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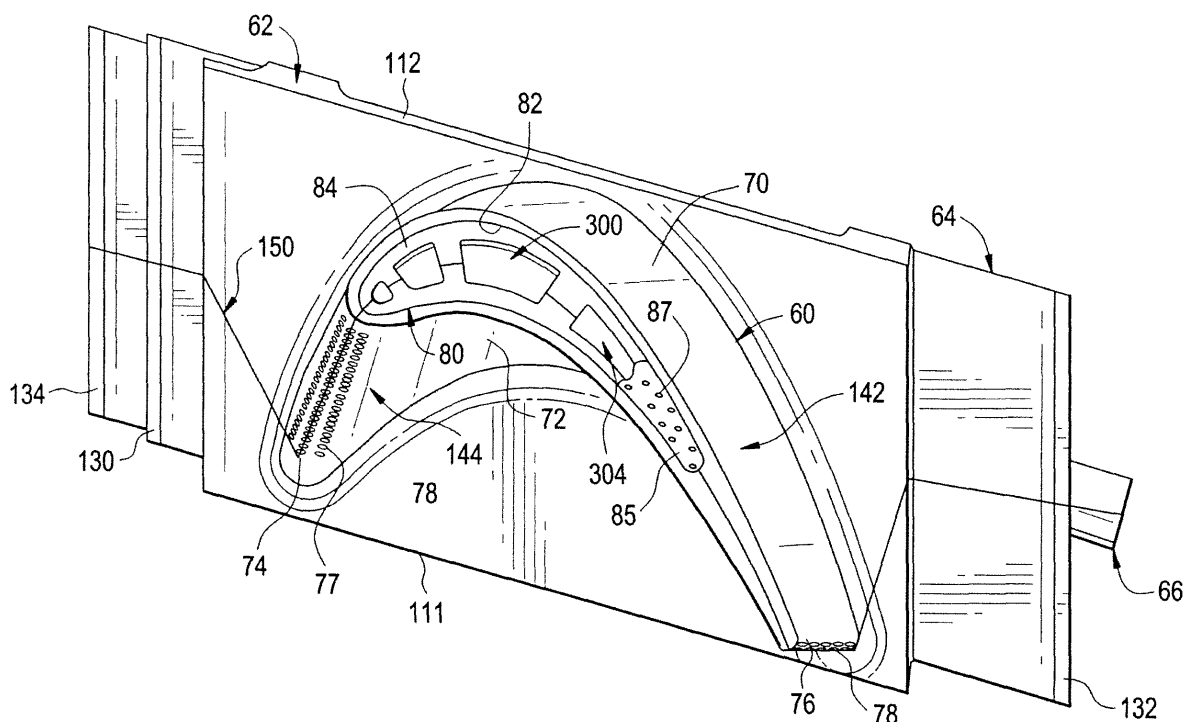
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(54) **Multi-part cast turbine engine component having an internal cooling channel and method of forming a multi-part cast turbine engine component**

(57) A multi-part cast component for a turbine engine includes a first component section having a main body portion including at least one cooling flow passage section, and a second component section having a main body including at least one cooling flow passage section.

The first and second component sections are joined along a parting line to form a turbine engine component with the at least one cooling flow passage section of the first component section aligning with the at least one cooling flow passage of the second component section to form a cooling flow channel.

FIG. 3



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention pertains to the art of turbine engines and, more particularly, to a two part cast turbine engine component having internally formed cooling cavities.

[0002] In general, gas turbine engines combust a fuel/air mixture to release heat energy in the form of a high temperature gas stream that is channeled to a turbine section via a hot gas path. More specifically, a compressor compresses incoming air to a high pressure. The high pressure air is delivered to a combustion chamber to mix with fuel and form a combustible mixture. The combustible mixture is then ignited to form a high pressure, high velocity gas stream which is delivered to the turbine. The high pressure air impacts upon rotor blades or buckets that form part of a turbine rotor assembly. In this manner, the turbine converts thermal energy from the high temperature, high velocity gas stream to mechanical energy that rotates a turbine shaft.

