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(54) ROTOR BLADE FOR A GAS TURBINE ENGINE HAVING A METALLIC STRUCTURAL MEMBER AND A COMPOSITE FAIRING

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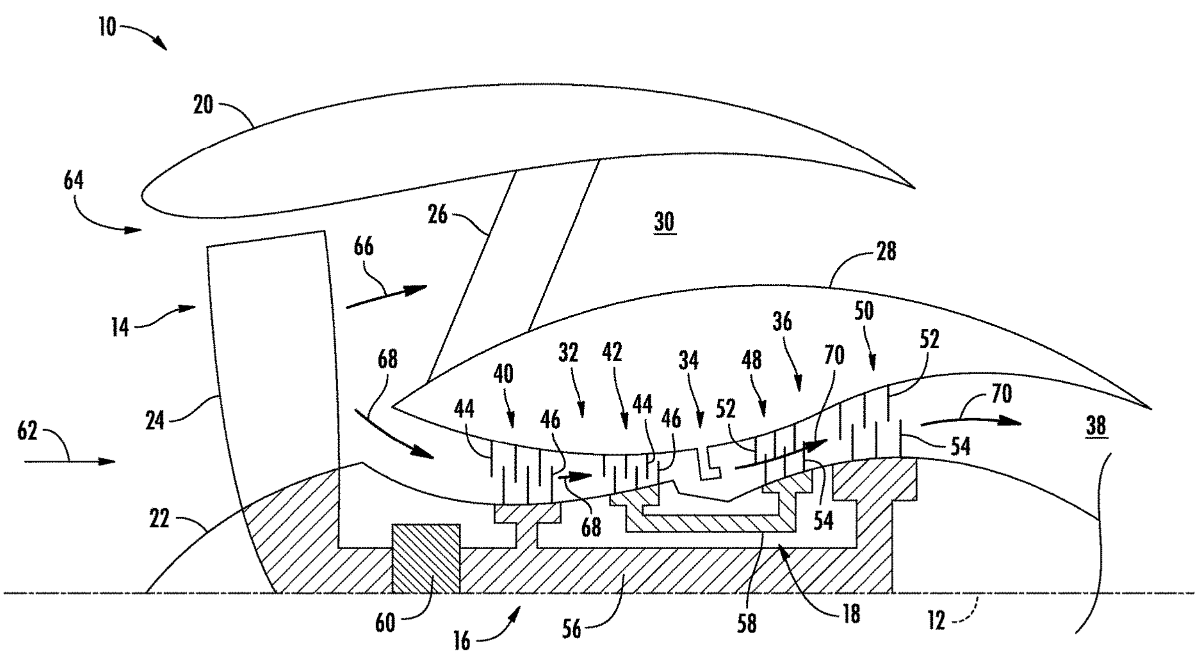
(57) **ABSTRACT**

A rotor blade for a gas turbine engine includes a structural member formed from a metallic material. The structural member, in turn, includes a base portion, a spar, and a tip cap, with the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade. Furthermore, the structural member includes a fairing formed from a composite material. The fairing is, in turn, coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade. Additionally, the fairing including a first fairing panel and a second fairing panel in contact with the first fairing panel at a first split line and a second split line.



