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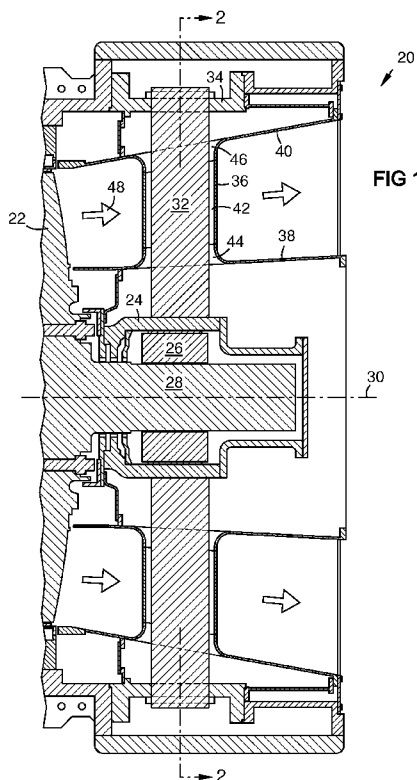
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(54) Title: MANUFACTURING METHOD FOR STRUT SHIELD COLLAR OF GAS TURBINE EXHAUST DIFFUSER



(57) Abstract: A method for casting a collar (44, 46) for a heat shield (36) of a strut (32) in a gas turbine exhaust section (20). A casting geometry (60, 70) is defined with extra wall thickness (56, 68) in an area of wall curvature (53, 54), which provides a flow path beyond a final geometry of the collar to facilitate a flow of molten metal in the mold (63, 64). The extra thickness is removed after casting, leaving the collar in its final geometry, which may have uniform wall thickness (T, T2). The extra thickness in the casting geometry may be provided by increased radius (R3) in the wall curvature and/or by casting feed portals (66, 68) that span the wall curvature between a tubular portion (50) and a flange (52) of the collar.



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MANUFACTURING METHOD FOR STRUT SHIELD COLLAR OF GAS TURBINE EXHAUST DIFFUSER

FIELD OF THE INVENTION

The invention relates to manufacturing methods for support structures in a gas turbine exhaust section, and particularly to manufacturing of end collars for exhaust diffuser strut shields.

BACKGROUND OF THE INVENTION

A gas turbine (GT) exhaust diffuser is a divergent annular duct formed between inner and outer annular shells through which the exhaust gas passes. The cross-sectional area of the duct progressively increases in the flow direction. This serves to reduce the speed of the exhaust flow and increase its pressure. The exhaust gas may have a temperature of 550-650° C. or more. This causes thermal stresses on components of the exhaust section due to operational thermal gradients and cyclic fatigue from GT starts and shutdowns. Such stresses are concentrated at interconnections between support structures due to differential thermal expansion.

A circular array of struts span between the aft hub of the turbine shaft and the surrounding cylindrical case of the exhaust section. Each strut is surrounded by a heat shield connected between the inner and outer diffuser shells. Each shield is a tube with a cross section that surrounds the strut and provides coolant space along the strut. Stress concentrations occur in a collar at each end of the heat shield. The collars attach the heat shield to the respective diffuser shell.

Components in the exhaust flow path are often made of superalloy materials. These are metal alloys that maintain strength and resist creep, corrosion, and oxidation at high temperatures. The base element is usually nickel, cobalt, or nickel-iron. An example is the Inconel® family of austenitic nickel-chromium based superalloys. Such materials are difficult to cast in complex thin-wall shapes because they solidify quickly around sharp corners of a mold, resulting in low yield and/or defects. Pressure and/or vacuum may be used to accelerate the casting flow, but this adds expense compared to a gravity feed casting process.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is explained in the following description in view of the drawings that show:

FIG. 1 is an axial sectional view of an exhaust section of a gas turbine taken along line 1-1 of FIG. 2.

FIG. 2 is a transverse sectional view of the exhaust section taken along line 2-2 of FIG 1.

FIG. 3 is a perspective view of a heat shield collar.

FIG. 4 is a sectional view of a final geometry of a heat shield collar.

FIG. 5 is a sectional view of a casting geometry of a heat shield collar.

FIG. 6 is a sectional view of a final geometry of a heat shield collar being checked with a template.

FIG. 7 is a conceptual sectional view of a casting mold for the casting geometry of FIG 5.

FIG. 8 is a conceptual sectional view of a casting mold for the casting geometry of FIG 9.

FIG. 9 is a perspective view of a casting geometry with multiple feed portals spanning a curved transition area of the collar.

FIG. 10 is a sectional view of a heat shield collar with compound curvature in a transition area between the tubular portion and the flange.

