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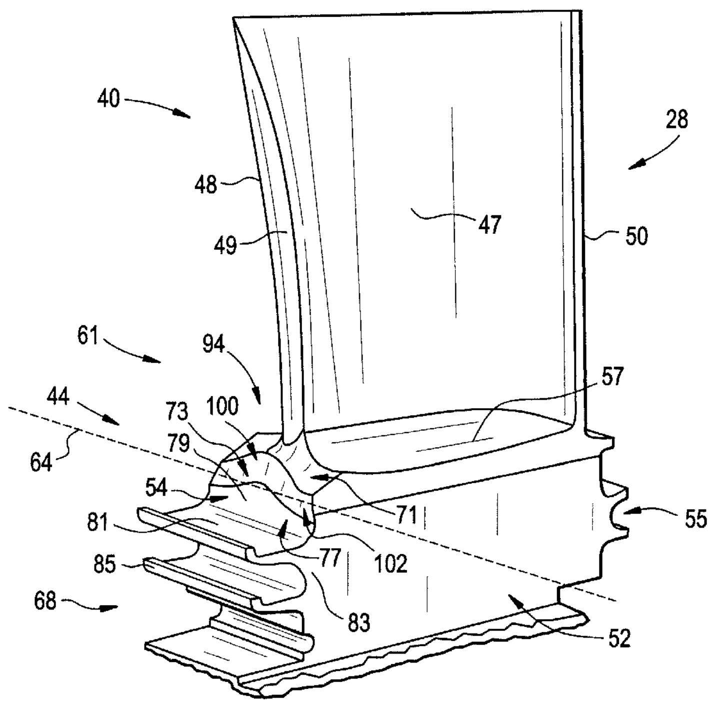
(54) **Turbomachine Component having a Flow Contour Feature**

(57) A turbomachine component includes a main body (52) having a gas path surface (71,73) configured to be exposed to gases passing along a turbomachine gas path (61), a non gas path surface (77) configured to be arranged in a turbomachine wheelspace outside the turbomachine gas path, and a non-axisymetric flow contour feature (94) extending from the gas path surface (71,73) to the non gas path surface (77).

FIG. 2



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Description

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to the art of turbomachines and, more particularly, to turbomachine components having a flow contour feature.

[0002] In general, gas turbomachines include a combustor assembly within which a fuel/air mixture is combusted to release heat energy. The heat energy forms a high temperature gas stream that is channeled to a turbine portion via a hot gas path. The turbine portion converts thermal energy from the high temperature gas stream to mechanical energy that rotates a turbine shaft. The turbine portion may be used in a variety of applications, such as for providing power to a pump or an electrical generator.

[0003] The high temperature gas stream passes over vanes and blades arranged in sequential stages along the hot gas path. A first stage of the turbine portion includes first stage vanes including an airfoil that is configured to direct the high temperature gas stream tangentially toward first stage blades. The high temperature gas stream aerodynamically interacts with and induces rotation of the first stage blades.

[0004] With such construction, the first turbine stages exhibit strong secondary flows in which high energy and high temperature fluids flow in a direction transverse to a main flow direction. That is, if the main flow direction is presumed to be axial, the secondary flows propagate circumferentially or radially. Thus, the secondary flows can negatively impact the stage efficiency and has led to development of non-axisymetric endwall contouring (EWC), which has been effective in reducing secondary flow losses for turbines. Current EWC is, however, only geared towards gas path surfaces.

BRIEF DESCRIPTION OF THE INVENTION

[0005] According to one aspect of the invention, a turbomachine component includes a main body having a gas path surface configured to be exposed to gases passing along a turbomachine gas path, a non gas path surface configured to be arranged in a turbomachine wheelspace outside the turbomachine gas path, and a non-axisymetric flow contour feature extending from the gas path surface to the non gas path surface.

[0006] According to another aspect of the invention, a turbomachine bucket includes an airfoil portion, and a base portion supporting the airfoil portion. The base portion includes one or more gas path surfaces configured to be exposed to gases passing along a turbomachine gas path, one or more non gas path surfaces configured to be arranged outside the turbomachine gas path, and a non-axisymetric flow contour feature extending from at least one of the one or more gas path surfaces to at least one of the one or more non gas path surfaces.

