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(54) **BLADE ELEMENT CROSS-TIES**

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Description**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims priority to U.S. Provisional Application No. 61/991,328 filed on May 09, 2014 and titled Blade Element Cross-Ties, the disclosure of which is hereby incorporated by reference in its entirety.

FIELD

[0002] The present disclosure relates to a method for fabricating a blade element of a gas turbine engine.

BACKGROUND

[0003] A gas turbine engine typically includes one or more blades in each of the compressor and turbine sections of the engine. These components are exposed to high-speed air/gas flow during operation. In addition, gas turbine engine components are exposed to high temperatures. As such, airfoils are typically provided with cooling channels (see, for example, EP 1431514, US 7780414 and US 4278400). Airfoil structures experience high levels of stress during operation which may limit component operation life (see, for example, US 2005/0084380). There exists a desire to extend the operational life of components.

[0004] Manufacturing of airfoil components can include using ceramic cores to form passages in airfoils. Conventional methods include the use of stiffening rods to supporting cast elements. These rods are removed with cast elements during manufacture of the component. Accordingly, there rods do not provide structural support during operation.

[0005] While there have been approaches to fabricating components, there is a need in the art to extend component life and improve integrity.

BRIEF SUMMARY OF THE EMBODIMENTS

[0006] Disclosed and claimed herein is a method for fabricating a blade element of a gas turbine engine according to claim 1.

[0007] Other aspects, features, and techniques will be apparent to one skilled in the relevant art in view of the following detailed description of the embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The features, objects, and advantages of the present disclosure will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

FIGS. 1A-1C depict graphical representations of a blade element;

FIG. 2A depicts a graphical representation of a blade element cross-tie;

FIG. 2B depicts a cross-sectional view of the cross-tie of FIG. 2A;

FIG. 3 depicts a graphical representation of a blade element cast; and

FIG. 4 depicts a process for manufacturing a blade element according to one or more embodiments.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS**Overview and Terminology**

[0009] Blade elements for a gas turbine engine are disclosed. According to one embodiment, a blade element, such as fan blades, turbine blades and vanes, may be fabricated including one or more cross-ties. As used herein, a cross-tie is a structural element configured to provide rigidity to an interior passage or hollow section of a blade element. According to one or more described arrangements, each cross-tie may have a curved profile with surface blended to inner walls of a blade element. According to another arrangement cross-ties may include a non-circular cross section. Cross-ties may be placed and configured to provide support and rigidity to unsupported areas of a blade element. Cross-ties may additionally allow for internal connections within a blade element without restricting airflow or changing heat transfer of the blade element.

[0010] The disclosure is directed to manufacturing blade elements to include one or more cross-ties. According to one embodiment, a cast having positives and negatives may be formed for manufacturing a blade element having one or more cross-ties.

[0011] As used herein, the terms "a" or "an" shall mean one or more than one. The term "plurality" shall mean two or more than two. The term "another" is defined as a second or more. The terms "including" and/or "having" are open ended (e.g., comprising). The term "or" as used herein is to be interpreted as inclusive or meaning any one or any combination. Therefore, "A, B or C" means "any of the following: A; B; C; A and B; A and C; B and C; A, B and C". An exception to this definition will occur only when a combination of elements, functions, steps or acts are in some way inherently mutually exclusive.

[0012] Referring now to the figures, FIGS. 1A-1C depict graphical representations of a blade element. Referring first to FIG. 1A, blade element 100 is shown including leading edge 105, blade surface 106 (e.g., a first blade surface) and trailing edge 110. Blade element 100 may be one of a turbine blade, fan blade, vane, and gas turbine engine component. FIG. 1A depicts blade element 100 including base structure 120.

[0013] According to one arrangement, blade element 100 may include one or more cross-ties configured to connect a first blade surface, such as an inner surface of blade surface 106, to a second inner blade surface.