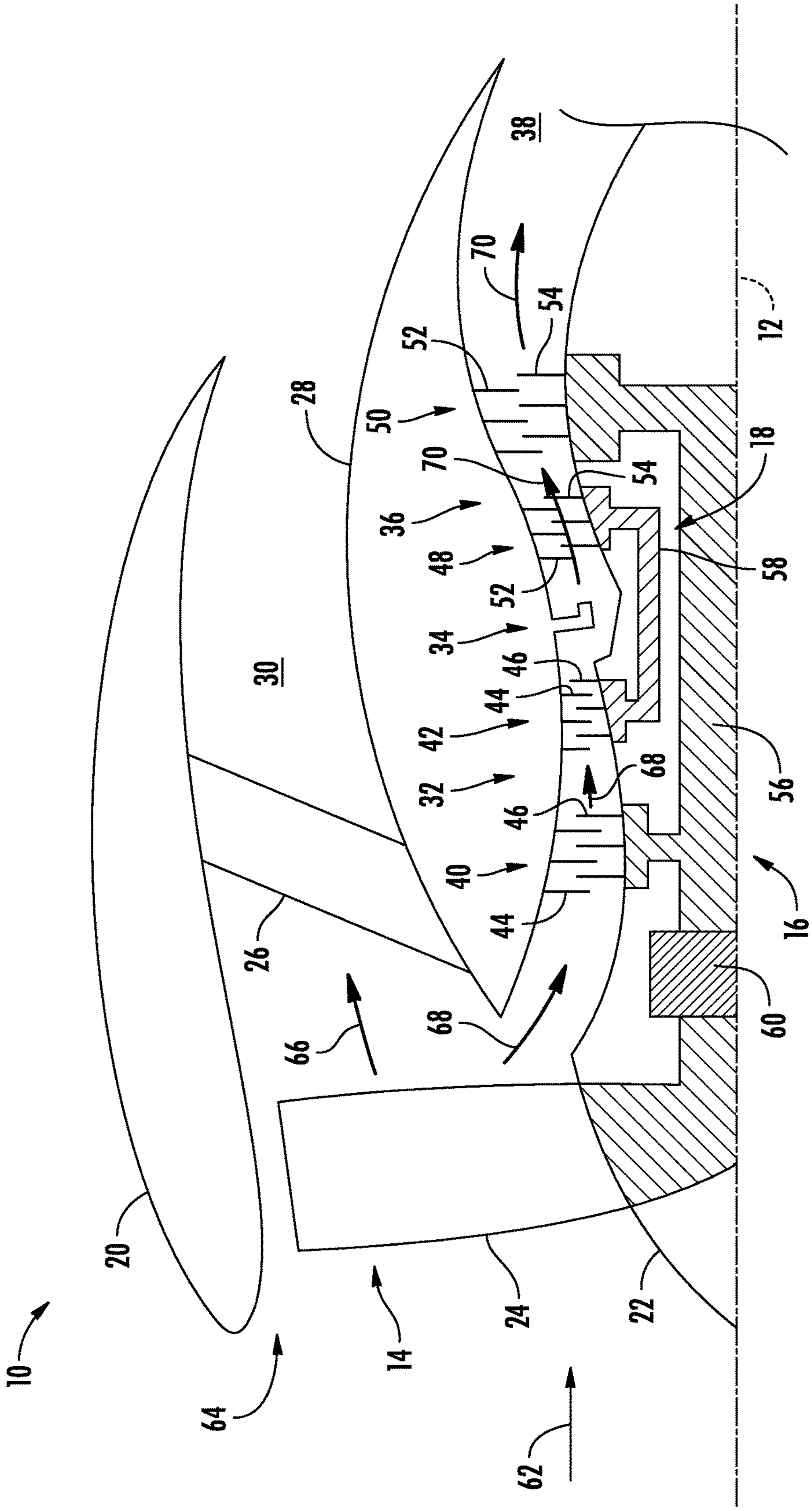

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FIG. 1

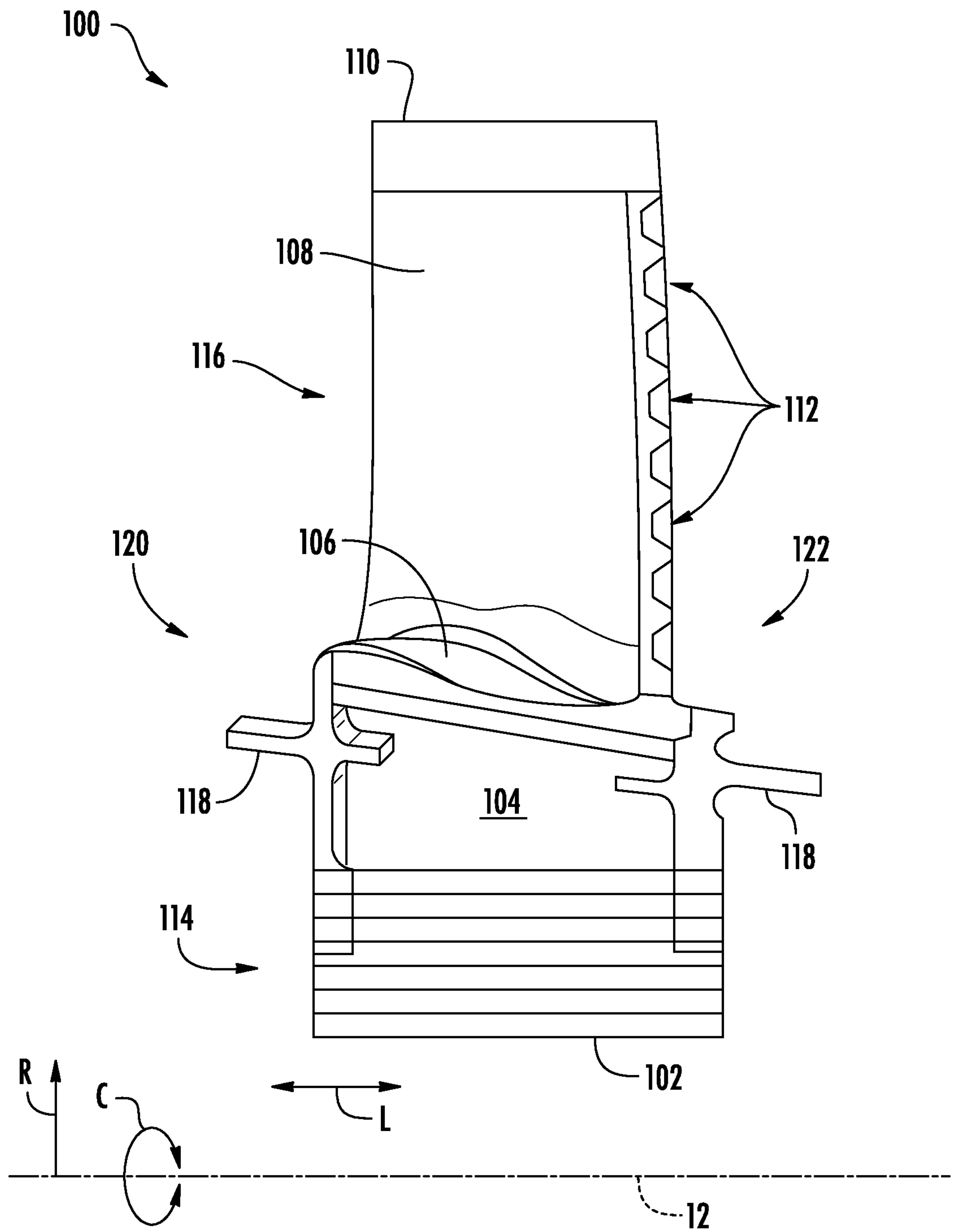

FIG. 2

