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(54) **PLATFORM COOLING OF A TURBINE BLADE ASSEMBLY**

(71) Applicant: **General Electric Company**, (US)

(72) Inventors: **Bradley Taylor Boyer**, Greenville, SC (US); **Randall Richard Good**, Simpsonville, SC (US)

(73) Assignee: **GENERAL ELECTRIC COMPANY**, Schenectady, NY (US)

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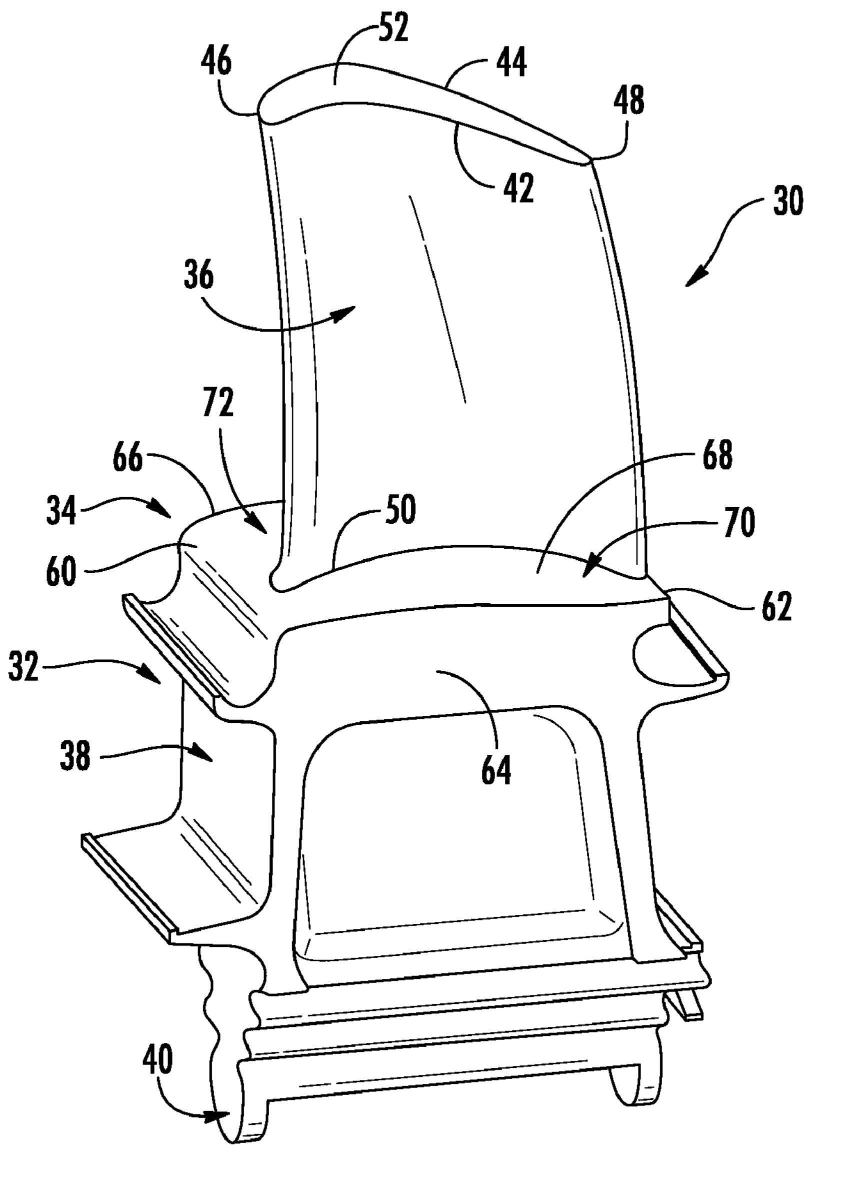
(57) **ABSTRACT**

A turbine blade generally includes a platform having a pressure side, a suction side, a leading edge, a trailing edge, a pressure side slash face and a suction side slash face. A platform cooling circuit extends within the platform. The platform cooling circuit may extend from the suction side of the platform to the pressure side of the platform. The platform cooling circuit generally defines a fluid flow path that directs a cooling medium from the platform suction side to the platform pressure side.