DETAILED DESCRIPTION OF THE INVENTION

FIG 1 illustrates an exhaust section 20 behind a last row of rotating blades 22 of a gas turbine engine. A bearing hub 24 may extend into the exhaust section and enclose an aft bearing 26 that supports the turbine shaft 28 for rotation about an axis 30. Inner and outer diffuser liners or shells 38, 40 define a divergent annular flow path between them for the exhaust gas 48. Struts 32 span between the hub and a cylindrical casing 34 in a circular array. For conceptual clarity, FIG 1 appears as though the struts are oriented radially. However, they may be oriented tangentially to the hub as shown in FIG 2. Each strut is surrounded by a heat shield 36 connected between the inner 38 and outer 40 diffuser shells. Each shield is a tube that surrounds the strut and may provide a coolant space 42 along the strut. An inner collar 44 and an outer collar 46 on

each shield 36 attach the shield to the respective diffuser shell 38, 40. These collars may be welded to the shield and the diffuser along butt joints for a smooth gas flow surface.

Because the collars have complex geometries and relatively thin wall thicknesses, it has traditionally been necessary to design such collars to have varying wall thicknesses in different portions of the collar to facilitate the flow of molten metal during casting in order to achieve acceptable casting yield rates. The present inventors have realized that such prior art collars generate undesired levels of stress during thermal transients due to their varying wall thicknesses. In order to reduce such stress, the present inventors have developed collars 44 with more uniform wall thicknesses than in prior art designs, and have further developed manufacturing methods which allow such complex, thin-wall components to be cast successfully.

FIG 2 is a transverse sectional view of the GT exhaust section 20 of FIG 1. A hub 24 encloses an aft bearing 26 that supports the turbine shaft 28. A circular array of struts 32 connects the hub to the casing 34 for mutual support. The struts may be oriented tangentially to the hub as shown to accommodate differential thermal expansion between the hub, struts, and case. Each strut is surrounded by a heat shield 36 connected between the inner 38 and outer 40 diffuser shells. An inner collar 44 and an outer 46 collar are used to attach each heat shield to the respective diffuser shell 38, 40.

FIG 3 is a perspective view of a heat shield collar 44. The inventors recognized that an ideal collar would be uniformly cast in a superalloy material with a tubular portion 50 for welding the collar to the shield and a flared welding flange 52 for welding the collar to the diffuser shell. It should have uniformly thin walls for uniform thermal expansion and cooling. However, due to the tangential orientation of the struts and the shape of the diffuser shells, the tubular portion 50 of the collar is oblique to the flange 52. This creates a sharply curved transition portion 54 that is difficult to cast with uniformly thin walls in a superalloy material by gravity feed without defects. The transverse section of the tubular portion 50 may have a generally aerodynamic shape, which may or may not include a sharp trailing edge. In an aspect of one embodiment, it may have a racetrack shape as shown with two parallel sides and two rounded ends.

FIG 4 illustrates a final geometry of an inner collar 44, with a tubular portion 50, a flange 52, and a smoothly curved transition 53, 54 there between. A target uniform wall thickness may be an overall uniform wall thickness T as shown. Alternately it may be a uniform maximum thickness dimension around both of the curved transition portions 53, 54. A first portion 53 of the transition has a curvature angle $A1$ of less than 90 degrees. A second portion 54 of the transition has a curvature angle $A2$ of greater than 90 degrees. Angles $A1$ and $A2$ are not supplementary due the curvature of the diffuser shell 38. The respective radii $R1$, $R2$ of the curved transition areas 53, 54 may be the same or different from each other (they are shown the same in this figure). A smaller radius and/or a greater curvature angle $A1$, $A2$ reduces the molten metal flow speed in the area of the angle within a casting mold. Angle $A1$ may be less than 85 degrees, and angle $A2$ may be greater than 100 degrees in a tangential strut design such as shown in FIG 2. Such angles represent casting restriction regions.

FIG 5 illustrates a casting geometry 60 of an inner collar that provides a tubular portion 50, a flange 52, and a smoothly curved transition 53, 54 or flare there between. In an aspect of the invention, the casting geometry provides extra wall thickness 56 for an additional flow path beyond the final geometry of FIG 4 (shown as a dashed line in FIG. 5) in one or both areas of curvature 53, 54, such as in the area of greater curvature 54. The extra wall thickness can be provided for example by increasing the radius of curvature $R3$ of the external surface 58 of an area of curvature 54 in the casting geometry. The additional thickness may be limited to the area of greater curvature 54, or it may be provided around the whole flare or around selected portions thereof. The extra wall thickness 56 represents a reduction in the restriction of the casting restriction region of the angle. The extra wall thickness may be removed, such as by machining or grinding, after casting so that the collar 44 achieves a final geometry. The material removal may be guided by manual templates or may be done by computer numerical control machine tools.