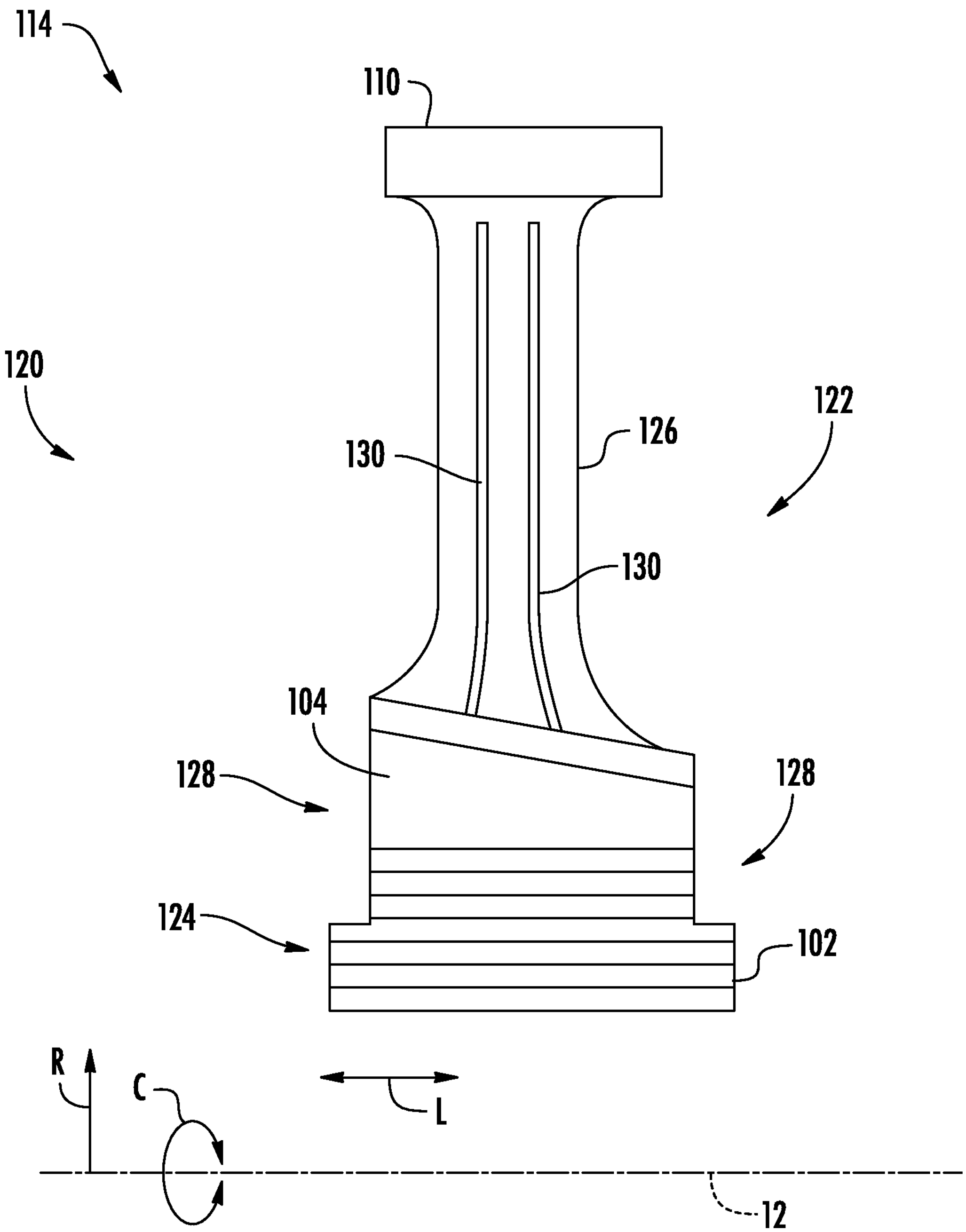

FIG. 3

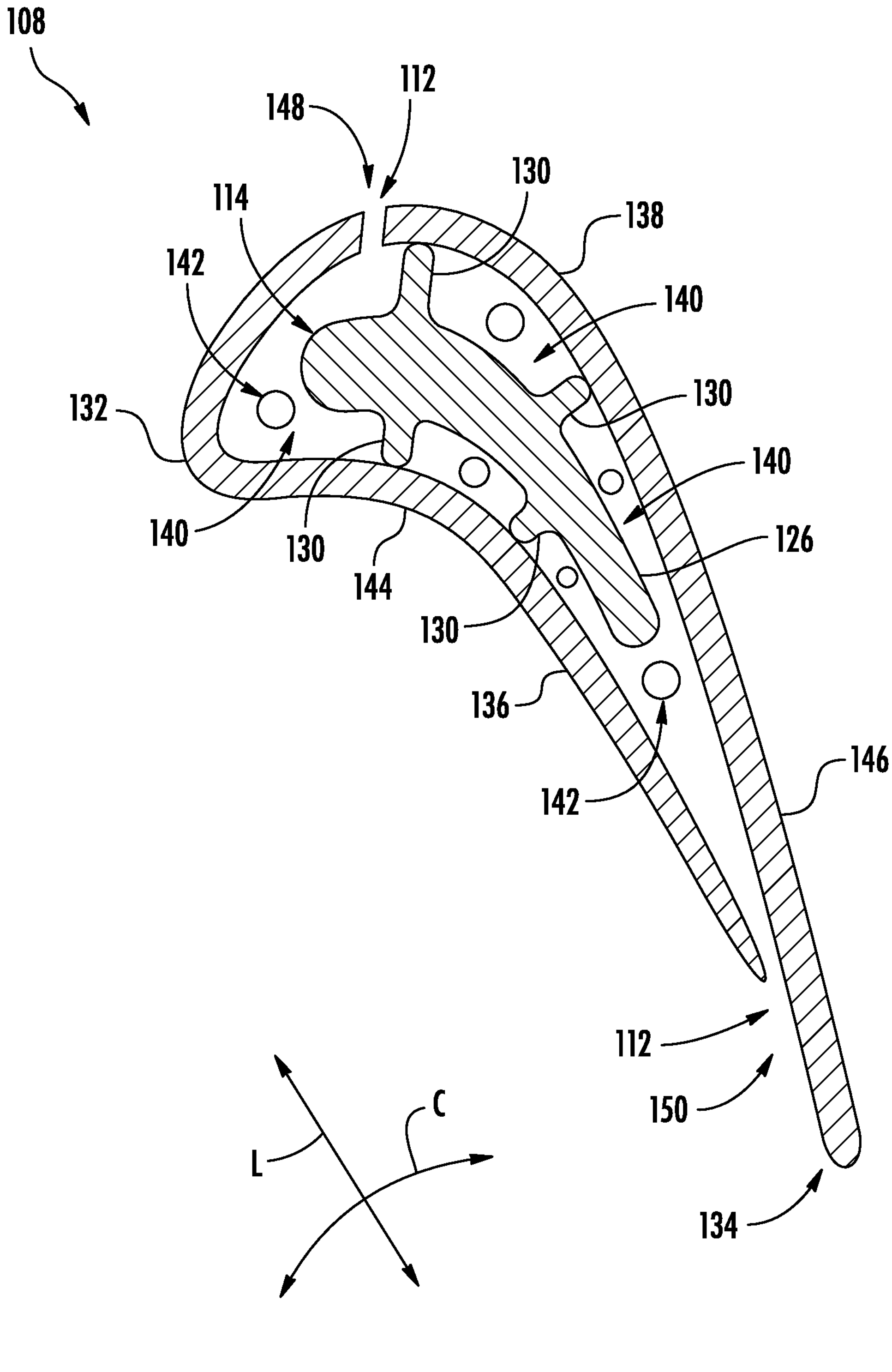
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FIG. 4

