **112** are arranged an angle of about 30° to 75° relative to the elongated pedestals of the first pedestal group **110**. The flow within the cavity **94** will not want to turn and flow out the tip **80**. The longer second pedestals **116** prevent flow separation in the second exit region **100**, which can result in cooling fluid being forced back into the cavity **94** and out the first exit region **98** due to the higher pressure at the high pressure region **106**.

The first and second pedestals **114**, **116** include first and second lengths L**1**, L**2** respectively and first and second widths W**1**, W**2** respectively. The first and second lengths L**1**, L**2** are greater than their corresponding first and second widths W**1**, W**2**. In one embodiment, $1<L1/W1<20$ and $1<L2/W2<20$. The first and second pedestals **114**, **116** are arranged in alternating relationship with one another. In the example, multiple first pedestals **114** are arranged between adjacent second pedestals **116**.

The interior region **96** includes a third pedestal group **118** interconnecting the pressure and suction sidewalls **86**, **88** to provide further structural stability and increased cooling to the trailing edge portion of the airfoil.

The longer second pedestals **116** act as "pressure gradient separators" that add to guide the flow through the cavity **94** and out the second exit region **100**. Thus, the entire trailing edge tip can be cooled with minimal risk of flow separation and ingestion. By maintaining the continuous slot exit, it is less susceptible to coating deposition. There is internal convection throughout the entire trailing edge tip as well as adequate flow fill in the tip shelf, if one is used. Consequently, tip integrity is maintained and part life is improved. In addition, the blade would retain an improved aerodynamic efficiency over its life cycle.

FIGS. **6** and **7** illustrate one approach to forming the pedestals in the cavity. A core **124** having holes **128** corresponding to the pedestal shapes is placed in a mold **126**. The core **124** defines the shape of the cavity. The cooling cavity and pedestals can be formed by other manufacturing techniques, such as additive manufacturing, if desired.

Another embodiment is shown in FIGS. **8**A and **8**B that illustrate the first and second pedestal groups **210**, **212** in a cavity **194** near the leading edge **182** of the airfoil **164**. In this example, the first and second pedestals **214**, **216** are arranged near the tip **180**. FIG. **9** depicts a core **224** having holes **228** corresponding to the pedestal shapes in FIGS. **8**A and **8**B.

It should also be understood that although a particular component arrangement is disclosed in the illustrated embodiment, other arrangements will benefit herefrom. Although particular step sequences are shown, described, and claimed, it should be understood that steps may be performed in any order, separated or combined unless otherwise indicated and will still benefit from the present invention.

Although the different examples have specific components shown in the illustrations, embodiments of this invention are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components from another one of the examples.

Although example embodiments have been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of the claims. For that and other reasons, the following claims should be studied to determine their true scope and content.

What is claimed is:

1. An airfoil for a gas turbine engine comprising:

an airfoil including spaced apart pressure and suction side walls joined at leading and trailing edges to provide an exterior airfoil surface extending in a radial direction from a platform to a tip;

a cavity provided between the pressure and suction side walls near the trailing edge, the cavity includes an interior region bounded by a first exit region at the trailing edge and a second exit region at the tip, the first and second exit regions arranged at angle relative to one another, the first and second exit regions are respectively in low and high pressure regions relative to one another; and

first and second pedestal groups respectively arranged at the first and second exit regions, the second pedestal group has first and second pedestals each terminating in an end, the ends of the second pedestals extend beyond the ends of first pedestals, the second pedestals are longer than the first pedestals and in that the second pedestal group is recessed from the tip.

2. The airfoil according to claim **1**, wherein the airfoil is a blade.

3. The airfoil according to claim **1**, wherein the airfoil extends from the leading edge to the trailing edge in a chord-wise direction, the cavity is provided in at least the last 20% of the airfoil near the trailing edge in the chord-wise direction.

4. The airfoil according to claim **3**, wherein the interior region includes a third pedestal group interconnecting the pressure and suction sidewalls.

5. The airfoil according to claim **1**, wherein the first pedestal group is recessed from the trailing edge or extending to the trailing edge.

6. The airfoil according to claim **1**, wherein a natural flow direction extends from the interior region to the first exit region, and a desired flow direction extends from the interior region to the second exit region, and the ends of the second pedestals extend beyond the ends of first pedestals in the desired flow direction.

7. The airfoil according to claim **6**, wherein the natural flow direction corresponds to an aft direction in the chord-wise direction.

8. The airfoil according to claim **7**, wherein the desired flow direction corresponds to the radial direction.

9. The airfoil according to claim **1**, wherein the first and second pedestals include first and second lengths respectively and first and second widths respectively, the first and second lengths greater than their corresponding first and second widths.

10. The airfoil according to claim **9**, wherein the first and second pedestals are in alternating relationship with one another.

11. The airfoil according to claim **10**, wherein at least one first pedestal is arranged between adjacent second pedestals.

12. The airfoil according to claim **9**, wherein the first length has a ratio relative to the first width of $1<L1/W1<20$ and the second length has a ratio relative to the second width of $1<L2/W2<20$.

13. A component for a gas turbine engine comprising:

a structure including spaced apart walls that provide an exterior surface extending in first and second directions to first and second edges, respectively;

a cavity provided between the walls near the first and second edges, the cavity includes an interior region bounded by first and second exit regions arranged at angle relative to one another that terminate at the first and second edges arranged at an angle in a range of 60°-120°, the first and second exit regions respectively in low and high pressure regions relative to one another;

first and second pedestal groups respectively arranged at the first and second exit regions, the second pedestal group has first and second pedestals each terminating in an end, the ends of the second pedestals extend beyond the ends of first pedestals; and

wherein the first and second pedestals include first and second lengths respectively and first and second widths respectively, the first and second lengths greater than their corresponding first and second widths, wherein the first and second pedestals are in alternating relationship with one another, the second pedestals are longer than the first pedestals and in that the second pedestal group is recessed from the second edge.

14. The component according to claim **13**, wherein first and second edge are arranged at about 90° relative to one another.

15. The component according to claim **13**, wherein at least one first pedestals is arranged between adjacent second pedestals.

16. The component according to claim **13**, wherein the first pedestal group is recessed from the first edge.

17. The component according to claim **13**, wherein the structure is one of a vane, a blade, a blade outer air seal, a combustor liner or an exhaust liner.

18. The component according to claim **17**, wherein the structure is an airfoil of a blade.

19. The component according to claim **13**, wherein a natural flow direction extends from the interior region to the first exit region, and a desired flow direction extends from the interior region to the second exit region, and the ends of the second pedestals extend beyond the ends of first pedestals in the desired flow direction.

* * * * *