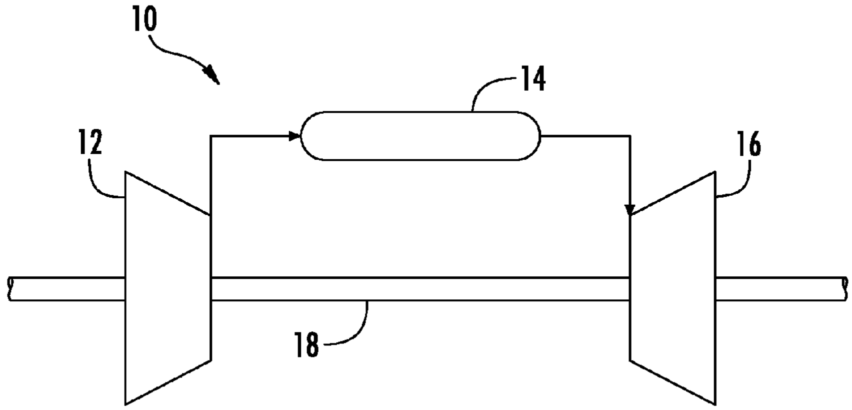



FIG. 1

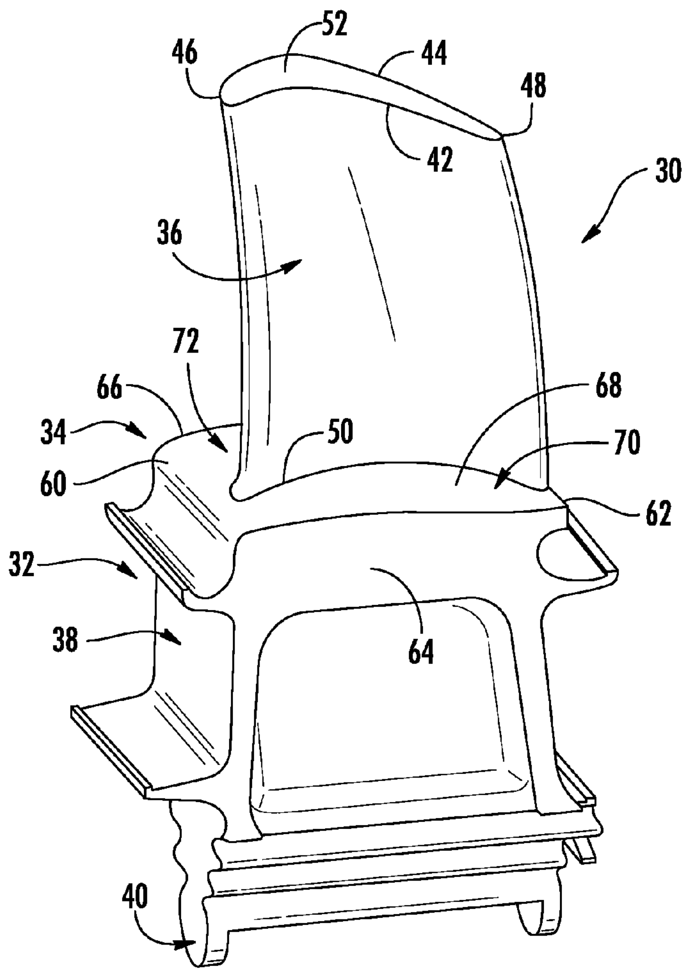



FIG. 2

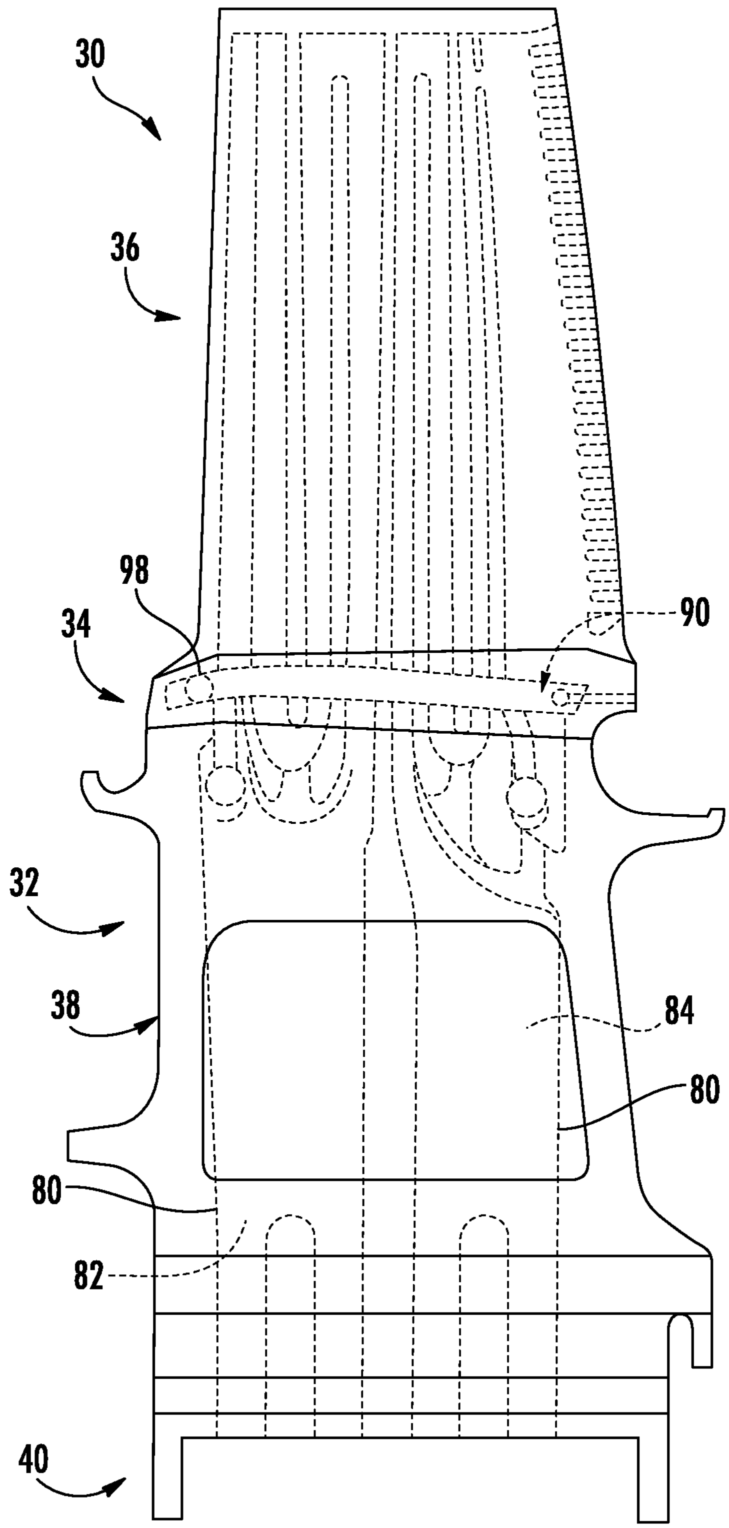



FIG. 3

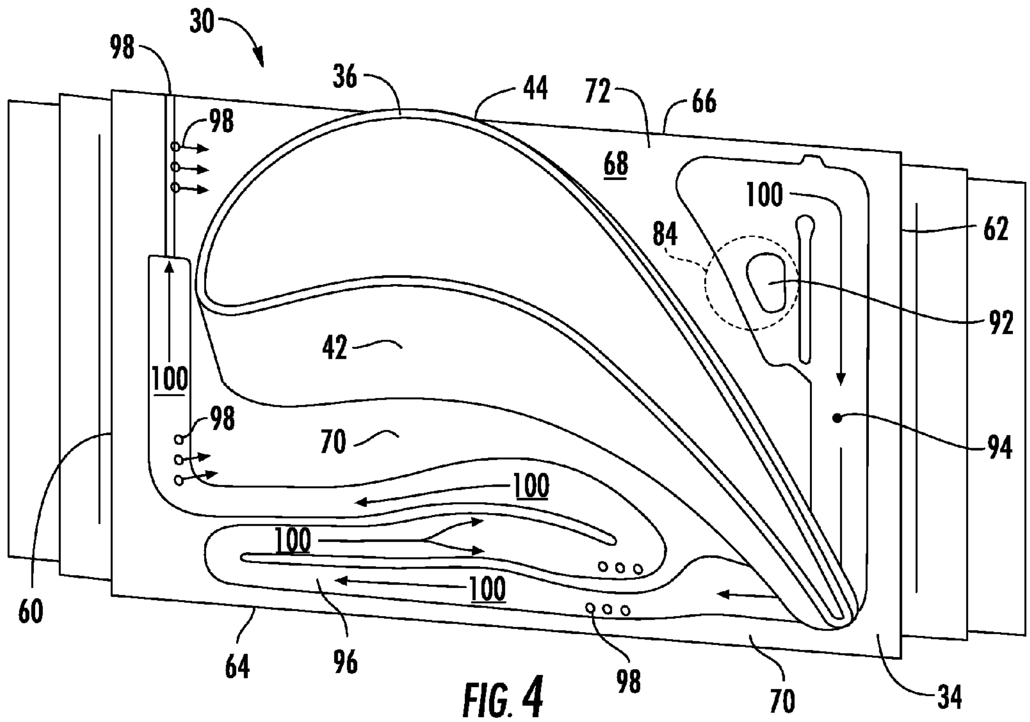

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FIG. 4

