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Mane et al.

(54) **SYSTEM AND METHOD FOR CONTROLLING FLOW IN TURBOMACHINERY**

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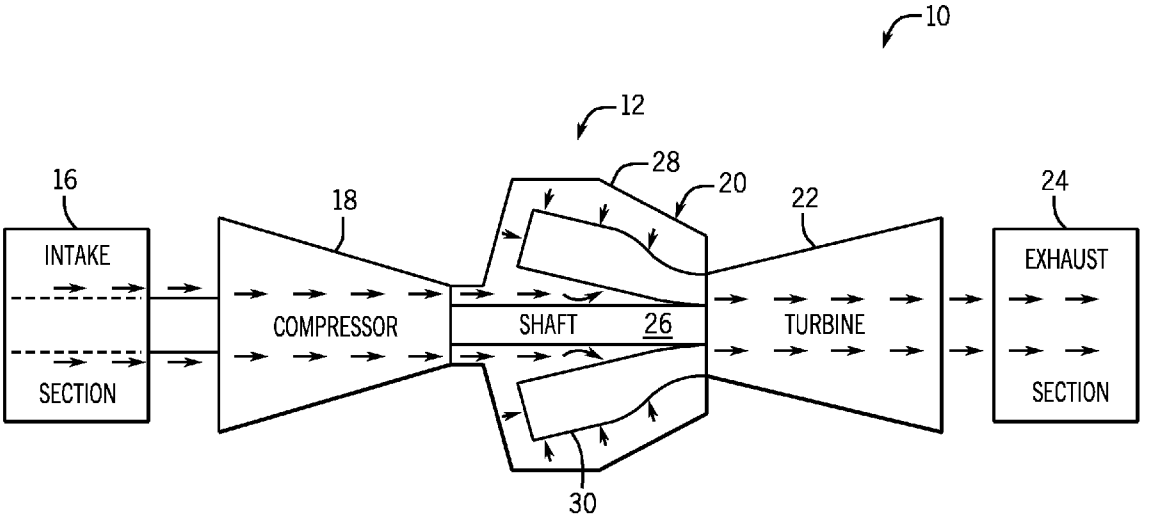
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(57) **ABSTRACT**

A system includes a turbine. The turbine includes a first turbine blade comprising a leading edge, a blade platform coupled to the first turbine blade, and a protrusion disposed on the blade platform adjacent the leading edge of the first turbine blade. The protrusion is configured to increase a first static pressure of a cooling flow near the leading edge above a second static pressure of a hot gas flow near the leading edge.