By way of example, cross-ties may connect inner surfaces of the blade element. Cross-ties may be positioned near and/or along trailing edge 110 of blade element 100, wherein the cross-tie is positioned and configured to reduce vibration mode effects of the blade element 100. As discussed herein, vibration mode effects can relate to one or more of blade surface stress, blade surface strain, vibratory stress, vibratory strain, and blade deformation. Cross-ties may be configured to provide stiffening to reduce one or more of the vibratory effects. It should be appreciated that the frequency of vibratory stress may be driven up or down. While stress should be generally reduced everywhere in blade element 100, there are situations where the vibratory frequency needs to be driven upward. Thus, cross-ties as discussed herein may be configured to reduce stress and/or strain associated with the vibratory mode of a blade element.

[0014] In one arrangement, cross-ties of blade element 100 are positioned between 20-90% of a span length, shown generally as area 115 in FIG. 1A, of blade element 100. The trailing edge portion of the blade may relate to portions of the blade element 100 near trailing edge 110. Blade element 100 may include a plurality of cross-ties along the trailing edge 110 in area 115. Each cross-tie may be formed integrally with an inner surface of blade element 100 within a particular area shown as section 116. Section or area 116 is shown in more detail with respect to FIGS. 2A-2B. In some arrangements, cross-ties may be positioned in other portions of blade element 100.

[0015] FIG. 1B depicts a top down representation of blade element 100. As shown in FIG. 1B, blade element 100 includes a first blade surface of the blade element, blade surface 106 with corresponding first inner surface 108, and a second blade surface, blade surface 107 with corresponding second inner surface 109. Blade surface 108 is opposite from blade surface 109, wherein the blade surfaces are between leading edge 105 and trailing edge 110. In one arrangement, blade surface 108 is opposite from blade surface 109 meaning the surfaces are on opposing ends of an interior portion. It can be appreciated that surfaces 108 and 109 may be parallel, substantially parallel, or not parallel. It can also be appreciated that surfaces 108 and 109 may not correspond to the surface shape characteristics of surfaces 106 and 107. By way of example, while surfaces 106 and 107 may be smooth, surfaces 108 and 109 may be formed on one or more protrusions of other interior features of a blade element. As further depicted in FIG. 1B, blade element 100 includes a representation of cross-tie 130₁. Cross-tie 130₁ is configured to connect blade surface 106 to blade surface 107. Cross-tie 130₁ is positioned near trailing edge 110 of blade element 100. Cross-tie 130₁ may be configured to reduce vibration mode of blade element 100 by providing increased stiffness for walls of the blade element.

[0016] FIG. 1C depicts a cut-away representation of blade element 100. According to one arrangement, blade

element 100 may include cooling area 125 to provide cooling air/air flow for cooling blade element 100. Cooling area 125 may be one or more hollow sections of blade element 100. Cross-ties 130_{1-n} are shown relative to inner surface 109 and near trailing edge 110. In certain arrangements, cross-ties 130_{1-n} may be positioned to provide structural integrity without restricting airflow.

[0017] FIG. 2A depicts a graphical representation of a blade element cross-tie according to one or more arrangements. In FIG. 2A, section 200 of a blade element (e.g., blade element 100) includes cross-tie 205. Cross-tie 205 includes a first portion blended to an inner wall of blade surface 206, a second portion blended to an inner wall of blade surface 207, and a non-circular cross-section 210 between the first and second portions. As shown in FIG. 2A, non-circular cross-section 210 is reduced in size relative to the first and second portions of the cross-tie blended to blade surfaces. Cross-tie 205 may be configured to provide a connection between surfaces 206 and 207 and provide both in-plane (shear) and out-of-plane (compressive/tensile) support. By providing stiffening, cross-tie 205 can reduce the extent to which surfaces 206 and 207 participate in the vibration mode of the blade element.

[0018] FIG. 2B depicts a cross-sectional view of the cross-tie of FIG. 2A according to one or more arrangements. Blade element section 250 is a cross sectional view along reference line A-A of FIG. 2A, which is associated with the central axis of the cross-tie 205. As shown in FIG. 2A, cross-tie 205 is formed to include a non-circular blend between first and second portions of the cross-tie blended to blade surfaces. Non-circular curved/bending is shown by arcs 255, 260, 265 and 270. Cross-tie 205 includes a long axis oriented with the direction of centrifugal pull of a blade element (e.g., blade element 105). According to one arrangement, cross-tie 205 increases stability of the blade element by supporting the first and second blade element surfaces in a hollow section of the blade element. Cross-tie 205 may be configured to provide in-plane and out-of-plane support for the blade element. In-plane support provided by the blade element may relate support along an axis of cross-tie 205, while out-of-plane support may relate to support for vibratory and steady state stress of the blade element in general.

