US 20140056716A1

(19) United States
(12) Patent Application Publication
Messmann et al.
(10) Pub. No.: US 2014/0056716 A1
(43) Pub. Date: Feb. 27, 2014

(54) **BICAST TURBINE ENGINE COMPONENTS**

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(21) Appl. No.: **14/071,687**

(22) Filed: **Nov. 5, 2013**

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/752,460, filed on Apr. 1, 2010.

Publication Classification

(51) **Int. Cl.**
F01D 5/22 (2006.01)

(52) **U.S. Cl.**
CPC ***F01D 5/22*** (2013.01)
USPC .... **416/96 R**; 416/212 R; 164/98

(57) **ABSTRACT**

A turbine blade assembly includes a turbine blade having a pressure sidewall and an opposed suction sidewall and a first snubber assembly associated with one of the pressure sidewall and the suction sidewall. The first snubber assembly includes a first base portion extending outwardly from the one of the pressure sidewall and the suction sidewall, and a first snubber portion. The first base portion is integrally cast with the turbine blade and includes first connection structure. The first snubber portion is bicast onto the first base portion and includes second connection structure that interacts with the first connection structure to substantially prevent separational movement between the first base portion and the first snubber portion.

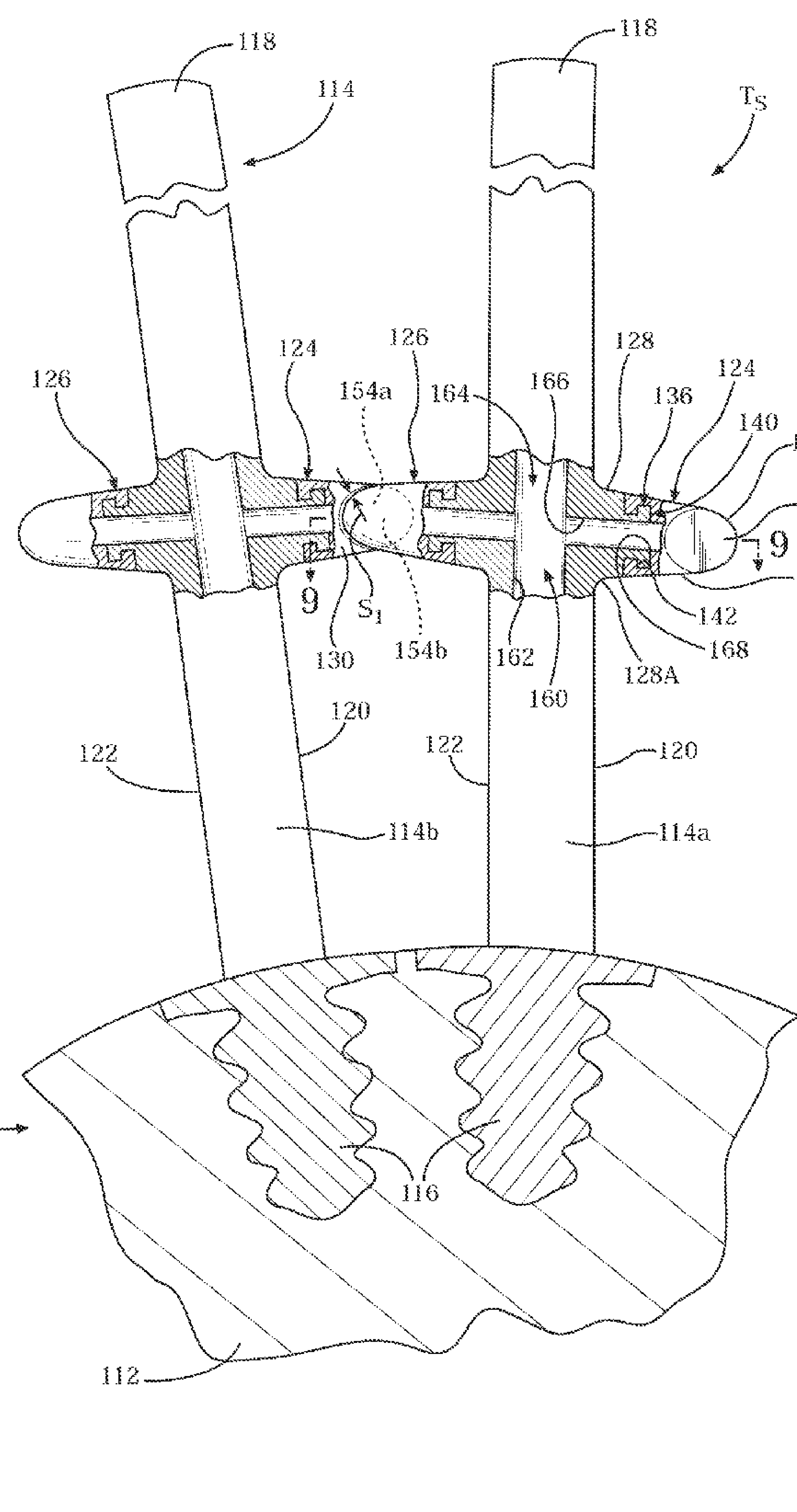

FIG 1

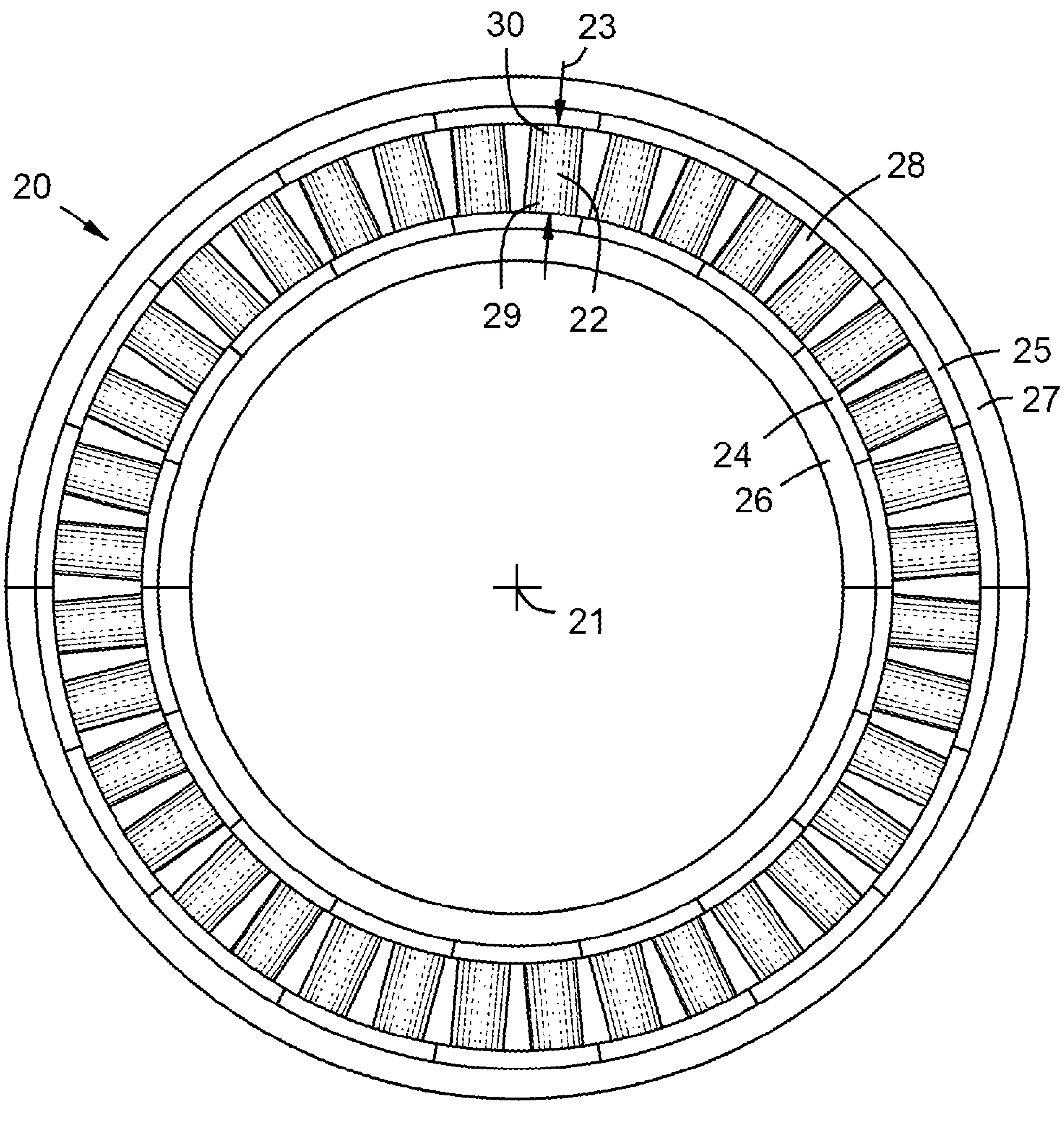

FIG 2

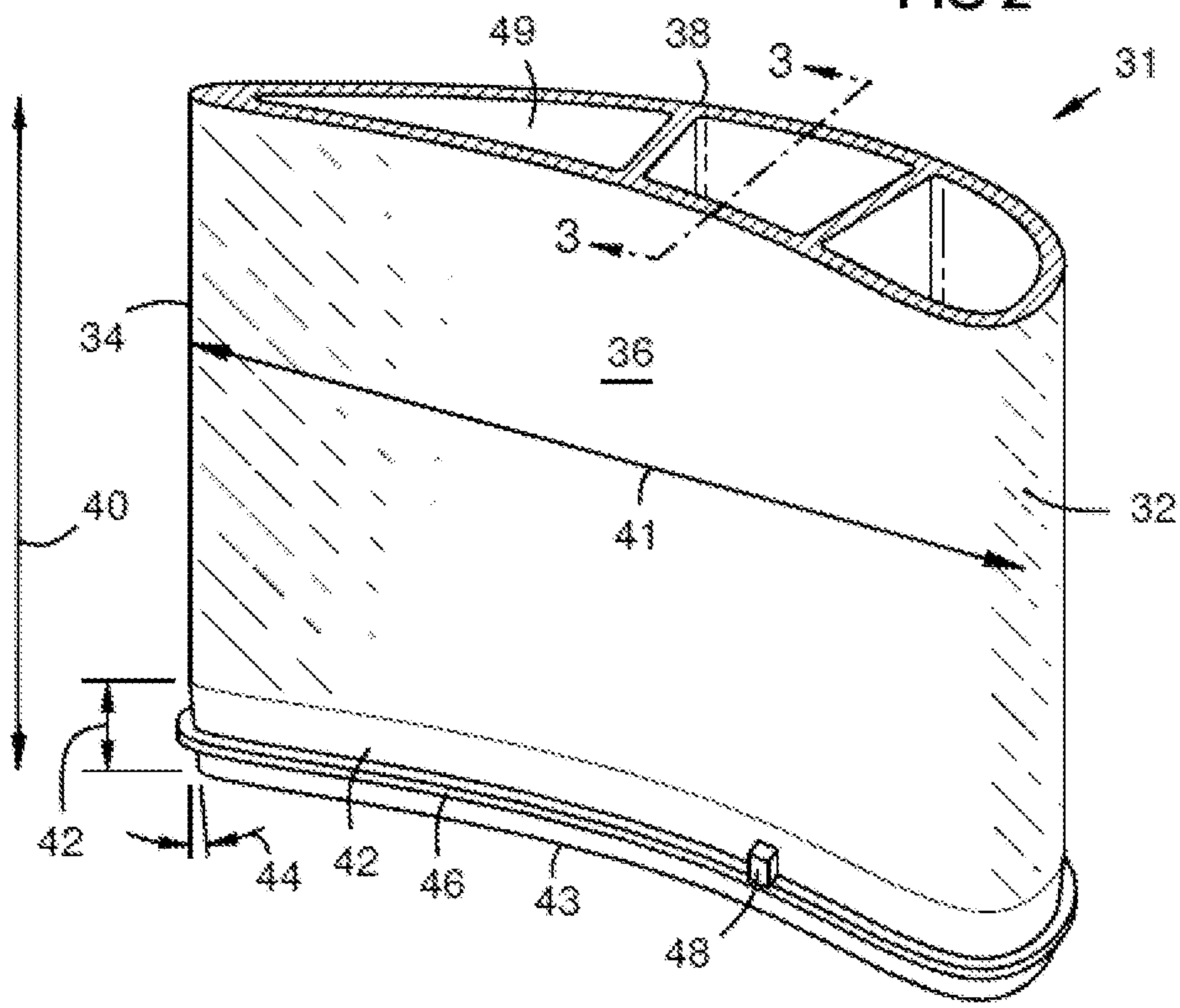
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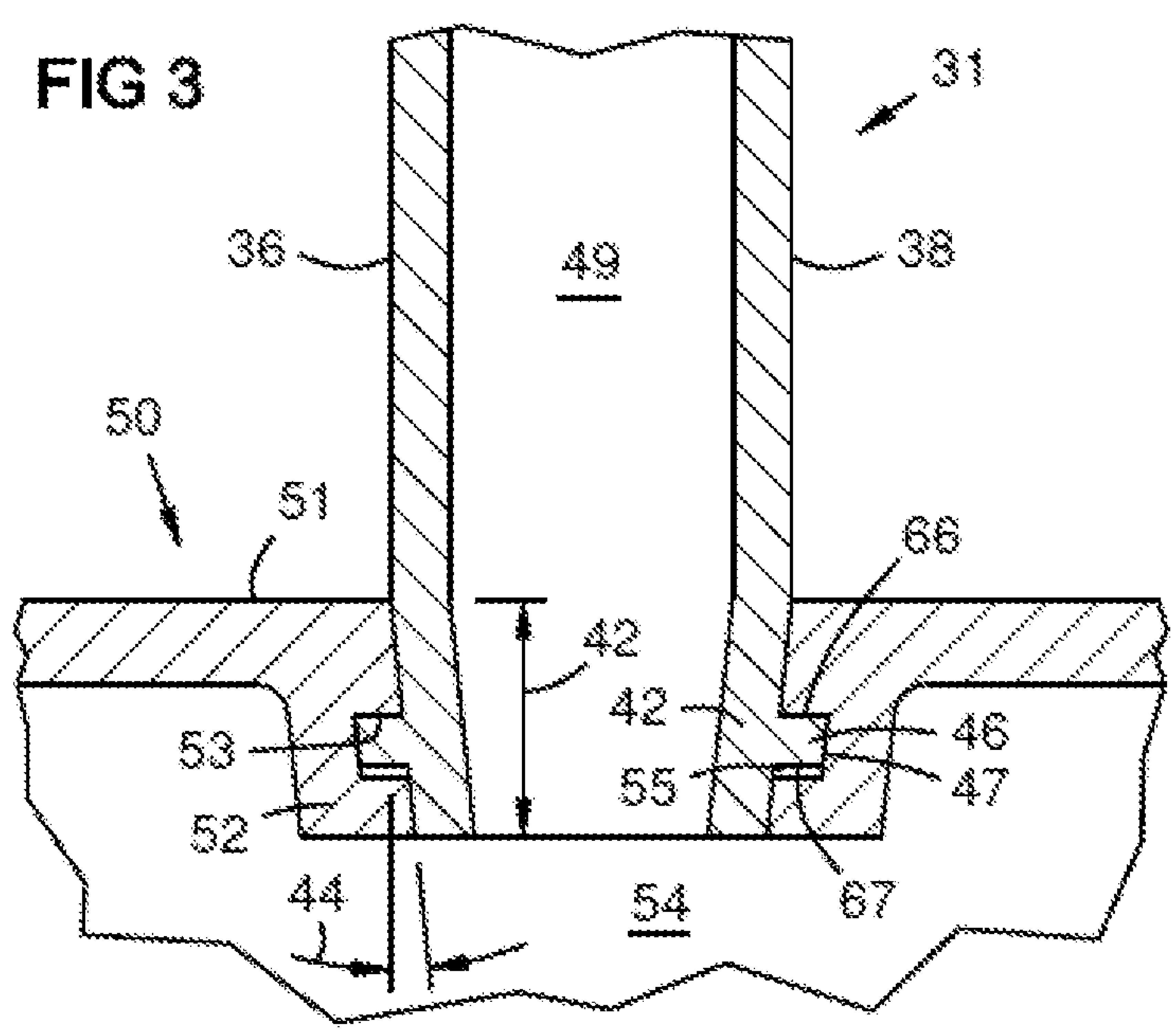
FIG 3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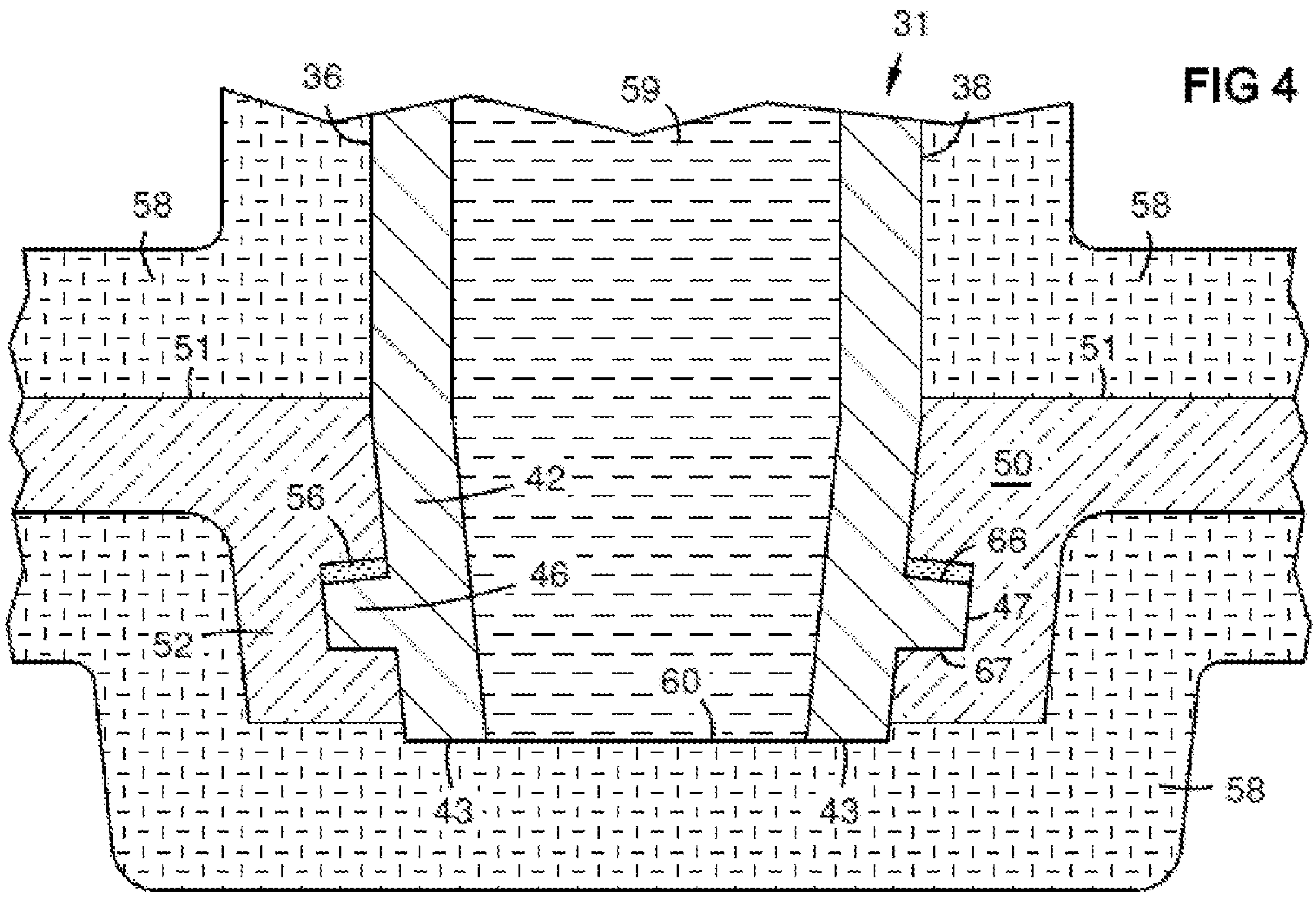
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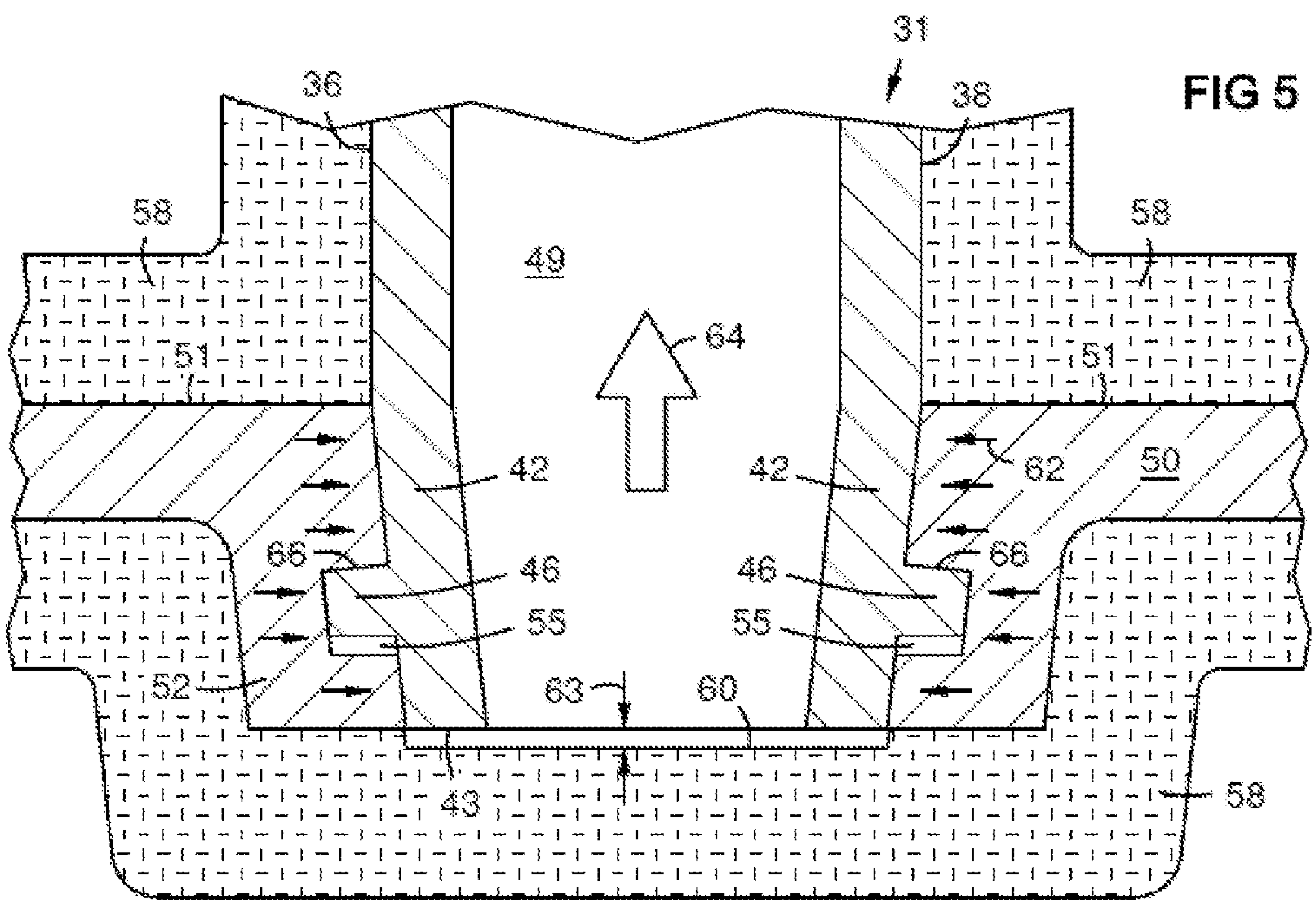
FIG 4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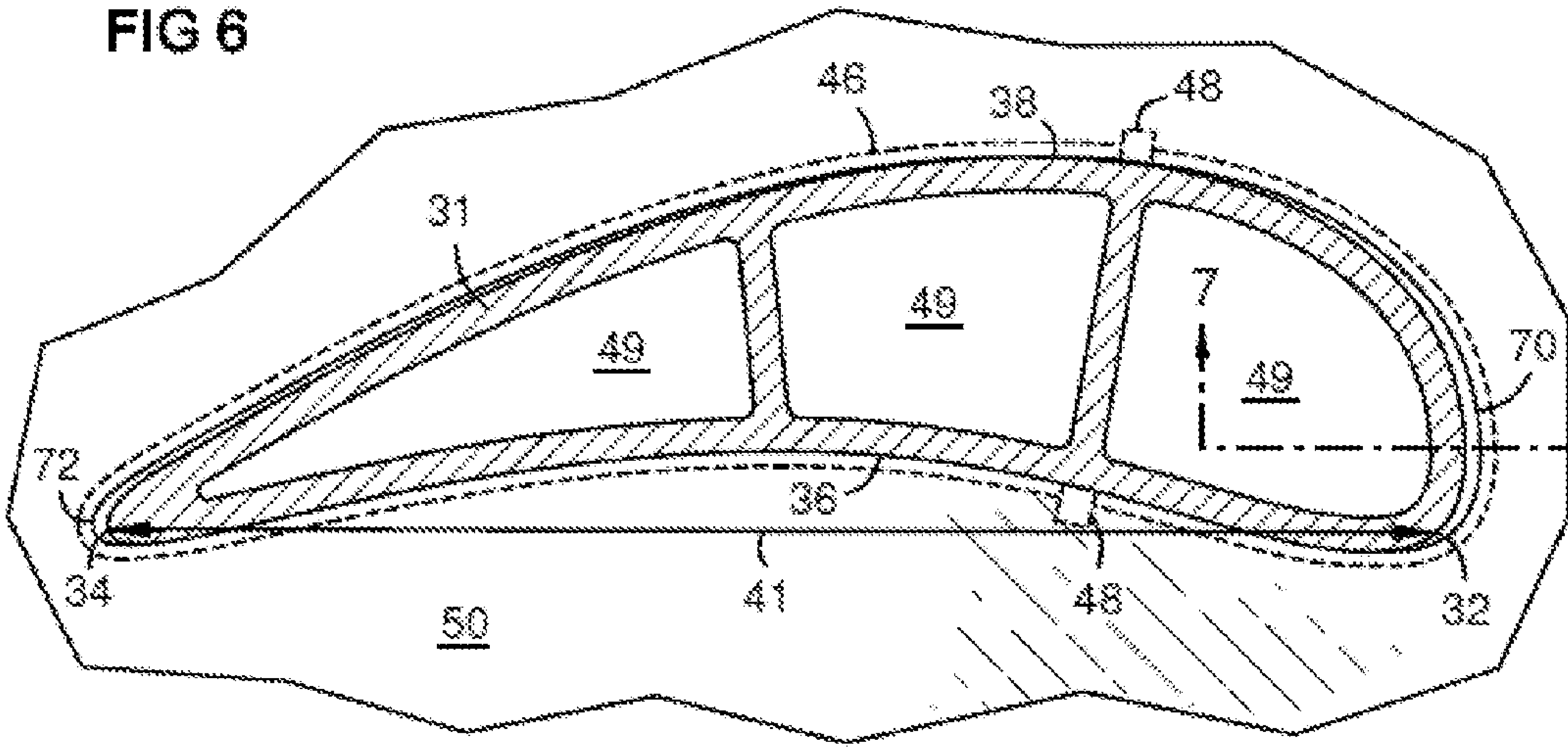
58