[0007] According to yet another aspect of the invention, a turbomachine includes a housing, a gas path extending through the housing, a wheelspace arranged within the housing and substantially fluidly separated from the gas path, and at least one turbomachine component arranged in the housing. The turbomachine component includes at least one gas path surface arranged within the gas path, at least one non gas path surface arranged within the wheelspace, and a non-axisymetric flow contour feature extending from the at least one gas path surface to the at least one non gas path surface.

[0008] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING

[0009] 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 diagram of a turbomachine including a rotor blade having a flow contour feature in accordance with an exemplary embodiment;

FIG. 2 is plan view of a rotor blade having a flow contour in accordance with an exemplary embodiment;

FIG. 3 is a detail view of a portion of the rotor blade of FIG. 2 illustrating a flow contour feature in accordance with one aspect of the exemplary embodiment;

FIG. 4 is a detail view of a portion of a rotor blade of FIG. 2 illustrating a flow contour feature in accordance with another aspect of the exemplary embodiment; and

FIG. 5 is a detail view of a portion of a rotor blade of FIG. 2 illustrating a flow contour feature in accordance with yet another aspect of the exemplary embodiment.

[0010] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0011] With reference to FIG. 1, a turbomachine in accordance with an exemplary embodiment is indicated generally at 2. Turbomachine 2 includes a compressor portion 4 and a turbine portion 6. Compressor portion 4 is fluidly coupled to turbine portion 6 through a combustor assembly 8. Compressor portion 4 is also mechanically linked to turbine portion 6 via a common compressor/turbine shaft 10. Turbine portion 6 includes a plurality of stages 14 that extend along a hot gas path 15. Stages 14 include a first stage 16, a second stage 18, and a third stage 20. The number of stages for turbine portion 6 could of course vary. First stage 16 includes a plurality of stationary vanes one of which is indicated at 22 and a plurality of rotating airfoil members or buckets one of which is indicated at 24. Likewise, second stage 18 includes a plurality of second stage stationary vanes one of which is indicated at 26 and second stage rotating airfoil members or buckets one of which is indicated at 28. Third stage 20 includes a plurality of third stage stationary vanes one of which is indicated at 30 and a plurality of third stage rotating airfoil members or buckets one of which is indicated at 32.

[0012] At this point reference will be made to FIGS. 2-3 in describing second stage bucket 28 with an understanding that first and third stage buckets 24 and 32 may include similar structure. As shown, second stage bucket 28 includes an airfoil portion 40 and a base portion 44. Airfoil portion 40 extends from base portion 44 and includes a pressure side 47, a suction side 48, a leading edge 49, and a trailing edge 50. Airfoil portion 40 is exposed to combustion gases flowing along a hot gas path (not separately labeled) of turbine portion 6. Base portion 44 includes a main body 52 having a front face 54, an aft face 55, and an airfoil support surface 57 and a connection member (not shown). Airfoil support surface 57 supports airfoil portion 40 while the connection member provides an interface to a second stage turbine wheel or rotor (also not shown).

[0013] Second stage bucket 28 includes a gas path portion 61 that includes airfoil portion 40 and portions of base portion 44 above a point denoted by a line 64, and a non-gas path portion 68 that includes portions of base portion 44 below line 64. Gas path portion 61 includes all portions of second stage blade 28 that are exposed to combustion gases flowing along the hot gas path. Non-gas path portion 68 includes all surfaces of base portion 44 that are arranged in a wheelspace (not shown) of turbine portion 6. Base portion 44 includes a first gas path surface 71 that includes airfoil support surface 57 and a second gas path surface 73 that includes a portion of front face 54 above line 64. Base portion 44 also includes non-gas path surfaces 77 that include a trench surface portion 79, a buffer surface portion 81, an upper angel wing 83 and a lower angel wing 85. Of course, it should be understood that aft face 55 also includes gas path and non-gas path surfaces (not separately labeled).

[0014] In accordance with an exemplary embodiment, second stage bucket 28 includes a flow contour feature 94. Flow contour feature 94 is shown positioned on front face 54 and extends from first gas path surface 71 onto non-gas path surfaces 77. In the exemplary embodiment shown, flow contour feature 94 takes the form of a non-axisymetric feature including a trough/depression 100 and a protrusion 102 formed in base portion 44. Flow contour feature is positioned so as to alter local pressures at circumferential locations within the turbine portion wheelspace. More specifically, flow contour feature 94 creates an elevation in wheelspace static pressure at particular circumferential locations that generally experience high pressures at a wheelspace/gas path border due to wakes, bow waves shocks and the like. Thus, flow contour feature 94 increases local backflow margins that prevent localized hot gas ingestions from the gas path to the wheelspace thereby reducing the need for additional purge flows in the wheelspace while also maintaining cooler wheelspace temperatures.