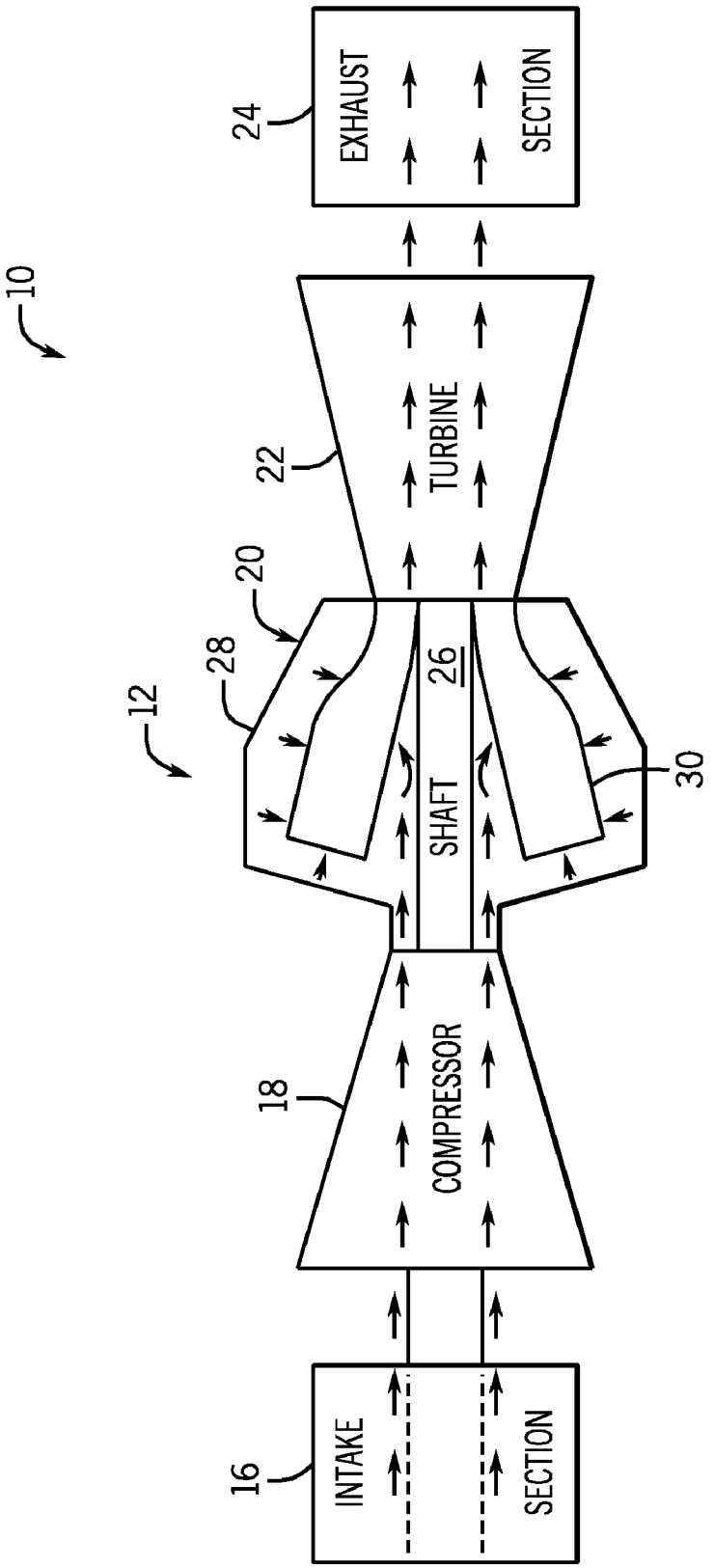

10
12
16
INTAKE
SECTION
18
COMPRESSOR
20
22
TURBINE
24
EXHAUST
SECTION
26
SHAFT
28
30

FIG. 1

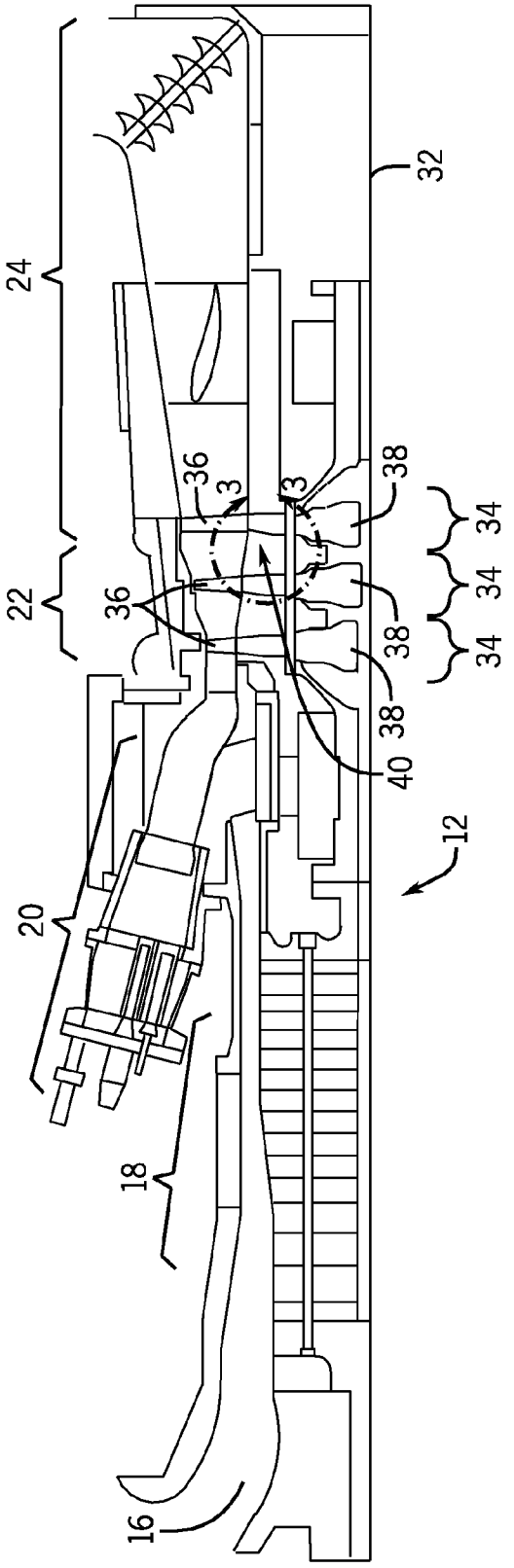


FIG. 2

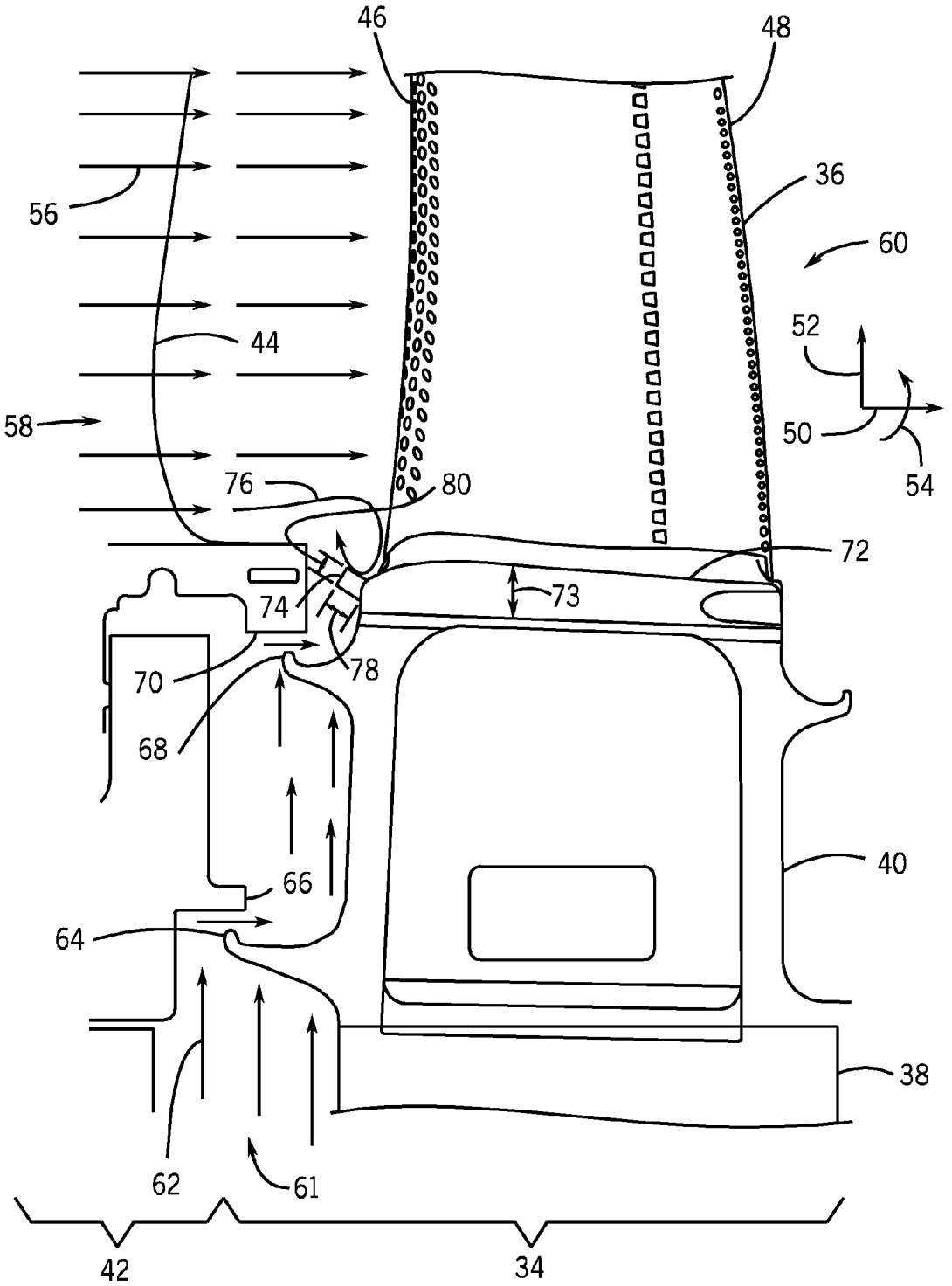

46
48
56
36
60
52
44
58
50
54
76
80
72
74
73
70
78
68
66
40
64
38
62
61