FIG 5

FIG 6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72
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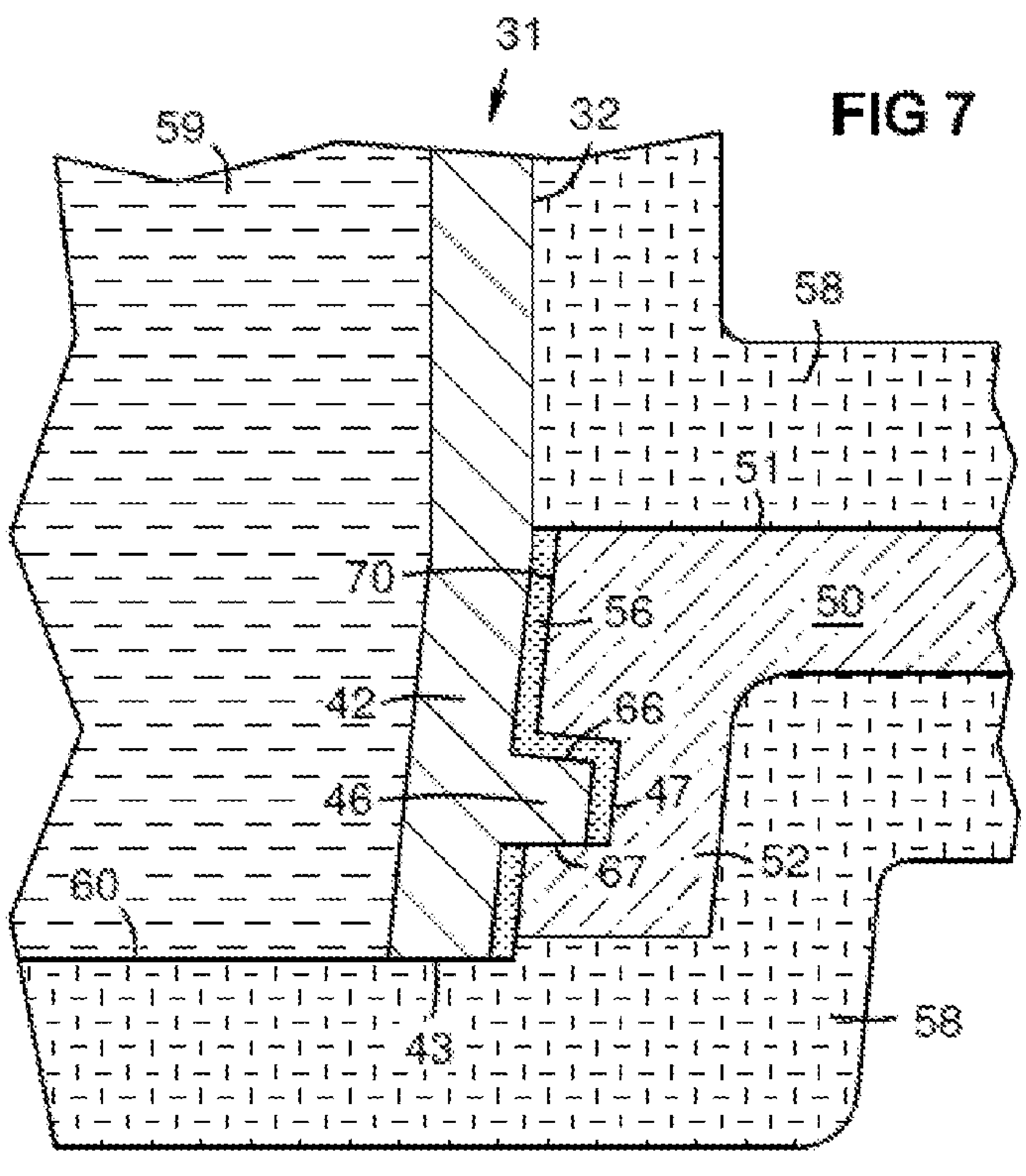
FIG 7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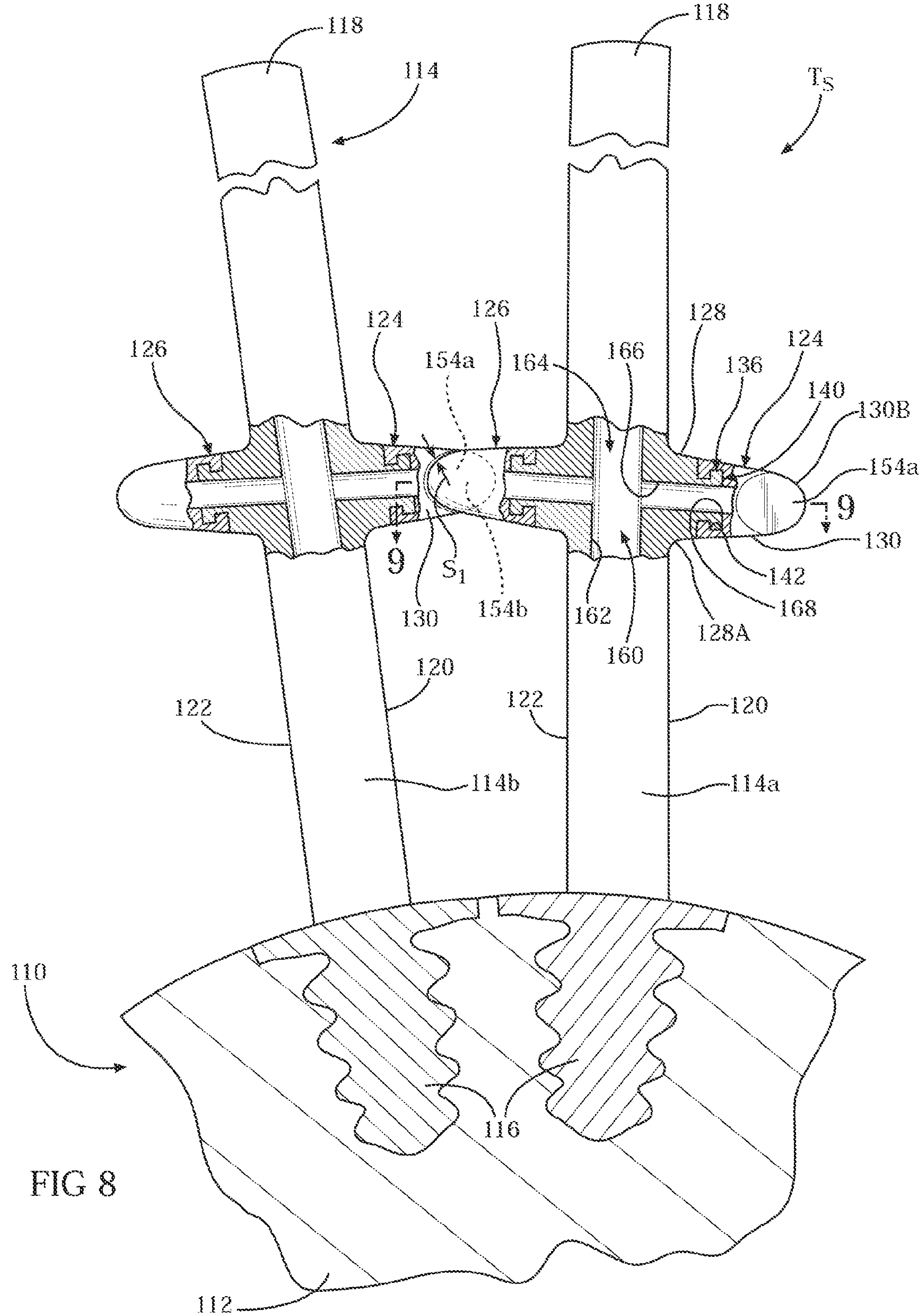
118
118
114
T_S
126
124
126
128
124
154a
164
166
136
140
130B
154a
9
9
130
S_1
154b
162
160
128A
168
142
130
120
122
122
120
114b
114a
110
116
112