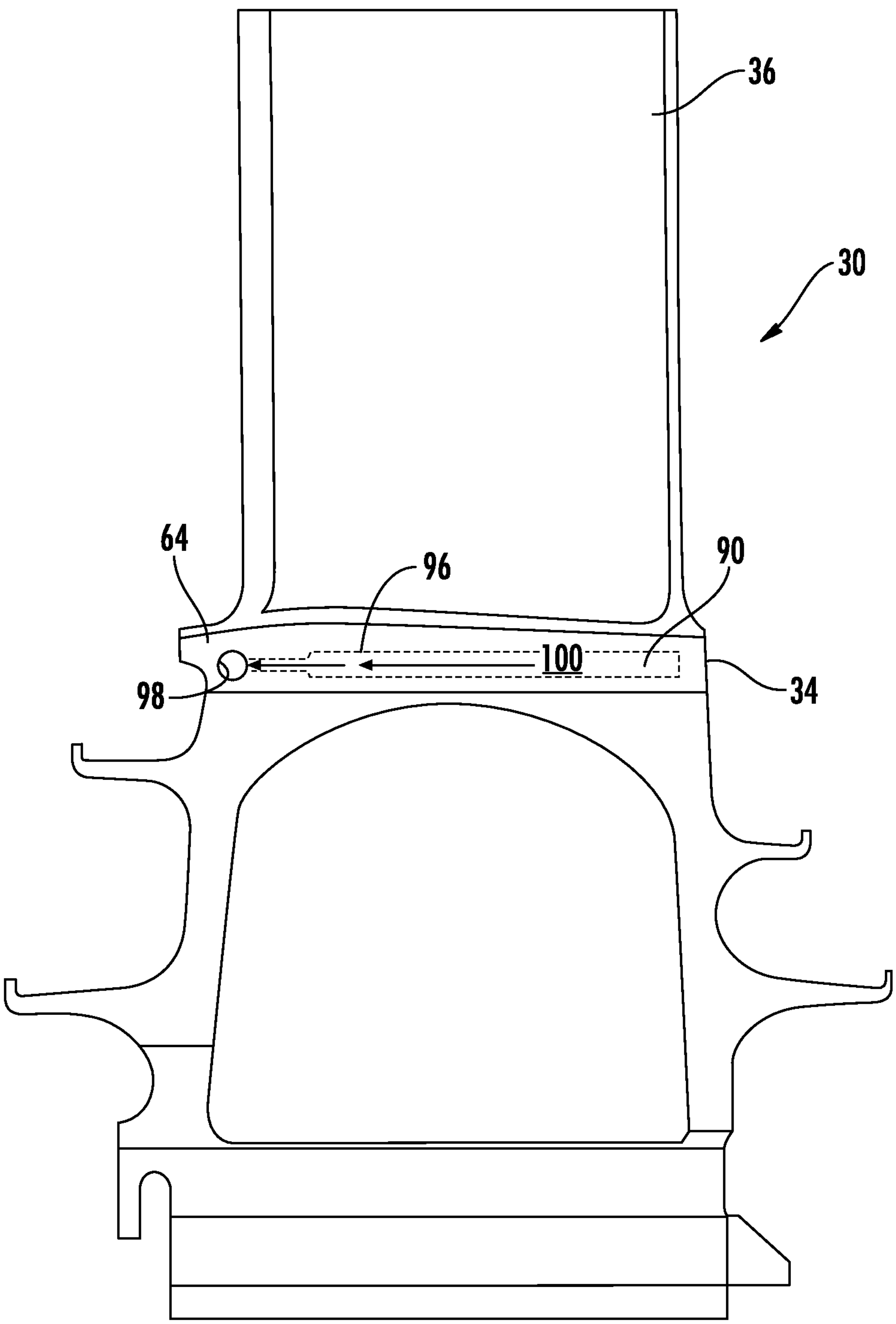


FIG. 5

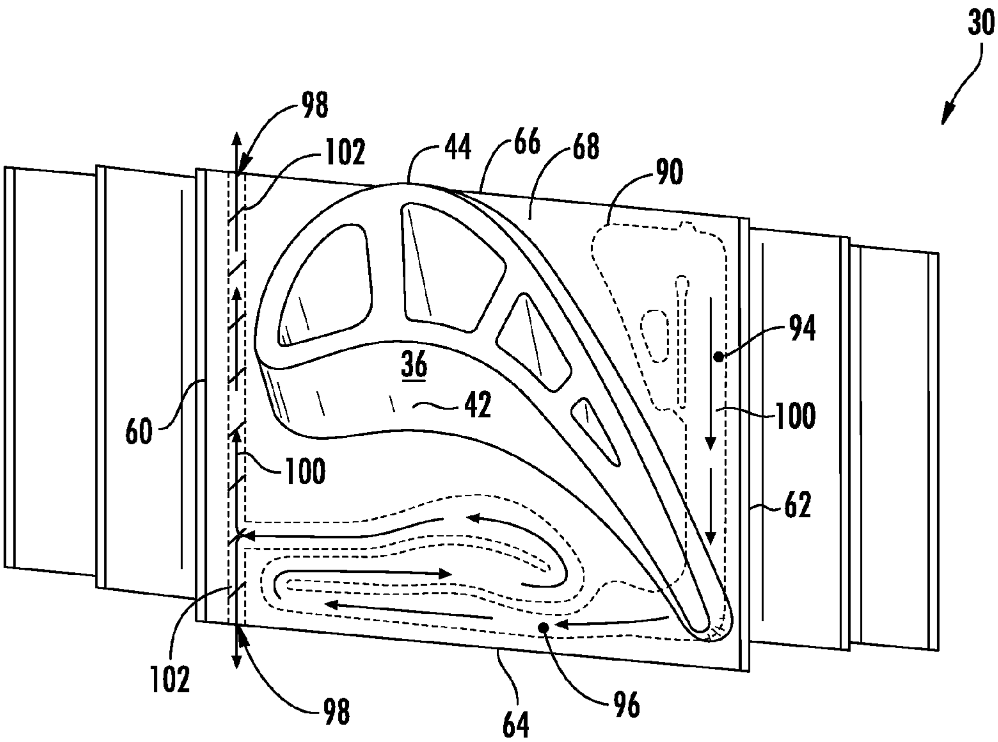


FIG. 6

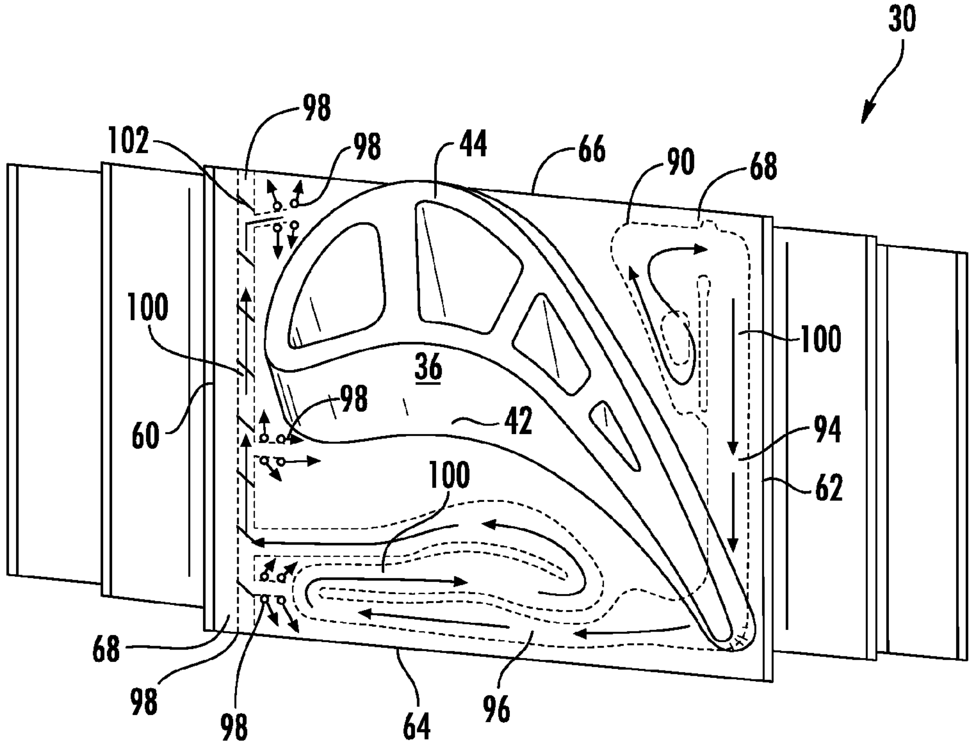


FIG. 7

# PLATFORM COOLING OF A TURBINE BLADE ASSEMBLY

## FIELD OF THE INVENTION

**[0001]** The present invention generally involves cooling a platform of a turbine blade. More specifically, the invention involves a platform cooling circuit that defines a fluid flow path from a suction side of the platform to a pressure side of the platform.