[0019] FIG. 3 depicts a graphical representation of a blade element cast according to one or more arrangements. According to one arrangement, blade elements (e.g., blade element 100) may be cast to include one or more cross-ties. Cast 300 is a simplified representation of a cast element including negatives and positives that may be employed to fabricate a blade element as described herein. As shown in FIG. 3, cast 300 includes a plurality of negatives, shown as 305_{1-n}, to allow for cross-ties to be formed. Cast 300 also includes a plurality of positives, shown as 310_{1-n}, to allow for cooling passages to be formed.

[0020] FIG. 4 depicts a process for manufacturing a

blade element (e.g., blade element 100) according to one or more embodiments. Process 400 is initiated at block 405 with determining one or more cross-tie locations for a blade element. Modelling of a blade element indicates one or more locations where additional stiffness or an internal connection is required. According to the invention, determining one or more cross-tie locations for the blade element includes modelling a blade element for one or more of vibratory frequency, vibratory mode shape and vibratory stress.

[0021] At block 410, a cast (e.g., cast 300) for the blade element may be generated. According to the present disclosure, a cast may be formed at block 410 to include one or more negatives and positives, to form cross-ties and cooling paths.

[0022] Process 400 may continue to block 415 to fabricate a blade element based on the cast generated at block 410 to include one or more cross-ties. Fabricating a blade element of a gas turbine engine at block 415 includes forming a first blade surface of the blade element, and forming a second blade surface of the blade element, wherein the second blade surface is opposite from the first blade surface. Fabricating a blade element of a gas turbine engine at block 415 also includes forming one or more cross-ties configured to connect the inner surface of a first blade surface to the inner surface of a second blade surface on a trailing edge of the blade element. Forming cross-ties at block 415 includes forming a plurality of cross-ties along the trailing edge of the blade element.

[0023] While this disclosure has been particularly shown and described with references to exemplary embodiments thereof, it will be understood by those skilled in the art that various changes to form and details may be made therein without departing from the scope of the claimed embodiments

Claims

1. A method for fabricating a blade element (100) of a gas turbine engine, wherein the blade element comprises:

a first inner surface (108) of the blade element, wherein the first inner surface (108) is associated with a first outer blade surface (106) of the blade element;

a second inner surface (109) of the blade element, wherein the second inner surface (109) is associated with a second outer blade surface (107) of the blade element and wherein the second inner surface (109) is opposite from the first inner surface (108); and

one or more cross-ties (130;205) configured to connect the first inner surface (108) to the second inner surface (109), wherein the one or more cross-ties (130;205) are positioned along a trailing

ing edge (110) of the blade element and the one or more cross-ties (130;205) are positioned and configured to reduce vibration mode effects of the blade element (100) reducing the stress and/or strain associated with a vibration mode of the blade element;

wherein the or each cross-tie (130;205) includes a first portion blended to the first inner surface, a second portion blended to the second inner surface, and a non-circular cross-section (210) between the first and second portions, the non-circular cross-section (210) being reduced in size relative to the first and second portions of the cross-tie (130;205), and also being formed to include a non-circular blend between first and second portions of the cross-tie blended to blade surfaces;

the method comprising:

forming a first blade surface (106) of the blade element, wherein the first blade surface includes the first inner surface (108);

forming a second blade surface (107) of the blade element, wherein the second blade surface includes the second inner surface (109) and wherein the second inner surface (109) is opposite from the first inner surface (108);

determining one or more cross-tie locations for a blade element (100), wherein determining one or more cross-tie locations for the blade element (100) includes modelling a blade element for one or more of vibratory frequency, vibratory mode shape and vibratory stress;