[0015] Reference will now be made to FIG. 4 in describing a second stage bucket 101 in accordance with another aspect of the exemplary embodiment. Second stage bucket 101 includes an airfoil portion 102 and a base portion 103. Airfoil portion 102 extends from base portion 103 and includes a pressure side 104, a suction side 105, a leading edge 106, and a trailing edge 107. In a manner similar to that described above, airfoil portion 102 is exposed to combustion gases flowing along the hot gas path (not separately labeled) of turbine portion 6. Base portion 103 includes a main body 110 having a front face 111, an aft face (not shown), an airfoil support surface 113, and a connection member (also not shown). Airfoil support surface 113 supports airfoil portion 102 while the connection member provides an interface to a second stage turbine wheel or rotor (also not shown).

[0016] Second stage bucket 101 includes a gas path portion 120 that includes airfoil portion 102 and portions of base portion 103 above a point denoted by a line 124, and a non-gas path portion 128 that includes portions of base portion 103 below line 124. Gas path portion 120 includes all portions of second stage blade 101 that are exposed to combustion gases flowing along the hot gas path. Non-gas path portion 128 includes all surfaces of base portion 103 that are arranged in a wheelspace (not shown) of turbine portion 6. Base portion 103 includes a first gas path surface 131 that includes airfoil support surface 113 and a second gas path surface 133 that includes a portion of front face 111 above line 124. Base portion 103 also includes non-gas path surfaces 140 that include a trench surface portion 141, a buffer surface portion 142, an upper angel wing 143 and a lower angel wing 145. Of course, it should be understood that the aft face also includes gas path and non-gas path surfaces (not separately labeled).

[0017] In accordance with an exemplary embodiment, second stage bucket 101 includes a flow contour feature 150. Flow contour feature 150 is shown positioned on front face 111 extending from first gas path surface 131 onto non-gas path surfaces 140. In the exemplary embodiment shown, flow contour feature 150 takes the form of non-axisymetric trench or depression 160 formed in base portion 103. As discussed above, flow contour feature 150 is positioned so as to alter local pressures at circumferential locations within the turbine portion wheelspace. More specifically, flow contour feature 150 creates an elevation in wheelspace static pressure at particular circumferential locations that generally experience high pressures at a wheelspace/gas path border due to wakes, bow waves shocks and the like. Thus, flow contour feature 150 increases local backflow margins that prevent localized hot gas ingestions from the gas path to the wheelspace thereby reducing the need for additional purge flows in the wheelspace while also maintaining cooler wheelspace temperatures.

[0018] Reference will now be made to FIG. 5, wherein like reference numbers represent corresponding parts in the respective views, in describing second stage bucket 180 in accordance with another aspect of the exemplary embodiment. Second stage bucket 180 includes an airfoil portion 185 and a base portion 186. Airfoil portion 185 extends from base portion 186 and includes a pressure side 188, a suction side 189, a leading edge 190, and a trailing edge 191. In a manner similar to that described above, airfoil portion 185 is exposed to combustion gases flowing along a hot gas path (not separately labeled) of turbine portion 6. Base portion 186 includes a main body 187 having a front face 193, an aft face (not shown), an airfoil support surface 195, and a connection member (also not shown). Airfoil support surface 195 supports airfoil portion 185 while the connection member provides an interface to a second stage turbine wheel or rotor (also not shown).

[0019] Second stage bucket 180 includes a gas path portion 211 that includes airfoil portion 185 and portions of base portion 186 above a point denoted by a line 214, and a non-gas path portion 218 that includes portions of base portion 190 below line 214. Gas path portion 211 includes all portions of second stage bucket 180 that are exposed to combustion gases flowing along the hot gas path. Non-gas path portion 218 includes all surfaces of base portion 190 that are arranged in a wheelspace (not shown) of turbine portion 6. For example, base portion 186 includes a first gas path surface 221 that includes airfoil support surface 195 and a second gas path surface 223 that includes a portion of front face 193 above line 214. Base portion 186 also includes non-gas path surfaces 227 that include a trench surface portion 229, a buffer surface portion 231, an upper angel wing 233 and a lower angel wing 235. Of course, it should be understood that aft face also includes gas path and non-gas path surfaces (not separately labeled).