FIG 8

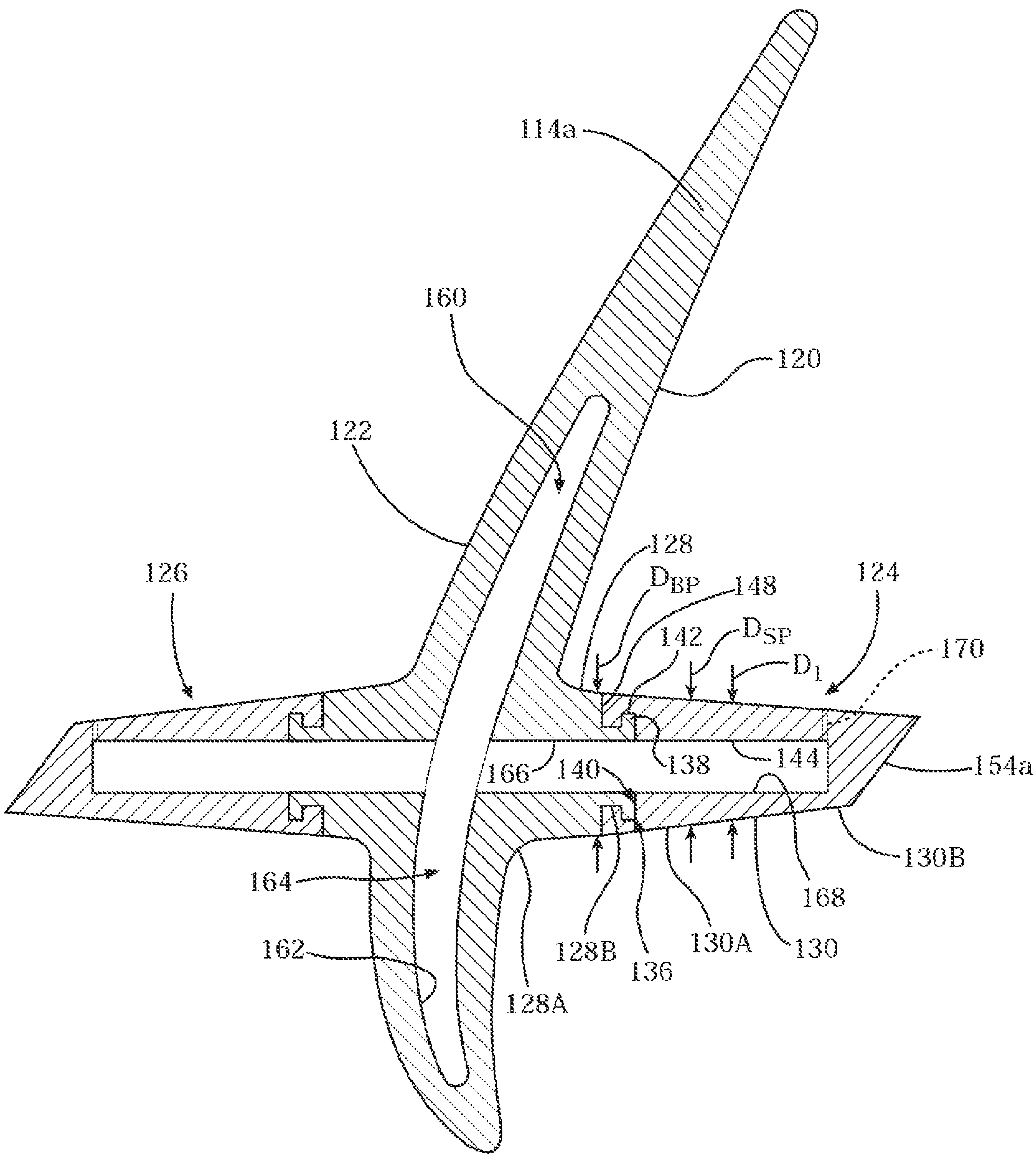
114a
160
120
122
128
126
D_{BP}
148
124
142
D_{SP}
D_1
170
138
144
154a
166
140
164
168
130B
128B
136
130A
130
162
128A

FIG 9

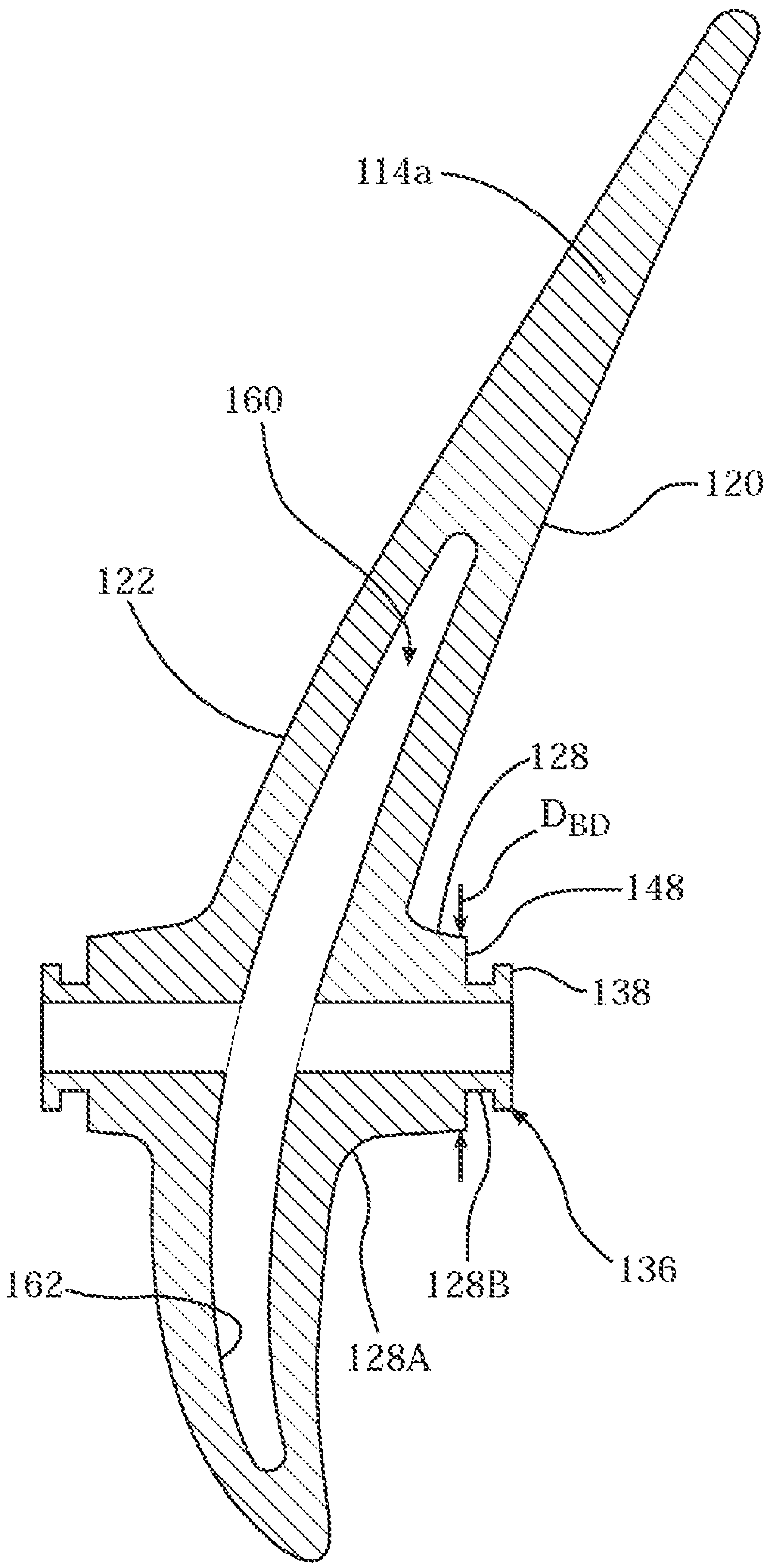

FIG 10

BICAST TURBINE ENGINE COMPONENTS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation-In-Part of U.S. patent application Ser. No. 12/752,460, filed Apr. 1, 2010 and entitled "TURBINE AIRFOIL TO SHROUD ATTACHMENT" by Christian X. Campbell et al., the entire disclosure of which is incorporated by reference herein.