FIG 6 is a sectional view of a heat shield collar being checked with a template 61 having an edge 62 with a particular curvature of the final geometry. Checking may be done during manual machining or after computer numerical control machining. Either an overall uniform wall thickness $T1$ or a uniform maximum wall thickness dimension $T2$

around both of the curved transition areas 53, 54 may be achieved in the final geometry. T2 may thicker than T1.

FIG 7 is a conceptual view of a casting mold 63 used for creating the casting geometry of FIG 5.

FIG 8 is a conceptual view of a casting mold 64 with feed portals 66 that span curved transition areas of the casting geometry, thus providing extra flow paths and corresponding wall thicknesses 68 in the casting geometry beyond the final geometry. The extra thicknesses 68 are effective to reduce the casting restriction created by the sharply angled geometry of the final geometry. The extra thickness may be machined away post casting to achieve the final geometry, which may have uniform wall thickness as previously described. A plurality of such feed portals may be provided in an arrangement that provides uniform distribution and fast feeding of the molten metal by gravity.

FIG 9 is a perspective view of a casting geometry 70 with extra wall thickness 68 in areas provided by the flow paths of feed portals spanning curved transition areas 53, 54 between the tubular portion 50 and the flange 52. The feed portal walls may be tapered 71 relative to the final walls 50, 52, and may provide corner fillets 72 to minimize post casting stress concentrations.

FIG 10 is a sectional view of an inner heat shield collar 44 with a compound curve R2A, R2B in a transition 54 area between the tubular section 50 and the flange 52. The compound curve has a varying radius. For example, it may have a relatively shorter radius R2A adjacent the tubular section 50, and a relatively longer radius R2B adjacent the flange 52 as shown (exaggerated for clarity). The longer radius R2B reduces stress concentration in and near the flange 52 from expansion and contraction of the diffusion shell 38. The shorter radius R2A minimizes collar width compared to a single larger radius, thus minimizing impedance of exhaust flow around the collar. This compound curve may be elliptical for example or other curve shapes. The manufacturing method previously described facilitates such compound curvature by providing extra wall thickness in the casting geometry around the smaller radius R2A.

While various embodiments of the present invention have been shown and described herein, it will be obvious that such embodiments are provided by way of example only. Numerous variations, changes and substitutions may be made without

departing from the invention herein. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.

CLAIMS

The invention claimed is:

1. A method for manufacturing a collar for a gas turbine exhaust diffuser strut shield, the method comprising:

casting the collar of metal in a mold that provides a flow path defining a casting geometry of the collar in excess of a final geometry of the collar, wherein the flow path facilitates a flow of the metal through a casting restriction region into the final geometry; and then

removing excess metal beyond the final geometry to conform the collar to the final geometry.

2. The method of claim 1, wherein:

the metal is a superalloy;

the flow path in excess of the final geometry enables the flow of the superalloy into the mold without pressure or vacuum assistance; and

the casting is performed by gravity feed without pressure or vacuum assistance.

3. The method of claim 1, wherein:

the final geometry of the collar comprises a tubular portion with a flared flange on one end thereof and a smoothly curved transition there between;

the flange is disposed at an oblique angle relative to the tubular portion, and the transition varies from an area of lesser curvature angle on a first side of the tubular portion to an area of greater curvature angle on a second side thereof; and

the flow path in excess of the final geometry comprises space in the mold for an extra wall thickness in the collar along the area of greater curvature angle, and the removing step removes the extra wall thickness.

4. The method of claim 3, wherein the extra wall thickness is provided by increasing a radius of curvature of an exterior surface of the curved transition in the casting geometry over the final geometry.

5. The method of claim 3, further comprising providing the tubular portion and the welding flange with a uniform wall thickness in the final geometry.

6. The method of claim 3, wherein the curvature angle is less than 85 degrees on the first side of the tubular portion and greater than 100 degrees on the second side thereof.

7. The method of claim 3, further comprising casting the collar in a superalloy material that cannot flow around the area of greater curvature angle in the final geometry by gravity, but can flow around the area of greater curvature angle in the casting geometry via the flow path in excess of the final geometry by gravity.

8. The method of claim 1, wherein:
the final geometry of the collar comprises a tubular portion with a flared flange on one end thereof and a smoothly curved transition there between;
the flange is disposed at an oblique angle relative to the tubular portion, and the transition varies from an area of lesser curvature angle on a first side of the tubular portion to an area of greater curvature angle on a second side thereof; and
further comprising providing the flow path in excess of the final geometry by providing a plurality of mold feed portals, at least some of which span between the tubular portion and the flange across the transition area of greater curvature angle.

9. The method of claim 8, further comprising providing the tubular portion and the welding flange with a uniform wall thickness in the final geometry.

10. The method of claim 1, further comprising providing the final geometry with a uniform maximum thickness dimension around a curved transition area between a tubular portion and an oblique flared flange on an end of the tubular portion.