## BACKGROUND OF THE INVENTION

**[0002]** Turbines are widely used in fields such as power generation. A conventional gas turbine may generally include a compressor, a combustor, and a turbine. During operation, various components within the gas turbine are subjected to high temperature flows, which can cause the components to fail. Since higher temperature flows generally result in increased performance, efficiency, and power output of the gas turbine, the components that are subjected to high temperature flows must be cooled to allow the gas turbine to operate at increased temperatures.

**[0003]** Various strategies are known in the art for cooling various gas turbine components. For example, a cooling medium may be routed from the compressor and provided to various components. Other methods may include routing an alternate cooling medium such as steam through the various components within the gas turbine. In the compressor and turbine sections of the system, the cooling medium may be utilized to cool various compressor and turbine components.

**[0004]** Turbine blades are one example of a hot gas path component that must be cooled. For example, various parts of the turbine blade, such as the airfoil, the platform, the shank, and the dovetail, are disposed in a hot gas path and exposed to relatively high temperatures, and thus require cooling. Various cooling passages and cooling circuits may be defined in the various parts of the turbine blade, and cooling medium may be flowed through the various cooling passages and cooling circuits to cool the turbine blade.

**[0005]** In many known turbine blades, portions of the turbine blades may reach higher temperatures than other portions of the turbine blade. One specific area that is of particular concern in known turbine blades is the suction side of the platform that is generally adjacent to the suction side slash face and that extends across the trailing edge of the platform. In addition or in the alternative, the cooling medium may flow from the pressure side of the platform to an exhaust port or passage on the suction side of the platform. However, as the cooling medium flows from the pressure side, heat energy is transferred to the cooling medium, thereby reducing the cooling effect of the cooling medium as it flows through and/or across the platform. Thus, cooling of the suction side may be reduced.

**[0006]** Accordingly, an improved turbine blade for a turbine system is desired in the art. Specifically, a turbine blade with improved cooling features would be advantageous.

## BRIEF DESCRIPTION OF THE INVENTION

**[0007]** Aspects and advantages of the invention are set forth below in the following description, or may be obvious from the description, or may be learned through practice of the invention.

**[0008]** One embodiment of the present invention is a turbine blade. The turbine blade generally includes a platform having a pressure side, a suction side, a leading edge, a trailing edge, a pressure side slash face and a suction side slash face. A platform cooling circuit extends within the platform. The platform cooling circuit may extend from the suction side of the platform to the pressure side of the platform. The platform cooling circuit generally defines a fluid flow path that directs a cooling medium from the platform suction side to the platform pressure side.

**[0009]** Another embodiment of the present invention is a turbine blade having a main body that defines a primary cooling circuit within the main body. A platform at least partially surrounds the main body. The main body includes a platform having a pressure side, a suction side, a leading edge, a trailing edge, a pressure side slash face and a suction side slash face. A platform cooling circuit extends within the platform and is in fluid communication with the primary cooling circuit of the main body. The platform cooling circuit extends within the platform from the suction of the platform to the pressure side of the platform. The platform cooling circuit defines a fluid flow path that directs a cooling medium from the primary cooling circuit of the main body, across the platform trailing edge to the platform pressure side.

**[0010]** The present invention may also include a gas turbine having a compressor, a combustor downstream form the compressor and a turbine downstream from the combustor, the turbine having at least one turbine blade. A platform at least partially surrounds the turbine blade, the platform having a leading edge, a trailing edge, a pressure side slash face, a suction side slash face, and a top surface, the top surface having a pressure side and a suction side. The platform defines one or more outlet ports that extend through at least one of the pressure side slash face, the suction side slash face or the top surface of the platform. A platform cooling circuit extends within the platform and is in fluid communication with the at least one outlet port. The platform cooling circuit extends beneath the top surface of the platform from a point generally adjacent to the suction side slash face, along the trailing edge and to the pressure side of the platform. The platform cooling circuit defines a fluid flow path that directs a cooling medium from the platform suction side to the platform pressure side and exhaust the cooling medium through the at least one outlet port.

**[0011]** Those of ordinary skill in the art will better appreciate the features and aspects of such embodiments, and others, upon review of the specification.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0012]** A full and enabling disclosure of the present invention, including the best mode thereof to one skilled in the art, is set forth more particularly in the remainder of the specification, including reference to the accompanying figures, in which:

**[0013]** FIG. **1** is a schematic illustration of a gas turbine system according to one embodiment of the present disclosure;

**[0014]** FIG. **2** is a perspective view of a turbine blade according to one embodiment of the present disclosure;

**[0015]** FIG. **3** is a side view illustrating the internal components of a turbine blade according to one embodiment of the present disclosure;

**[0016]** FIG. **4** is a top view of a turbine blade according to at least one embodiment of the present disclosure;

**[0017]** FIG. **5** is a side view of a turbine blade according to at least one embodiment of the present disclosure;

**[0018]** FIG. **6** is a top view of a turbine blade according to at least one embodiment of the present disclosure; and

**[0019]** FIG. **7** is a top view of a turbine blade according to at least one embodiment of the present disclosure.

## DETAILED DESCRIPTION OF THE INVENTION

**[0020]** Reference will now be made in detail to present embodiments of the invention, one or more examples of which are illustrated in the accompanying drawings. The detailed description uses numerical and letter designations to refer to features in the drawings. Like or similar designations in the drawings and description have been used to refer to like or similar parts of the invention. As used herein, the terms "first", "second", and "third" may be used interchangeably to distinguish one component from another and are not intended to signify location or importance of the individual components. In addition, the terms "upstream" and "downstream" refer to the relative location of components in a fluid pathway. For example, component A is upstream from component B if a fluid flows from component A to component B. Conversely, component B is downstream from component A if component B receives a fluid flow from component A.

