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(54) **Turbine packing deflector**

(57) A turbine includes a rotor (102) being rotatable about an axis, a circumferential array of nozzles (110) having circumferentially spaced airfoils (112) and inner (114) and outer bands disposed at opposite ends thereof, the inner band (114) having a leading portion (203) and a trailing portion (204), and an array of directors (126) arranged on the inner band (114), the array of directors (126) operative to direct a flow path (10) of fluid, the flow path (10) of fluid partially defined by the rotor (102) and the inner band (114).

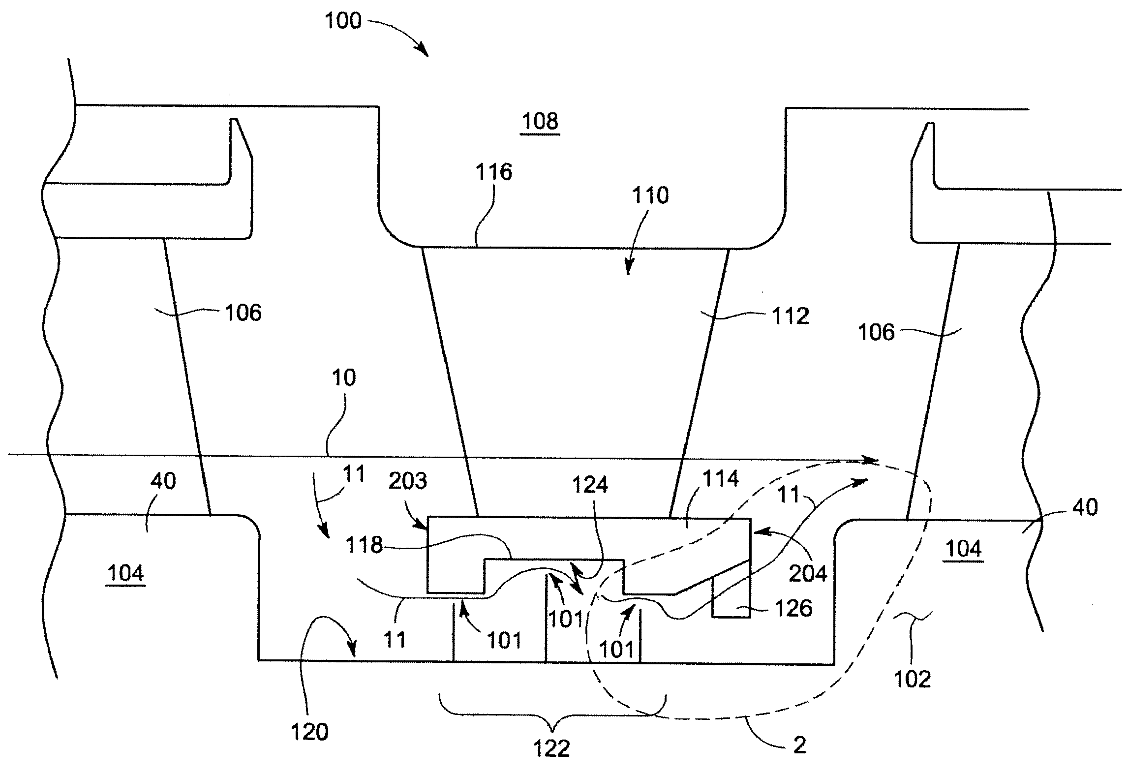


FIG. 1

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## Description

### BACKGROUND OF THE INVENTION

**[0001]** The subject matter disclosed herein relates to turbine engines.

**[0002]** The flowpath through a turbine along the root radius is defined in part by the inner bands or rings of the nozzles and flow surfaces along the platforms at the roots of the buckets on the rotor. Any fluid flow leakage exiting the flowpath along the root radii bypasses the buckets and nozzles, and directly decreases the performance of the turbine stage. Teeth arranged on the rotor adjacent to the fluid flow leakage increase the swirl of the fluid flow leakage. A typical nozzle and bucket design of, for example, a steam turbine stage, includes a nozzle root diameter equal to the bucket root diameter, resulting in a significant probability of an upstream facing step, which disturbs the streamline characteristics of the fluid flow in the flowpath. Radial reentry flows cause fluid flow random mixing along the flowpath with consequent aerodynamic efficiency losses.

### BRIEF DESCRIPTION OF THE INVENTION

**[0003]** According to a first aspect of the invention, an inner band of turbine nozzle array includes a leading portion and a trailing portion, and an array of directors arranged on the inner band, the array of directors operative to direct a flow path of fluid, the flow path of fluid partially defined by a rotor and the inner band.