[0020] In accordance with an exemplary embodiment, second stage bucket 180 includes a flow contour feature 244. Flow contour feature 244 is shown positioned on front face 193 extending from first gas path surface 221 onto non-gas path surfaces 227. In the exemplary embodiment shown, flow contour feature 244 takes the form of a non-axisymetric ridge or raised area 250 formed on base portion 190. In a manner similar to that discussed above, flow contour feature is positioned so as to alter local pressures at circumferential locations within the turbine portion wheelspace. More specifically, flow contour feature 244 creates an elevation in wheelspace static pressure at particular circumferential locations that generally experience high pressures at a wheelspace/gas path border due to wakes, bow waves shocks and the like. Thus, flow contour feature 244 increases local backflow margins that prevent localized hot gas ingestions from the gas path to the wheelspace thereby reducing the need for additional purge flows in the wheelspace while also maintaining cooler wheelspace temperatures.

[0021] At this point it should be understood that the exemplary embodiments flow contour features for turbine buckets that enhance back flow margins to limit the need for additional purge flows from the compressor to the wheelspace. By limiting purge flows to the wheelspace, more compressor flow can be passed to the turbine portion to generate shaft work. The flow contour features are not only positioned on surfaces exposed to combustion gases but also on surfaces that are arranged in the wheelspace. Positioning the flow contour feature on surfaces exposed to the wheelspace creates localized pressure increases at points which experience higher combustion gas pressures. In this manner, the flow contour features limit ingestion of combustion gases to the wheelspace. It should be further understood that while shown and described in connection with a rotating turbomachine component, the flow contour feature in accordance with the exemplary embodiments could also be provided on stationary turbomachine components. In addition, while shown on a leading edge of the turbomachine component, the flow contour feature is not limited to any one physical location and may be arranged on other surfaces.

[0022] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

Claims

1. A turbomachine component comprising:

   a main body (52) having one or more gas path surfaces (61) configured to be exposed to gases passing along a turbomachine gas path, one or more non gas path surfaces (68) configured to be arranged in a turbomachine wheelspace outside the turbomachine gas path, and a non-axisymetric flow contour feature (94) extending from at least one of the one or more gas path surfaces (61) to at least one of the one or more non gas path surfaces (68).

2. The turbomachine component according to claim 1,

wherein the main body (52) includes a front face (54) and an aft face (55), the non-axisymetric flow contour feature (94) being arranged on the front face (54).

3. The turbomachine bucket according to claim 1 or 2, wherein the at least one of the one or more non gas path surfaces (77) defines one or more an angle wings (83,85).

4. The turbomachine bucket according to any of claims 1 to 3, wherein the non-axisymetric flow contour member (94) comprises a trough (100) formed in the at least one of the one or more gas path surfaces (71) and the at least one of the one or more non gas path surfaces (77).

5. The turbomachine bucket according to any of claims 1 to 3, wherein the non-axisymetric flow contour member (244) comprises a ridge (250) formed in the at least one of the one or more gas path surfaces (221,223) and the at least one of the one or more non-gas path surfaces (77).

6. The turbomachine bucket according to any of claims 1 to 3, wherein the non-axisymetric flow contour feature (94) comprises a depression (100) and a protrusion (102) formed in the at least one of the one or more gas path surfaces (71) and the at least one of the one or more non gas path surfaces (77).

7. The turbomachine component according to claim 6, wherein the depression (100) is formed in the gas path surface (71).

8. The turbomachine component according to claim 6 or 7, wherein the protrusion (102) is formed in the non gas path surface (77).

9. A turbomachine bucket (28) comprising:

   an airfoil portion (40); and
   a base portion (44) supporting the airfoil portion (40), the base portion (44) comprising the turbomachine component of any of claims 1 to 8.

10. A turbomachine comprising:

   a housing (2);
   a gas path (15) extending through the housing;
   a wheelspace arranged within the housing and substantially fluidly separated from the gas path (15); and
   at least one turbomachine component (28) arranged in the housing, the turbomachine component as recited in any of claims 1 to 8.