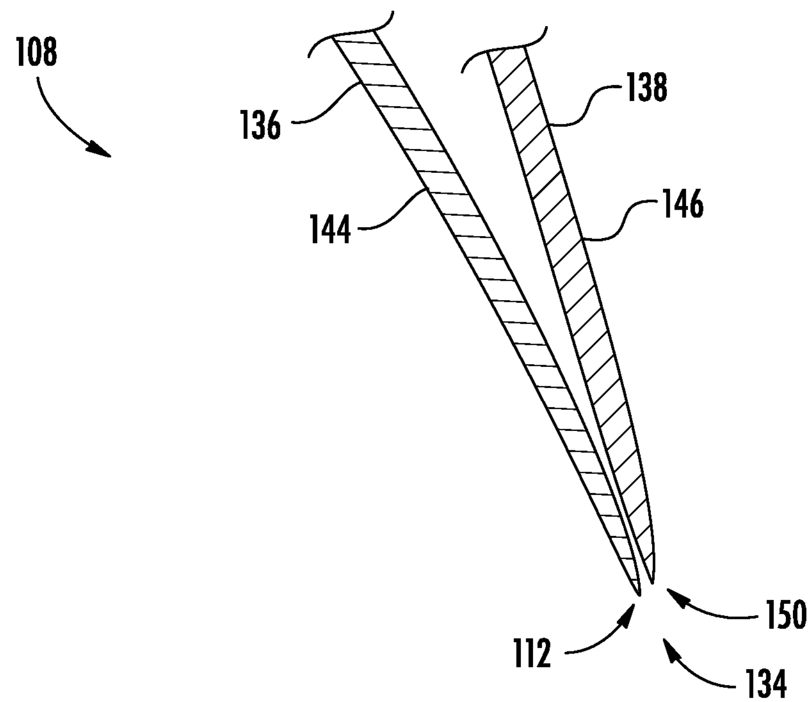

FIG. 5

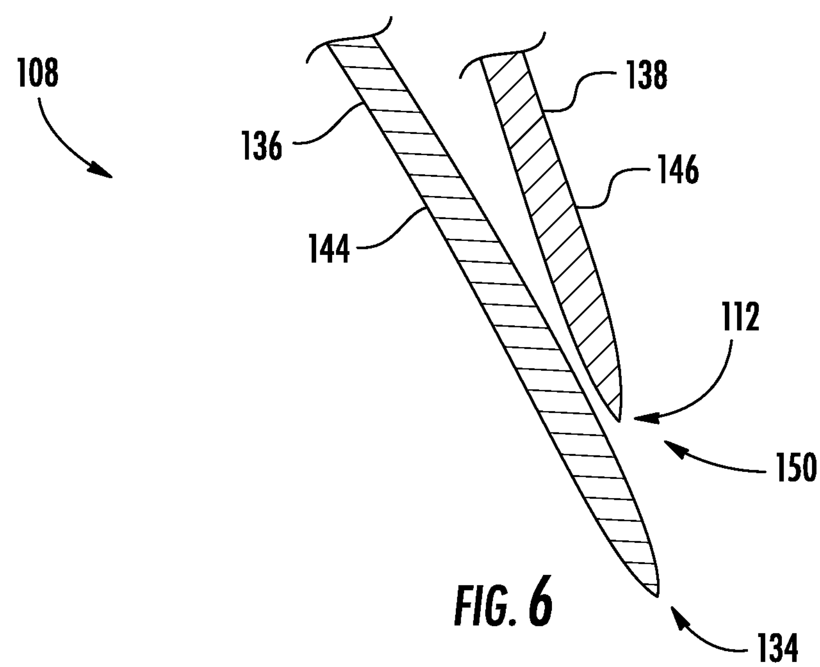

FIG. 6

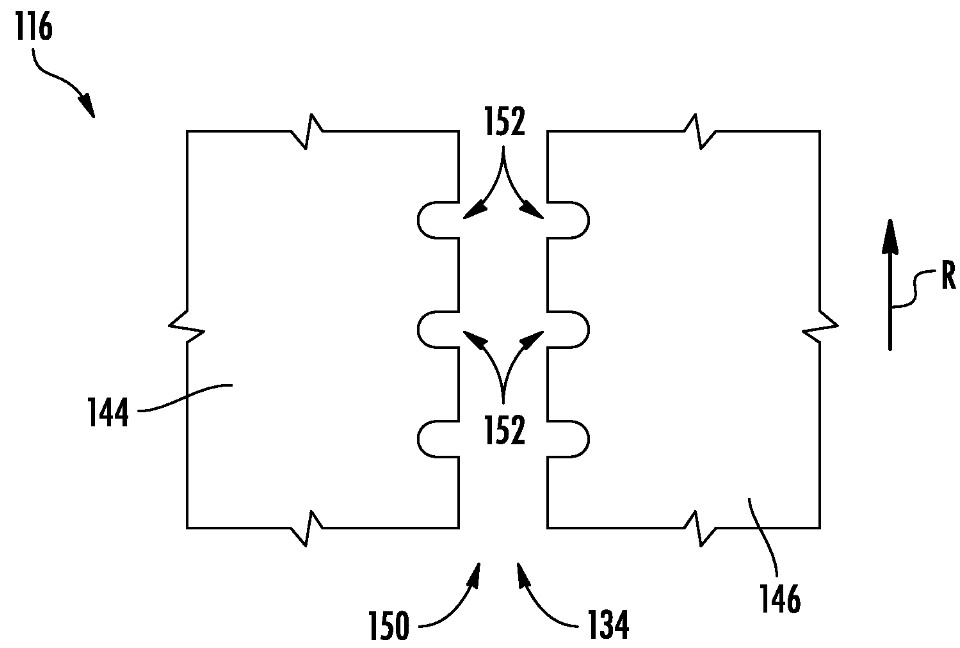

FIG. 7

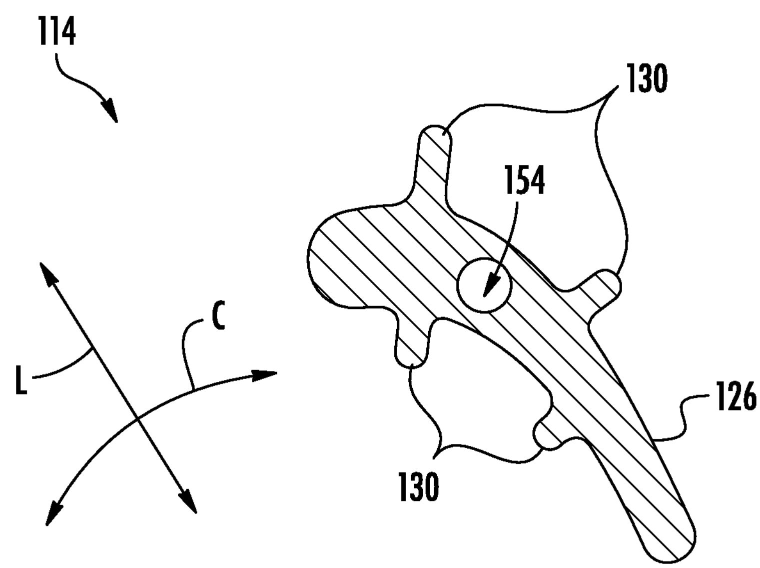

FIG. 8

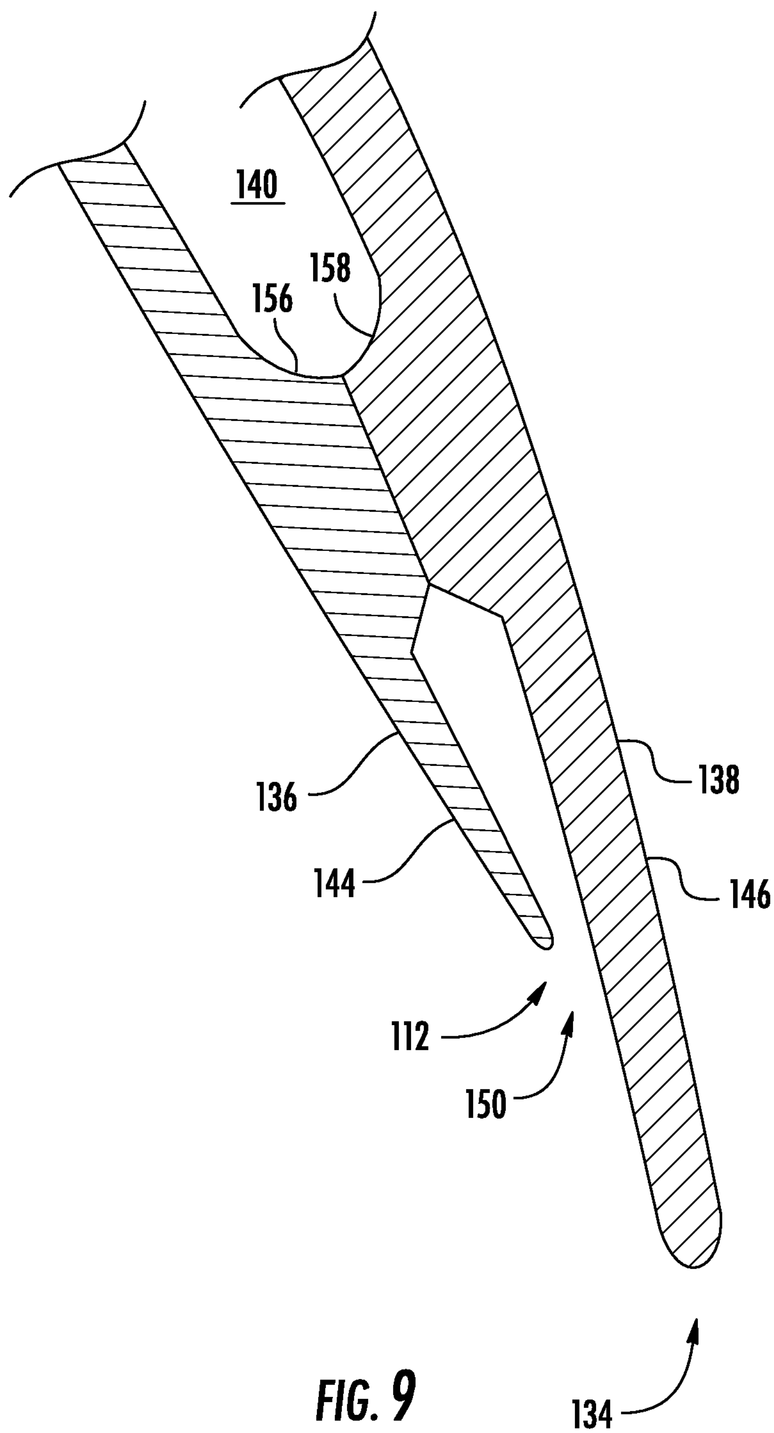

FIG. 9

ROTOR BLADE FOR A GAS TURBINE ENGINE HAVING A METALLIC STRUCTURAL MEMBER AND A COMPOSITE FAIRING

FIELD

[0001] The present disclosure generally pertains to rotor blades for gas turbine engines, and, more specifically, to a rotor blade for a gas turbine engine having a metallic structural member and a composite fairing.

BACKGROUND

[0002] A gas turbine engine generally includes a compressor section, a combustion section, and a turbine section. During operation, the compressor section progressively increases the pressure of air entering the engine and supplies this compressed air to the combustion section. The compressed air and a fuel mix within the combustion section and burn within a combustion chamber to generate high-pressure and high-temperature combustion gases. The combustion gases flow through a hot gas path defined by the turbine section before exiting the engine. In this respect, the turbine section converts energy from the combustion gases into rotational energy. Specifically, the turbine section includes a plurality of rotor blades, which extract kinetic energy and/or thermal energy from the combustion gases flowing therethrough. The extracted rotational energy is, in turn, used to rotate one or more shafts, thereby driving the compressor section and/or a fan assembly of the gas turbine engine.

[0003] Traditionally, turbine rotor blades have been formed from metallic materials, such as nickel-based alloys. While well-suited for the mechanical loads placed on the rotor blades, such metallic materials limit the temperatures at which the engine can operate. As such, in recent years, the use of ceramic matrix composite (CMC) materials to form turbine rotor blades has grown dramatically. CMC materials are capable of withstanding higher temperatures than metallic materials, thereby increasing the operating temperature range of the engine. However, CMC materials are unable to withstand the same mechanical loads as metallic materials. In this respect, turbine rotor blades incorporating both metallic and CMC materials have been developed. While such turbine rotor blades work well, further improvement are needed.

[0004] Accordingly, an improved rotor blade for a gas turbine engine would be welcomed in the technology.