[0002] This invention was made with U.S. Government support under Contract Number DE-FC26-05NT42644 awarded by the U.S. Department of Energy. The U.S. Government has certain rights to this invention.

FIELD OF THE INVENTION

[0003] The present invention relates generally to couplings between components in a turbine engine, and, more particularly, to bicast couplings between turbine engine components, such as turbine blades and snubber assemblies.

BACKGROUND OF THE INVENTION

[0004] A turbomachine, such as a steam or gas turbine is driven by a hot working gas flowing between rotor blades arranged along the circumference of a rotor so as to form an annular blade arrangement, and energy is transmitted from the hot working gas to a rotor shaft through the rotor blades. As the capacity of electric power plants increases, the volume of flow through industrial turbine engines has increased more and more and the operating conditions (e.g., operating temperature and pressure) have become increasingly severe. Further, the rotor blades have increased in size to harness more of the energy in the working gas to improve efficiency. A result of all the above is an increased level of stresses (such as thermal, vibratory, bending, centrifugal, contact and torsional) to which the rotor blades are subjected.

[0005] In order to limit vibrational stresses in the blades, various structures may be provided to the blades to form a cooperating structure between blades that serves to dampen the vibrations generated during rotation of the rotor. For example, mid-span snubber structures, such as cylindrical standoffs, may be provided extending from mid-span locations on the blades for engagement with each other. Two mid-span snubber structures are typically located at the same height on either side of a blade with their respective contact surfaces pointing in opposite directions. The snubber contact surfaces on adjacent blades are separated by a small space when the blades are stationary. However, when the blades rotate at full load and untwist under the effect of the centrifugal forces, snubber surfaces on adjacent blades come in contact with each other to dampen vibrations by friction at the contacting snubber surfaces.

SUMMARY OF THE INVENTION

[0006] In accordance with one aspect of the invention, a turbine blade assembly is provided in a turbine engine. The turbine blade assembly comprises a turbine blade having a pressure sidewall and an opposed suction sidewall and a first snubber assembly associated with one of the pressure sidewall and the suction sidewall. The first snubber assembly comprises a first base portion extending outwardly from the one of the pressure sidewall and the suction sidewall, and a first snubber portion. The first base portion is integrally cast with the turbine blade and includes first connection structure. The first snubber portion is bicast onto the first base portion and includes second connection structure that interacts with the first connection structure to substantially prevent separational movement between the first base portion and the first snubber portion.

[0007] In accordance with a second aspect of the invention, a coupling is provided between two components in a turbine engine. The coupling comprises a first component formed by a first casting procedure and including first connection structure comprising one of a continuous annular ridge and a continuous annular groove, and a second component bicast onto the first component during a second casting procedure and having second connection structure comprising the other of a continuous annular ridge and a continuous annular groove. The second connection structure interacts with the first connection structure to substantially prevent separational movement between the first component and the second component.

[0008] In accordance a third aspect of the invention, a method is provided for forming a turbine blade assembly. A first casting procedure is performed to form: a turbine blade having a pressure sidewall and an opposed suction sidewall; and a base portion of a snubber assembly, the base portion extending from one of the pressure sidewall and the suction sidewall. A second casting procedure is performed by casting a snubber portion onto the base portion such that first connection structure of the base portion interacts with second connection structure of the snubber portion to substantially prevent separational movement between the base portion and the snubber portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] While the specification concludes with claims particularly pointing out and distinctly claiming the present invention, it is believed that the present invention will be better understood from the following description in conjunction with the accompanying Drawing Figures, in which like reference numerals identify like elements, and wherein:

[0010] FIG. **1** schematically illustrates a prior art ring of vanes centered on an axis;

[0011] FIG. **2** is a partial perspective view of a vane airfoil according to aspects of the present invention;

[0012] FIG. **3** is a sectional view taken along line **3-3** of FIG. **2** including a partial shroud platform;

[0013] FIG. **4** is a sectional view of a stage of bi-casting of a platform on an end portion of a vane in which the platform is molten;

[0014] FIG. **5** is a sectional view of a stage of bi-casting in which the platform has solidified and contracted and fugitive materials have been removed;

[0015] FIG. **6** shows a partial plan view of a platform with a vane in section

[0016] FIG. **7** shows a sectional view taken along line **7-7** of FIG. **6**;

[0017] FIG. **8** is a partial end view of a rotor partially in section, as viewed in an axial flow direction, taken in a plane perpendicular to an axis of rotation and showing another embodiment of the present invention;

[0018] FIG. **9** is a cross sectional view of only a first turbine blade taken on the plane indicated by the line **9-9** in FIG. **8**; and

[0019] FIG. **10** is a view similar to that of FIG. **9** after a first casting procedure has been performed but before a second casting procedure, also referred to as a bicasting procedure or a bicast, has been performed in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0020] In the following detailed description of the preferred embodiment, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration, and not by way of limitation, a specific preferred embodiment in which the invention may be practiced. It is to be understood that other embodiments may be utilized and that changes may be made without departing from the spirit and scope of the present invention.

[0021] FIG. **1** illustrates a prior art ring **20** of stationary vanes **22** centered on an axis **21** in a turbine. Each vane **22** is an airfoil with first and second ends **29**, **30**. The vane spans radially **23** between inner and outer shroud segments or platforms **24**, **25**. Herein "radially" means perpendicular to the axis **21** and "axially" means generally parallel to the axis **21**, although is noted that the terms "inner", "outer", "radial", "axial", "circumferential", and the like, as used herein, are not intended to be limiting with regard to orientation of the elements recited for the present invention. The platforms **24**, **25** may be attached to respective inner and outer ring structures **26**, **27**, which may be support rings and/or cooling air plenum structures. Between each pair of vanes **22** is a working gas flow passage **28**. In a gas turbine, the vanes **22** direct a combustion gas flow against an adjacent downstream ring of rotating blades not shown. Individual vane segments are traditionally cast with one or more airfoils per pair of inner/outer platforms **24**, **25** to form what is sometimes called a nozzle. For large industrial gas turbine vanes, easily cast alloys (e.g. the cobalt based alloy ECY-768) may be cast with two or three airfoils per vane segment, while alloys that are more difficult to cast (e.g. nickel based superalloys such as IN939 and CM247LC) are limited to single airfoil vane segments.

[0022] FIGS. **2** and **3** show a portion of a turbine airfoil **31**, also referred to herein as a first component, according to an embodiment of the invention. It has leading and trailing edges **32**, **34**, pressure and suction sides **36**, **38**, an end **43**, and an end portion **42** with a taper **44** and a ridge **46**, also referred to herein as first connection structure, with proximal and distal sides **66**, **67**. The ridge **46** may surround the airfoil continuously or discontinuously along the pressure side, leading edge, suction side, and trailing edge. A radial spanwise dimension **40** is defined along a length of the airfoil. A chordwise dimension **41** is defined between the leading and trailing edges **32**, **34**, and may be considered as being parallel to a working gas containment surface **51** at the connection under consideration.

[0023] A tab **48** may extend from the pressure and/or suction sides of the end portion **42** to function in cooperation with an associated vane platform to define an origin for differential expansion and contraction of the platform in the chordwise dimension. Tab **48** may be located for example at a mid-chord position or at a maximum airfoil thickness position as shown in FIG. **6**. The opposite end of the airfoil **31** (not shown) may use the same connection type as the shown end portion **42** or it may use a different connection type. Cooling chambers **49** may be provided in the airfoil.

[0024] FIG. **3** is a sectional view taken along line **3**-**3** of FIG. **2**. A bi-cast platform **50**, also referred to herein as a second component, has a working gas containment surface **51** and a collar portion **52** that holds the end portion **42** of the airfoil **31**. It may have a cooling air plenum **54**. The ridge **46** has a proximal side **66** that contacts a proximal side **53** of a bi-cast groove, also referred to herein as second connection structure, surrounding the ridge **46** in the collar **52** to create a coupling between the airfoil **31** and the platform **50**, which coupling substantially prevents separational movement between the airfoil **31** and the platform **50**, although in the illustrated embodiment clearance **55** is provided in the groove below the ridge **46** for spanwise differential expansion of the airfoil **31**. The ridge **46** may have a top surface **47** aligned with the adjacent taper angle **44**.

[0025] The taper angle **44** may vary around the airfoil to accommodate varying amounts of differential contraction of the platform **50** and collar **52** at different points around the curvature of the airfoil. The taper angle on the pressure side **36** may be less than on the suction side in order to equalize pressure on the various contact surfaces. In an exemplary engineering model, a taper angle of 3-5 degrees on the pressure side and 50% greater than the pressure side taper angle on the suction side was found to be advantageous—for example, 4 degrees on the pressure side and 6 degrees on the suction side. The optimum angles depend on the airfoil shape.