11. A product formed by the method of claim 1.

12. A product formed by the method of claim 3.

13. A product formed by the method of claim 8.

14. A method for manufacturing a collar for a gas turbine exhaust diffuser strut shield, the method comprising:

casting the collar in a casting geometry with extra wall thickness beyond that of a final geometry of the collar in a curved transition area between a tubular portion and an oblique flared flange on an end of the tubular portion, wherein the extra wall thickness facilitates a flow of a molten metal into the final geometry; and

removing the extra wall thickness beyond the final geometry, leaving the final geometry with a uniform maximum thickness dimension around the curved transition area.

15. The method of claim 14, further comprising:

providing the final geometry with the transition area varying from a curvature angle of less than 85 degrees on a first side of the collar to a curvature angle of greater than 100 degrees on a second side of the collar;

the extra wall thickness is provided in the transition area on at least the second side of the collar;

and the removing step leaves the final geometry with the uniform maximum thickness dimension in the transition area around both the first and second sides of the collar.

16. A product formed by the process of claim 15.

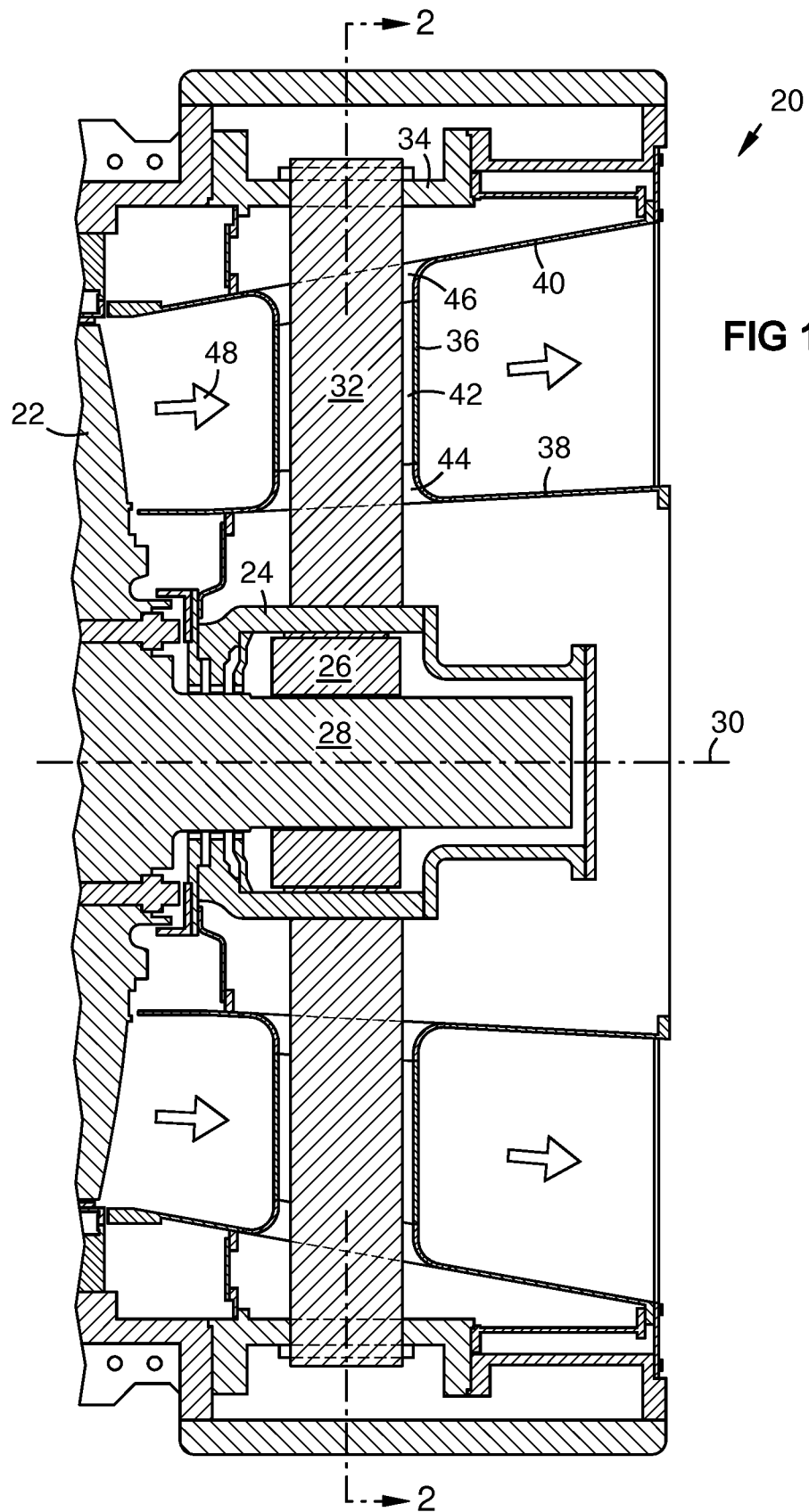
17. The method of claim 15, further comprising providing the extra wall thickness in the casting geometry by a plurality of casting feed portals that span across the transition area between the tubular portion and the flange on an inner surface of the casting geometry.

