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(54) **Sealing system for a turbine rotor blade and corresponding gas turbine engine**

(57) An embodiment of the present invention takes the form of a seal (180) that may substantially reduce cross-shank leakage between components mounted on a shaft. Embodiments of the seal (180) may be connected to a wide variety of rotatable components (155) including, but not limited to, compressor blades, turbine buckets (155), or the like.

FIG. 3A

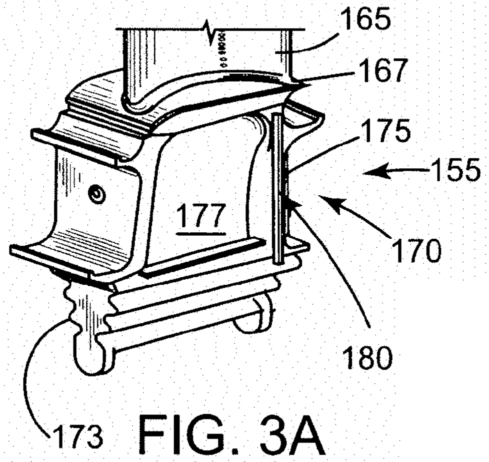

FIG. 3A

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to seals for air-ingesting turbomachines, and more particularly to a seal for the shank region of a rotating component of the turbomachine.

[0002] Conventional turbomachines includes compressor and turbine sections that each has a plurality of rotating components (compressor blades, turbine components, etc.) attached about a circumference of a turbine rotor. Each rotating component is located at a distance away from an adjacent rotating component to allow movement and expansion during operation. Each rotatable component includes: a shank that attaches to the rotor, a platform, and an airfoil that extends radially outwardly from the platform.

[0003] The area between the adjacent rotating components is considered the shank pocket. Generally, the cavities between the rotating components and adjacent stationary components forward and aft of the shank pocket are at different operating pressures. Fluid naturally flows from the higher pressure cavity to the lower pressure cavity through gaps; which allow for movement and expansion, between adjacent rotating components. In addition, fluid flowing over the platform can leak into the shank pocket. These sources of "cross-shank" leakage are detrimental to the performance of the turbomachine. The severity of the leakage depends, in part, on the size of the shank.

[0004] For the foregoing reasons, there is a need for a system that reduces cross-shank leakage. The system should provide a simple seal design that may be applied to a turbine bucket and/or a compressor blade.

BRIEF DESCRIPTION OF THE INVENTION

[0005] Certain embodiments commensurate in scope with the originally claimed invention are summarized below. These embodiments are not intended to limit the scope of the claimed invention, but rather these embodiments are intended only to provide a brief summary of possible forms of the invention. Indeed, the invention may encompass a variety of forms that may be similar to or different from the embodiments set forth below.

[0006] In accordance with a first aspect of the present invention, a system comprising: a rotatable component comprising: an airfoil portion comprising a first end, an opposite second end, and suction and pressure surfaces located between the first end and the opposite second end; a shank portion comprising a mount and a slot, wherein the slot is positioned near a wall and is adjacent a downstream edge of the airfoil portion; a platform portion that connects the airfoil portion to the shank portion; a seal comprising: an arm portion; and a hook portion; wherein the arm and hook portions are shaped to mate with the slot such that the slot restrains the movement of the seal; wherein the seal is sized to substantially prevent a cooling flow from leaking through a shank pocket.

[0007] In accordance with a second aspect of the present invention, a system comprising: a gas turbine comprising: a compressor section and a turbine section; a turbine bucket installed in the turbine section, wherein the turbine bucket comprises: an airfoil comprising a tip, a base, and suction and pressure surfaces that connected the tip and the base; a shank comprising a mount and a slot, wherein the slot is positioned near a surface that is adjacent an edge of the airfoil, and an end of the slot is adjacent to a top portion of the mount; a platform portion that connects the airfoil to the shank; a seal comprising: an arm; and a hook; wherein the arm and hook are sized to allow insertion into the slot such that the slot secures the movement of the seal; wherein the seal has a width that substantially prevents a cooling flow from leaking through a shank pocket, which is formed between the shank portion of the rotatable component and an another shank portion of an adjacent rotatable component.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG 1 is a schematic view, in cross-section, of a gas turbine, illustrating the environment in which an embodiment of the present invention operates.