**[0004]** According to another aspect of the invention, a turbo machine includes a rotor being rotatable about an axis, a circumferential array of nozzles having circumferentially spaced airfoils and inner and outer bands disposed at opposite ends thereof, the inner band having a leading portion and a trailing portion, and an array of directors arranged on the inner band, the array of directors operative to direct a flow path of fluid, the flow path of fluid partially defined by the rotor and the inner band.

**[0005]** According to yet another aspect of the invention, an array of directors includes a plurality of fins extending from a guide surface of an inner band portion of a turbine, the inner band portion arranged at an end portion of an array of nozzles, the plurality of fins being operative to direct a flow path of a fluid, the flow path partially defined by the inner band portion and a portion of a rotor having an axis of rotation.

**[0006]** These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0007]** Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG. 1 illustrates a portion of an exemplary embodiment of a turbine.

FIG. 2 illustrates a partial view of the region 2 of FIG. 1.

FIG. 3 illustrates the partial view of the region 2 of FIG. 1 with an indicated leakage flow path.

FIG. 4 illustrates a perspective, partially cut-away view of a portion of an exemplary embodiment of the turbine of FIG. 1.

FIG. 5 illustrates a perspective, partially cut-away view of a portion of another exemplary embodiment of the turbine of FIG. 1.

FIG. 6 illustrates an exemplary embodiment of the turbine.

FIG. 7 illustrates another exemplary embodiment of the turbine.

FIG. 8 illustrates an exemplary embodiment of a turbine machine compressor.

FIG. 9 illustrates another exemplary embodiment of a turbo machine.

**[0008]** 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

**[0009]** FIG. 1 illustrates a portion of an exemplary embodiment of a turbo machine 100. The turbine defines an inner or root region of a flowpath, indicated by the arrow and generally designated 10. Energetic fluid, e.g., steam, flows along main flow path 10 and in the direction of the arrow. The turbo machine 100 includes a rotor 102 rotatable about a horizontal axis and a plurality of axially spaced rotor wheels 104, each carrying a plurality of circumferentially spaced buckets 106. FIG. 1 includes a stationary component 108 of the turbine, including axially spaced arrays of nozzles 110. Each array of nozzles 110 has circumferentially spaced stationary airfoils 112 mounted between inner bands or rings 114 and outer bands or rings 116. The inner bands 114 include leading portions 203 and trailing portions 204, where the leading portion 203 is upstream of the flowpath 10 relative to the trailing portions 204. The inner bands 114 each define a plane normal to the axis of rotation of the rotor 102. Each nozzle 110 and a downstream array of buckets 106 form a turbine stage, there being a plurality of stages within the turbine section of the turbine. Packing rings (packing ring segments) 118 are provided between the stationary component 108, e.g., inner bands 114, and the rotor surface 120 between the rotor wheels 104 for sealing leakage flowpaths between the stationary and rotary components. Teeth 122 are arranged on the rotor surface 120 proximate to and corresponding with an inner surface 124 of the inner band 114. The teeth 122 and the inner surface 124 of the inner bands 114 define gaps 101. The gap 101 defines a leakage flow path of energetic fluid indicated by the arrows 11. The leakage flow path results in an aerodynamic inefficiency when the fluid reenters the root region of the flow path.

**[0010]** In this regard, a plurality of directors (diverters) 126 are arranged at the trailing portions 204 of the inner bands 114 and in the leakage flow path. The directors 126 in the illustrated embodiment are operative to direct the leakage flow into the root region of the main flow path while reducing the aerodynamic inefficiency of the introduction of the leakage flow path into the root region of the flow path. The directors 126 may include fins or other similar structures extending from the inner bands 114. The directors 126 may include fins having opposing planar profiled sides or fins having arcuate shaped opposing sides.