42
34

FIG. 3

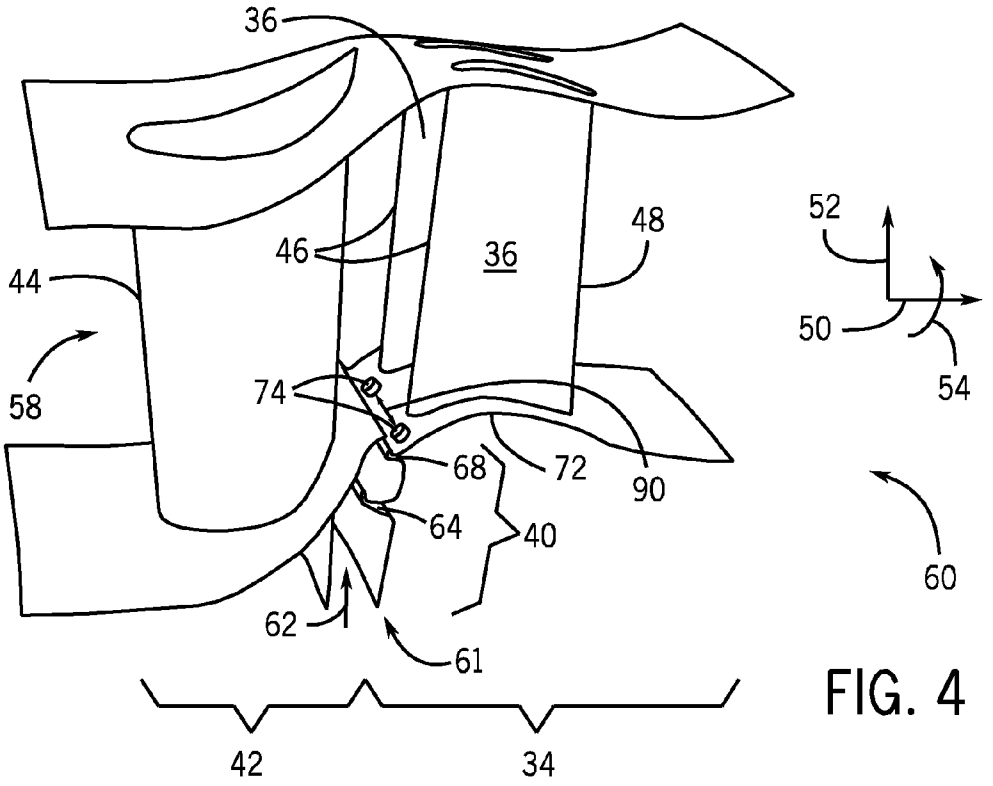

36
48
46
36
44
52
50
54
58
74
68
72
90
64
40
60
62
61
42
34

FIG. 4

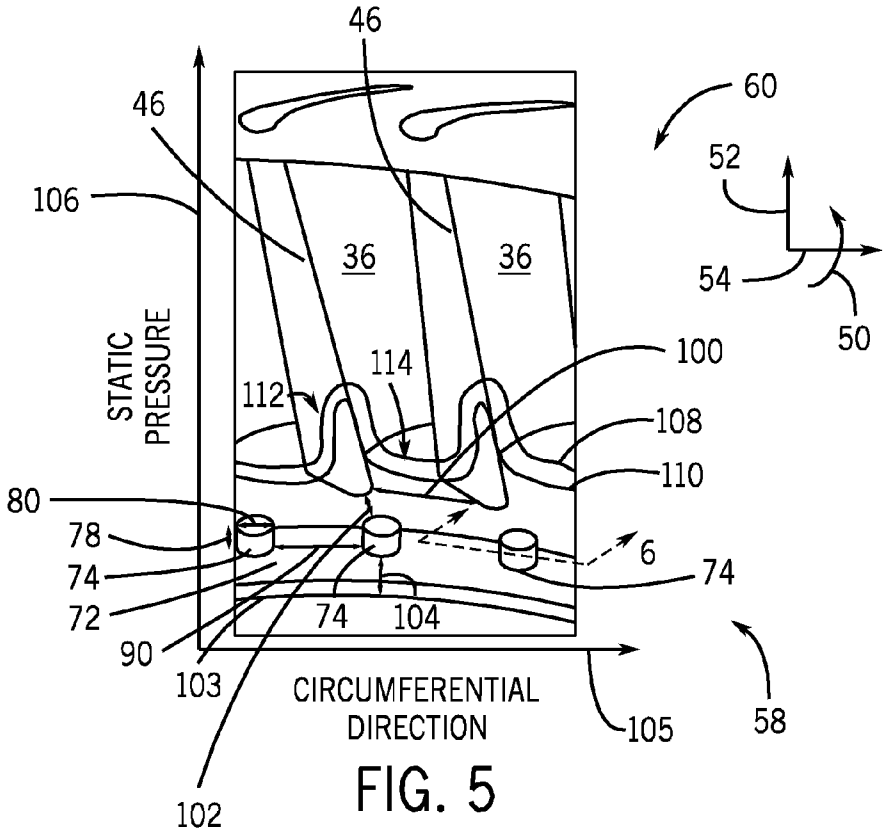

46
46
60
52
106
36
36
54
50
STATIC PRESSURE
114
100
112
108
110
80
78
74
6
74
72
74
104
90
103
CIRCUMFERENTIAL DIRECTION
105
58
102