FIG 2 is a schematic view illustrating the cross-section of the turbine section illustrated in FIG 1.

FIGS 3A and 3B, collectively FIG 3, illustrate side and isometric views of the rotating component illustrated in FIGS 1 and 2.

FIG 4 is a schematic illustrating an arrangement of multiple rotating components, facing downstream.

FIG 5 is a partial-isometric view of a rotating component, in accordance with an embodiment of the present invention.

FIG 6 illustrates a partial-isometric view of a rotating component and a seal, in accordance with an embodiment of the present invention.

FIG 7 illustrates another partial-isometric view of a rotating component and a seal, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0009] One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in an engineering or design project, numerous implementation-specific decisions are made to achieve the specific goals, such as compliance with system-related and/or business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0010] Detailed example embodiments are disclosed herein. However, specific structural and functional details disclosed herein are merely representative for purposes of describing example embodiments. Embodiments of the present invention may, however, be embodied in many alternate forms, and should not be construed as limited to only the embodiments set forth herein.

[0011] Accordingly, while example embodiments are capable of various modifications and alternative forms, embodiments thereof are illustrated by way of example in the figures and will herein be described in detail. It should be understood, however, that there is no intent to limit example embodiments to the particular forms disclosed, but to the contrary, example embodiments are to cover all modifications, equivalents, and alternatives falling within the scope of the present invention.

[0012] The terminology used herein is for describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises", "comprising", "includes" and/or "including", when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0013] Although the terms first, second, primary, secondary, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, but not limiting to, a first element could be termed a second element, and, similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term "and/or" includes any, and all, combinations of one or more of the associated listed items.

[0014] Certain terminology may be used herein for the convenience of the reader only and is not to be taken as a limitation on the scope of the invention. For example, words such as "upper", "lower", "left", "right", "front", "rear", "top", "bottom", "horizontal", "vertical", "upstream", "downstream", "fore", "aft", and the like; merely describe the configuration shown in the FIGS. Indeed, the element or elements of an embodiment of the present invention may be oriented in any direction and the terminology, therefore, should be understood as encompassing such variations unless specified otherwise.

[0015] The present invention may be applied to the variety of turbomachines that produce an exhaust fluid, such as, but not limiting of, a heavy-duty gas turbine; an aero-derivative gas turbine; or the like. An embodiment of the present invention may be applied to either a single turbomachine or a plurality of turbomachines. An embodiment of the present invention may be applied to a turbomachine operating in a simple cycle or a combined cycle configuration.

[0016] An embodiment of the present invention takes the form of a seal that may substantially reduce cross-shank leakage. The elements of the present invention may be fabricated of any material that can withstand the operating environment under which embodiments of the present invention may operate. Embodiments of the seal may be connected to a wide variety of rotatable components including, but not limited to, compressor blades, turbine buckets, or the like.

[0017] Referring now to the Figures, where the various numbers represent like elements throughout the several views, FIG 1 is a schematic view, in cross-section, of a gas turbine 100, illustrating the environment in which an embodiment of the present invention operates. FIG 1 illustrates a known configuration of a gas turbine 100 that includes: a compressor section 105; a combustion section 130; and a turbine section 150.

[0018] Generally, the compressor section 105 includes a plurality of rotating blades 110 and stationary vanes 115 structured to compress a fluid. The compressor section 105 may also include a compressor discharge casing 125.

[0019] Generally, the combustion section 130 includes a plurality of combustion cans 135, a plurality of fuel nozzles 140, and a plurality of transition sections 145. Within each of the combustion cans 135, compressed air is received from the compressor section 105 and mixed with fuel received from a fuel source. The mixture is ignited and creates a working fluid. The working fluid generally flows downstream from the aft end of the plurality of fuel nozzles 140, downstream through the transition section 145, and into the turbine section 150.

[0020] Generally, the turbine section 150 includes a plurality of rotating components 155, and a plurality of stationary components 160. The turbine section 150 converts the energy of the working fluid to a mechanical torque.