18. A product formed by the process of claim 17.

19. The method of claim 14, further comprising providing the transition area in the final geometry with a curvature of compound radius having a relatively shorter radius adjacent the tubular portion and a relatively longer radius adjacent the flange.

20. The method of claim 14, further comprising checking for the final geometry during the removing step with a manual template comprising an edge with a curvature of the transition area of the final geometry.

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FIG 2

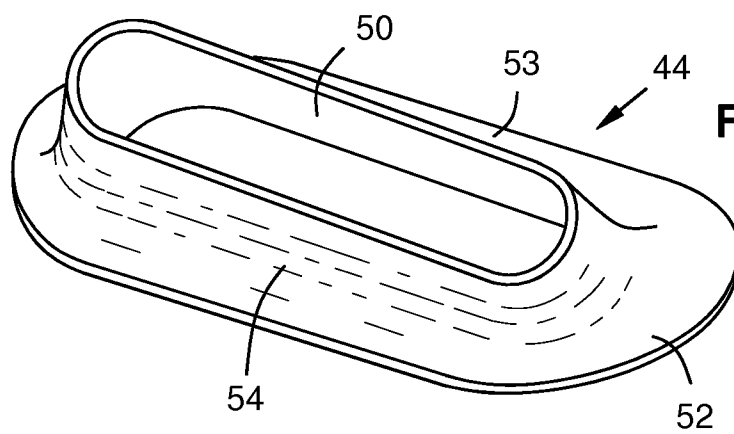
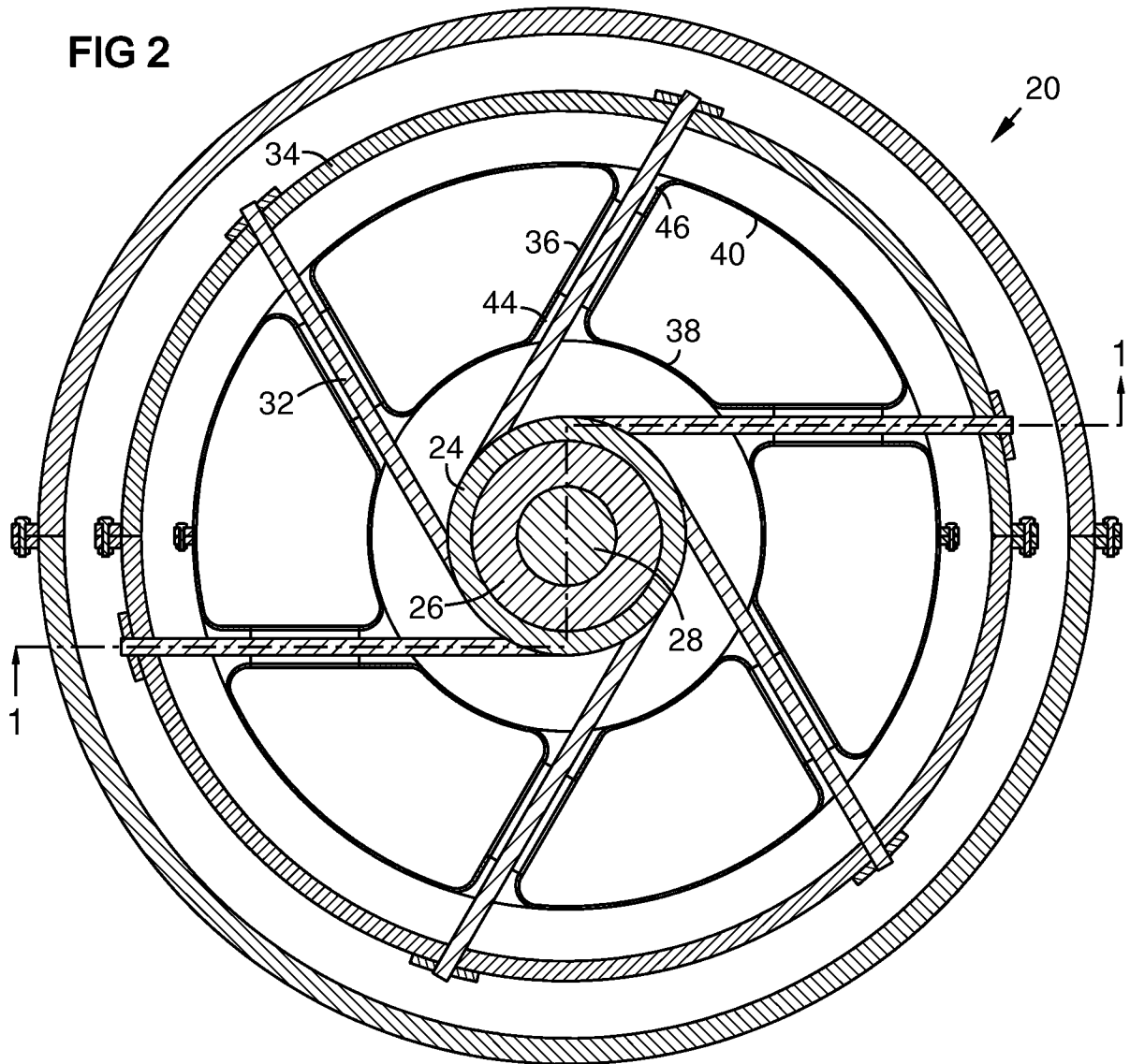