FIG. 5

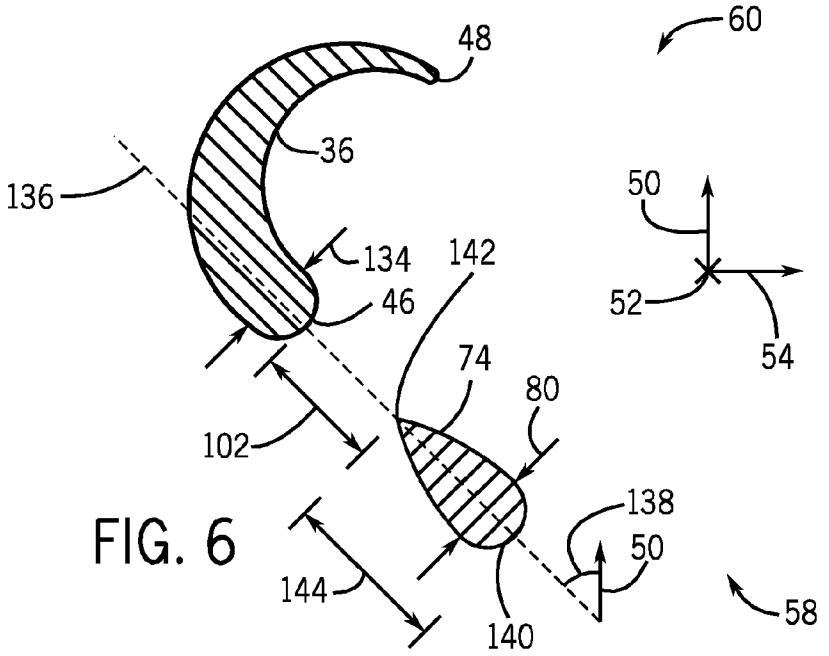


FIG. 6

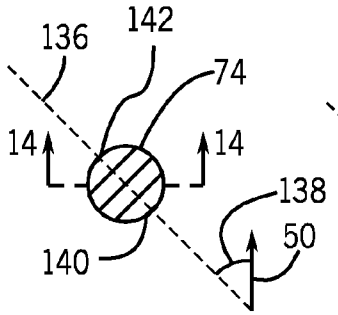


FIG. 7

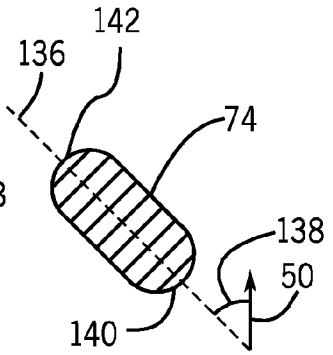


FIG. 8

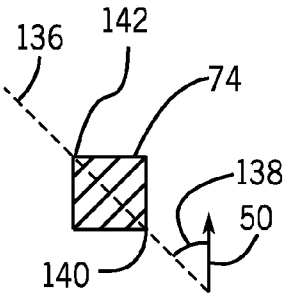


FIG. 11

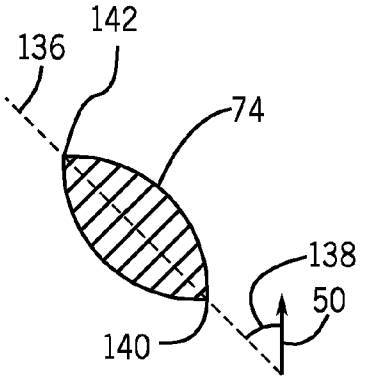


FIG. 9

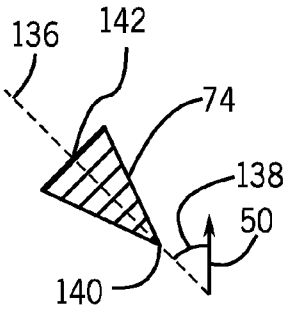


FIG. 10

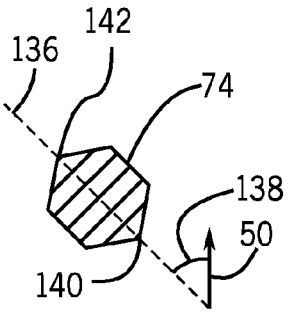


FIG. 12

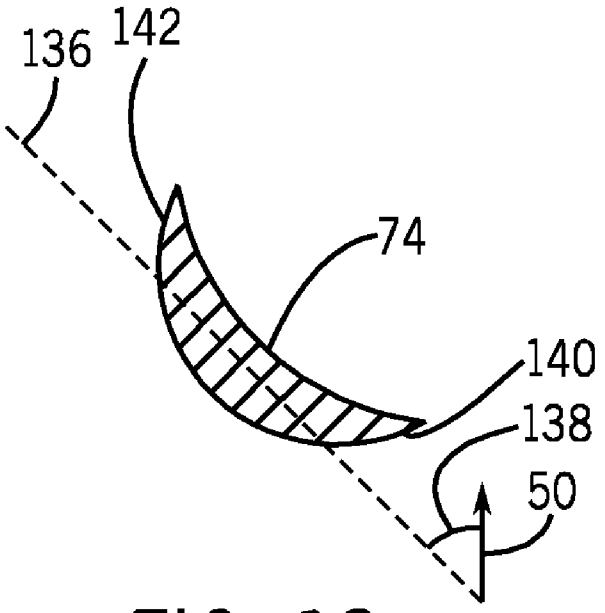


FIG. 13

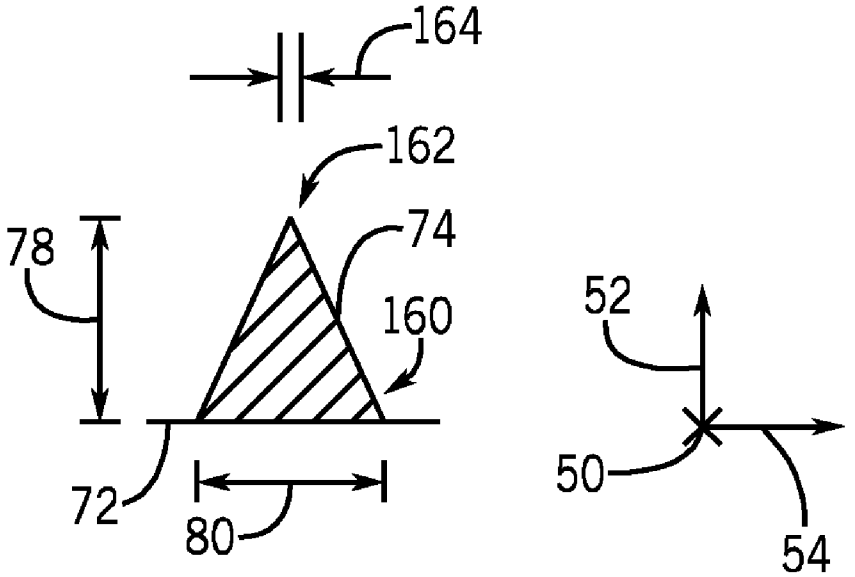


FIG. 14

SYSTEM AND METHOD FOR CONTROLLING FLOW IN TURBOMACHINERY

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to turbomachinery, and more specifically, to controlling flow within turbines.

[0002] In general, gas turbine engines combust a mixture of compressed air and fuel to produce hot combustion gases. The combustion gases may flow through one or more turbine stages to generate power for a load and/or compressor. Surfaces of the gas turbine engine expected to come in contact with the hot combustion gases may be made from materials able to withstand hot temperatures. Such high-temperature materials may be difficult to obtain and/or expensive. Other surfaces of the gas turbine engine that are not expected to come in contact with the hot combustion gases may be made from more readily available and/or less expensive materials. Such low-temperature materials may not be designed to be exposed to the hot combustion gases. Unfortunately, in certain situations, the hot combustion gases may come in contact with the surfaces not designed to withstand high temperatures, thereby potentially degrading these surfaces and the gas turbine engine. Similarly, other turbomachinery, such as steam turbines, for example, may be susceptible to such degradation caused by high temperature gases contacting surfaces designed for exposure to lower temperatures.

BRIEF DESCRIPTION OF THE INVENTION

[0003] Certain embodiments commensurate in scope with the originally claimed invention are summarized below. These embodiments are not intended to limit the scope of the claimed invention, but rather these embodiments are intended only to provide a brief summary of possible forms of the invention. Indeed, the invention may encompass a variety of forms that may be similar to or different from the embodiments set forth below.