[0003] In many cases, a cooling gas is delivered to internal portions of each rotor blade in order to lower temperatures, particularly in air foil portions of the rotor blade. The cooling gas is delivered through internal passages integrally molded with the blade. In some cases, the passages are formed using a lost wax investment casting method. In other cases, the passages are formed around a ceramic core. In either case, the passages are difficult to manufacture, expensive, and limited in shape. In addition, ceramic cores can react negatively with various alloys used in creating the blades. Moreover, ceramic cores are fragile and prone to shifting and breakage. Finally, internal surfaces of the passages may contain residual core defects, bad grain orientation or finning. The above manufacturing methods make visual inspection of the passages difficult, if not impossible.

BRIEF DESCRIPTION OF THE INVENTION

[0004] In accordance with one aspect, the present invention provides a multi-part cast component for a turbine engine. The multi-part cast component includes a first component section having a main body portion including a interior portion that defines a first cooling flow passage and a second component section having a main body portion including a interior portion that defines a second cooling flow passage section. The first and second component sections are joined along a parting line to form a turbine engine component with the first and second cooling flow passage sections aligning to form a cooling flow channel.

[0005] In accordance with another aspect, the present invention provides a method of forming a multi-part cast component for a turbine engine. The method includes casting a first component section, forming a first cooling flow passage section in the first component section, cast-

ing a second component section and forming a second cooling flow passage section in the second turbine component section. The method also requires joining the first and second component sections along a parting line to form a turbine engine component, with the first and second cooling flow passage sections aligning to establish a cooling flow channel.

[0006] It should be appreciated that the present invention provides a two part cast turbine engine component having an interior cooling channel whose formation is readily formed and which can be easily visually inspected while avoiding many of the drawbacks associated with other casting methods. In any event, additional objects, features and advantages of the various aspects of the present invention will become more readily apparent from the following detailed description of embodiments provided by way of example only when taken in conjunction with the drawings wherein like reference numerals refer to corresponding parts in the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 is a schematic illustration of a gas turbine engine including a two-part cast engine component, shown in the form of a rotor blade, constructed in accordance with an aspect of the invention;

[0008] Figure 2 is an enlarged perspective view of the rotor blade of Figure 1;

[0009] Figure 3 is an end view of the rotor blade of Figure 1; and

[0010] Figure 4 is an elevational view showing two component sections of the rotor blade of Figure 1 prior to being joined.

DETAILED DESCRIPTION OF THE INVENTION

[0011] With initial reference to Figure 1, a gas turbine engine constructed in accordance with the present invention is generally indicated at 10. Turbine engine 10 includes a compressor 12 operatively coupled to a turbine 14 and an electrical generator 16 via a shaft 18. Shaft 18 is illustrated as a single, monolithic component, however, it should be readily understood that shaft 18 could also be formed in multiple segments with each segment being coupled to an adjacent engine component.

[0012] In any event, engine 10 is further shown to include a combustor 20 in which air 21 from compressor 12 and a fuel 22 are mixed to form a combustible mixture. The combustible mixture is ignited to form a high pressure, high temperature combustion product or gas 28 that is used to drive turbine 14. More specifically, high pressure, high temperature gas 28 enters into turbine 14 and impinges upon a rotor assembly 35 having a plurality of rotor blades, two of which are indicated at 40 and 41. Rotor assembly 35 converts thermal energy from high pressure, high temperature gas 28 into mechanical, rotational, energy.

[0013] When coupled to rotor assembly 35, rotor

blades 40 and 41 are connected to a rotor disk (not shown) that is rotateably mounted to a rotor shaft, such as shaft 18. In an alternative configuration, rotor blades 40 and 41 are mounted within a rotor spool (not shown). In any event, circumferentially adjacent rotor blades 40 and 41 are identical such that a detailed description will follow referring to rotor blade 40. However, it should be understood that in the exemplary embodiment, each of the plurality of rotor blades is similarly constructed.

[0014] As best shown in Figures 2 and 3, rotor blade 40 includes an airfoil portion 60, a platform portion 62, a shank portion 64 and a dovetail 66 which are collectively known as a bucket. Each airfoil portion 60 includes a first sidewall 70 and a second sidewall 72. In the embodiment shown, first sidewall 70 is convex and defines a suction side of airfoil portion 60. Conversely, second sidewall 72 is concave and defines a pressure side of airfoil portion 60. Sidewalls 70 and 72 collectively form a leading edge 74 and an axially spaced trailing edge 76 of airfoil portion 60. More specifically, trailing edge 76 is spaced chordwise and downstream from leading edge 74.