**[0011]** FIG. 2 illustrates a partial view of the region 2 (of FIG. 1). The director 126 is arranged proximate to the trailing portion 204 of the inner band 114. In the illustrated embodiment, the trailing portion 204 includes a surface portion 206 that is substantially perpendicular to the axis of rotation of the rotor 102 and a guide surface portion 202 that is arranged at an angle ($\varphi$) relative to the axis of rotation of the rotor 102. The line 201 is shown parallel to the axis of rotation of the rotor 102. The surface portion 206 and the guide surface portion 202 define an angle ($\theta$). In the illustrated embodiment the angle $\theta$ is greater than 90° while the angle $\varphi$ is less than 90°. In alternate embodiments, the angles $\theta$ and $\varphi$ may include any number of degrees, for example the angles $\theta$ and $\varphi$ may each be 90° or greater than or less than 90°. The angles $\theta$ and $\varphi$ may be selected in the design process to reduce the aerodynamic inefficiency of the introduction of the leakage flow path into the root region of the flow path. The angles $\theta$ and $\varphi$ may depend on the pressure and flow rate of the fluid at a particular nozzle stage and the geometry of the nozzle stage. The position of the tooth 122 relative to the position of the directors 126 (as shown by the indicated distance x) may be chosen to direct the leakage flow path to generally follow along the surface 208, which is arranged generally coaxially with the rotor 102. By following the surface 208, the leakage flow path impinges upon the directors 126. The distance x may be determined partially by the distance y, which is defined by the surface portion 206 and a surface 220 of the rotor wheel 104. The ratio of x:y should between 0.3 to 1, where $x<y$. The desired value of the ratio may be determined by considering the axial movement of the rotor 104 during transient conditions (i.e., startup and shutdown conditions).

**[0012]** FIG. 3 illustrates a perspective partially transparent view of the region 2 (of FIG. 1) with the leakage flow path indicated by the arrow 11. The leakage flow path is diverted by the directors 126 and the guide surface portion 202 (of FIG. 2) such that the leakage flow path flows more efficiently and less randomly into the root region of the flow path. The leakage flow path is partially defined by the guide surface portion 202, the directors 126, and a leading edge surface 220 of the rotor wheel 104.

**[0013]** FIG. 4 illustrates a perspective, partially cutaway view of a portion of an exemplary embodiment of the turbo machine 100. In the illustrated embodiment, the directors 126 are shown arranged radially on the guide surface 202. The directors 126 are arranged substantially parallel to each other. Each director 126 is partially defined by opposing linear surfaces that are substantially parallel to each other. The directors 126 are arranged such that the linear axis of the directors 126 illustrated by line 401 and a line 403 perpendicular to the axis of rotation of the rotor 102 defines an angle ($\omega$). The angle $\omega$ may be selected during the design of the turbo machine 100 to reduce the aerodynamic inefficiency of the introduction of the leakage flow path into the root region of the flow path and may include any angle between, for example, 0°-180°.

**[0014]** FIG. 5 illustrates a perspective, partially cutaway view of a portion of another exemplary embodiment of the turbo machine 100. In the illustrated embodiment the directors 126 are formed in an arcuate shape. The leading and trailing edges of the directors 126 define a chord line 501 the chord line and a line 503 perpendicular to the axis of rotation of the rotor 102 define the angle $\omega$. As described above the angle $\omega$ may include any angle that reduces aerodynamic inefficiency of the introduction of the leakage flow path into the root region of the flow.

**[0015]** FIG. 6 illustrates an exemplary embodiment of the turbo machine 100, where the directors 126 are arranged on a base portion 602 that is secured to the inner band 114. The base portion 602 may be secured to the inner band 114 by any suitable method including, fasteners, welding, or brazing.

**[0016]** FIG. 7 illustrates another exemplary embodiment of the turbo machine 100, wherein the directors 126 are arranged on a base portion 702 that slidably engages a portion of inner band 114.

**[0017]** FIG. 8 illustrates an exemplary embodiment of a turbine machine compressor 800. The compressor 800 includes diverters 126 arranged on inner bands 114. Teeth 122 are arranged on the rotor surface 120. The main flow path 802 is generally designated by the arrow 80. The inner bands 114 and the teeth 122 define a leakage flow path 81 generally designated by the arrow 81. In the illustrated embodiment, the diverters 126 are arranged proximate to an upstream portion 805 of the inner bands 114. The leakage flow path 81 flows generally from a down stream portion 803 of the inner bands 114 to the up stream portion 805 where the diverters 126 induce effects to the leakage flow path 81 as described above in the turbo machine 100.

**[0018]** FIG. 9 illustrates another exemplary embodiment of a turbo machine 900. In the illustrated embodiment, the a plurality of directors (diverters) 126 are arranged between the leading portions 203 and trailing portions 204 of the inner bands 114 and in the leakage flow path indicated by the arrows 11. The directors 126 are disposed between two of the teeth 122 however, in alternate embodiments, the directors 126 may be arranged before or after the teeth 122 relative to the flow path 10.

**[0019]** The embodiments described above increase the efficiency of a turbine machine by reducing the mixing losses and randomness of the introduction of leakage flows into root regions of the main flow path. The increased efficiency is realized by the use of diverters arranged on inner rings proximate to the trailing edges of the turbine nozzles. The diverters reduce the aerodynamic inefficiency of the introduction of the leakage flow into the root region of the main flow path.