[0004] In a first embodiment, a system includes a turbine. The turbine includes a first turbine blade comprising a leading edge, a blade platform coupled to the first turbine blade, and a protrusion disposed on the blade platform adjacent the leading edge of the first turbine blade. The protrusion is configured to increase a first static pressure of a cooling flow near the leading edge above a second static pressure of a hot gas flow near the leading edge.

[0005] In a second embodiment, a system includes an ingestion restrictor configured to mount on a blade platform adjacent a leading edge of a turbine blade of a turbine. The ingestion restrictor is configured to block entry of a hot gas flow into a wheel space cavity near the leading edge of the turbine blade.

[0006] In a third embodiment, a method includes mounting an ingestion restrictor on a blade platform upstream of a leading edge of a first turbine blade of a turbine and increasing a first static pressure of a cooling flow near the leading edge of the first turbine blade above a second static pressure of a hot gas flow using the ingestion restrictor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0008] FIG. **1** is a schematic flow diagram of an embodiment of a gas turbine engine that may employ ingestion restrictors;

[0009] FIG. **2** is a cross-sectional side view of an embodiment of the gas turbine engine of FIG. **1** taken along the longitudinal axis;

[0010] FIG. **3** is a cross-sectional side view of an embodiment of a stage of a gas turbine engine that may employ injection restrictors;

[0011] FIG. **4** is a perspective view of an embodiment of a stage of a gas turbine engine that may employ ingestion restrictors;

[0012] FIG. **5** is a perspective view of an embodiment of an ingestion restrictor;

[0013] FIG. **6** is a cross-sectional top view of an embodiment of an ingestion restrictor and a gas turbine blade;

[0014] FIG. **7** is a cross-sectional top view of an embodiment of an ingestion restrictor;

[0015] FIG. **8** is a cross-sectional top view of an embodiment of an ingestion restrictor;

[0016] FIG. **9** is a cross-sectional top view of an embodiment of an ingestion restrictor;

[0017] FIG. **10** is a cross-sectional top view of an embodiment of an ingestion restrictor;

[0018] FIG. **11** is a cross-sectional top view of an embodiment of an ingestion restrictor;

[0019] FIG. **12** is a cross-sectional top view of an embodiment of an ingestion restrictor;

[0020] FIG. **13** is a cross-sectional top view of an embodiment of an ingestion restrictor; and

[0021] FIG. **14** is a cross-sectional side view of an embodiment of an ingestion restrictor.

DETAILED DESCRIPTION OF THE INVENTION

[0022] One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0023] When introducing elements of various embodiments of the present invention, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

[0024] The present disclosure is directed to turbomachinery, such as multi-stage turbines, e.g., gas turbine engines or steam turbine engines. The multi-stage turbine may include a first turbine blade that includes a leading edge and a blade platform coupled to the first turbine blade. A protrusion may be disposed on the blade platform adjacent the leading edge of the first turbine blade. In certain embodiments, the protrusion

may increase a first static pressure of a cooling flow near the leading edge above a second static pressure of a hot gas flow near the leading edge. For example, the cooling flow may flow radially outward from an axial axis of the turbine to help cool components of the turbine near the axial axis. In a gas turbine engine, the hot gas flow may be generated by combustion of a fuel with oxygen and may flow axially along a hot gas flow path through the turbine. In a steam turbine engine, the hot gas flow may be a steam flow. By increasing the first static pressure of the cooling flow, the protrusion may help block the hot gas flow from reaching surfaces and/or areas of the turbine not in the hot gas flow path, such as the surfaces cooled by the cooling flow. Entry of the hot gas flow into such areas of the turbine may be referred to as ingestion, and the protrusion may be referred to as an injection restrictor.

[0025] Use of such protrusions, or ingestion restrictors, may offer several advantages. For example, the first turbine blade and other components of the turbine in the hot gas flow path may be made from materials suitable for high temperatures. However, the components of the turbine not in the hot gas flow path may be made from different materials not suitable for high temperatures. Such materials may be degraded upon exposure to the hot gas flow. Thus, by helping to block the hot gas flow from entering areas of the turbine outside the hot gas flow path, the protrusion may help reduce the possibility of degradation of components of the turbine disposed in those areas not designed for exposure to high temperatures. In addition, the disclosed protrusions may offer advantages compared to other methods of ingestion restriction. For example, the protrusions may be located adjacent to only the leading edge of the first turbine blade, where ingestion may be more likely. Thus, the protrusions are not disposed upstream of the spaces between adjacent turbine blades of the turbine. Thus, any reduction in the aerodynamic performance of the turbine caused by the protrusions may be reduced. In addition, such small protrusions may be easy to manufacture, inexpensive, and easy to install in the turbine. Embodiments of the protrusions may be used to avoid ingestion in any turbomachinery, such as gas turbine engines and steam turbine engines, for example. In the following discussion, a gas turbine engine is used as one non-limiting example of turbomachinery in which such embodiments of the protrusions may be used.

[0026] Turning to the drawings, FIG. **1** is a block diagram of an exemplary system **10** including a gas turbine engine **12** that may employ protrusions, or ingestion restrictors, as described in detail below. In certain embodiments, the system **10** may include an aircraft, a watercraft, a locomotive, a power generation system, or combinations thereof. The illustrated gas turbine engine **12** includes an air intake section **16**, a compressor **18**, a combustor section **20**, a turbine **22**, and an exhaust section **24**. The turbine **22** is coupled to the compressor **18** via a shaft **26**.

[0027] As indicated by the arrows, air may enter the gas turbine engine **12** through the intake section **16** and flow into the compressor **18**, which compresses the air prior to entry into the combustor section **20**. The illustrated combustor section **20** includes a combustor housing **28** disposed concentrically or annularly about the shaft **26** between the compressor **18** and the turbine **22**. The compressed air from the compressor **18** enters combustors **30**, where the compressed air may mix and combust with fuel within the combustors **30** to drive the turbine **22**.

[0028] From the combustor section **20**, the hot combustion gases flow through the turbine **22**, driving the compressor **18** and a load via the shaft **26**. For example, the combustion gases may apply motive forces to turbine rotor blades within the turbine **22** to rotate the shaft **26**, which may be used to drive a load, such as an electrical generator. After flowing through the turbine **22**, the hot combustion gases may exit the gas turbine engine **12** through the exhaust section **24**. As discussed below, the turbine **22** may include a plurality of protrusions (e.g., ingestion restrictors) disposed adjacent leading edges of the turbine rotor blades.