[0021] FIG 2 is a schematic illustrating a close-up elevation view of the turbine section 150 illustrated in FIG 1. The plurality of rotatable component 155 (hereinafter "turbine bucket") are commonly arranged in a plurality of stages. For example, but not limited to, FIGS 1 and 2 illustrate an arrangement of three stages of turbine buckets 155.

[0022] FIGS 3A and 3B, collectively FIG 3, illustrate side and isometric views of the turbine buckets 155 of FIGS 1 and 2. Each of the turbine buckets 155 may comprise: an airfoil 165, a platform 167, and a shank 170.

[0023] The airfoil 165 may generally comprise a first end (or tip); an opposite second end (or base); and suction and pressure surfaces located between the first end and the opposite second end.

[0024] The shank 170 may comprise a mount 173, a slot 175, and a shank pocket 177. An embodiment of the mount 173 may comprise any mating shape that allows the turbine bucket 155 to mate with a turbine wheel slot 405 on a turbine wheel 400, as illustrated in FIG 4.

[0025] The slot 175 functions to secure a seal 180. As illustrated in FIG 6, the shape of the slot 175 corresponds to that of the seal 180, which allows mating to occur, as illustrated in FIG 6. An embodiment of the slot 175 may be vertically positioned near a side wall that is substantially aligned with a downstream edge of the airfoil 165, as illustrated in FIGS 3 and 5. In an embodiment of the present invention, an end of the slot 175 is adjacent to a top portion of the mount 173. Here, an overall height of the slot 175 may extend from around the top portion of the mount 173 to a bottom portion of the platform 167; as illustrated in FIG 5. However, other embodiments may comprise a shorter height.

[0026] The platform 167 provides the structure that connects the bottom of the airfoil 165 to the top of the shank 170.

[0027] FIG 4 is a schematic illustrating an arrangement, facing downstream, of multiple rotating components 155 mounted on a turbine wheel 400. Here, the mount 173 is illustrated in a dovetail shape; however other forms of axially insertable mounts 173 may be used with embodiments of the present invention. The mounts 173 are inserted into the turbine wheel slots 405, located along the outer periphery of the turbine wheel 400. This allows each turbine bucket 155 to be attached to the turbine wheel 400.

[0028] FIG 4 also provides an overview of the flow path of the working fluid and the cooling circuits; and how both of which impact the turbine bucket 155. One cooling circuit utilizes the collective shank pockets 177 formed by shanks 170 and platforms 167 of adjacent turbine buckets 155. This design may extract air from a cooling purge 200 and uses that air to pressurize the shank pockets 177. The shank pocket 177 can also be pressurized using coolant flows from other circuits. Once pressurized, the shank pockets 177 may supply cooling air to other locations on the platform 167. Impingement cooling is often incorporated in this type of cooling circuit to enhance heat transfer. The cooling air may exit the shank pockets 177 through film cooling holes in the platform 167 or through axial cooling holes which direct the air out of the shank pocket 177.

[0029] Embodiments of the present invention provide a seal 180 that may prevent leakage of the working fluid out of those shank pockets 177. The seal 180 may be very beneficial to the reducing cross-shank leakage.

[0030] FIG 6 is a partial-isometric view of a turbine bucket 155 and an embodiment of the seal 180, in accordance with an embodiment of the present invention. The seal 180 is designed to take advantage of two deterministic that are naturally acting on the turbine buckets 155, as the gas turbine 105 operates. First, a centrifugal force that may regularly apply tension. Second, is a force due to the pressure difference between the shank pocket 177 and an aft cooling purge 600 that may constantly force the seal 180 into the slot 175. This second force may help to maintain a relatively tight clearance.

[0031] An embodiment of the seal 180 may comprise the form of a strip of metal that is inserted between adjacent turbine buckets 155 and attached near the dovetail region associated with the mount 173. Here, the seal 180 may comprise an arm 185 with a hook 190 at an end. In an embodiment of the present invention, the hook 190 may be located at the portion of the seal 180 that is located near the mount 173. The hook 190 helps to position the seal 180 within the mating slot 175.