FIG. 1

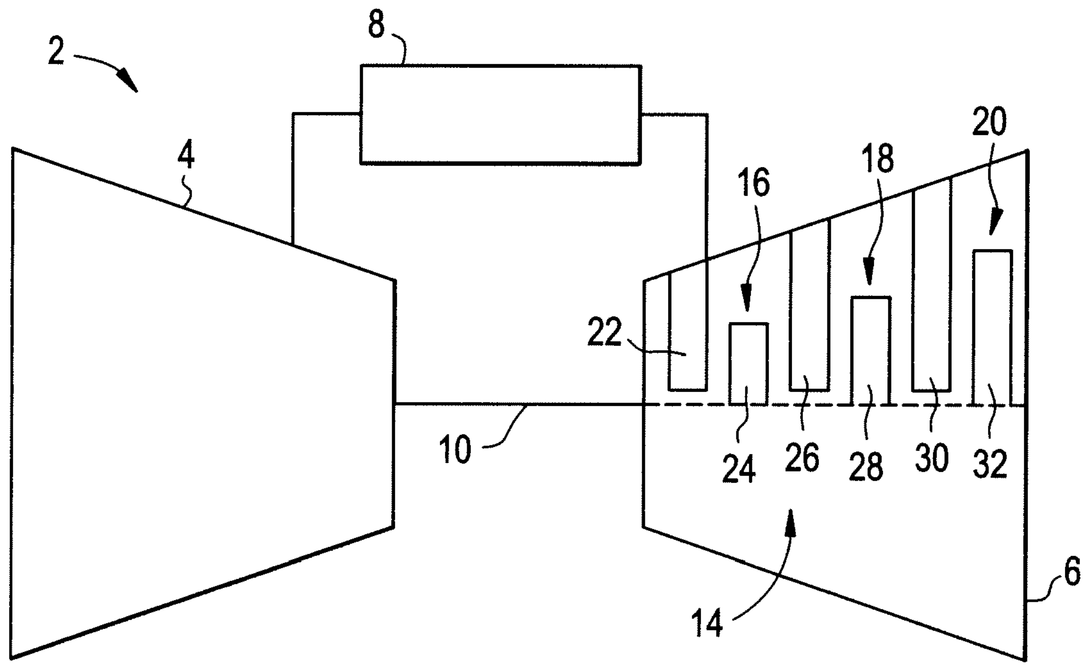

FIG. 2

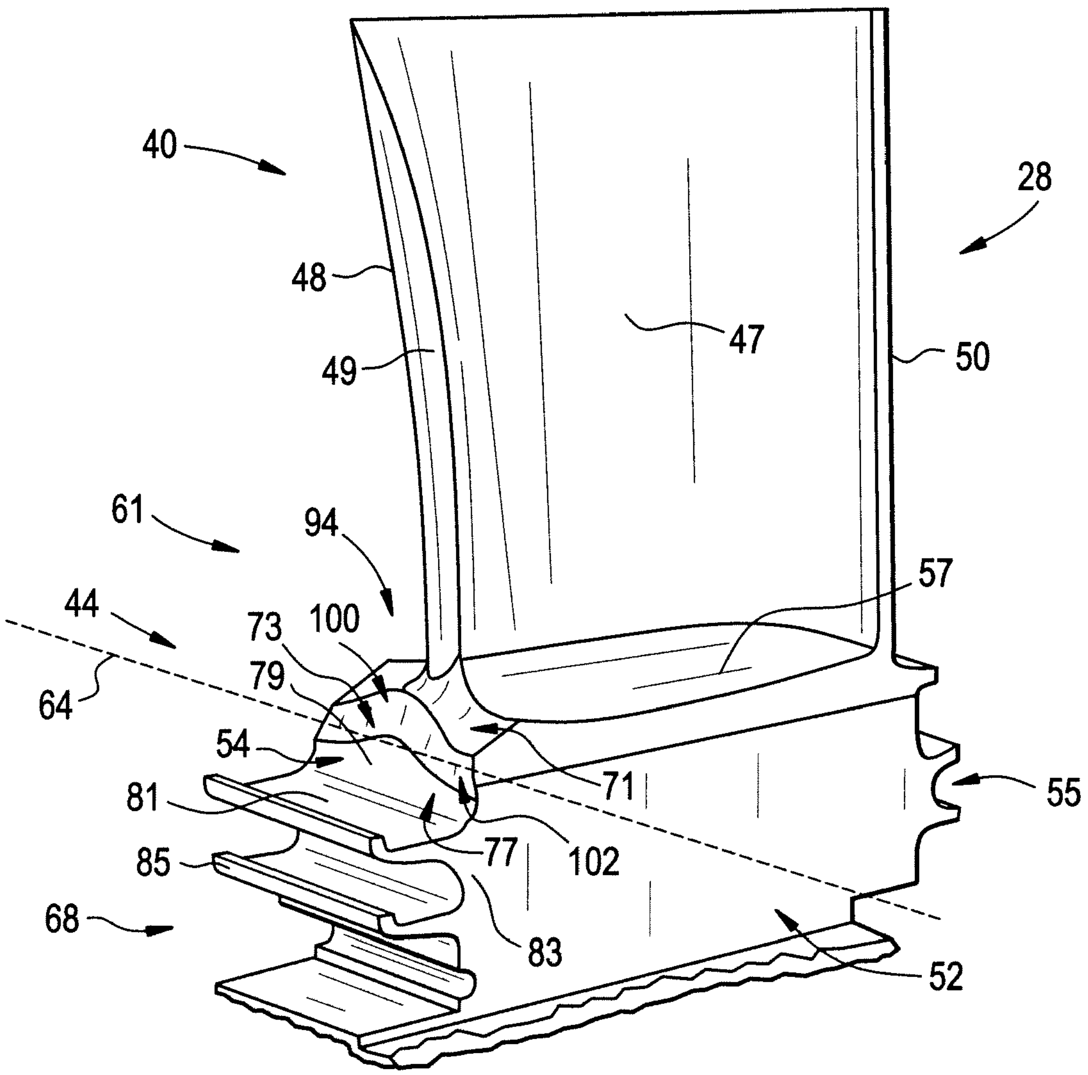
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FIG. 3