[0029] FIG. **2** is a cross-sectional side view of an embodiment of the gas turbine engine **12** of FIG. **1** taken along a longitudinal axis **32**. As depicted in FIG. **2**, the gas turbine **22** includes three separate stages **34**. Each stage **34** includes a set of blades **36** coupled to a rotor wheel **38** that may be rotatably attached to the shaft **26** (FIG. **1**). The blades **36** extend radially outward from the rotor wheels **38** and are partially disposed within the path of the hot combustion gases. Seals **40** extend between and are supported by adjacent rotor wheels **38**. As discussed below, protrusions may be disposed adjacent the leading edges of the blades **36**. Although the gas turbine **22** is illustrated as a three-stage turbine, the protrusions described herein may be employed in any suitable type of turbine with any number of stages and shafts. For example, the protrusions may be included in a single stage gas turbine, in a dual turbine system that includes a low-pressure turbine and a high-pressure turbine, or in a steam turbine. Further, the protrusions described herein may also be employed in a rotary compressor, such as the compressor **18** illustrated in FIG. **1**. The protrusions may be made from various high-temperature alloys, such as, but not limited to, nickel based alloys.

[0030] As described above with respect to FIG. **1**, air enters through the air intake section **16** and is compressed by the compressor **18**. The compressed air from the compressor **18** is then directed into the combustor section **20** where the compressed air is mixed with fuel. The mixture of compressed air and fuel is generally burned within the combustor section **20** to generate high-temperature, high-pressure combustion gases, which are used to generate torque within the turbine **22**. Specifically, the combustion gases apply motive forces to the blades **36** to turn the wheels **38**. In certain embodiments, a pressure drop may occur at each stage **34** of the turbine **22**, which may allow gas leakage flow through unintended paths. For example, the hot combustion gases may leak into the interstage volume between turbine wheels **38**, which may place thermal stresses on the turbine components. In certain embodiments, the interstage volume may be cooled by a cooling flow, such as discharge air bled from the compressor or provided by another source. However, flow of hot combustion gases into the interstage volume may abate the cooling effects of the cooling flow. Accordingly, the protrusions may be disposed adjacent leading edges of the blades **36** to block the hot combustion gases from leaking into the interstage volume. In addition, the protrusions may increase a static pressure of the cooling flow near the leading edges of the blades **36** above a static pressure of the hot combustion gases near the leading edges. The hot combustion gases may be blocked from entering the interstage volume because the cooling flow has a higher static pressure than the hot combustion gases.

[0031] FIG. **3** is a cross-sectional side view of an embodiment of one of the rotor stages **34** shown in FIG. **2**. In the following discussion, reference may be made to an axial

direction or axis **50**, a radial direction or axis **52**, and a circumferential direction or axis **54**, relative to the longitudinal axis **32** of the gas turbine engine **12**. Hot fluids, such as hot combustion gases or steam, with a flow path **56** (illustrated generally by arrows) enters at an upstream side **58** and exits at a downstream side **60** relative to the stage **34**. For illustrative purposes, only a portion of the stage **34** is illustrated in FIG. **3**. In addition, a portion of a stator stage **42** upstream of the rotor stage **34** is shown in FIG. **3**. For example, a portion of a stator blade **44** is shown adjacent to the rotor blade **36**. The rotor blade **36** and the stator blade **44** may be made from materials selected for high temperature service because of their exposure to the hot fluids during operation of the gas turbine engine **12**. In addition, the rotor blade **36** may have a leading edge **46** facing the upstream side **58** and a trailing edge **48** facing the downstream side **60**.

[0032] As shown in FIG. **3**, a cooling flow enters an interstage volume **61**, or wheel space cavity, between the stator stage **42** and the rotor stage **34**, flowing in the radial direction **52** along a cooling flow path **62** (illustrated generally by arrows). A temperature of the cooling flow may be less than a temperature of the hot fluids. Thus, components of the interstage volume **61** (e.g., the rotor wheel **38** and the seal **40**) may be made from materials that are unsuitable for high temperature service. If such components are exposed to the hot fluids, the components may experience thermal stresses that may degrade the components. The coolant (e.g., air) flows in the radial direction **52** past the rotor wheel **38** and toward a first wing seal **64**, which may help to seal the interstage volume **61** from the hot fluids. The cooling flow moves past the first wing seal **64** and then moves in the axial direction **50** after encountering a first projection **66** of the stator stage **42**. The cooling flow then turns in the radial direction **52** again toward a second wing seal **68**, which also may help seal the interstage volume **61** from the hot fluids. The first and second wing seals **64** and **68** may extend circumferentially **54** about the axial axis **50** without any circumferential gaps or spaces. The cooling flow moves past the second wing seal **68** and then moves in the axial direction **50** after encountering a second projection **70** of the stator stage **42**. The cooling flow **62** then turns in the radial direction **52** again toward a blade platform **72**, which couples the blade **36** to the seal **40**. The blade platform **72** may be defined by a radial height **73**.

[0033] A protrusion, or an ingestion restrictor, **74** may be disposed on the upstream side **58** of the blade platform **72**. As shown in FIG. **3**, a portion **76** of the hot combustion gases is blocked from entering the interstage volume **61** by the protrusion **74**. As described in detail below, the protrusion **74** may help increase a static pressure of the cooling flow above a static pressure of the hot fluids adjacent to the blade **36**, thereby helping to block the hot fluids from entering the interstage volume **61**. The protrusion **74** may be defined by a height **78** and a width **80**. In certain embodiments, the height **78** and/or the width **80** may be between approximately 0.5 cm to 15 cm, 1.5 cm to 10 cm, or 2.5 cm to 5 cm. In other embodiments, the height **78** may be less than the width **80** to help reduce any effect of the protrusion **74** on the aerodynamic efficiency of the gas turbine engine **12**. For example, an aspect ratio (e.g., ratio of the width **80** to the height **78**) may be between approximately 1.1:1 to 5:1, 1.3:1 to 3:1, or 1.5:1 to 2:1. In general, the aspect ratio of the protrusion **74** may refer to any ratio of a first dimension of the protrusion **74** to a second dimension of the protrusion **74**. In addition, a ratio of the radial height **73** of the blade platform **72** to the width **80** of the protrusion **72** may be between approximately 1.1:1 to 4:1, 1.3:1 to 3:1, or 1.5:1 to 2:1. By blocking the portion **76** of the hot combustion gases, the protrusion **74** helps to protect the components of the interstage volume **61** from degradation caused by the hot fluids.