BRIEF DESCRIPTION

[0005] Aspects and advantages of the invention will be set forth in part in the following description, or may be obvious from the description, or may be learned through practice of the invention.

[0006] In one aspect, the present subject matter is directed to a rotor blade for a gas turbine engine. The rotor blade includes a structural member formed from a metallic material. The structural member, in turn, includes a base portion, a spar, and a tip cap, with the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade. Furthermore, the structural member includes a fairing formed from a composite material. The fairing is, in turn, coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade. Additionally, the fairing includes a first fairing panel and a second fairing panel in contact with the first fairing panel at a first split line and a second split line.

[0007] In another aspect, the present subject matter is directed to a gas turbine engine. The gas turbine engine includes a compressor section, a combustion section, a turbine section, and a rotor blade positioned within the turbine section. The rotor blade, in turn, includes a structural member formed from a metallic material. Moreover, the structural member including a base portion, a spar, and a tip cap, with the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade. Additionally, the rotor blade includes a fairing formed from a composite material. The fairing is, in turn, coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade. Furthermore, the fairing includes a first fairing panel and a second fairing panel in contact with the first fairing panel at a first split line and a second split line.

[0008] In a further aspect, the present subject matter is directed to a rotor blade for a gas turbine engine. The rotor blade includes a structural member formed from a metallic material. The structural member, in turn, includes a base portion, a spar, and a tip cap, with the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade. Furthermore, the structural member includes a fairing formed from a composite material. The fairing is, in turn, coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade. Additionally, the fairing includes a first fairing panel having a first projection and a second fairing panel having a second projection in contact with the first projection.

[0009] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

[0011] FIG. **1** is a schematic cross-sectional view of one embodiment of a gas turbine engine;

[0012] FIG. **2** is a side view of one embodiment of a rotor blade for a gas turbine engine;

[0013] FIG. **3** is a side view of one embodiment of a structural member of a rotor blade for a gas turbine engine;

[0014] FIG. **4** is a cross-sectional view of one embodiment of an airfoil of a rotor blade for a gas turbine engine, particularly illustrating a plurality of cooling passages defined by the rotor blade;

[0015] FIG. **5** is an enlarged, partial cross-sectional view of another embodiment of an airfoil of a rotor blade for a gas turbine engine;

[0016] FIG. **6** is an enlarged, partial cross-sectional view of a further embodiment of an airfoil of a rotor blade for a gas turbine engine;

[0017] FIG. **7** is a partial rear view of one embodiment of an airfoil of a rotor blade for a gas turbine engine, particularly illustrating a plurality of cooling holes defined by the blade;

[0018] FIG. **8** is cross-sectional view of another embodiment of a structural member of a rotor blade for a gas turbine engine, particularly illustrating a spar of a structural member of the rotor blade defining a cooling passage; and

[0019] FIG. **9** is an enlarged, partial cross-sectional view of yet another embodiment of an airfoil of a rotor blade for a gas turbine engine.

[0020] Repeat use of reference characters in the present specification and drawings is intended to represent the same or analogous features or elements of the present invention.

DETAILED DESCRIPTION

[0021] Reference now will be made in detail to exemplary embodiments of the presently disclosed subject matter, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation and should not be interpreted as limiting the present disclosure. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present disclosure without departing from the scope or spirit of the present disclosure. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present disclosure covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0022] 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.

[0023] Furthermore, the terms "upstream" and "downstream" refer to the relative direction with respect to fluid flow in a fluid pathway. For example, "upstream" refers to the direction from which the fluid flows, and "downstream" refers to the direction to which the fluid flows.

[0024] Additionally, the terms "low," "high," or their respective comparative degrees (e.g., lower, higher, where applicable) each refer to relative speeds within an engine, unless otherwise specified. For example, a "low-pressure turbine" operates at a pressure generally lower than a "high-pressure turbine." Alternatively, unless otherwise specified, the aforementioned terms may be understood in their superlative degree. For example, a "low-pressure turbine" may refer to the lowest maximum pressure turbine within a turbine section, and a "high-pressure turbine" may refer to the highest maximum pressure turbine within the turbine section.

[0025] In general, the present subject matter is directed to a rotor blade for a gas turbine engine. As will be described below, the disclosed rotor blade may be incorporated into a compressor section or a turbine section of the gas turbine engine. Specifically, in several embodiments, the rotor blade includes a structural member formed from a metallic material. The structural member, in turn, supports or otherwise absorbs the mechanical loads placed on the rotor blade. In several embodiments, the structural member includes a base portion that at least partially forms a root and a shank of the rotor blade. Furthermore, the structural member includes a spar coupled to and extending outward from the base portion in a radial direction. In addition, the structural member includes a tip cap coupled to the outer radial end of the spar. For example, in one embodiment, the structural member is integrally formed as a single monolithic component.

[0026] Moreover, the rotor blade includes a fairing formed from a composite material. In general, the fairing supports or otherwise absorbs the thermal loading placed on the rotor blade. Thus, the use of a composite fairing and a metallic structural member decouples the thermal and mechanical loads placed on the rotor blade. In several embodiments, the fairing is coupled to the structural member such that the fairing forms at least a portion of an airfoil and a platform of the rotor blade. As such, the fairing encloses the spar and is positioned between the base portion and the tip cap in the radial direction. Additionally, the fairing includes first and second fairing panels, with such panels contacting each other at first and second split lines. In some embodiments, the fairing defines a plurality of cooling holes (e.g., film cooling holes) at the split lines.

[0027] The use of first and second fairing panels that contact each other at first and second split lines provides one or more technical advantages. More specifically, conventional rotor blade incorporating metallic and composite materials are split at the shank (i.e., have a two-piece shank). However, the shank is one of the most highly loaded portions of the rotor blade. In this respect, splitting the rotor blade at the airfoil as disclosed herein (as opposed to the shank) allows the rotor blade to withstand higher mechanical (e.g., centripetal) loads. Thus, the disclosed rotor blade allows a gas turbine engine to operate at higher rotational speeds than conventional rotor blades.

[0028] Referring now to the drawings, FIG. **1** is a schematic cross-sectional view of one embodiment of a gas turbine engine **10**. In the illustrated embodiment, the engine **10** is configured as a high-bypass turbofan engine. However, in alternative embodiments, the engine **10** may be configured as a propfan engine, a turbojet engine, a turboprop engine, a turboshaft gas turbine engine, or any other suitable type of gas turbine engine.

[0029] In general, the engine **10** includes a fan **14**, a low-pressure (LP) spool **16**, and a high pressure (HP) spool **18** at least partially encased by an annular nacelle **20**. More specifically, the fan **14** may include a fan rotor **22** and a plurality of fan blades **24** (one is shown) coupled to the fan rotor **22**. In this respect, the fan blades **24** are circumferentially spaced apart from each other and extend outward from the fan rotor **22**. Moreover, the LP and HP spools **16**, **18** are positioned downstream from the fan **14** along the axial centerline **12**. As shown, the LP spool **16** is rotatably coupled to the fan rotor **22**, thereby permitting the LP spool **16** to rotate the fan **14**. Additionally, a plurality of outlet guide vanes or struts **26** circumferentially spaced apart from each other extend between an outer casing **28** surrounding the LP and HP spools **16**, **18** and the nacelle **20**. As such, the struts **26** support the nacelle **20** relative to the outer casing **28** such that the outer casing **28** and the nacelle **20** define a bypass airflow passage **30** positioned therebetween.

[0030] The outer casing **28** generally surrounds or encases, in serial flow order, a compressor section **32**, a combustion section **34**, a turbine section **36**, and an exhaust section **38**. For example, in some embodiments, the compressor section **32** may include a low-pressure (LP) compressor **40** of the LP spool **16** and a high-pressure (HP) compressor **42** of the HP spool **18** positioned downstream from the LP compressor **40** along the axial centerline **12**.