forming one or more cross-ties (130;205) configured to connect the first inner surface (108) to the second inner surface (109) along a trailing edge (110) of the blade element; and

positioning and configuring the one or more cross-ties (130;205) at the one or more determined cross tie locations to reduce vibration mode effects of the blade element (100) reducing the stress and/or strain associated with a vibration mode of the blade element (100);

wherein the or each cross-tie (130;205) includes a first portion blended to the first inner surface, a second portion blended to the second inner surface, and a non-circular cross-section (210) between the first and second portions, the non-circular cross-section (210) being reduced in size relative to the first and second portions of the cross-tie (130;205), and also being formed to include a non-circular blend between first and second portions of the cross-tie blended to

blade surfaces.

2. The method of claim 1, wherein the one or more cross-ties (130;205) increase stability of the blade element (100) by supporting the first and second blade element surfaces in at least one of a cooling passage and hollow portion of the blade element. 5
3. The method of claim 1 or 2, wherein forming one or more cross-ties (130;205) includes forming a plurality of cross-ties along the trailing edge (110) of the blade element (100). 10

Patentansprüche 15

1. Verfahren zum Herstellen eines Schaufelelements (100) eines Gasturbinentriebwerks, wobei das Schaufelelement Folgendes umfasst: 20
 - eine erste Innenfläche (108) des Schaufelelements, wobei die erste Innenfläche (108) einer ersten Schaufelaußenfläche (106) des Schaufelelements zugeordnet ist;
 - eine zweite Innenfläche (109) des Schaufelelements, wobei die zweite Innenfläche (109) einer zweiten Schaufelaußenfläche (107) des Schaufelelements zugeordnet ist und wobei die zweite Innenfläche (109) der ersten Innenfläche (108) gegenüberliegt; und 25
 - eine oder mehrere Querstreben (130; 205), die dazu konfiguriert ist, die erste Innenfläche (108) mit der zweiten Innenfläche (109) zu verbinden, wobei die eine oder mehreren Querstreben (130; 205) entlang einer Hinterkante (110) des Schaufelelements angeordnet sind und die eine oder mehreren Querstreben (130; 205) dazu angeordnet und konfiguriert sind, Schwingungsauswirkungen des Schaufelelements (100) zu verringern, was die einer Schwingungsform des Schaufelelements zugeordnete Belastung und/oder Beanspruchung verringert; 30
 - wobei die oder jede Querstrebe (130; 205) einen ersten Abschnitt, der in die erste Innenfläche übergeht, einen zweiten Abschnitt, der in die zweite Innenfläche übergeht, und einen nicht kreisförmigen Querschnitt (210) zwischen dem ersten und dem zweiten Abschnitt beinhaltet, wobei der nicht kreisförmige Querschnitt (210) relativ zum ersten und zum zweiten Abschnitt der Querstrebe (130; 205) in der Größe verringert ist und auch so ausgebildet ist, dass er einen nicht kreisförmigen Übergang zwischen dem ersten und dem zweiten Abschnitt der Querstrebe, die in die Schaufelflächen übergehen, beinhaltet; 35
 - wobei das Verfahren Folgendes umfasst: 40

Herstellen einer ersten Schaufelfläche (106) des Schaufelelements, wobei die erste Schaufelfläche die erste Innenfläche (108) beinhaltet;

Herstellen einer zweiten Schaufelfläche (107) des Schaufelelements, wobei die zweite Schaufelfläche die zweite Innenfläche (109) beinhaltet und wobei die zweite Innenfläche (109) der ersten Innenfläche (108) gegenüberliegt;

Bestimmen eines oder mehrerer Querstrebenstandorte für ein Schaufelelement (100), wobei das Bestimmen eines oder mehrerer Querstrebenstandorte für das Schaufelelement (100) Modellieren eines Schaufelelements für eines oder mehrere von Schwingungsfrequenz, Schwingungsformgestalt und Schwingungsbeanspruchung beinhaltet;