[0034] FIG. **4** is a perspective view of an embodiment of one of the rotor stages **34** shown in FIG. **2**. Elements in FIG. **4** in common with those shown in FIG. **3** are labeled with the same reference numerals. As shown in FIG. **4**, the protrusions **74** are disposed adjacent the leading edges **46** of the turbine blades **36**. Thus, the protrusions **74** are separated by a distance **90**. In other words, the protrusions **74** are disposed only adjacent to the leading edges **46** of the turbine blades **36** and are not disposed in, and/or do not extend into, gaps or spaces between the turbine blades **36**. Thus, each protrusion **74** may be aligned or centered in front of only one blade **36**, such that the protrusion **74** generally does not impede the gas flow between adjacent blades **36**. Accordingly, the protrusions **74** are different from other components of the gas turbine engine **12** that extend completely circumferentially **54** about the axial axis **50**, such as, for example, the first and second wing seals **64** and **68**. Thus, the protrusions **74** may have a minimal impact on the overall aerodynamic efficiency of the gas turbine engine **12**. Further, it may be relatively simple and inexpensive to add the protrusions **74** to the blade platform **72**. In certain embodiments, the protrusions **74** may be coupled to the blade platform **72** in a multi-piece structure using a variety of techniques, such as, but not limited to, welding, brazing, adhesives, fasteners, and so forth. In other embodiments, the protrusions **74** may be integrally formed on the blade platforms **74** as a one-piece structure. In certain embodiments, a ratio of the width **80** of the protrusion **72** to the distance **90** may be between approximately 0.1:1 to 4:1, 0.2:1 to 2:1, or 0.3:1 to 0.5:1.

[0035] FIG. **5** is a perspective view of the protrusions **74** and the turbine blades **36**. As shown in FIG. **5**, the leading edges **46** of the turbine blades **36** are separated by a distance **100**. The distance **100** may correspond to approximately the separation distance **90** between the protrusions **74**. Thus, the protrusions **74** are disposed adjacent to the leading edges **46** of the turbine blades **36**. In other words, the protrusions **74** do not extend into the distance **100** between the blades **36** and are generally limited to the area in front of the leading edges **46**. In addition, the protrusions **74** are separated from the leading edges **46** by a distance **102**. In certain embodiments, the distance **102** may be between approximately 0.5 cm to 15 cm, 1.5 cm to 10 cm, or 2.5 cm to 5 cm. In addition, the protrusions **74** are separated from a front edge **103** of the blade platform **72** by a distance **104**. In certain embodiments, the distance **104** may be between approximately 0.5 cm to 15 cm, 1.5 cm to 10 cm, or 2.5 cm to 5 cm. Thus, the protrusions **74** may be generally limited to the area between the front edge **103** of the blade platform **72** and the leading edge **46** of the turbine blades **36**.

[0036] In addition, a graph of static pressures associated with the protrusions **74** is superimposed over the perspective view shown in FIG. **5**. Specifically, an x-axis **105** corresponds to the circumferential direction **54** and a y-axis **106** corresponds to a static pressure of a fluid. A first curve **108** shows the static pressure associated with the cooling flow flowing along the cooling flow path **62**. A second curve **110** shows the static pressure associated with the hot fluids flowing along the flow path **56**. As shown in FIG. **5**, the cooling flow static pressure **108** is greater than the hot fluid static pressure **110** in

the entire circumferential direction **54**. In other words, the protrusions **74** help the cooling flow static pressure **108** not to fall below the hot fluid static pressure **110**. For example, the hot fluid static pressure **110** increases at peaks **112** near the leading edges **46** because the blades **36** at least partially resist the flow of the hot fluids. Similarly, the protrusions **74** adjacent to the leading edges **46** help to increase the cooling flow static pressure **108** at the peaks **112** because the protrusions **74** at least partially resist the flow of the cooling flow. When the cooling flow static pressure **108** exceeds the hot fluid static pressure **110**, the hot fluids may be blocked from entering the interstage volume **61**. Without the protrusions **74**, the hot fluid static pressure **110** may exceed the cooling flow static pressure **108** at the peaks **112**, thereby enabling the hot fluids to enter the interstage volume **61**. At troughs **114** between the blades **36**, the cooling flow static pressure **108** exceeds the hot fluid static pressure **110** because the turbine blades **36** are not present to resist the flow of the hot fluids. In other words, the protrusions **74** are not used between the turbine blades **36** because the cooling flow static pressure **108** already exceeds the hot fluid static pressure **110**, thereby blocking the hot fluids from entering the interstage volume **61**. Thus, the protrusions **74** increase the cooling flow static pressure **108** only where needed to help block ingestion of the hot fluids into the interstage volume **61**, namely adjacent to the leading edges **46** of the blades **36**.

[0037] FIG. **6** is cross-sectional top view of an embodiment of the protrusion **74** and the blade **36**. As shown in FIG. **6**, the leading edge **46** of the blade **36** faces the upstream side **58** and the trailing edge **48** faces the downstream side **60**. The leading edge **46** of the blade **36** may have width **134**. In certain embodiments, the width **134** may be between approximately 0.5 cm to 15 cm, 1.5 cm to 10 cm, or 2.5 cm to 5 cm. Thus, a ratio of the width **134** of the blade **36** to the width **80** of the protrusion **74** may be between approximately 0.5:1 to 4:1, 0.75:1 to 3:1, or 1:1 to 2:1. The leading edge **46** of the blade **36** may be generally bisected by an axis **136**, which is offset by an angle **138** from the axial axis **50**. In certain embodiments, the angle **138** may be between approximately 10 degrees to 90 degrees, 25 degrees to 75 degrees, or 40 degrees to 60 degrees. As shown in FIG. **6**, the blade **36** curves away from the axis **136** toward the trailing edge **48**. The protrusion **74** may also have a leading edge **140** and a trailing edge **142**. In the illustrated embodiment, the protrusion **74** has an aerodynamic shape, such as an airfoil shape or a teardrop shape. Such a shape for the protrusion **74** may help reduce the resistance to gases flowing past the protrusion **74**. Thus, an aerodynamically-shaped protrusion **74** may reduce any negative effect on the aerodynamic efficiency of the gas turbine engine **12** caused by the protrusion **74**. As shown in FIG. **6**, the protrusion **74** may be generally aligned with the axis **136**. In other words, the protrusion **74** is oriented at the angle **138** from the axial axis **50**. In addition, the protrusion **74** may have a length **144**, which may be between approximately 1 cm to 30 cm, 3 cm to 20 cm, or 5 cm to 10 cm. Thus, the length **144** of the protrusion **74** may be greater than the width **80**. In other embodiments, the length **144** may be less than the width **80** or the length **144** and width **80** may be approximately the same. The separation distance **102** between the protrusion **74** and the blade **36** may be adjusted to determine the effect of the protrusion **74** on the cooling flow static pressure **108**. For example, as the separation distance **102** is increased, the cooling flow static pressure **108** may decrease. Similarly, as the separation distance **102** is decreased, the cooling flow static pressure **108** may increase. Thus, the separation distance **102** may be selected to help the cooling flow static pressure **108** to generally exceed the hot fluid static pressure **110** under a wide variety of operating conditions of the gas turbine engine **12**. In certain embodiments, the separation distance **102** may be between approximately 1 cm to 30 cm, 3 cm to 20 cm, or 5 cm to 10 cm.