Each compressor **40**, **42** may, in turn, include one or more rows of stator vanes **44** interdigitated with one or more rows of compressor rotor blades **46**. Moreover, in some embodiments, the turbine section **36** includes a high-pressure (HP) turbine **48** of the HP spool **18** and a low-pressure (LP) turbine **50** of the LP spool **16** positioned downstream from the HP turbine **48** along the axial centerline **12**. Each turbine **48**, **50** may, in turn, include one or more rows of stator vanes **52** interdigitated with one or more rows of turbine rotor blades **54**.

[0031] Additionally, the LP spool **16** includes the low-pressure (LP) shaft **56** and the HP spool **18** includes a high pressure (HP) shaft **58** positioned concentrically around the LP shaft **56**. In such embodiments, the HP shaft **58** rotatably couples the rotor blades **54** of the HP turbine **48** and the rotor blades **46** of the HP compressor **42** such that rotation of the HP turbine rotor blades **54** rotatably drives HP compressor rotor blades **46**. As shown, the LP shaft **56** is directly coupled to the rotor blades **54** of the LP turbine **50** and the rotor blades **46** of the LP compressor **40**. Furthermore, the LP shaft **56** is coupled to the fan **14** via a gearbox **60**. In this respect, the rotation of the LP turbine rotor blades **54** rotatably drives the LP compressor rotor blades **46** and the fan blades **24**.

[0032] In several embodiments, the engine **10** may generate thrust to propel an aircraft. More specifically, during operation, air (indicated by arrow **62**) enters an inlet portion **64** of the engine **10**. The fan **14** supplies a first portion (indicated by arrow **66**) of the air **62** to the bypass airflow passage **30** and a second portion (indicated by arrow **68**) of the air **62** to the compressor section **32**. The second portion **68** of the air **62** first flows through the LP compressor **40** in which the rotor blades **46** therein progressively compress the second portion **68** of the air **62**. Next, the second portion **68** of the air **62** flows through the HP compressor **42** in which the rotor blades **46** therein continue progressively compressing the second portion **68** of the air **62**. The compressed second portion **68** of the air **62** is subsequently delivered to the combustion section **34**. In the combustion section **34**, the second portion **68** of the air **62** mixes with fuel and burns to generate high-temperature and high-pressure combustion gases **70**. Thereafter, the combustion gases **70** flow through the HP turbine **48** which the HP turbine rotor blades **54** extract a first portion of kinetic and/or thermal energy therefrom. This energy extraction rotates the HP shaft **58**, thereby driving the HP compressor **42**. The combustion gases **70** then flow through the LP turbine **50** in which the LP turbine rotor blades **54** extract a second portion of kinetic and/or thermal energy therefrom. This energy extraction rotates the LP shaft **56**, thereby driving the LP compressor **40** and the fan **14** via the gearbox **60**. The combustion gases **70** then exit the engine **10** through the exhaust section **38**.

[0033] The configuration of the gas turbine engine **10** described above and shown in FIG. **1** is provided only to place the present subject matter in an exemplary field of use. Thus, the present subject matter may be readily adaptable to any manner of gas turbine engine configuration, including other types of aviation-based gas turbine engines, marine-based gas turbine engines, and/or land-based/industrial gas turbine engines.

[0034] FIG. **2** is a side view of one embodiment of a rotor blade **100**, which may be incorporated into the engine **10** in place of any of the compressor rotor blades **40** and/or the turbine rotor blades **48**. As shown, the rotor blade **100** defines a longitudinal direction L, a radial direction R, and a circumferential direction C. In this respect, the longitudinal direction L extends parallel to the axial centerline **16** of the engine **10**, the radial direction R extends generally orthogonal to the axial centerline **16**, and the circumferential direction C extends generally concentrically around the axial centerline **16**.

[0035] In general, the rotor blade **100** includes a root **102**, a shank **104**, a platform **106**, and an airfoil **108**. More specifically, the root **102** couples the rotor blade **100** to a rotor disk (not shown) of one of the LP or HP shafts **56**, **58** (FIG. **1**). In the illustrated embodiment, the root **102** is configured as a fir-tree type root. However, in alternative embodiments, the root **102** may be configured as a dovetail root or any other suitable structure for coupling the rotor blade **100** to the rotor disk. Additionally, the shank **106** is coupled to and extends outward from the root **102** in the radial direction R. Moreover, the platform **106** is coupled to and extends outward from the shank **104** in the radial direction R. The platform **106** forms the inner radial boundary of the flow path (i.e., for the air **68** or the combustion gases **70**) through the corresponding compressor section **32** or turbine section **36**. Furthermore, the airfoil **108** is coupled to and extends outward from the platform **106** to a tip cap **110** in the radial direction R. As such, the airfoil **108** is positioned within the flow of the air **68** or the combustion gases **70**, thereby imparting energy thereto or extracting energy therefrom. In addition, as will be described below, the airfoil **108** may define one or more cooling holes **112** (e.g., a film cooling hole(s)) for cooling the exterior surface of the airfoil **108**.

[0036] The various portions of the rotor blade **100** described above are at least partially formed from a structural member **114**, a fairing **116**, and a pair of side members **118**. More specifically, in several embodiments, the root **102** and the shank **104** are formed by the structural member **114** and the side members **118**. Moreover, in such embodiments, the platform **106** is formed by the fairing **116** and the side members **118**. Additionally, in such embodiments, the airfoil **108** is formed by the fairing **116** and the structural member **114** (i.e., the tip cap **110**). However, in alternative embodiments, the various portions of the rotor blade **100** may generally be formed by any combination the structural member **114**, the fairing **116**, and the side members **118** so long as the majority of the root **102** and the shank **104** are formed by the structural member **114** and the majority of the platform **106** and the airfoil **108** are primarily formed by the fairing **116**.

[0037] In several embodiments, the side members **118** secure the fairing **116** to the structural member **114**. More specifically, the fairing **116** is installed on or otherwise coupled to the structural member **114** such that the fairing **116** is positioned between at least a portion of the side members **118** and the tip cap **110** in the radial direction R. In the illustrated embodiment, one side member **118** is coupled to a forward end **120** (i.e., relative to the flow of the air/combustion gases **68**/**70**) of the rotor blade **100**. Moreover, in the illustrated embodiment, a second side member **118** is coupled to an aft end **122** (i.e., relative to the flow of the air/combustion gases **68**/**70**) of the rotor blade **100**. As such, the side members **118** prevent the fairing **116** from moving inward (i.e., toward the axial centerline **12** of the engine **10**) along the radial direction R relative to the structural member **114**. Furthermore, the tip cap **110** prevents the fairing **116** from moving outward (i.e., away the axial centerline **12** of the engine **10**) along the radial direction R relative to the structural member **114**.

[0038] The structural member **114** and the fairing **116** allow the mechanical and thermal loads placed on the rotor blade **100** to be decoupled. More specifically, the root **102** and the shank **104** generally experience the majority of the mechanical (e.g., centripetal) loading placed on the rotor blade **100**. Conversely, the platform **106** and the airfoil **108** experience the majority of the thermal loading paced on the rotor blade **100**. As mentioned above, metallic materials are typically better suited to withstand mechanical loads than CMC materials, while CMC materials are typically better suited to withstand thermal loads than metallic materials. In this respect, the structural member **114**, which forms the majority of the root **102** and the shank **104**, is formed from a metallic material (e.g., a nickel-based alloy). Conversely, the fairing **114**, which forms the majority of the platform **106** and the airfoil **108**, is formed from a composite material, such as a ceramic matrix composite (CMC)). Thus, the portions of the rotor blade **100** experiencing the highest mechanical loading are formed from a material (i.e., a metal) well-suited for such loading, while the portions of the rotor blade **100** experiencing the highest thermal loading are formed from a material (i.e., a composite) well-suited for such loading. Additionally, the side members **118** may be formed from either metallic materials or composite materials.