[0015] As will be discussed more fully below, leading edge 74 is provided with a plurality of openings 77 that serve as ventilation ducts allowing a cooling gas to pass through rotor blade 40. Likewise, trailing edge 76 includes a plurality of openings 78 that also serve as cooling gas ventilation ducts. First and second sidewalls 70 and 72 extend outward in span from a bucket or blade root 79 located adjacent to platform portion 62 to an airfoil tip 80. As best shown in Figure 3, airfoil tip 80 includes an opening 82 defined by a recessed seat 84. A tip cap 85 is provided in recessed seat 84 and closes opening 82. However, tip cap 85 may be provided with small openings, such as indicated at 87 that allow a small portion of the cooling gas to pass into a hot gas path (not shown).

[0016] In the embodiment shown, shank portion 64 extends radially inward from platform portion 62 to dovetail 66, and dovetail 66 extends radially inward from shank portion 64 to facilitate securing rotor blade 40 to the rotor disk (not shown). Platform portion 62 also includes an upstream side or skirt 107 and a downstream side or skirt 109 that are connected by a pressure-side edge 111 and a suction-side edge 112. Shank portion 64 is shown to include a substantially concave side wall 120 and a substantially convex sidewall (not shown) that are connected at an upstream sidewall 124 and a downstream sidewall 126. In this manner, concave sidewall 120 is recessed relative to upstream and downstream sidewalls 124 and 126 respectively, such that when rotor blade 40 is coupled within rotor assembly 35, a shank cavity 128 is defined between adjacent rotor blades 40 and 41.

[0017] As further shown in Figures 2 and 3, rotor blade 40 includes a forward angel wing 130 and an aft angel wing 132 which extend outward from upstream side wall 124 and downstream sidewall 126 respectively. Forward and aft angel wings 130 and 132 are configured to seal corresponding forward and aft angel wing cavities (not shown) defined within rotor assembly 35. In addition, ro-

tor blade 40 includes a forward, lower angel wing 134 which extends outward from upstream sidewall 124 to facilitate sealing between rotor blade 40 and the rotor disk (not shown).

[0018] In accordance with one aspect of the present invention, rotor blade 40 is a multi-part, cast component of engine 10. More specifically, rotor blade 40 includes a first component section 142 and a second component section 144 which are cast separately and joined together along a parting line 150. In accordance with an exemplary embodiment, first and second component sections 142 and 144 are cast from aluminum. However, component sections 142 and 144 can be formed from a variety of materials, such as super alloys, and through a variety of known forming techniques.

[0019] Reference will now be made to Figure 4 is describing first and second component sections 142 and 144 of rotor blade 40. As shown, first component section 142 includes a main body portion 160 having an interior portion 162 that defines first and second cooling gas passage sections 164 and 165. As shown, first cooling gas passage section 164 includes an inlet section 168 which, in the exemplary embodiment, is bifurcated and leads into a flow chamber 170. Flow chamber 170 empties into a first flow section 171 that extends longitudinally through interior portion 162 to a first flow reversing section 172. From first flow reversing section 172, first cooling flow passage section 164 leads to a flow return section 174 that extends longitudinally back through interior portion 162. Flow return section 174 terminates in a second flow reversing section 176 that leads to an outlet flow section 178. Outlet flow section 178 delivers cooling gas through openings 77 in leading edge 74 as well as openings 87 in airfoil tip 80.

[0020] In a manner similar to that described above, second cooling flow passage section 165 includes an inlet section 188 which, in the exemplary embodiment, is bifurcated and leads into a flow chamber 190. Flow chamber 190 empties into a first flow section 191 that extends longitudinally through interior portion 162 to a first flow reversing section 192. From first flow reversing section 192, second cooling flow passage section 165 leads to a flow return section 194 that extends longitudinally back through interior portion 162. Flow return section 194 terminates in a second flow reversing section 196 that leads to an outlet flow section 198. Outlet flow section 198 delivers cooling gas through openings 78 in trailing edge 76 as well as openings 82 in airfoil tip 80. At this point it should be understood that while first and second cooling flow passage sections 164 and 165 appear to be similar, the particular path taken by each cooling passage section 164, 165 could differ depending upon the particular configuration or geometry of rotor blade 40.