[0032] The seal 180 may prevent coolant flow from leaking through the shank pocket 177. The location of the seal 180 may be critical. As the turbine bucket 155 begins to rotate, the seal 180 may be in tension instead of compression. Here, compression may damage the seal 180. Operationally, a large pressure difference typically exists between the shank pocket 177 and the aft cooling purge 600. Here, the force exerted on the seal 180 may prevent leakage, as discussed.

[0033] FIG 7 illustrates another partial-isometric view of a rotating component 155 and a seal 180, in accordance with an embodiment of the present invention. An embodiment of the seal 180 may be manufactured of a relatively thin sheet of metal that is generally flexible to conform to the surfaces of the mating slot 175, and provide a desired seal against the intrusion of the working fluid. The material utilized for the seal 180 should be selected to withstand the pressures and temperatures associated with a specific application and to allow for some plastic deformation. The seal 180 may plastically deform in response to the thermal and centrifugal loads to conform and fit the contours of the slot 175. The plastic deformation may provide a desired seal against the intrusion of the working fluid and may minimize leakage of cooling/ purge flow.

[0034] FIG 7 illustrates reference locations for the following dimensional ranges, in accordance with embodiments of the present invention. However, it is not the intent to limit the present invention to the following dimensional ranges. In an embodiment of the present invention a width ("W") of the seal 180 may comprise a range of from about 0.2 inches to about 1.0 inch. In an embodiment of the present invention a length ("L") of the seal 180 may comprise a range of from about 2.0 inches to about 10.0 inches. In an embodiment of the present invention a thickness ("T") of the seal 180 may comprise a range of from about 0.1 inches to about 0.5 inches. The shape of the hook 190 may include an arc portion, a polygon or combinations thereof. In an embodiment of the present invention a diameter ("D") of the arc of the hook 190 may comprise a range of from about 0.2 inches to about 1.0 inch.

[0035] In addition to the above benefits, embodiments of the present invention may allow continued use or turbine buckets 155 having relatively larger shanks 170, while minimizing cross-shack leakage with a simple seal 180. Embodiments of the seal 180 may improve the overall performance and efficiency of the gas turbine 105.

[0036] Although specific embodiments have been illustrated and described herein, those of ordinary skill in the art appreciate that any arrangement, which is calculated to achieve the same purpose, may be substituted for the specific embodiments shown and that the invention has other applications in other environments. This application is intended to cover any adaptations or variations of the present invention. The following claims are in no way intended to limit the scope of the invention to the specific embodiments described herein.

[0037] As one of ordinary skill in the art will appreciate, the many varying features and configurations described above in relation to the several embodiments may be further selectively applied to form other possible embodiments of the present invention. Those in the art will further understand that all possible iterations of the present invention are not provided or discussed in detail, even though all combinations and possible embodiments embraced by the several claims below or otherwise are intended to be part of the instant application. In addition, from the above description of several embodiments of the invention, those skilled in the art will perceive improvements, changes, and modifications. Such improvements, changes, and modifications within the skill of the art are also intended to be covered by the appended claims. Further, it should be apparent that the foregoing relates only to the described embodiments of the present application and that numerous changes and modifications may be made herein without departing from the spirit and scope of the application as defined by the following claims and the equivalents thereof.

Claims

1. A system comprising:

a rotatable component (155) comprising:
an airfoil portion (165) comprising a first end, an opposite second end, and suction and pressure surfaces located between the first end and the opposite second end;
a shank portion (170) comprising a mount (173) and a slot (175), wherein the slot (175) is positioned near a wall and is adjacent a downstream edge of the airfoil portion (165);
a platform portion (167) that connects the airfoil portion (165) to the shank portion (170);

a seal (180) comprising:

an arm portion (185); and
a hook portion (190);
wherein the arm and hook portions (185,190) are shaped to mate with the slot (175) such that the slot (175) restrains the movement of the seal (180);
wherein the seal (180) is sized to substantially prevent a cooling flow from leaking through a shank pocket (177).