[0039] FIG. **3** is a side view of one embodiment of the structural member **114**. As shown, the structural member **114** includes a base portion **124**, a spar **126**, and a tip cap **110**. In this respect, the base portion **124** forms portions of the root **102** and the shank **104**. Thus, the base portion **124** forms the innermost portion of the structural member **114** in the radial direction R. In some embodiments, the base portion **124** defines a pair of cavities **128** in which the side members **118** (FIG. **2**) are at least partially received. Furthermore, the spar **126** is coupled to and extends outward in the radial direction R from the base portion **124** to the tip cap **110**. In this respect, the spar **126** extends through the fairing **116**, thereby coupling the base portion **124** and the tip cap **110**. In one embodiment, one or more ribs **130** extend outward from and run along the radial length of the spar **126**. As will be described below, the ribs **130** may partially define cooling passages within the airfoil **108**.

[0040] Additionally, in several embodiments, the structural member **114** is integrally formed, such as from a single crystal of a nickel-based alloy. Such integral construction increases the mechanical loading that the structural member **114** can withstand. However, in alternative embodiments, the structural member **114** may be formed from multiple components joined (e.g., welded) together.

[0041] FIG. **4** is a cross-sectional view of the airfoil **108** of the rotor blade **100**. As shown, the airfoil **108** extends from a leading edge **132** to a trailing edge **134**. In this respect, the airfoil **108** includes a pressure-side surface **136** and a suction-side surface **138** extending between the leading and trailing edges **132**, **134** on opposite sides of the airfoil **108**. As mentioned above, the airfoil **108** is primarily formed by the fairing **116**. In this respect, the fairing **116** primarily forms the pressure- and suction-side surfaces **136**, **138**.

[0042] Moreover, one or more cooling passages **140** may extend through the airfoil **108**. More specifically, the fairing **116** encloses or otherwise surrounds the spar **126** of the structural member **114**. That is, the fairing **116** is hollow such that the spar **126** can extend through the fairing **116** between the shank **104** (FIG. **3**) and the tip cap **110** (FIG. **3**). Thus, as shown in FIG. **4**, the fairing **116** and the spar **126** are spaced apart from each other (e.g., in the longitudinal and circumferential directions L, C) such that a clearance or cavity is present between the fairing **116** and the spar **126**. Furthermore, as mentioned above, in some embodiments, one or more ribs **130** extend outward from and run along the radial length of the spar **126**. In such embodiments, the rib(s) **130** contact the fairing **116** such that the clearance/cavity between the fairing **116** and the spar **126** is divided into a plurality of cooling passages **140**. Such cooling passages **140** may be fed with coolant received from passages **142** extending through the root **102** and the shank **104**. In this respect, each cooling passage **140** may be sized to create the desired flow speed of coolant therethrough. However, in alternative embodiments, the structural member **114** may not include any ribs **130** such that the clearance/cavity forms a single cooling passage. In a further embodiment without ribs **130**, the clearance/cavity may not form a cooling passage(s). Instead, in such an embodiment, the clearance/cavity may be filled with stagnant air. Additionally, as shown, in one embodiment, the spar **126** has a solid cross-section.

[0043] The fairing **116** is formed from a first fairing panel **144** and a second fairing panel **146**. In general, the use of the first and second fairing panels **144**, **146** allows installation of the fairing **116** on the structural member **114**, such as when the structural member **114** is integrally formed. More specifically, as shown, the first and second panels **144**, **146** contact or abut each other at first and second split lines or seams **148**, **150**. For example, in the illustrated embodiment, the first split line **148** is located on the suction-side surface **138** between the leading and trailing edge **132**, **134**. Furthermore, in the illustrated embodiment, the second split line **150** is located at or adjacent to the trailing edge **134**. In this respect, the first fairing panel **144** forms the pressure-side surface **136** and a forward portion of the suction-side surface **138**. Conversely, the second fairing panel **146** forms an aft portion of the suction-side surface **138**. As will be described below, cooling holes **112** (e.g., film cooling holes) may be formed at the split lines **148**, **150**. However, in alternative embodiments, the split lines **148**, **150** may be located at any other suitable locations on the airfoil **108**. Moreover, in further embodiments, the fairing **114** may include three or more panels.

[0044] As mentioned above, the second split line **150** may be positioned adjacent to the trailing edge **132** of the airfoil **108**. For example, as shown in FIG. **4**, in one embodiment, the second split line **150** is positioned on the pressure-side surface **136** of the airfoil **108** adjacent to the trailing edge **132**. Moreover, as shown in FIG. **5**, in another embodiment, the second split line **150** is positioned at the trailing edge **132**. Furthermore, as shown in FIG. **6**, in a further embodiment, the second split line **150** is positioned on the suction-side surface **138** of the airfoil **108** adjacent to the trailing edge **132**. However, in alternative embodiments, the second split line **150** may be positioned at any other suitable position.

[0045] The use of the first and second fairing panels **144**, **146** that contact/abut each other at the first and second split lines **148**, **150** provides one or more technical advantages. More specifically, conventional rotor blades incorporating metallic and composite materials are split at the shank (i.e., have a two-piece shank). However, the shank is one of the most highly loaded portions of the rotor blade. In this respect, splitting the rotor blade **100** at the airfoil **108** as opposed to the shank **104** (the shank **104** is almost entirely a single piece except for the portions formed by the side members **118**) allows the rotor blade **100** to withstand higher mechanical (e.g., centripetal) loads. Thus, the disclosed rotor blade **100** allows a gas turbine engine **10** to operate at higher rotational speeds than conventional rotor blades.

[0046] FIG. **7** is a partial rear view of one embodiment of the airfoil **108**. Specifically, FIG. **7** illustrates a portion of the trailing edge **134** of the airfoil **108**, with the first and second fairing panels **144**, **146** spaced apart at the second split line **150** for clarity. As shown, the first and second fairing panels **144**, **146** define a plurality of notches **152** at the second split line **150**. As such, when the first and second fairing panels **144**, **146** are in contact with each other, the notches **152** form cooling holes **112** (FIGS. **2** and **4**) at the second split line **150**. Although the embodiment shown in FIG. **7** includes notches **152** formed in both of the first and second fairing panels **144**, **146**, the notches **152** may only be formed in one of the first and second fairing panels **144**, **146**. Additionally, the first and/or second fairing panels **144**, **146** may define a plurality of notches **152** at the first split line **148** such that the cooling holes **112** are similarly formed at the first split line **148**. While it is generally desirable to form cooling holes **112** at the first and second split lines **148**, **150** as these seams/joints are difficult to seal, in some embodiments, no cooling holes may be present at the split lines **148**, **150**.

[0047] The cooling holes **112** may have any suitable shapes and/or geometries. For example, the cooling holes **112** may be circular holes, elliptical holes, elongated slots, trenches, and/or the like.

[0048] FIG. **8** is cross-sectional view of another embodiment of a structural member **114**. Like the embodiment of the structural member **114** shown in FIG. **4**, the structural member **114** shown in FIG. **8** includes a spar **126**. However, unlike the embodiment of the structural member **114** shown in FIG. **4**, the spar **126** shown in FIG. **8** defines a cooling passage **154** extending therethrough. The cooling passage **154** may, in turn, provide coolant to the tip cap **110** (FIGS. **2** and **3**) for cooling the tip cap **110**. Such cooling of the tip cap **110** may be in addition to or in lieu of any tip cap cooling provided by the cooling passages **140** (FIG. **4**). Although FIG. **8** only illustrates one cooling passage **154**, any other suitable number of cooling passages **154** may extend through the spar **126** to provide coolant to the tip cap **110**.