[0038] FIGS. **7** through **13** show cross-sectional top views of various embodiments of the protrusions **74** with different cross-sectional shapes. For example, in FIG. **7**, the protrusion **74** has a circular cross-sectional shape. Such a shape may be easier to manufacture than other shapes. In addition, the orientation of the protrusion **74** with respect to the axis **136** may be unimportant. In FIG. **8**, the protrusion **74** has a generally oval shape, which may also be easy to manufacture because of the curved shape of the protrusion **74**. As shown in FIG. **8**, the leading and trailing edges **140** and **142** are generally curved. In FIG. **9**, the protrusion **74** has a bullet shape or football shape with sharp edges for the leading and trailing edges **140** and **142**. Such a configuration of the protrusion **74** may offer aerodynamic characteristics different from the protrusions shown in FIGS. **7** and **8**, for example. In FIG. **10**, the protrusion **74** has a generally triangular shape. In other words, the leading edge **140** has a sharp edge and the trailing edge **142** is generally flat. In FIG. **11**, the protrusion **74** has a generally square or rectangular shape. Again, the leading and trailing edges **140** and **142** have generally sharp edges. In FIG. **12**, the protrusion **74** has a generally polygonal cross-sectional shape (e.g., hexagonal shape) with sharp edges for the leading and trailing edges **140** and **142**. In FIG. **13**, the protrusion **74** has a crescent or arcuate cross-sectional shape. The leading and trailing edges **140** and **142** may have generally curved surfaces facing toward and away from the upstream and downstream sides **58** and **60**. FIGS. **7** through **13** are meant to only provide several examples of cross-sectional shapes for the protrusions **74**. In other embodiments, other shapes may be selected based on the requirements of a particular application. For example, the protrusion **74** may have a cross-sectional shape that is a combination of one or more of the shapes shown in FIGS. **7** through **13**.

[0039] FIG. **14** is a cross-sectional side view of an embodiment of the protrusion **74** taken along line **14-14** of FIG. **7**. As shown in FIG. **14**, a base **160** of the protrusion **74** may be wider than a tip **162**. In other words, a width **164** of the tip **162** may be less than the width **80** of the base **160**. Thus, the protrusion has a generally triangular, or tapered, side cross-sectional shape, which may be used with any of the previous embodiments of the protrusion **74** described in FIGS. **6** through **13**. In other embodiments, the width **80** of the base **160** and the width **164** of the tip **162** may be approximately the same. In further embodiments, the width **164** of the tip **162** may be greater than the width **80** of the base **160**. Thus, the protrusion **74** may have a variety of side cross-sectional shapes including at least one of, but not limited to, circles, ovals, squares, rectangles, triangles, polygons, hourglass, trapezoids, and so forth. The particular side cross-sectional shape selected may depend on the requirements of a particular application. For example, additional blocking of the hot fluids may be needed near the base **160** of the protrusion **74**. Thus, the width **80** of the base **160** may be configured to be greater than the width **164** of the tip **162**, thereby reducing any effect on the aerodynamic efficiency of the gas turbine engine **12**.

[0040] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

1. A system, comprising:
a turbine, comprising:
a first turbine blade comprising a leading edge;
a blade platform coupled to the first turbine blade; and
a protrusion disposed on the blade platform adjacent the leading edge of the first turbine blade, wherein the protrusion is configured to increase a first static pressure of a cooling flow near the leading edge above a second static pressure of a hot gas flow near the leading edge.

2. The system of claim **1**, wherein the protrusion is configured to block entry of the hot gas flow into a wheel space cavity near the leading edge of the first turbine blade.

3. The system of claim **1**, comprising a second turbine blade, wherein the protrusion does not extend across a space between the first turbine blade and the second turbine blade.

4. The system of claim **1**, wherein the protrusion is configured to increase the first static pressure of the cooling flow only near the leading edge of the first turbine blade.

5. The system of claim **1**, wherein the protrusion comprises at least one of a circular cross-sectional shape, an oval cross-sectional shape, a triangular cross-sectional shape, a square cross-sectional shape, a rectangular cross-sectional shape, a polygonal cross-sectional shape, an aerodynamic cross-sectional shape, an arcuate cross-sectional shape, or a combination thereof.

6. The system of claim **1**, wherein an aspect ratio of the protrusion is less than approximately 2:1, the aspect ratio comprises a ratio of a first dimension of the protrusion to a second dimension of the protrusion.

7. The system of claim **1**, wherein the protrusion is disposed between a front edge of the blade platform and the leading edge of the first turbine blade.

8. The system of claim **1**, comprising a one-piece structure having the protrusion integrally formed on the blade platform, or a multi-piece structure having the protrusion coupled to the blade platform.

9. A system, comprising:
an ingestion restrictor configured to mount on a blade platform adjacent a leading edge of a turbine blade of a turbine, wherein the ingestion restrictor is configured to block entry of a hot gas flow into a wheel space cavity near the leading edge of the turbine blade.

10. The system of claim **9**, wherein the ingestion restrictor is configured to increase a first static pressure of a cooling flow near the leading edge above a second static pressure of the hot gas flow near the leading edge.

11. The system of claim **9**, wherein a width of the ingestion restrictor is less than a radial height of the blade platform.

12. The system of claim **11**, wherein a ratio of the radial height of the blade platform to the width of the ingestion restrictor is less than approximately 2:1.

13. The system of claim **9**, wherein the ingestion restrictor is disposed between a front edge of the blade platform and the leading edge of the turbine blade.

14. The system of claim **9**, wherein the ingestion restrictor comprises at least one of a circular cross-sectional shape, an oval cross-sectional shape, a triangular cross-sectional shape, a square cross-sectional shape, a rectangular cross-sectional shape, a polygonal cross-sectional shape, an aerodynamic cross-sectional shape, an arcuate cross-sectional shape, or a combination thereof.

15. The system of claim **9**, wherein the ingestion restrictor is oriented at an angle from an axial axis of the turbine.

16. The system of claim **9**, comprising the turbine having the ingestion restrictor.

17. A method, comprising:
mounting an ingestion restrictor on a blade platform upstream of a leading edge of a first turbine blade of a turbine, and
increasing a first static pressure of a cooling flow near the leading edge of the first turbine blade above a second static pressure of a hot gas flow using the ingestion restrictor.

18. The method of claim **17**, comprising blocking entry of the hot gas flow into a wheel space cavity near the leading edge of the first turbine blade using the ingestion restrictor.

19. The method of claim **17**, comprising disposing the ingestion restrictor between a front edge of the blade platform and the leading edge of the first turbine blade.

20. The method of claim **17**, comprising locating the ingestion restrictor to not extend across a space between the first turbine blade and a second turbine blade.

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