[0026] FIG. **4** illustrates a stage of bi-casting, also referred to herein as a second casting procedure, in a mold **58** in which the platform **50** material is molten. The mold material may encapsulate the airfoil. The airfoil **31** may be filled with a fugitive ceramic core **59** to block the molten alloy from entering the cooling chambers. The tapered end **42** of the airfoil is placed in the mold **58**. The mold may have a positioning depression **60** that fits the end **43** of the airfoil to a given depth **63** best seen in FIG. **5**. For example, this depth may be equal to the clearance **55**. Prior to placing the airfoil in the mold, a layer of fugitive material **56** may be applied to the proximal side **66** of the ridges **46** as shown.

[0027] FIG. **5** illustrates a stage of bi-casting after the platform **50** has solidified and further cooled. The platform **50** shrinks **62** as it cools. The airfoil **31** shrinks less than the platform due to a temperature differential during bi-casting. Molten metal is poured or injected into the mold **58**. The airfoil stays cooler than the platform during bi-casting. As an example, the temperature of the airfoil end portion **42** may reach about 900.degree. C. when the platform solidifies at about 1300.degree. C. Cooling from this point causes differential shrinkage that compresses **62** the collar **52** onto the tapered end portion **42** of the airfoil. This pushes **64** the airfoil upward in the drawing, or proximally with respect to the airfoil, due to the reverse wedging effect of the taper **44**. The taper angle should be high enough to overcome the high contact friction between the contacting surfaces to allow sliding.

[0028] FIG. **6** shows a partial plan view of a platform **50** with a vane **31** in section. Stress relief slots **70**, **72** may be provided at the leading edge **32** and/or trailing edge **34** to accommodate platform contraction during casting, and airfoil expansion during operation. These slots **70**, **72** may be formed with a fugitive material such as alumina and/or silica coating deposited by slurry or a spray process that is chemically leached away after casting. This may be a continuation of the fugitive material **56** on the ridge **46**. The leaching chemical may reach the fugitive material on the ridge **46** via the stress relief slots **70**, **72**. The slots **70**, **72** may extend across the tapered end portion as seen in FIG. **7**. They may extend in respective leading and trailing chordwise directions **41**.

[0029] FIG. **7** shows a sectional view taken along line **7-7** of FIG. **6**, illustrating a stage of bi-casting with fugitive material **56** on the leading edge of the tapered end portion **42** to form a leading edge stress relief slot **70**.

[0030] The combination of stress relief slots **70**, **72**, spanwise clearance gap **55**, and varying taper angles **44** provides substantially uniformly distributed contact pressures in the connection over a range of operating temperatures and differential thermal expansion conditions. The connection allows a limited range of relative movement, maintains a gas seal along the contact surfaces, minimizes vibration, minimizes stress concentrations, and provides sufficient contact area and pressure for rigidity and stability of the vane ring assembly.

[0031] The use of bi-casting enables less costly repair should the platform become damaged in service. The platform can be cut off, saving the high-value airfoil, and then a new replacement platform can be bi-cast onto the airfoil.

[0032] Referring now to FIG. **8**, a portion of a turbine section T_S in a gas or steam turbine engine is illustrated. A rotor **110** illustrated in FIG. **8** comprises a rotor disc **112** and a plurality of blades **114**, illustrated herein as an exemplary first blade **114***a* and an adjacent exemplary second blade **114***b*. The blades **114***a*, **114***b* comprise radially elongated structures extending from a blade root **116** engaged with the rotor disc **112** to a blade tip **118**. Each of the blades **114***a*, **114***b* includes a pressure sidewall **120** and a suction sidewall **122** opposed form the pressure sidewall **120**. It is noted that the blades **114***a*, **114***b* and rotor disc **112** illustrated in FIG. **8** and the blade **114***a* illustrated in FIG. **9** are schematically shown and may have other configurations than as shown without departing from the scope and spirit of the invention.

[0033] Each of the blades **114***a*, **114***b* further includes first and second snubber assemblies **124**, **126** located generally mid-span between the blade root **116** and the blade tip **118** of each of the blades **114***a*, **114***b*.

[0034] The first snubber assembly **124** associated with the first blade **114***a* will now be described, it being understood that the first snubber assemblies **124** of the other blades **114** are substantially identical to the first snubber assembly **124** described herein. As shown in FIGS. **8** and **9**, the first snubber assembly **124** comprises a first base portion **128** extending from the pressure sidewall **120** of the first blade **114***a* at a first end **128**A of the first base portion **128**, and a first snubber portion **130** affixed to the first base portion **128**. As shown in FIGS. **8** and **9**, the first snubber assembly **124** is a tapered member having an outer diameter D_1 (see FIG. **9**) that decreases as the first snubber assembly **124** extends away from the pressure sidewall **120** of the first blade **114***a*, although it is understood that the first snubber assembly **124** could have a generally constant outer diameter D_1 and/or could have other shapes or configurations as desired, such as, for example, elliptical, airfoil-shaped, etc.

[0035] As will be described herein, the first base portion **128** is cast integrally with the first blade **114***a* during a first casting procedure. The first base portion **128** and the first blade **114***a* may be formed, for example, from an equiaxed material or a directionally solidified material. More specifically, the base portion **128** and the first blade **114***a* may be formed, for example from a nickel based superalloy, such as CM247CC or CM247DS.

[0036] The first snubber portion **130** is cast onto the first base portion **128** of the first snubber assembly **124** during a second casting procedure, also referred to herein as a bicasting procedure or a bicast. The first snubber portion **130** is formed from a material that preferably has good oxidation, corrosion, and/or creep resistance characteristics. It is noted that the first snubber portion **130** may preferably be formed from the same/similar material as the first base portion **128** and the first blade **114***a* such that each of these components has the same or similar coefficient of thermal expansion, although the first snubber portion **130** may be formed from a different material than the first base portion **128** and the first blade **114***a*.

[0037] As shown in FIGS. **8** and **9**, the first base portion **128** includes first connection structure **136** comprising an annular ridge **138** (see FIGS. **9** and **10**) or flange that extends radially outwardly from a second end portion **128**B of the first base portion **128** distal from the first blade **114***a*, wherein the second end portion **128**B has a reduced diameter than a remainder of the first base portion **128**. The first connection structure **136** may be formed in the first base portion **128** during the first casting procedure, or may be formed in the first base portion **128** during a material removal procedure, e.g., a grinding, electro-discharge machining, or waterjet machining procedure, subsequent to the first casting procedure. The first snubber portion **130** includes second connection structure **140** comprising an annular groove **142** or recess that extends radially outwardly from an inner wall **144** of the first snubber portion **130** near a first end portion **130**A of the first snubber portion **130**, see FIG. **9**. The second connection structure **140**, which is formed in the first snubber portion **130** during the bicasting procedure, receives the first connection structure **140** to create a coupling between the snubber portion **130** to the first base portion **128**, i.e., to secure the first snubber portion **130** to the first base portion **128**. That is, the second connection structure **140** interacts with the first connection structure **136** to substantially prevent separational movement between the first base portion **128** and the first snubber portion **130** during operation of the engine, which separational movement between the first base portion **128** and the first snubber portion **130** is substantially prevented by the first and second connection structures **136**, **140** without a bonding material.

[0038] As shown most clearly in FIG. **9**, the first base portion **128** and the first snubber portion **130** have substantially equivalent outer diameters D_{BP}, D_{SP} at a junction **148** therebetween such that there is substantially no discontinuity of the first snubber assembly **124** at the junction **148**. Hence, the first snubber assembly **124** being formed from two pieces, i.e., the first base portion **128** and the first snubber portion **130**, is not believed to adversely affect flow characteristics through the turbine section T_s of the engine when compared to prior art one-piece snubber assemblies.

[0039] A second end portion **130**B of the first snubber portion **130** in the embodiment shown defines a first angled surface **154***a*. The first angled surface **154***a* is spaced from a corresponding angled surface **154***b* of a snubber portion **130** of a snubber assembly **124** of the adjacent second blade **114***b*, such that a first space S_1 or gap is formed therebetween, see FIG. **8**.

[0040] Referring now to FIG. **9**, the first blade **114***a* includes a cooling circuit **160** comprising at least one cooling passage **162** in a hollow interior portion **164** of the first blade **114***a*. It is noted that while a single cooling passage **162** is schematically shown in the hollow interior portion **164** of the first blade **114** *a* in FIG. **9**, one skilled in the art will recognize that there are many types of configurations for cooling passages within turbine blades, such that the present invention is not intended to be limited to any specific type of internal blade cooling configuration. The cooling passage **162** receives cooling fluid, such as compressor discharge air, for cooling the first blade **114***a* during operation of the engine.