[0049] As indicated above, in several embodiments, the first and second fairing panels **144**, **146** contact each other at the first and second split lines **148**, **150**. However, in other embodiments, the panels **144**, **146** may contact each other at other locations. For example, as shown in FIG. **9**, the first fairing panel **144** includes a first projection **156** extending outward from its interior surface. Similarly, as shown, the second fairing panel **146** includes a second projection **158** extending outward from its interior surface. In such an embodiment, when the first and second fairing panels **144**, **146** are joined, the first and second projections **156**, **158** contact each other, thereby forming the airfoil **108**. In some embodiments, the first and second projections **156**, **158** may interlock with each other. Additionally, in the illustrated embodiment, the first and second projections **156**, **158** are positioned adjacent to the trailing edge **150**. However, in alternative embodiments, the first and second projections **156**, **158** may be positioned at any other suitable locations and/or the first and second fairing panels **144**, **146** may contact each other in any other suitable manner.

[0050] 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 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 language of the claims.

[0051] Further aspects of the invention are provided by the subject matter of the following clauses:

[0052] A rotor blade for a gas turbine engine, the rotor blade comprising: a structural member formed from a metallic material, the structural member including a base portion, a spar, and a tip cap, the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade; and a fairing formed from a composite material, the fairing coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade, the fairing including a first fairing panel and a second fairing panel in contact with the first fairing panel at a first split line and a second split line.

[0053] The rotor blade of one or more of these clauses, wherein the fairing encloses at least a portion of the spar.

[0054] The rotor blade of one or more of these clauses, wherein the fairing defines a plurality of cooling holes located at the first split line or the second split line.

[0055] The rotor blade of one or more of these clauses, wherein at least one of the first fairing panel or the second fairing panel defines a plurality of notches such that, when the first fairing panel is in contact with the second fairing panel at the first and second split lines, each of the plurality of notches partially defines one of the plurality of cooling holes.

[0056] The rotor blade of one or more of these clauses, wherein the first split line is located on a suction side of the airfoil between a leading edge of the airfoil and a trailing edge of the airfoil.

[0057] The rotor blade of one or more of these clauses, wherein the second split line is located adjacent to a trailing edge of the airfoil.

[0058] The rotor blade of one or more of these clauses, further comprising: first and second side members coupling the fairing to the base portion of the structural member.

[0059] The rotor blade of one or more of these clauses, wherein the first side member and the second side member partially form the root of the rotor blade.

[0060] The rotor blade of one or more of these clauses, wherein the structural member includes a plurality of ribs extending outward from the spar such that the plurality of ribs contacts the fairing.

[0061] The rotor blade of one or more of these clauses, wherein the spar, the fairing, and the plurality of ribs define one or more cooling channels.

[0062] The rotor blade of one or more of these clauses, wherein the structural member is integrally formed.

[0063] The rotor blade of one or more of these clauses, wherein the tip cap applies a compressive load on the fairing.

[0064] The rotor blade of one or more of these clauses, wherein the spar defines a cooling passage configured to direct coolant to the tip cap.

[0065] The rotor blade of one or more of these clauses, wherein the spar is solid.

[0066] A gas turbine engine, comprising: a compressor section; a combustion section; a turbine section; and a rotor blade positioned within the turbine section, the rotor blade comprising: a structural member formed from a metallic material, the structural member including a base portion, a spar, and a tip cap, the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade; and a fairing formed from a composite material, the fairing coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade, the fairing including a first fairing panel and a second fairing panel in contact with the first fairing panel at a first split line and a second split line.

[0067] The gas turbine engine of one or more of these clauses, wherein the fairing encloses at least a portion of the spar.

[0068] The gas turbine engine of one or more of these clauses, wherein the fairing defines a plurality of cooling holes located at the first split line or the second split line.

[0069] The gas turbine engine of one or more of these clauses, wherein at least one of the first fairing panel or the second fairing panel defines a plurality of notches such that, when the first fairing panel is in contact with the second fairing panel at the first and second split lines, each of the plurality of notches partially defines one of the plurality of cooling holes.

[0070] The gas turbine engine of one or more of these clauses, wherein the first split line is located on a suction side of the airfoil between a leading edge of the airfoil and a trailing edge of the airfoil and the second split line is located adjacent to the trailing edge.

[0071] A rotor blade for a gas turbine engine, the rotor blade comprising: a structural member formed from a metallic material, the structural member including a base portion, a spar, and a tip cap, the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade; and a fairing formed from a composite material, the fairing coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade, the fairing including a first fairing panel having a first projection and a second fairing panel having a second projection in contact with the first projection.

What is claimed is:

1. A rotor blade for a gas turbine engine, the rotor blade comprising:

a structural member formed from a metallic material, the structural member including a base portion, a spar, and a tip cap, the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade; and

a fairing formed from a composite material, the fairing coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade, the fairing including a first fairing panel and a second fairing panel in contact with the first fairing panel at a first split line and a second split line.

2. The rotor blade of claim **1**, wherein the fairing encloses at least a portion of the spar.

3. The rotor blade of claim **1**, wherein the fairing defines a plurality of cooling holes located at the first split line or the second split line.

4. The rotor blade of claim **3**, wherein at least one of the first fairing panel or the second fairing panel defines a plurality of notches such that, when the first fairing panel is in contact with the second fairing panel at the first and second split lines, each of the plurality of notches partially defines one of the plurality of cooling holes.

5. The rotor blade of claim **1**, wherein the first split line is located on a suction side of the airfoil between a leading edge of the airfoil and a trailing edge of the airfoil.

6. The rotor blade of claim **5**, wherein the second split line is located adjacent to a trailing edge of the airfoil.

7. The rotor blade of claim **1**, further comprising:

first and second side members coupling the fairing to the base portion of the structural member.

8. The rotor blade of claim **7**, wherein the first side member and the second side member partially form the root of the rotor blade.

9. The rotor blade of claim **1**, wherein the structural member includes a plurality of ribs extending outward from the spar such that the plurality of ribs contacts the fairing.

10. The rotor blade of claim **9**, wherein the spar, the fairing, and the plurality of ribs define one or more cooling channels.

11. The rotor blade of claim **1**, wherein the structural member is integrally formed.

12. The rotor blade of claim **1**, wherein the tip cap applies a compressive load on the fairing.

13. The rotor blade of claim **1**, wherein the spar defines a cooling passage configured to direct coolant to the tip cap.

14. The rotor blade of claim **1**, wherein the spar is solid.

15. A gas turbine engine, comprising:

a compressor section;

a combustion section;

a turbine section; and

a rotor blade positioned within the turbine section, the rotor blade comprising:

a structural member formed from a metallic material, the structural member including a base portion, a spar, and a tip cap, the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade; and

a fairing formed from a composite material, the fairing coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade, the fairing including a first fairing panel and a second fairing panel in contact with the first fairing panel at a first split line and a second split line.

16. The gas turbine engine of claim **15**, wherein the fairing encloses at least a portion of the spar.

17. The gas turbine engine of claim **15**, wherein the fairing defines a plurality of cooling holes located at the first split line or the second split line.

18. The gas turbine engine of claim **17**, wherein at least one of the first fairing panel or the second fairing panel defines a plurality of notches such that, when the first fairing panel is in contact with the second fairing panel at the first and second split lines, each of the plurality of notches partially defines one of the plurality of cooling holes.

19. The gas turbine engine of claim **15**, wherein the first split line is located on a suction side of the airfoil between a leading edge of the airfoil and a trailing edge of the airfoil and the second split line is located adjacent to the trailing edge.

20. A rotor blade for a gas turbine engine, the rotor blade comprising:

a structural member formed from a metallic material, the structural member including a base portion, a spar, and a tip cap, the base portion at least partially forming a root of the rotor blade and a shank of the rotor blade; and

a fairing formed from a composite material, the fairing coupled to the structural member such that the fairing forms at least a portion of an airfoil of the rotor blade and a platform of the rotor blade, the fairing including a first fairing panel having a first projection and a second fairing panel having a second projection in contact with the first projection.

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