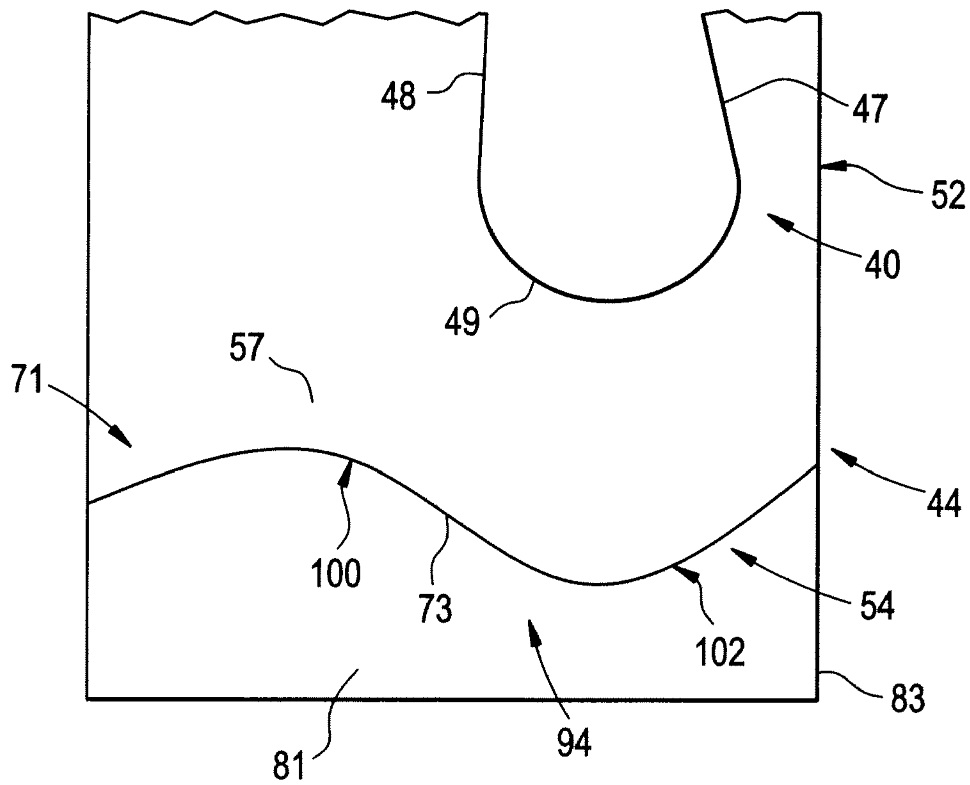

FIG. 4

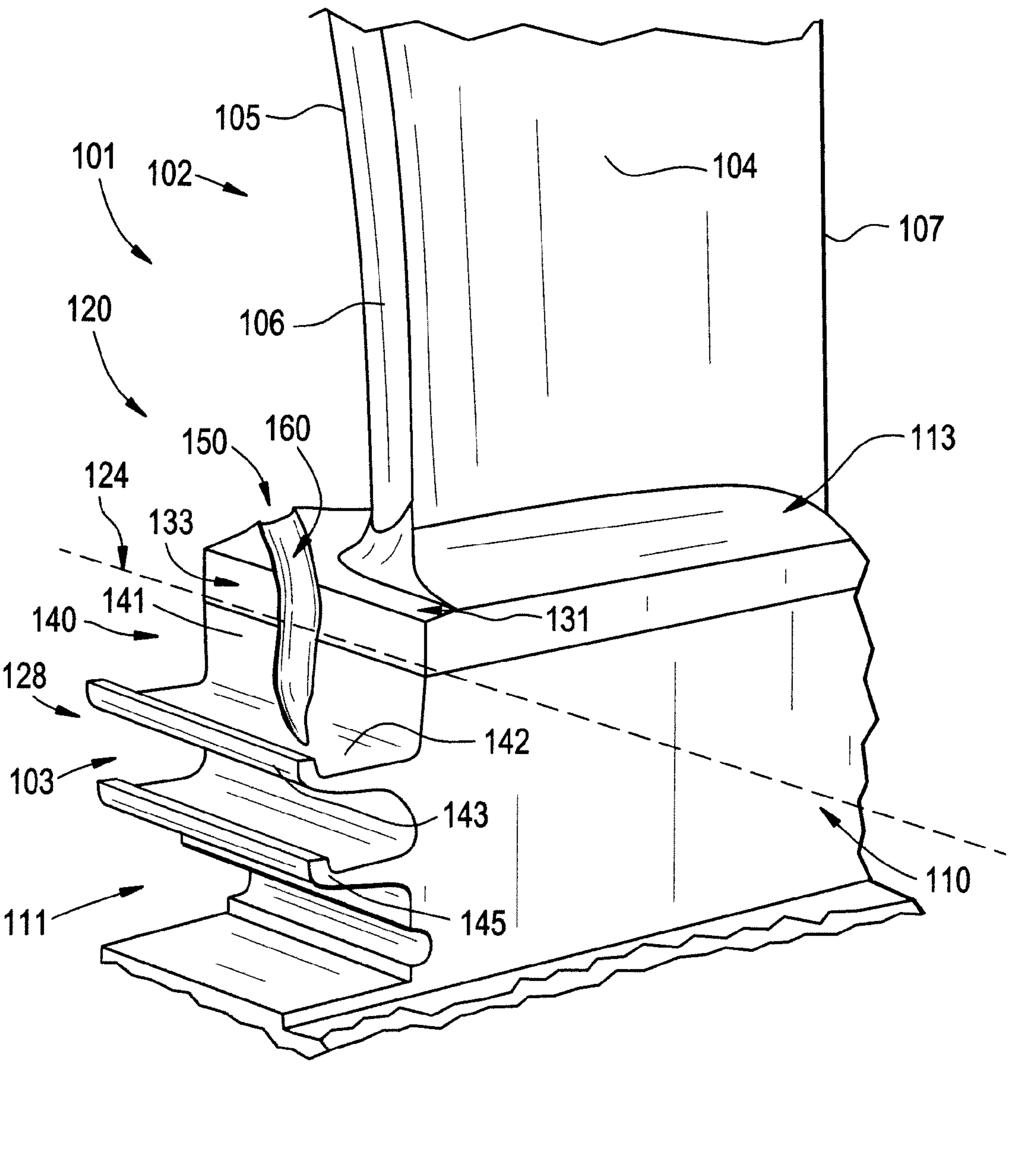
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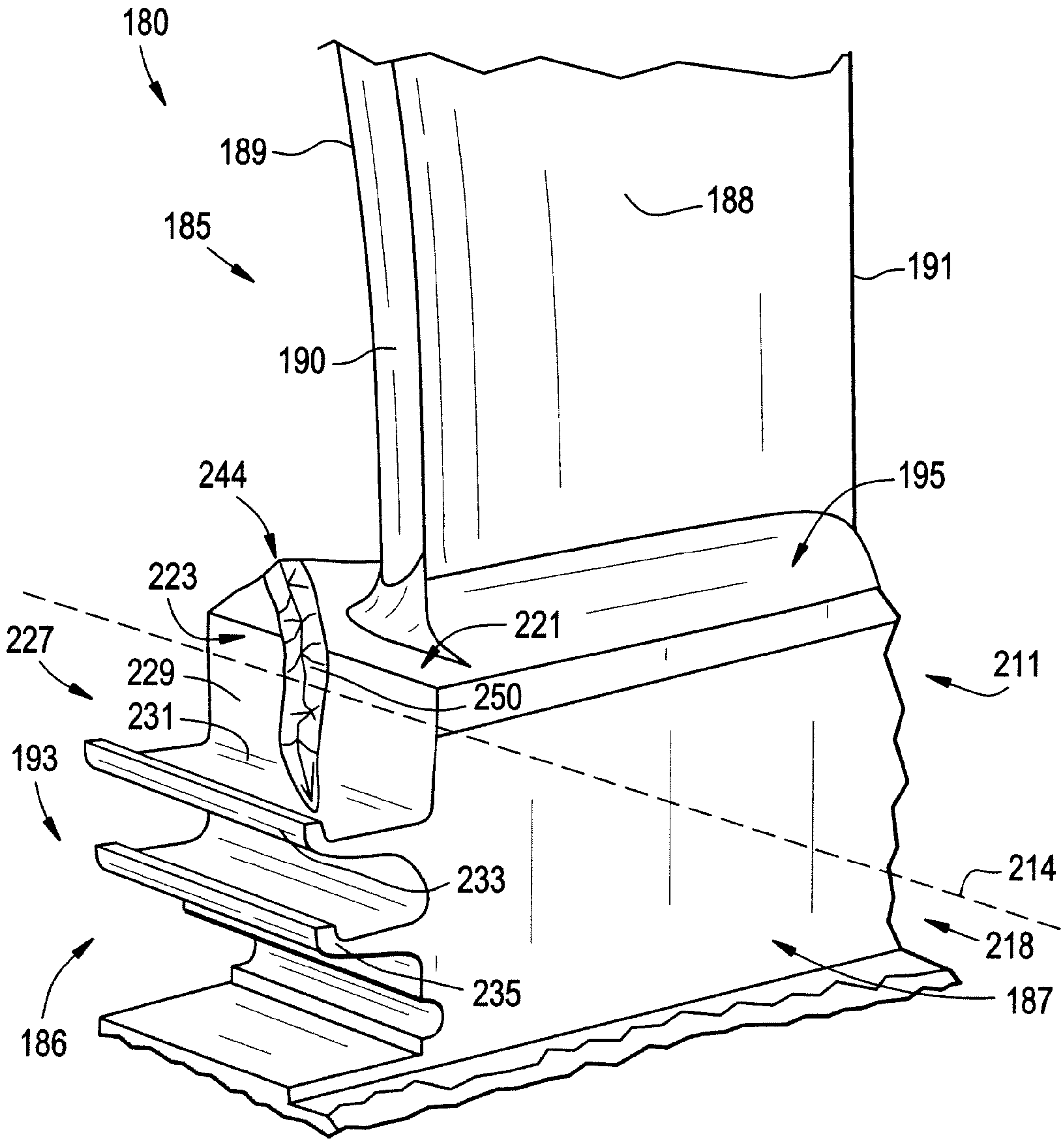
FIG. 5



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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 7836

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X	US 2006/269399 A1 (GIRGIS SAMI [CA] ET AL) 30 November 2006 (2006-11-30) * page 2, paragraph 22 - page 3, paragraph 31; figures 3-8 *	1,2,4-9	
X	EP 2 138 727 A2 (ROLLS ROYCE DEUTSCHLAND [DE]) 30 December 2009 (2009-12-30) * the whole document *	1,10	
X	US 2010/074734 A1 (LITTLE DAVID A [US]) 25 March 2010 (2010-03-25) * page 4, paragraph 38 - page 6, paragraph 53; figures 3-5 *	1-3,5,9	

TECHNICAL FIELDS SEARCHED (IPC)

F01D
F04D

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	20 February 2013	Rau, Guido

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 18 7836

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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20-02-2013

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82