2. The system of claim 1, wherein the rotatable component (155) is located in a turbine section (150) of an air-ingesting turbomachine (100).

3. The system of claim 1, wherein the rotatable component (155) is located in a compressor section (105) of an air-ingesting turbomachine (100).

4. The system of any of claims 1 to 3, wherein the seal (180) is maintained in the slot (175) by a pressure difference between the shank pocket (177) and a purge flow (600) associated with an aft end of the rotatable component (155).

5. The system of an of claims 1 to 4, wherein the width of the seal (180) comprises a range of from about 0.2 inches to about 1.0 inch.

6. The system of any preceding claim, wherein a length of the seal (180) extends from the platform (167) to the mount (173).

7. The system of any preceding claim, wherein a length of the seal (180) comprises a range of from about 2.0 inches to about 10.0 inches.

8. The system of any preceding claim, wherein a thickness of the seal (180) comprises a range of from about 0.1 inches to about 0.5 inches.

9. The system of any preceding claim, wherein a shape of the hook portion (190) includes: an arc portion, a polygon, or combinations thereof.

10. The system of claim 9, wherein a diameter of the arc portion comprises a range of from about 0.2 inches to about 1.0 inch.

11. A gas turbine (100) comprising: a compressor section (105) and a turbine section (150);
a turbine bucket (155) installed in the turbine section (150), the turbine bucket comprising the system of any of claims 1 to 10.