Ausbilden einer oder mehrerer Querstreben (130; 205), die dazu konfiguriert sind, die erste Innenfläche (108) mit der zweiten Innenfläche (109) entlang einer Hinterkante (110) des Schaufelelements zu verbinden; und

Anordnen und Konfigurieren der einen oder mehreren Querstreben (130; 205) an dem einen oder den mehreren bestimmten Querstrebenstandorten, um Schwingungsauswirkungen des Schaufelelements (100) zu verringern, was die einer Schwingungsform des Schaufelelements (100) zugeordnete Belastung und/oder Beanspruchung verringert;

wobei die oder jede Querstrebe (130; 205) einen ersten Abschnitt, der in die erste Innenfläche übergeht, einen zweiten Abschnitt, der in die zweite Innenfläche übergeht, und einen nicht kreisförmigen Querschnitt (210) zwischen dem ersten und dem zweiten Abschnitt beinhaltet, wobei der nicht kreisförmige Querschnitt (210) relativ zum ersten und zum zweiten Abschnitt der Querstrebe (130; 205) in der Größe verringert ist und auch so ausgebildet ist, dass er einen nicht kreisförmigen Übergang zwischen dem ersten und dem zweiten Abschnitt der Querstrebe, die in die Schaufelflächen übergehen, beinhaltet.

2. Verfahren nach Anspruch 1, wobei die eine oder mehreren Querstreben (130; 205) die Stabilität des Schaufelelements (100) erhöhen, indem sie die erste und die zweite Schaufelelementfläche in mindestens einem aus einem Kühlkanal und einem Hohlprofil des Schaufelelements unterstützt.
3. Verfahren nach Anspruch 1 oder 2, wobei das Aus-

bilden einer oder mehrerer Querstreben (130; 205) Ausbilden einer Vielzahl von Querstreben entlang der Hinterkante (110) des Schaufelelements (100) beinhaltet.

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Revendications

1. Procédé de fabrication d'un élément de pale (100) pour un moteur à turbine à gaz, dans lequel l'élément de pale comprend :

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une première surface interne (108) de l'élément de pale, dans lequel la première surface interne (108) est associée à une première surface de pale externe (106) de l'élément de pale ;
une seconde surface interne (109) de l'élément de pale, dans lequel la seconde surface interne (109) est associée à une seconde surface de pale externe (107) de l'élément de pale et dans lequel la seconde surface interne (109) est opposée à la première surface interne (108) ; et
une ou plusieurs traverses (130 ; 205) configurées pour relier la première surface interne (108) à la seconde surface interne (109), dans lequel les une ou plusieurs traverses (130 ; 205) sont positionnées le long d'un bord de fuite (110) de l'élément de pale et les une ou plusieurs traverses (130 ; 205) sont positionnées et configurées pour réduire les effets de mode de vibration de l'élément de pale (100) en réduisant la contrainte et/ou la déformation associée à un mode de vibration de l'élément de pale ;

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dans lequel la ou chaque traverse (130 ; 205) comporte une première partie associée à la première surface interne, une seconde partie associée à la seconde surface interne, et une section transversale non circulaire (210) entre les première et seconde parties, la section transversale non circulaire (210) étant de taille réduite par rapport aux première et seconde parties de la traverse (130 ; 205), et étant également formée pour comporter un assemblage non circulaire entre les première et seconde parties de la traverse associées aux surfaces de pale ;
le procédé comprenant :

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la formation d'une première surface de pale (106) de l'élément de pale, dans lequel la première surface de pale comporte la première surface intérieure (108) ;
la formation d'une seconde surface de pale (107) de l'élément de pale, dans lequel la seconde surface de pale comporte la seconde surface interne (109) et dans lequel la seconde surface interne (109) est opposée à la première surface interne (108) ;
la détermination d'un ou plusieurs empla-