**[0021]** Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that modifications and variations can be made in the present invention without departing from the scope or spirit thereof. For instance, features illustrated or described as part of one embodiment may be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

**[0022]** Various embodiments of the present invention include a platform cooling circuit that extends beneath a top surface of a turbine blade platform. The platform cooling circuit generally extends from a suction side of the platform to a pressure side of the platform. The platform cooling circuit at least partially defines a fluid flow path for a cooling medium to flow through the platform cooling circuit. One or more outlet ports may provide fluid communication from the platform cooling circuit into a hot gas path of the turbine. In the alternative, at least one outlet port may direct the cooling medium through a slash face of the turbine blade. The suction side of the platform near a trailing edge of the platform is an area of high temperatures that may potentially limit the mechanical life of the turbine blades. Current methods to cool the turbine blade flow the cooling medium along the pressure side only or direct the cooling medium from the pressure side to the suction side. However, it has been shown that the cooling medium is less effective at cooling the suction side once it flows through the high temperature portions of the pressure side of the platform. Therefore, by flowing the cooling medium along the suction side and along the trailing edge of the platform before flowing it to the pressure side of the platform may improve the cooling effectiveness of the cooling medium across the suction side while having a minimal impact on the cooling effectiveness of the cooling medium across the pressure side of the platform.

**[0023]** FIG. **1** is a schematic diagram of a gas turbine **10**. The gas turbine **10** may generally include a compressor **12**, a combustor **14**, and a turbine **16**. The compressor **12** and turbine **16** may be coupled by a shaft **18**. The shaft **18** may be a single shaft or may include a plurality of shaft segments coupled together to form the shaft **18**.

**[0024]** The turbine **16** may include at least one stage of airfoils (not shown). Each stage of the at least one stage of airfoils may generally include a row of stationary blades and a row of rotating turbine blades adjacent to and downstream from the row of stationary blades. The stator blades may be disposed and fixed circumferentially about the shaft **18**. The turbine blades may be spaced circumferentially around a rotor disk that is connected to the shaft **18**. The rotor disk may include one or more cooling passages that provide fluid communication to the turbine blades. The various stages of the turbine **16** may at least partially define a hot gas path (not shown) that directs hot gases from the combustor **14** through the turbine **16**. It should be understood that the turbine **16** is not limited to three stages. For example, the turbine **16** may have two, three, four or more stages. Similarly, the compressor **12** may include a plurality of compressor stages (not shown). Each stage of the compressor **12** may include a plurality of circumferentially spaced compressor stator blades and a plurality of rotating compressor blades.

**[0025]** FIG. **2** illustrates a perspective view of a turbine blade, and FIG. **3** provides a side view illustrating the internal components of a turbine blade. As shown in FIG. **2**, the turbine blade **30** may include a main body **32** and a platform **34**. The main body **32** typically includes an airfoil **36** and a shank **38**. The airfoil **36** may be positioned radially outward from the platform **34** and/or the shank **38**. The shank **38** may include a root **40**, which may be configured to attach with the rotor disk (not shown) which is attached and/or surrounds the shaft **18**. The airfoil **36** generally includes a pressure side **42** and suction side **44**, a leading edge **46** and a trailing edge **48**. In addition, the airfoil **36** generally includes a root **50** and a tip **52**. The airfoil **36** root **50** generally intersects with the platform **34**. The tip **52** is generally distal from the root **50** in a radial direction.

**[0026]** As shown in FIG. **2**, the platform **34** may at least partially surround the main body **32**. A typical platform **34** may be positioned at an intersection or transition between the airfoil **36** root **50** and the shank **38** of the main body **32**. The platform **34** may extend generally axially and tangentially outward from the main body **32**. It should be understood, however, that a platform according to the present disclosure may have any suitable position relative to the main body **32** and/or the airfoil **36** of the turbine blade **30**. The platform **34** may further include a leading edge **60**, a trailing edge **62**, a pressure side slash face **64** and a suction side slash face **66**. A top surface **68** of the platform **34** may extend at least partially between the leading edge **60**, trailing edge **62**, pressure side slash face **64** and suction side slash face **66** of the platform **34**.

**[0027]** The platform **34** may be generally divided into a pressure side **70** and a suction side **72**. In particular embodiments, the platform **34** top surface **68** may at least partially define the platform **34** pressure side **70** and the suction side **72**. The airfoil **36** may at least partially separate the platform **34** pressure side **70** from the platform **34** suction side **72**. For example, the pressure side **70** of the platform **34** may be at least partially defined between the pressure side **42** of the airfoil **36** and at least a portion of the pressure side slash face **64** of the platform **34**. The suction side **72** of the platform **34** may be at least partially defined between the suction side **44** of the airfoil **36**, at least a portion of the leading edge **60** of the platform, at least a portion of the trailing edge **62** of the platform **34** and the suction side slash face **66** of the platform **34**.