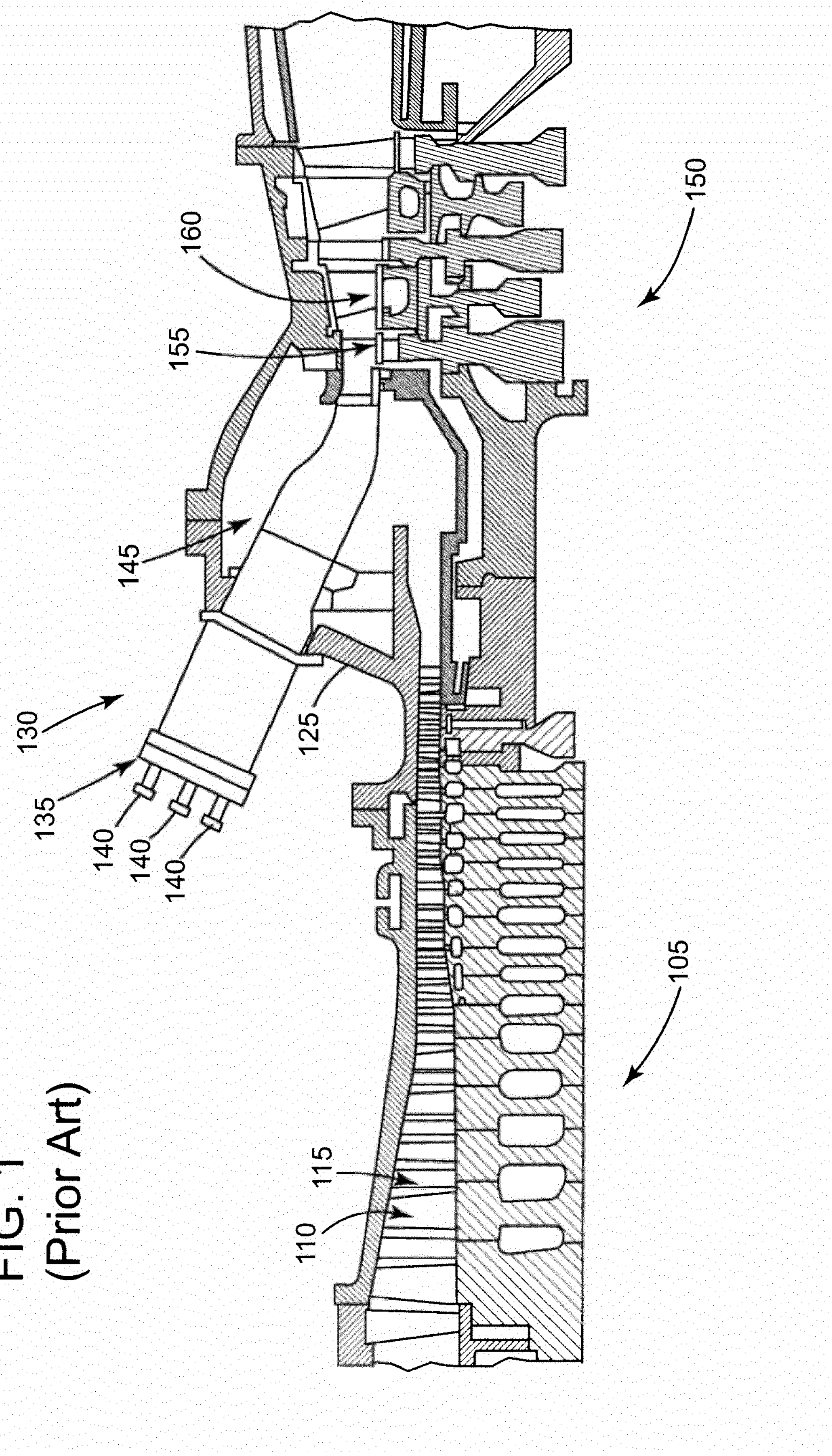

FIG. 1
(Prior Art)