**[0020]** Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. An array of directors comprising a plurality of fins extending from a guide surface of an inner band portion of a turbine, the inner band portion arranged at an end portion of an array of nozzles, the plurality of fins being operative to direct a flow path of a fluid, the flow path partially defined by the inner band portion and a portion of a rotor having an axis of rotation.

2. The array of directors of clause 1, wherein the fins of the plurality of fins include opposing planar sides arranged at an oblique angle relative to the axis of rotation of the rotor.

## Claims

**1.** An inner band (114) of a turbine machine, the inner band comprising:

a leading portion (203) and a trailing portion (204); and
an array of directors (126) arranged on the inner band (114), the array of directors (126) operative to direct a flow path of fluid, the flow path of fluid partially defined by a rotor (102) and the inner band (114).

**2.** The inner band of claim 1, wherein the array of directors (126) are arranged proximate to the trailing portion (204) of the inner band (114).

**3.** The inner band of claim 1 or 2, wherein the trailing portion (204) of the inner band (114) includes a guide surface portion (202) having a surface (208) arranged at an oblique angle relative to an axis intersecting a plane defined by the inner band (114), the axis normal to the plane.

**4.** The inner band of claim 1, wherein the array of directors (126) is arranged on a guide surface portion (202) of the inner band.

**5.** The inner band of claim 4, wherein the trailing portion (204) of the inner band (114) includes a guide surface portion (202) having a surface (208) arranged substantially parallel to an axis intersecting a plane defined by the inner band (114), the axis normal to the plane, and the array of directors (126) is arranged on the guide surface portion (202).

**6.** The inner band of any of claims 1 to 5, wherein each director (126) of the array of directors (126) defines a linear axis, the linear axis of each of the directors (126) are arranged substantially in parallel to each other.

**7.** The inner band of any of claims 1 to 5, wherein each directors (126) of the array of directors (126) has an arcuate shape that defines a chord line (501), wherein the chord line (501) of each of the directors (126) are arranged substantially parallel to each other.

**8.** A turbo machine (100) comprising:

a rotor (102) being rotatable about an axis;
a circumferential array of nozzles (110) having circumferentially spaced airfoils (112) and inner and outer bands (114, 116) disposed at opposite ends thereof, the inner band (114) as recited in any of claim 1 to 7.

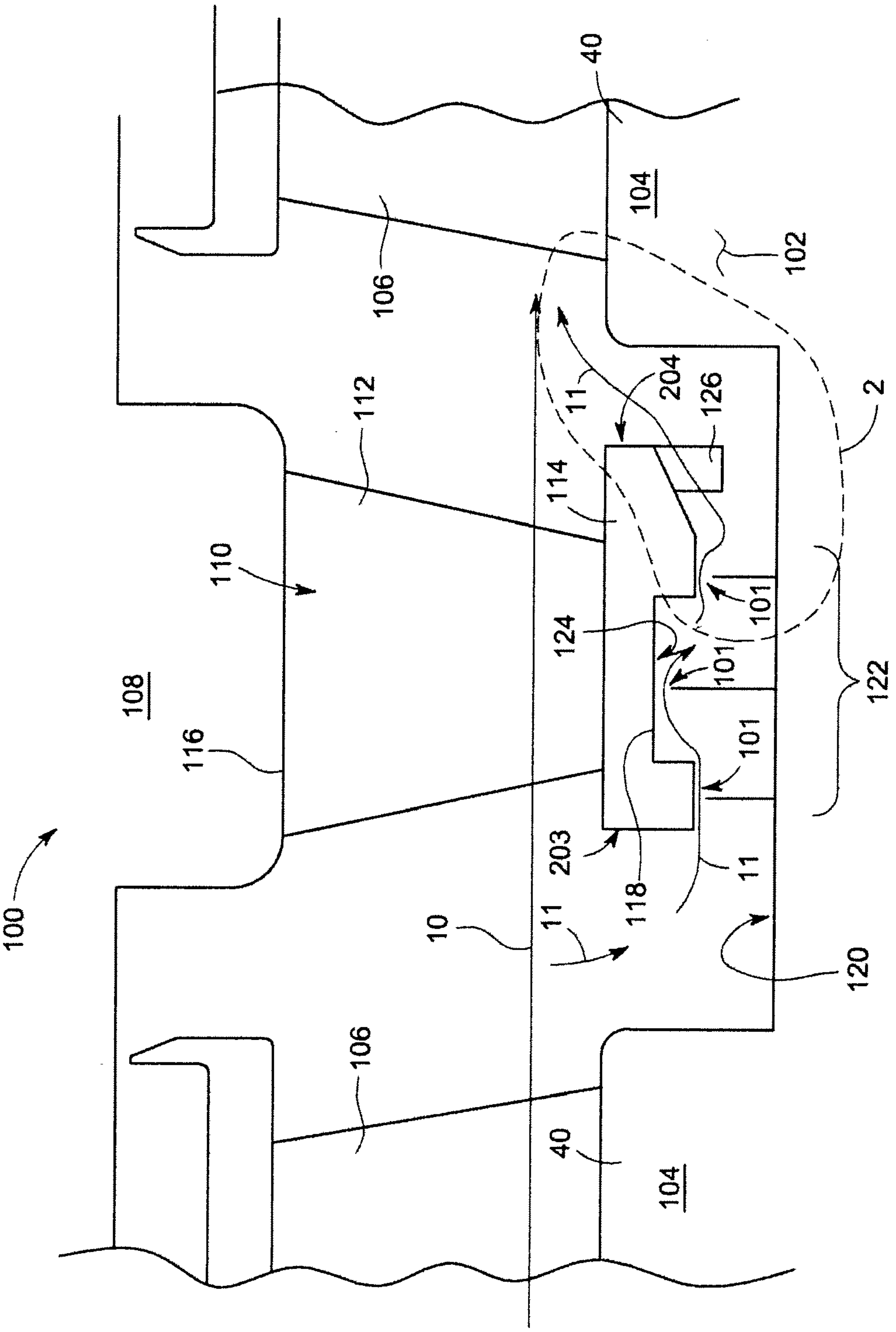
**9.** The machine of claim 8, wherein the rotor (102) includes a tooth (122) arranged on the rotor (102), the tooth and the inner band (114) defining a gap (101) therebetween.