[0028] As shown in FIG. 3, one or more internal main cooling circuits **80** may extend through the main body **32** shown in FIG. 3. The main cooling circuits **80** may extend through various portions of the main body **32** to provide one or more fluid flow paths to flow a cooling medium such as compressed air or steam to cool the main body **32** and/or the airfoil **36** during operation. For example, in some embodiments as shown in FIG. 3, the main body **32** may define a forward main cooling circuit **82** and an aft main cooling circuit **84**. The main cooling circuits **80** may have any suitable shape and may extend along any suitable path within the main body **32** and/or the airfoil **36**. For example, each main cooling circuit **80** may have various branches and serpentine portions and, as shown in FIG. 3, may extend through the various portions of the main body **32**, such as through the airfoil **36** and shank **38**. The cooling medium may enter the main cooling circuits **80** through the root **40** portion of the shank **38**.

[0029] FIG. 4 provides a top view of the turbine blade, FIG. 5 provides a side view of the turbine blade, and FIGS. 6 and 7 provide top views of the turbine blade according to various embodiments of the present disclosure. As shown in FIGS. 4 through 7, one or more platform cooling circuits **90** may be defined in the platform **34** and/or the main body **32** of the turbine blade **30**. As shown in FIGS. 5, 6 and 7 the platform cooling circuit **90** may be defined at least partially within the platform **34**. For example, in exemplary embodiments, a portion of the platform cooling circuit **90** is defined in the platform **34**, and extends through the platform **34** to cool it. As shown, the platform cooling circuit **90** generally extends beneath the top surface **68** of the platform **34**. Other portions of the platform cooling circuit **90** may extend into the main body **32** and/or into the airfoil **36**.

[0030] In at least one embodiment, as shown in FIG. 4, the platform cooling circuit **90** may include an inlet **92**, a suction side portion **94** and a pressure side portion **96**. The inlet **92** may be fluidly connected to at least one of the main cooling circuits **80** that extend through the main body **32** and/or through the airfoil **36**. For example, the inlet **92** may be fluidly connected to either or both of the forward or the aft main cooling circuits, **82** and **84** respectfully. In particular embodiments, the inlet **92** may be disposed beneath the top surface **68** of the platform **34** at least partially on the suction side **66** of the platform **34**. For example, the inlet **92** may be disposed within the platform **34** between the suction side **44** of the airfoil **36** and the suction side slash face **66** and the trailing edge **62** of the platform **34**.

[0031] The suction side portion **94** of the platform cooling circuit **90** generally extends from the inlet **92** across the suction side **66** of the platform **34**. In particular embodiments, as shown in FIG. 4, the suction side **66** of the platform cooling circuit **90** may generally extend from the inlet **92** towards and/or at least partially adjacent to at least a portion of the suction side slash face **66**. The suction side portion **94** may then extend from the suction side slash face **66** across the trailing edge **62** of the platform **34** and towards the pressure side slash face **64** of the platform **34**. The suction side portion **94** may extend generally parallel to the trailing edge **62** of the platform **34**. In addition or in the alternative, the suction side portion **66** may reverse directions one or more times across the suction side **66** of the platform **34**. The suction side portion **94** of the platform cooling circuit **90** generally transitions into the pressure side portion **96** as the platform cooling circuit **90** crosses underneath and/or around the of the airfoil **36** and extends to the pressure side **70** of the platform **34**.

[0032] The pressure side portion **96** of the platform cooling circuit **90** generally extends under the top surface **68** of the pressure side **70** of the platform **34**. As shown, the pressure side portion **96** may extend generally adjacent to the pressure side slash face **64** of the platform **34** towards the leading edge **60** of the platform **34**. In particular embodiments, the pressure side portion **96** may reverse directions at least once along the pressure side **70** of the platform **34**. For example, as shown, the pressure side portion **96** may have a generally serpentine pattern across the pressure side **70** of the platform **34**.

[0033] As shown in FIGS. 5 through 7 at least one outlet port **98** may extend through at least one of the pressure side slash face **64** or the suction side slash face **66**. In addition or in the alternative, as shown in FIG. 7, the at least one outlet port **98** may extend through the top surface **68** of the platform **34** on the pressure side **70** and/or the suction side **72** of the platform **34**. For example, as shown in FIGS. 5 and 7, the at least one outlet port **98** may be positioned between the leading edge **46** of the airfoil **36** and the leading edge **60** of the platform **34**. In addition or in the alternative, the at least one outlet port **98** may extend through the top surface **68** of the platform **34** on at least one of the pressure side **70** or the suction side **72** of the platform **34**. As shown in FIGS. 5 through 7, the at least one outlet port **98** may be fluidly connected to the pressure side portion **96** of the platform cooling circuit **90**.

[0034] As shown in FIGS. 5 through 7, the platform cooling circuit **90** and the at least one outlet port **98** may at least partially define a fluid flow path **100** for flowing a cooling medium from the suction side **72** of the platform **34** to the pressure side **70** of the platform **34**, thereby removing heat energy from the suction side **72** of the platform **34** prior to flowing the cooling medium into the pressure portion **96** of the platform cooling circuit **90**. As a result, the suction side **72** of the platform **34** may be more effectively cooled, thereby improving overall mechanical performance of the turbine blade **30**. In particular embodiments, the cooling medium may flow from the platform cooling circuit **90** through the at least one outlet port **98** positioned along the pressure side slash face **64** and/or the suction side slash face **66**. In this manner, the cooling medium may be used to further cool the shank **38** portion and/or the pressures side and the suction side slash faces **64**, **66** of the main body **32** of the turbine blade **30**. In addition or in the alternative, as shown in FIG. 7, the cooling medium may flow from the platform cooling circuit **90** through the at least one outlet **98** disposed on the top surface **68** of the platform **34**, thereby proving film cooling to the top surface **68** of the platform **34**.