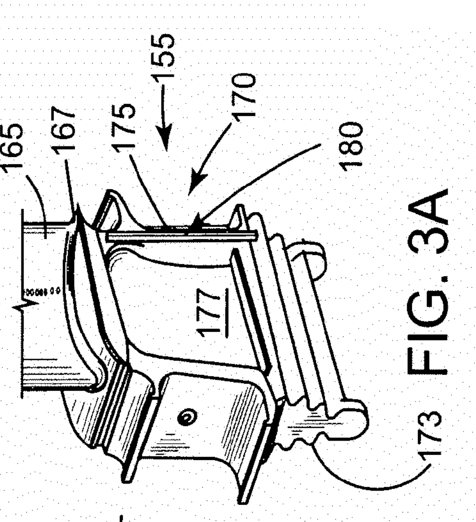

FIG. 3A

FIG. 3A

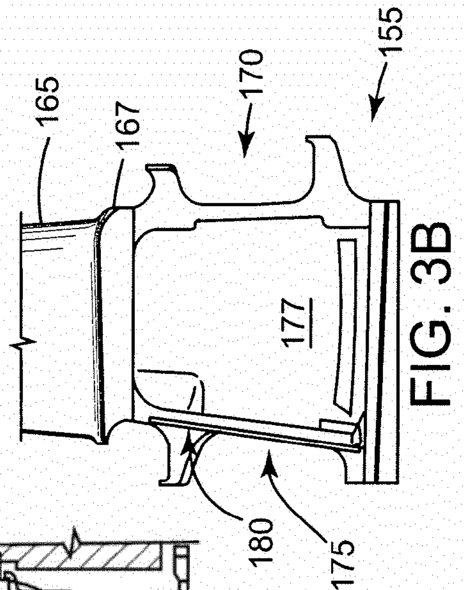

FIG. 3B

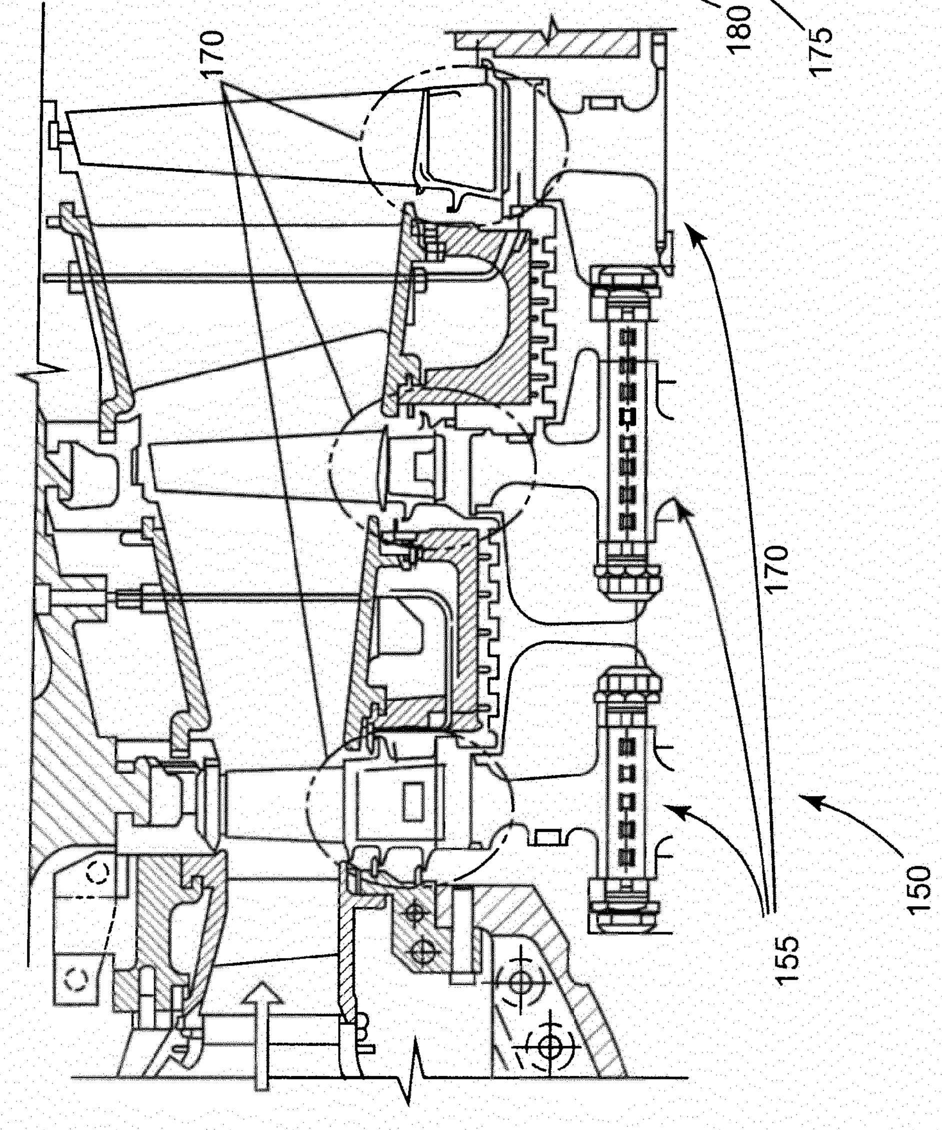

FIG. 2