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cements de traverse pour l'élément de pale (100), dans lequel la détermination d'un ou plusieurs emplacements de traverse pour l'élément de pale (100) comporte la modélisation d'un élément de pale pour l'une ou plusieurs d'une fréquence de vibration, d'une forme de mode vibratoire et d'une contrainte vibratoire ;

la formation d'une ou plusieurs traverses (130 ; 205) configurées pour relier la première surface interne (108) à la seconde surface interne (109) le long d'un bord de fuite (110) de l'élément de pale ; et
le positionnement et la configuration des une ou plusieurs traverses (130 ; 205) au niveau des un ou plusieurs emplacements de traverse déterminés pour réduire les effets de mode de vibration de l'élément de pale (100) en réduisant la contrainte et/ou la déformation associées à un mode de vibration de l'élément de pale (100) ;
dans lequel la ou chaque traverse (130 ; 205) comporte une première partie associée à la première surface interne, une seconde partie associée à la seconde surface interne, et une section transversale non circulaire (210) entre les première et seconde parties, la section transversale non circulaire (210) étant de taille réduite par rapport aux première et seconde parties de la traverse (130 ; 205), et étant également formée pour comporter un assemblage non circulaire entre les première et seconde parties de la traverse associées aux surfaces de pale.

2. Procédé selon la revendication 1, dans lequel les une ou plusieurs traverses (130 ; 205) augmentent la stabilité de l'élément de pale (100) en supportant les première et seconde surfaces de l'élément de pale dans au moins l'un d'un passage de refroidissement et d'une partie creuse de l'élément de pale.

3. Procédé selon la revendication 1 ou la revendication 2, dans lequel la formation d'une ou plusieurs traverses (130 ; 205) comporte la formation d'une pluralité de traverses le long du bord de fuite (110) de l'élément de pale (100).