[0035] In further embodiments, as shown in FIG. 6 at least one exhaust passage **102** may extend within the platform **34** and/or the main body **32** generally between the leading edge **46** of the airfoil **36** and the leading edge **60** of the platform **34**. The exhaust passage **102** may extend at least partially between the pressure side slash face **64** and the suction side slash face **66**. In particular embodiments, the exhaust passage **102** extends from the pressure side slash face **64** to the suction side slash face **66**. The exhaust passage **102** may be at least partially defined by the platform cooling circuit **90**. In the alternative, the exhaust passage **102** may be milled, cast or otherwise formed in the platform **34** separately from the platform cooling circuit **90**. The exhaust passage **102** may be fluidly connected to the platform cooling circuit **90** and to at least one of the at least one outlet ports **98**. The exhaust passage **102** may further define the fluid flow path **100**. As a result, the cooling medium may provide further cooling to an area generally adjacent to the leading edge **60** of the platform **34** before it is exhausted through the at least one outlet port **98**.

**[0036]** 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 and examples are intended to be within the scope of the claims if they include 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 languages of the claims.

What is claimed is:

**1**. A turbine blade, comprising:

a. a platform having a pressure side, a suction side, a leading edge, a trailing edge, a pressure side slash face and a suction side slash face;

b. a platform cooling circuit within the platform, wherein the platform cooling circuit extends from the suction side to the pressure side of the platform; and

c. wherein the platform cooling circuit defines a fluid flow path that directs a cooling medium from the platform suction side to the platform pressure side.

**2**. The turbine blade as in claim **1**, wherein the platform cooling circuit reverses direction at least once along the pressure side of the platform.

**3**. The turbine blade as in claim **1**, wherein the platform cooling circuit reverses direction at least once along the suction side of the platform.

**4**. The turbine blade as in claim **1**, further comprising at least one outlet port in fluid communication with the platform cooling circuit.

**5**. The turbine blade as in claim **4**, wherein the at least one outlet port provides fluid communication through at least one of the pressure side slash face or the suction side slash face.

**6**. The turbine blade as in claim **4**, wherein the platform further includes a top surface that extends between the platform leading edge, the pressure side slash face and the suction side slash face, the at least one outlet port extending through the top surface of the platform.

**7**. The turbine blade as in claim **1**, further comprising an exhaust passage that extends within the platform generally parallel to the leading edge, the exhaust passage fluidly connected to the pressure side portion of the platform cooling circuit.

**8**. The turbine blade as in claim **1**, further comprising an airfoil that extends from the platform, the airfoil at least partially separating the platform pressure side from the platform suction side.

**9**. The turbine blade as in claim **8**, wherein the platform cooling circuit passes under the airfoil from the suction side to the pressure side of the platform.

**10**. A turbine blade, comprising:

a. a main body defining a primary cooling circuit within the main body;

b. a platform that at least partially surrounds the main body, the platform having a pressure side, a suction side, a leading edge, a trailing edge, a pressure side slash face and a suction side slash face;

c. a platform cooling circuit within the platform, the platform cooling circuit in fluid communication with the primary cooling circuit of the main body; and

d. wherein the platform cooling circuit extends within the platform from a point on the suction side of the platform, along the trailing edge and to the pressure side of the platform, the platform cooling circuit defining a fluid flow path that directs a cooling medium from the primary cooling circuit of the main body, across the platform trailing edge and to the platform pressure side.

**11**. The turbine blade as in claim **10**, further comprising at least one outlet port in fluid communication with the platform cooling circuit.

**12**. The turbine blade as in claim **11**, wherein the at least one outlet port extends through at least one of the pressure side slash face or the suction side slash face of the platform.

**13**. The turbine blade as in claim **11**, wherein the platform further includes a top surface that extends between the platform leading edge, the pressure side slash face and the suction side slash face, the at least one outlet port extending through the top surface of the platform.

**14**. The turbine blade as in claim **10**, wherein the platform cooling circuit reverses direction at least once along the pressure side of the platform.

**15**. The turbine blade as in claim **10**, wherein the platform cooling circuit reverses direction at least once along the trailing edge of the platform.

**16**. The turbine blade as in claim **10**, wherein the at least one outlet port includes a first outlet port and a second outlet port.

**17**. The turbine blade as in claim **16**, wherein the platform further includes a top surface that extends between the platform leading edge, the pressure side slash face and the suction side slash face, the first outlet port extends through at least one of the pressure side slash face or the suction side of the platform, and the second outlet port extends through the platform top surface.

**18**. The turbine blade as in claim **10**, wherein the platform cooling circuit extends across the leading edge of the platform.

**19**. The turbine blade as in claim **10**, further comprising an airfoil that extends from the platform, the airfoil at least partially separating the platform pressure side from the platform suction side, wherein the platform cooling circuit passes under the airfoil from the suction side to the pressure side of the platform.

**20**. A gas turbine, comprising:

a. a compressor, a combustor downstream form the compressor and a turbine downstream from the combustor, the turbine having at least one turbine blade;

b. a platform that at least partially surrounds the turbine blade, the platform having a leading edge, a trailing edge, a pressure side slash face, a suction side slash face, and a top surface, the top surface having a pressure side and a suction side, the platform defining one or more outlet ports that extend through at least one of the pressure side slash face, the suction side slash face or the top surface of the platform;

c. a platform cooling circuit within the platform and in fluid communication with the at least one outlet port, wherein the platform cooling circuit extends beneath the top surface of the platform from a point generally adjacent to the suction side slash face, along the trailing edge and to the pressure side of the platform; and

d. wherein the platform cooling circuit defines a fluid flow path that directs a cooling medium from the platform suction side to the platform pressure side and exhaust the cooling medium through the at least one outlet port.

* * * * *