Prior Art

FIG. 4

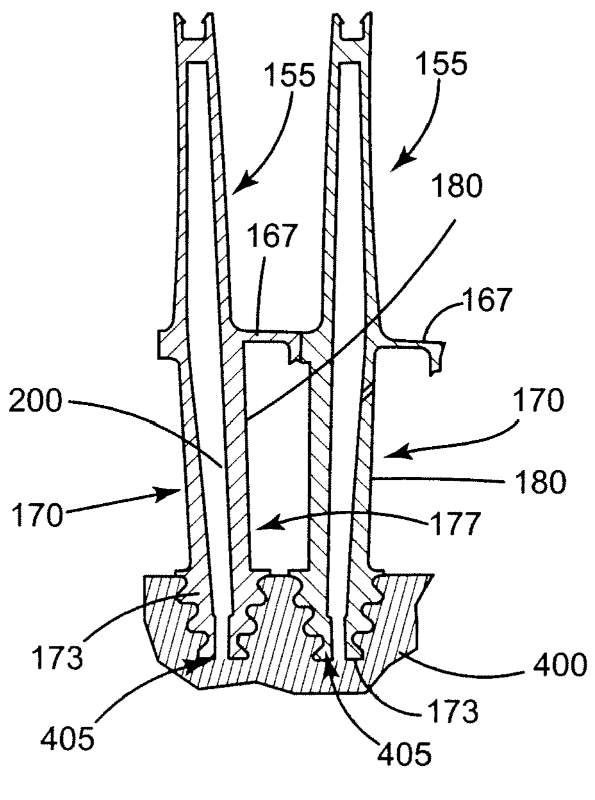

FIG. 5

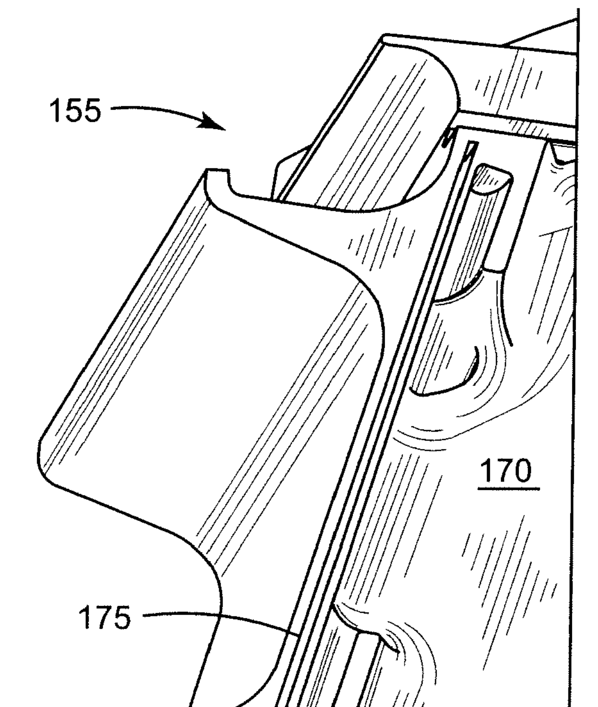

FIG. 6

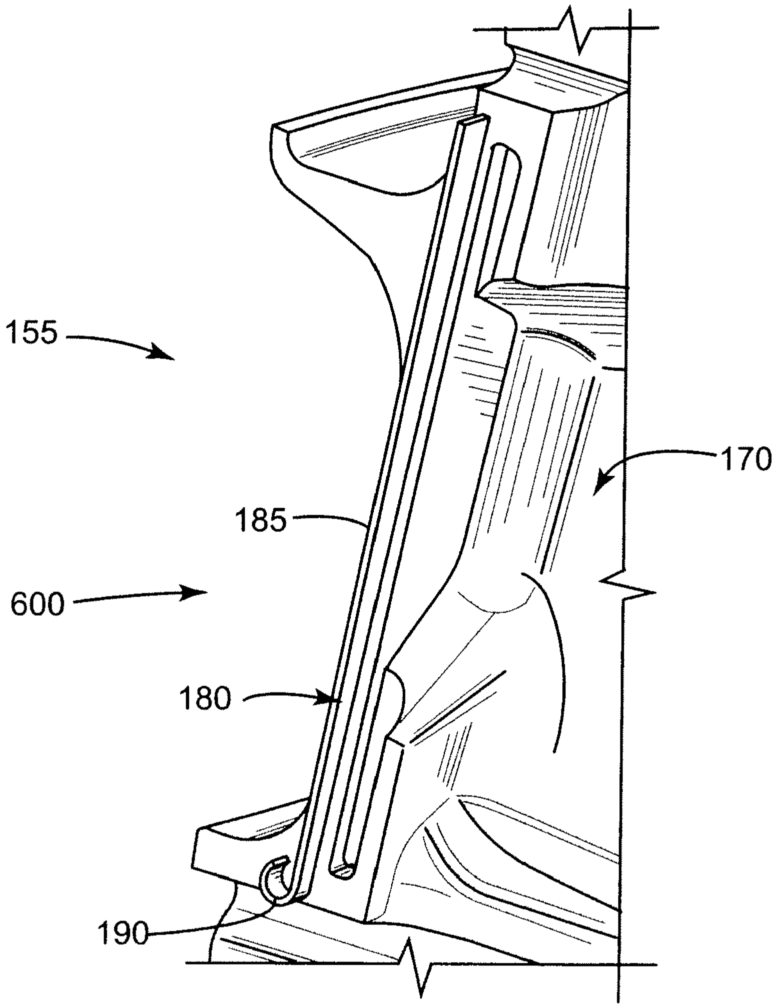

FIG. 7