**10.** The machine of claim 9, wherein the gap (10) further defines the flow path of fluid.

**11.** The machine of claim 8, 9 or 10 wherein the array of directors (126) are arranged a distance x from the tooth (122), and the inner band (114) is arranged a distance y from the rotor (102), where a ratio x:y is between 0.3 and 1.

**12.** The machine of any of claims 8 to 11, wherein the machine includes a turbine.

**13.** The machine of any of claims 8 to 12, wherein the machine includes a compressor (800).


100
108
110
116
112
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106
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104
40
40
102
2
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126
11
11
11
11
114
124
101
101
101
122
118
203
10
120

FIG. 1

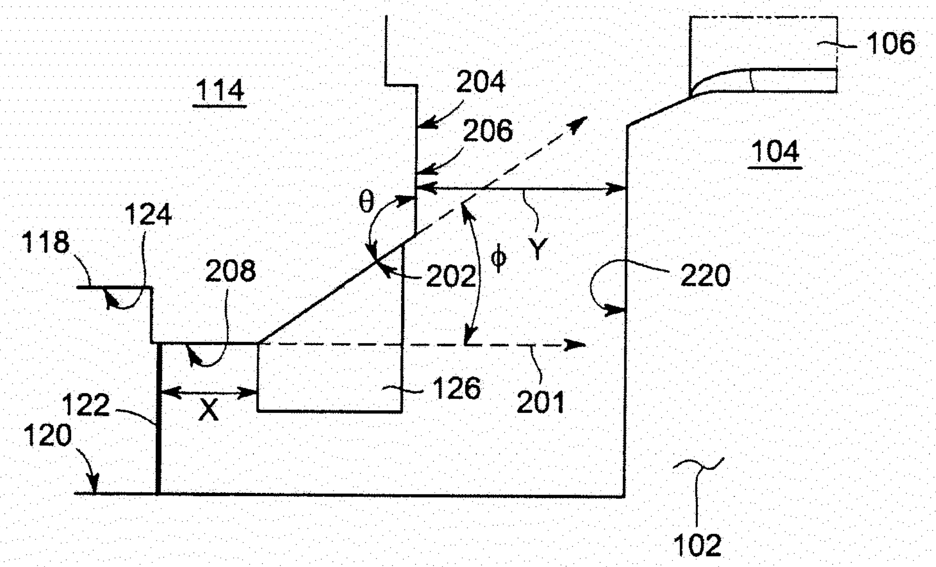

106
114
204
206
104
θ
124
118
208
202
ϕ
Y
220
126
201
122
X
120
102

FIG. 2

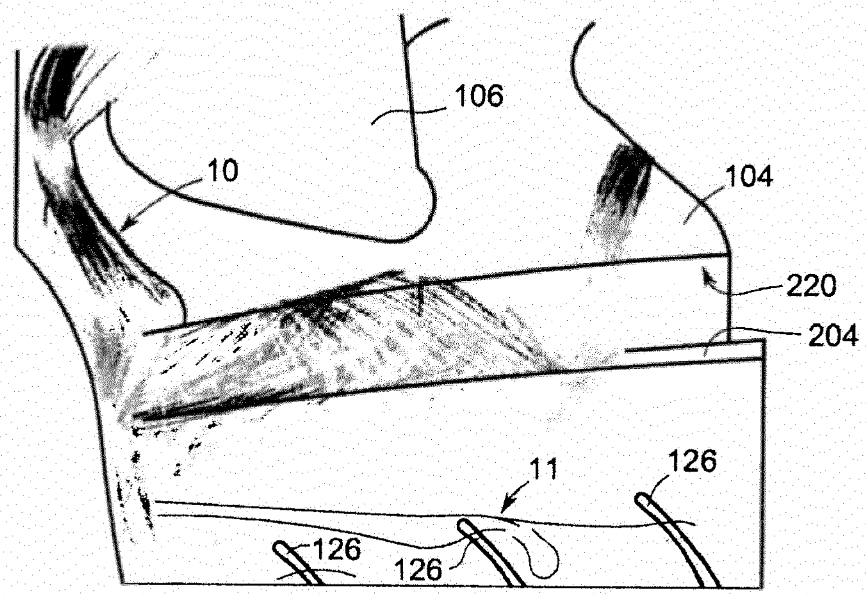

106
10
104
220
204
11
126
126
126

FIG. 3

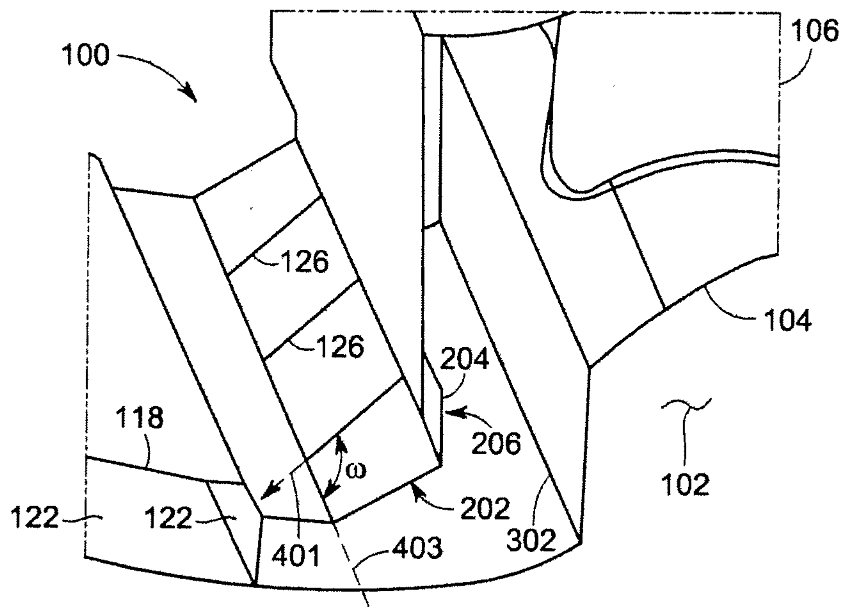
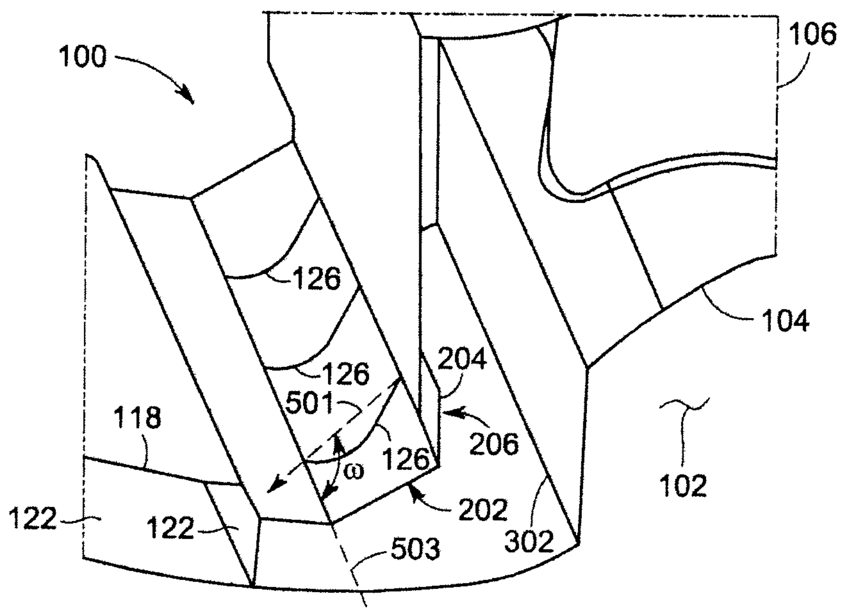