[0041] In accordance with an aspect of the present invention, the first base portion **128** of the first snubber assembly **124** includes an opening **166** formed therein, which opening **166** is in communication with the cooling passage **162** within the first blade **114***a*. The opening **166** may comprise a central bore formed in the first base portion **128**, which may be formed during the first casting procedure or subsequent to the first casting procedure during a machining operation. The opening **166** receives cooling fluid from the cooling passage **162** for cooling the first snubber assembly **124**.

[0042] The first snubber portion **130** in turn includes a cooling passageway **168** defined by the inner wall **144**, which cooling passageway **168** is in communication with the opening **166** in the first base portion **128**, see FIG. **9**. The cooling passageway **168** may comprise a central bore formed in the first snubber portion **130**, which may be formed during the bicasting procedure or subsequent to the bicasting procedure during a machining operation. The cooling passageway **168** receives cooling fluid from the opening **166** for cooling the first snubber portion **130**.

[0043] The first snubber portion **130** also includes at least one cooling fluid outlet **170** that discharges cooling fluid in the cooling passageway **168** from the first snubber assembly **124**, see FIG. **9**. While the illustrated first snubber assembly **124** includes only a single cooling fluid outlet **170** located near the second end portion **130**B of the first snubber portion **130**, the first snubber assembly **124** may include one or more additional cooling fluid outlets, which may be positioned in any suitable location.

[0044] The second snubber assembly **126** associated with the first blade **114***a* extends from the suction sidewall **124** of the first blade **114***a* but is otherwise generally a mirror image of the first snubber assembly **124** associated with the first blade **114***a*. The second snubber assembly **126** (and the second snubber assemblies **126** associated with the remaining blades **114**) will thus not be described in detail herein.

[0045] It is noted that while the illustrated first blade **114***a* includes the cooling circuit **160**, the present invention is not intended to be limited to blades including cooling circuits. For example, the snubber assemblies **124**, **126** described herein, which are formed by first and second casting procedures, could also be used with blades that are not cooled by internal cooling circuits. In such a case, the snubber assemblies **124**, **126** would not need to include the openings **166** or cooling passageways **168**.

[0046] During operation of the engine, centrifugal forces are exerted on the blades **114** and first and second snubber structures **124**, **126** as a result of the rotation of the blades **114** with the rotor **110**. These centrifugal forces cause the blades **114** to "untwist", which causes the first and second angled surfaces **154***a*, **154***b* of the respective snubber structures **124**, **126** to move toward each other to engage each other with a damping force. It should be noted that it is desirable to configure the snubber structures **124**, **126** to produce a damping force that is sufficient to produce damping at the interface between the snubber structures **124**, **126** to control blade vibration.

[0047] Referring to FIGS. **8-10**, a method will now be described for forming a turbine blade assembly including a blade, e.g., the first blade **114***a*, and first and second snubber assemblies, e.g., the first and second snubber assemblies **124**, **126**.

[0048] The first blade **114***a* and the base portions **128** of the first and second snubber assemblies **124**, **126** are formed during a first casting procedure. The resulting structure is illustrated in FIG. **10**, although, as noted above, the first connection structures **136** can be formed in the second end portions **128**B of the base portions **128** of the first and second snubber assemblies **124**, **126** during the first casting procedure or during a subsequent material removal operation. The openings **166** in the base portions **128** of the first and second snubber assemblies **124**, **126** can also be formed during the first casting procedure or during a subsequent material removal operation.

[0049] Thereafter, the snubber portions **130** of the first and second snubber assemblies **124**, **126** are formed during a second casting procedure, wherein the second connection structures **140** of the snubber portions **130** of the first and second snubber assemblies **124**, **126** interact with the first connection structures **136** of the base portions **128** of the first and second snubber assemblies **124**, **126** to substantially prevent separational movement between the snubber portions **130** and the base portions **128** of the first and second snubber assemblies **124**, **126**.

[0050] By forming the snubber assemblies **124**, **126** via first and second casting procedures, difficulties associated with the formation of prior art snubber assemblies are avoided. For example, prior art attempts to cast the entire snubber assembly with the blade during a single casting procedure have resulted in snubber assemblies having significant defects or deformities, which must be repaired to be suitable for use. In addition prior art attempts at casting a base portion of a snubber assembly with the blade during a first casting procedure and then affixing a snubber portion to the base portion by welding, brazing, or other technique using a bonding material are expensive and often result in damage to the blade, base portion, and/or snubber portion. These difficulties of the prior art are avoided by the formation of snubber assemblies using two casting procedures as disclosed herein.

[0051] While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

What is claimed is:

1. A turbine blade assembly in a turbine engine comprising:

a turbine blade having a pressure sidewall and an opposed suction sidewall; and

a first snubber assembly associated with one of the pressure sidewall and the suction sidewall and comprising:

a first base portion extending outwardly from the one of the pressure sidewall and the suction sidewall, the first base portion being integrally cast with the turbine blade and including first connection structure; and

a first snubber portion bicast onto the first base portion and having second connection structure that interacts with the first connection structure to substantially prevent separational movement between the first base portion and the first snubber portion.

2. The turbine blade assembly of claim **1**, wherein the first connection structure comprises one of an annular ridge and an annular groove and the second connection structure comprises the other of an annular ridge and an annular groove.

3. The turbine blade assembly of claim **1**, wherein the first base portion and the first snubber portion have substantially equivalent outer diameters at a junction therebetween such that there is substantially no discontinuity of the first snubber assembly at the junction.

4. The turbine blade assembly of claim **1**, wherein the outer diameter of the first snubber portion decreases as the first snubber portion extends away from the turbine blade.

5. The turbine blade assembly of claim **1**, wherein separational movement between the first base portion and the first snubber portion is substantially prevented by the first and second connection structures without a bonding material.

6. The turbine blade assembly of claim **1**, wherein the first base portion includes an opening formed therein in communication with a cooling passage within the turbine blade, the opening receiving cooling fluid from the cooling passage.

7. The turbine blade assembly of claim **6**, wherein the first snubber portion includes a cooling passageway in communication with the opening in the first base portion, the cooling passageway receiving cooling fluid from the opening.

8. The turbine blade assembly of claim **7**, wherein the first snubber portion includes at least one cooling fluid outlet that discharges cooling fluid in the cooling passageway from the first snubber assembly.

9. The turbine blade assembly of claim **1**, further comprising:

- a second snubber assembly associated with the other of the pressure sidewall and the suction sidewall and comprising:
  - a second base portion extending outwardly from the other of the pressure sidewall and the suction sidewall, the second base portion being integrally cast with the turbine blade and including third connection structure; and
  - a second snubber portion bicast onto the second base portion and having fourth connection structure that interacts with the third connection structure to substantially prevent separational movement between the second base portion and the second snubber portion.

10. A coupling between two components in a turbine engine comprising:

- a first component formed by a first casting procedure and including first connection structure comprising one of a continuous annular ridge and a continuous annular groove; and
- a second component bicast onto the first component during a second casting procedure and having second connection structure comprising the other of a continuous annular ridge and a continuous annular groove, the second connection structure interacting with the first connection structure to substantially prevent separational movement between the first component and the second component.

11. The coupling of claim **10**, wherein the first component and the second component have substantially equivalent outer diameters at a junction therebetween such that there is substantially no discontinuity between the first and second components at the junction.

12. The coupling of claim **10**, wherein separational movement between the first component and the second component is substantially prevented by the first and second connection structures without a bonding material.

13. A method for forming a turbine blade assembly comprising:

- performing a first casting procedure to form:
  - a turbine blade having a pressure sidewall and an opposed suction sidewall; and
  - a base portion of a snubber assembly, the base portion extending from one of the pressure sidewall and the suction sidewall;
- performing a second casting procedure comprising:
  - casting a snubber portion onto the base portion such that first connection structure of the base portion interacts with second connection structure of the snubber portion to substantially prevent separational movement between the base portion and the snubber portion.

14. The method of claim **13**, wherein:

- the first connection structure is machined into the base portion after the first casting procedure and comprises one of an annular ridge and an annular groove; and
- the second connection structure comprises the other of an annular ridge and an annular groove.

15. The method of claim **13**, wherein the base portion and the snubber portion are cast to have substantially equivalent outer diameters at a junction therebetween such that there is substantially no discontinuity of the snubber assembly at the junction.

16. The method of claim **13**, wherein separational movement between the base portion and the snubber portion is substantially prevented by the first and second connection structures without a bonding material.

17. The method of claim **13**, wherein the base portion is cast to include an opening in communication with a cooling passage cast within the turbine blade, the opening for receiving cooling fluid from the cooling passage during operation of an engine including the turbine blade assembly.

18. The method of claim **17**, wherein the snubber portion is cast to include a cooling passageway in communication with the opening in the base portion, the cooling passageway for receiving cooling fluid from the opening during operation of the engine.

19. The method of claim **18**, further comprising forming at least one cooling fluid outlet in the snubber portion, the at least one cooling fluid outlet for discharging cooling fluid in the cooling passageway from the snubber assembly during operation of the engine.

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