FIG 3

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FIG 4

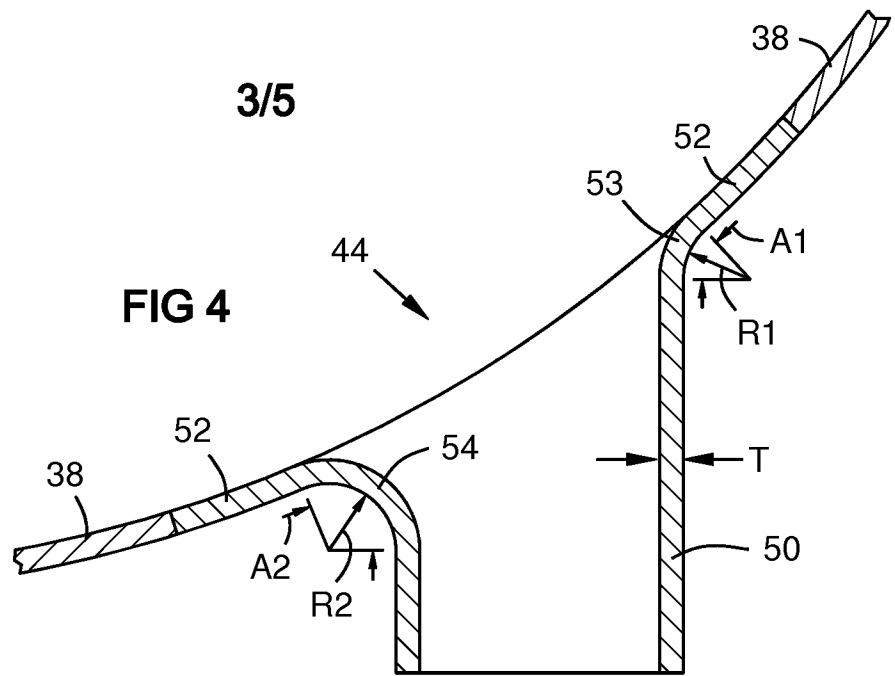


FIG 5

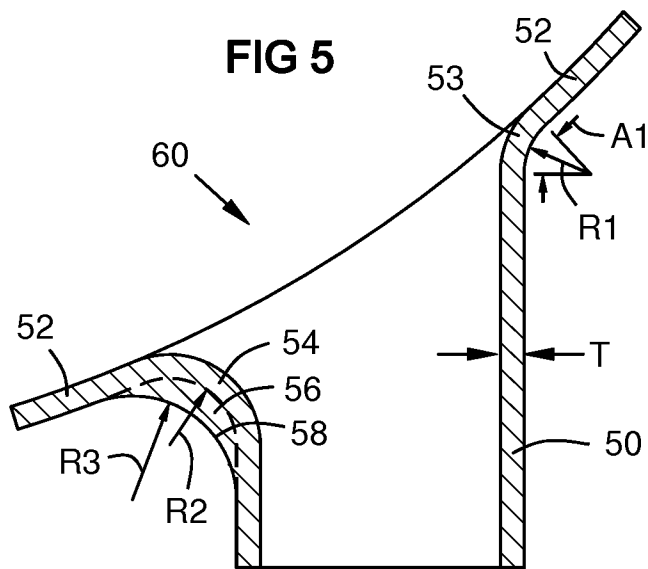
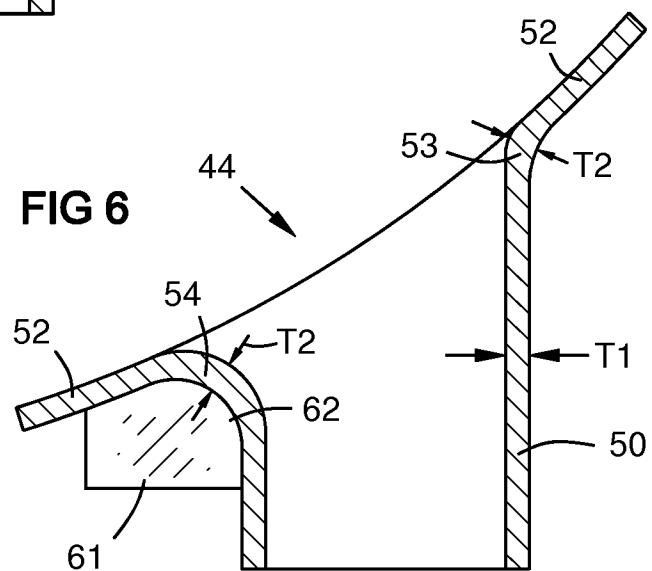
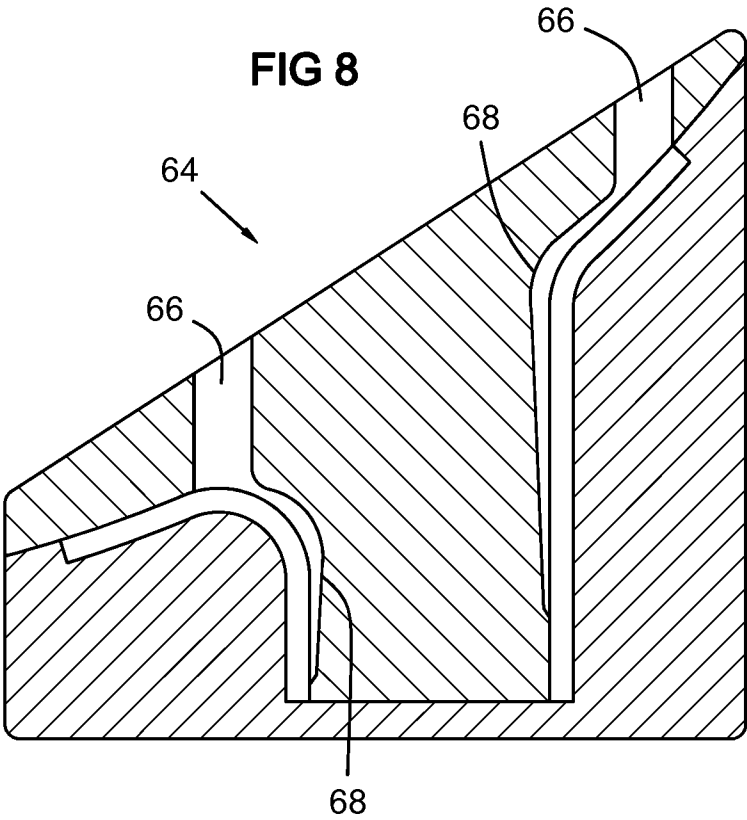
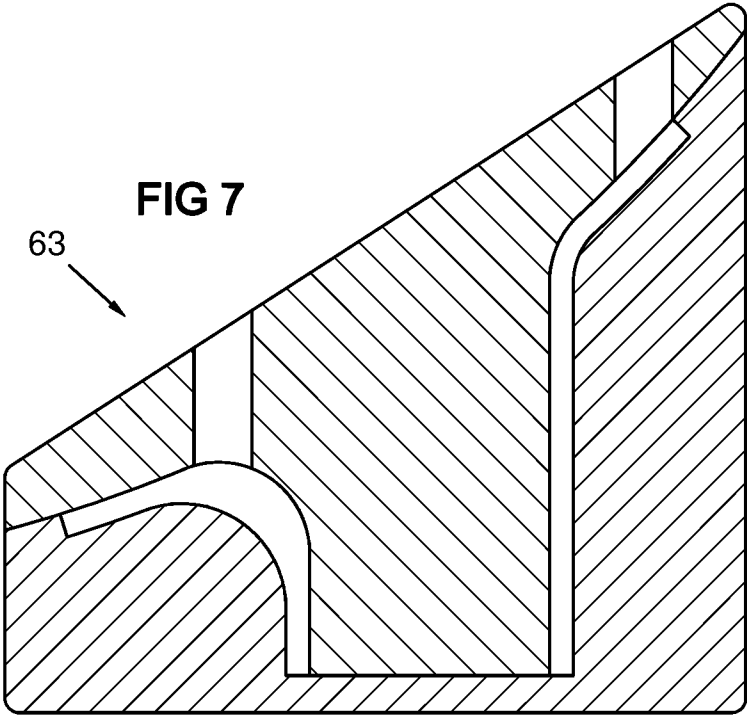
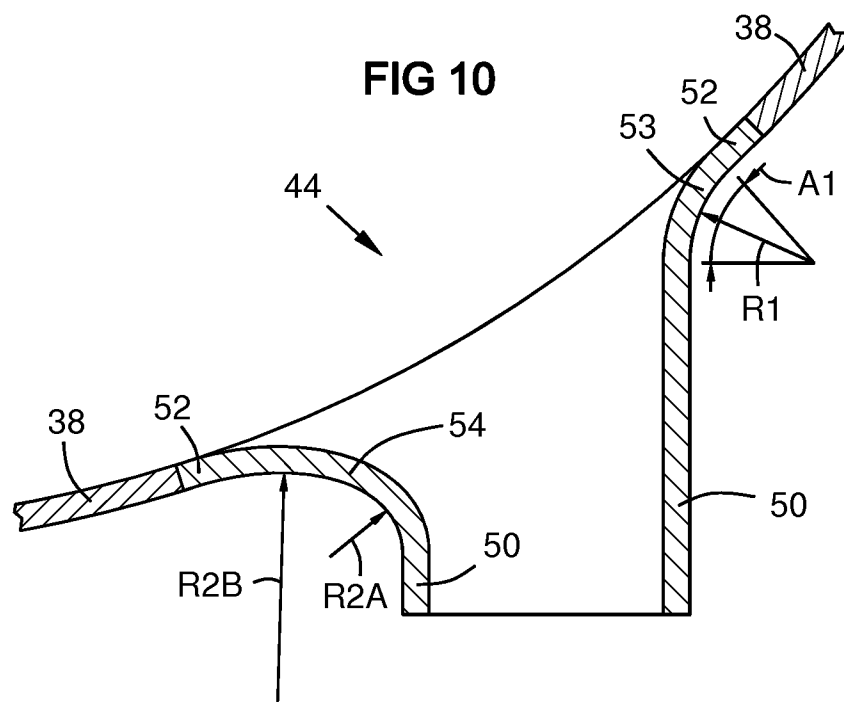
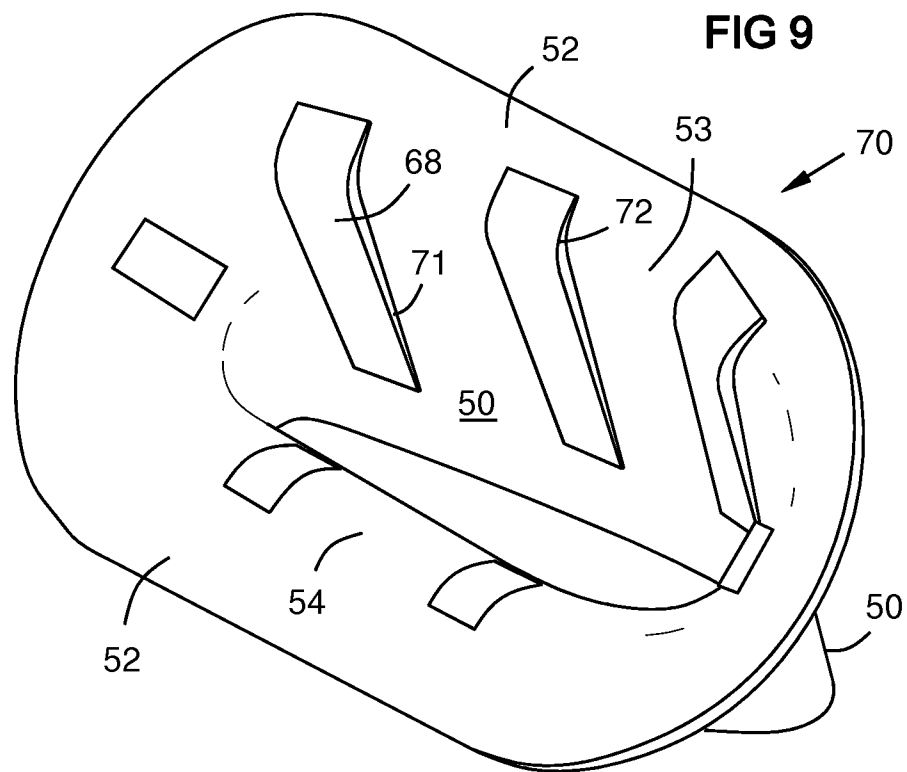


FIG 6





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INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER

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ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B22C B22D F01D B23P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 609 467 A (LENHART KENNETH J [US] ET AL) 11 March 1997 (1997-03-11) figures 4,7	1-13,16, 18
A	----- EP 2 365 191 A2 (UNITED TECHNOLOGIES CORP [US]) 14 September 2011 (2011-09-14) the whole document -----	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2014/045850

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5609467	A	11-03-1997	NONE	

EP 2365191	A2	14-09-2011	EP 2365191 A2	14-09-2011
			US 2011214433 A1	08-09-2011