100
106
126
126
104
204
206
118
ω
102
202
122
122
302
401
403

FIG. 4


100
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104
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501
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206
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ω
102
202
122
122
302
503

FIG. 5

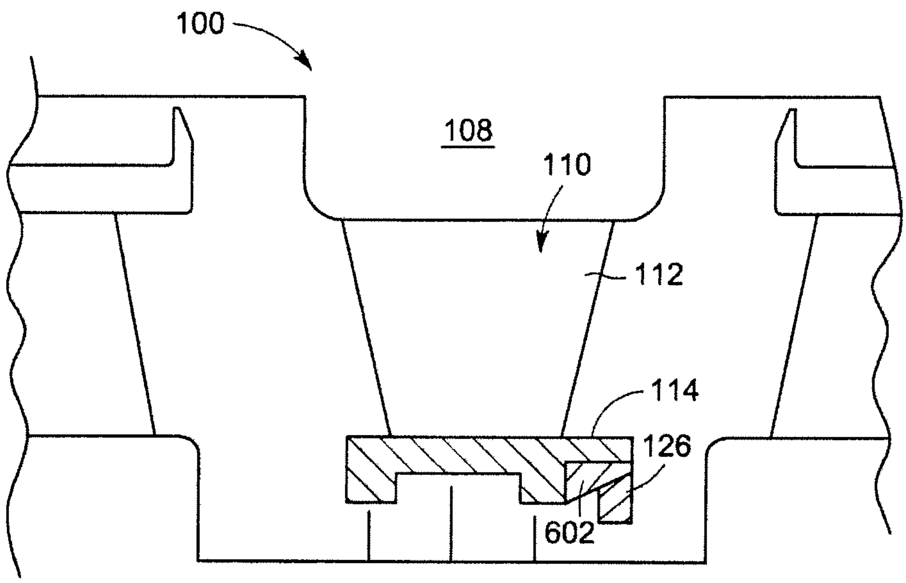



FIG. 6

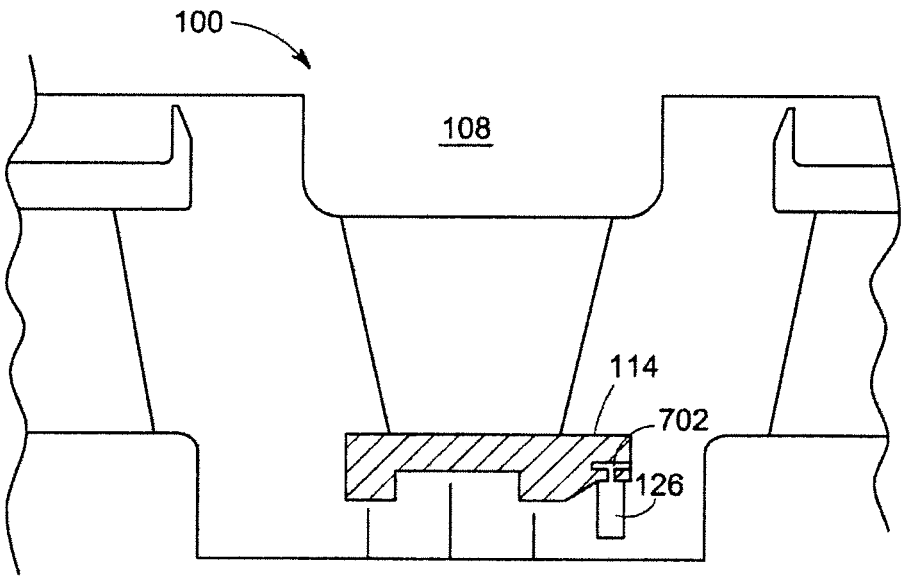



FIG. 7

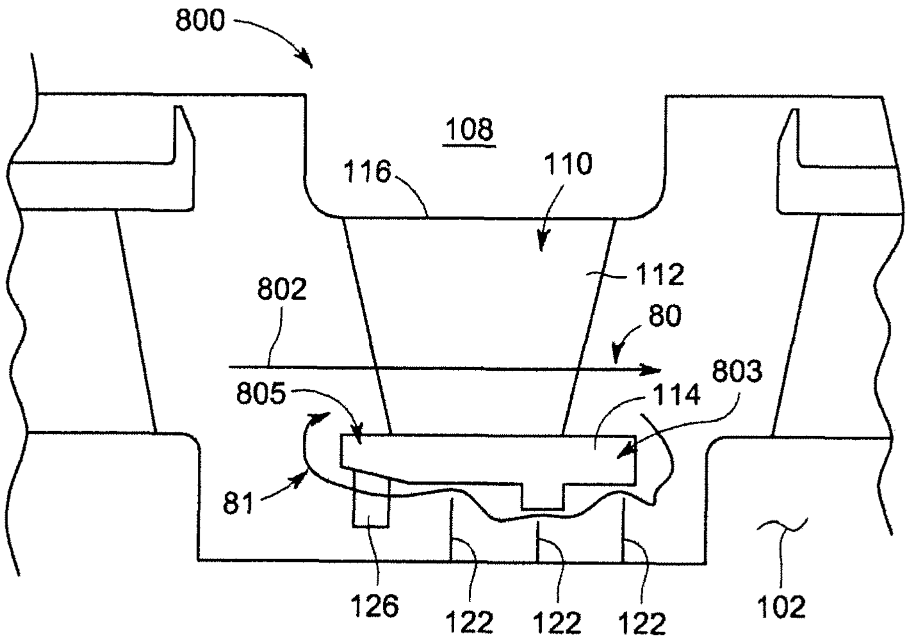
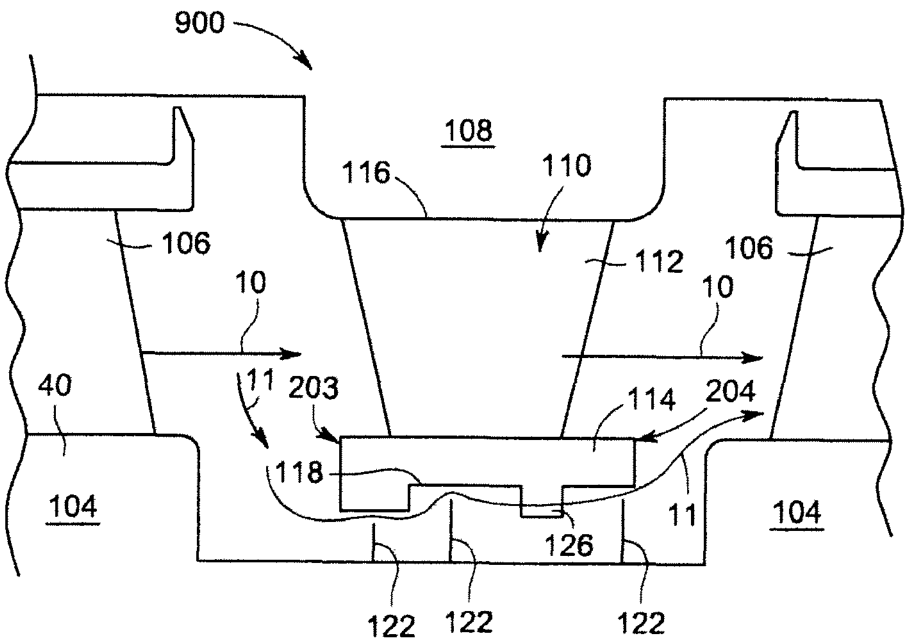

800
108
116
110
112
802
80
805
114
803
81
126
122
122
122
102

FIG. 8


900
108
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106
112
106
10
10
40
11
203
114
204
118
104
126
11
104
122
122
122

FIG. 9

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# EUROPEAN SEARCH REPORT

Application Number
EP 13 15 2139

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X<br>A | US 2008/056895 A1 (SENOO SHIGEKI [JP]) 6 March 2008 (2008-03-06)<br>* paragraph [0023] - paragraph [0039]; claims 1,4,6,9,10; figures 2,5-7 * | 1,2,8-13<br>3-7 | INV.<br>F01D9/02<br>F01D9/04<br>F01D11/00 |
| X<br>A | GB 2 417 053 A (ROLLS ROYCE PLC [GB]) 15 February 2006 (2006-02-15)<br>* page 3, line 34 - page 5, line 21 *<br>* page 6, line 21 - page 7, line 26; claims 1,5,6; figures 1,2, 6 * | 1,2,8-13<br>3-7 | |
| A | EP 0 894 944 A1 (SIEMENS AG [DE]) 3 February 1999 (1999-02-03)<br>* paragraph [0023] - paragraph [0028]; claims 1, 3-5; figures 1-5 * | 1-13 | |

TECHNICAL FIELDS SEARCHED (IPC)

F01D

The present search report has been drawn up for all claims

1

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 29 April 2013 | Balice, Marco |

CATEGORY OF CITED DOCUMENTS

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29-04-2013

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