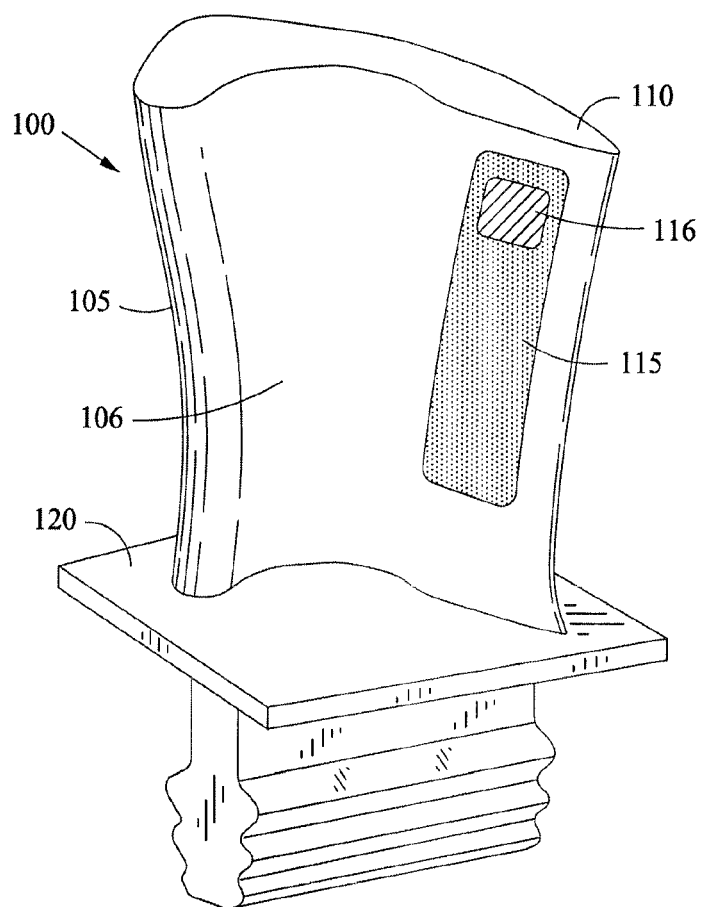


FIG. 1A

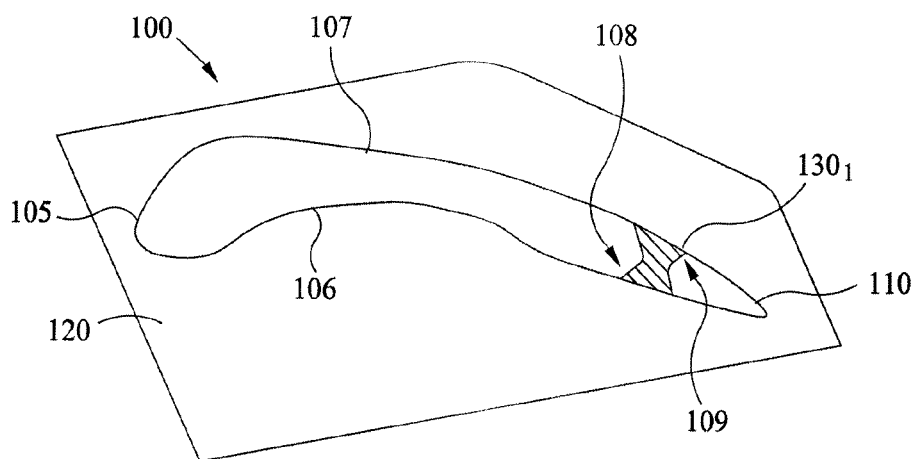


FIG. 1B

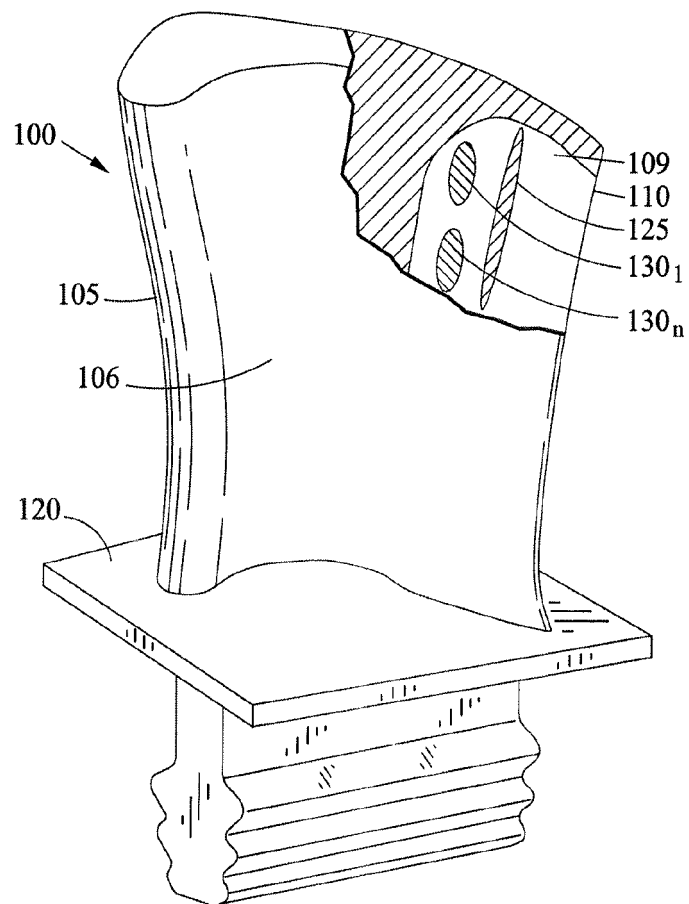


FIG. 1C

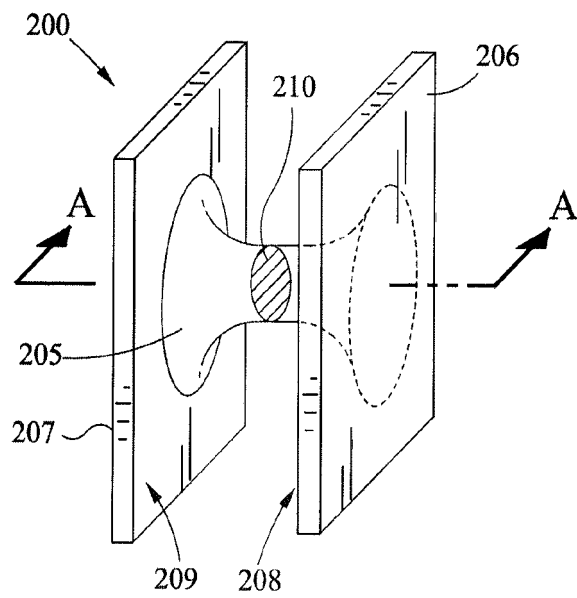


FIG. 2A

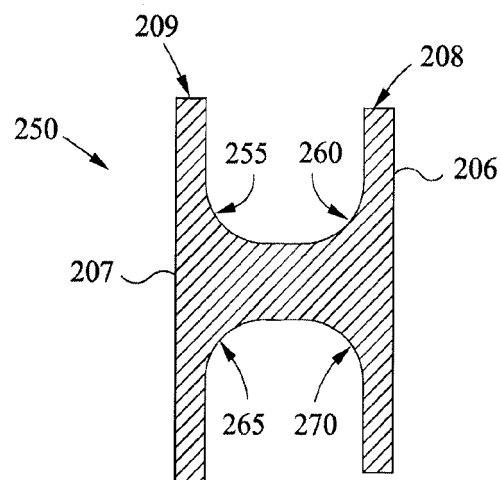


FIG. 2B

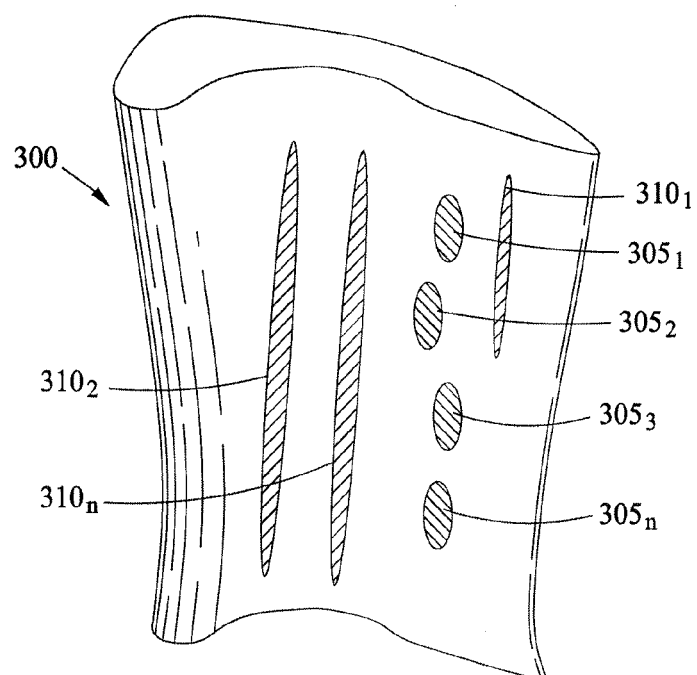


FIG. 3

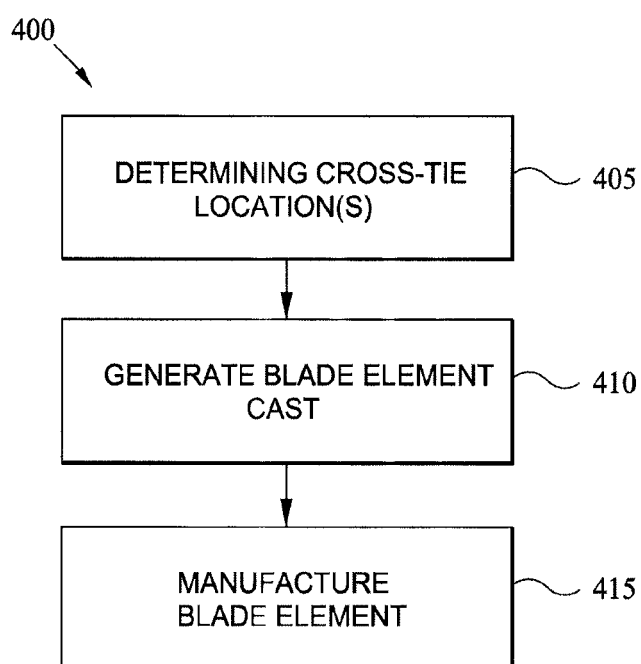


FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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