[0021] In a manner similar to that described above with respect to first component section 142, second component section 144 includes a main body portion 210 having an interior portion 212 that defines third and fourth cooling

flow passage sections 214 and 215. Second component section 144 is actually a mirror image of first component section 142. Accordingly, third cooling flow passage section 214 is a mirror image of first cooling flow passage section 164 while fourth cooling flow passage section 215 is a mirror image of second cooling flow passage section 165. However, for the sake of completeness, third cooling flow passage section 214 includes an inlet section 218 which, in the exemplary embodiment, is bifurcated and leads into a flow chamber 220. Flow chamber 220 empties into a first flow section 221 that extends longitudinally through interior portion 212 to a first flow reversing section 222. From first flow reversing section 222, third cooling flow passage section 214 leads to a flow return section 224 that extends longitudinally back through interior portion 212. Flow return section 224 terminates in a second flow reversing section 226 that leads to an outlet flow section 228. Outlet flow section 228 delivers cooling gas through openings 77 in leading edge 74 as well as openings 87 in airfoil tip 80.

[0022] Also in a similar manner, fourth cooling flow passage section 215 includes an inlet section 238 which, in the exemplary embodiment, is bifurcated and leads into a flow chamber 240. Flow chamber 240 empties into a first flow section 241 that extends longitudinally through interior portion 212 to a first flow reversing section 242. From first flow reversing section 242, fourth cooling flow passage section 215 leads to a flow return section 244 that extends longitudinally back through interior portion 212. Flow return section 244 terminates in a second flow reversing section 246 that leads to an outlet flow section 248. Outlet flow section 248 delivers cooling gas through openings 78 in trailing edge 76 as well as openings 82 in airfoil tip 80.

[0023] With this arrangement, cooling flow passages 164, 165 and 214, 215 are formed in respective first and second component sections 142 and 144 using a variety of techniques such as machining, molding and the like. Regardless of the technique employed, once formed, cooling flow passage sections 164, 165 and 214, 215 can be readily visually inspected for irregularities, which might detract from overall cooling efficiency. Next, first and second component sections 142 and 144 are joined along parting line 150 so that first cooling flow passage section 164 registers with third cooling flow passage section 214 to form a first cooling flow channel 300 in rotor blade 40. Similarly, second cooling flow passage section 165 registers with fourth cooling flow passage section 215 to form a second cooling flow channel 304 in rotor blade 40. Component sections 142 and 144 can be joined by a variety of known metal joining techniques such as welding, brazing and the like. Of course, if a super alloy or a material other than metal is used to form rotor blade 40, other joining techniques would be employed. In any event, once formed, rotor blade 40 is incorporated into rotor blade assembly 35 of a turbine engine 2.

[0024] At this point it should be understood that the various aspects of the present invention lower manufac-

turing costs and improve overall component quality. In addition, by forming the component in multiple parts, new cooling channel shapes and designs are now possible. That is, cooling channels can now be created that include thick and thin portions or even alternating thick and thin portions. Moreover, the present invention enables the formation of extremely small channels that can advantageously deliver a cooling gas to portions of the rotor blade heretofore unreachable by present passage formation techniques. More intricate serpentine shapes that carry the cooling medium through a larger portion of the component are also now possible. Ceramic core molding also has a tendency to react negatively with certain metals. The present invention avoids these problems. Finally the present invention enables close, visual, inspection of the component parts to check for voids or other casting defects that were heretofore undetectable. That is, existing ceramic core molding is not capable of forming channels having differing dimensions or passages that are extremely thin or possess other such characteristics. When using ceramic core molding techniques, once the channels are formed, the ceramic core must be carefully removed. Removing a ceramic core from channels that are thick and thin or extremely narrow is not possible without risking breakage. If the core breaks, the rotor blade must be discarded.

[0025] Although described with reference to illustrated aspects of the present invention, it should be readily understood that various changes and/or modifications can be made to the invention without departing from the scope thereof. For instance, while the first and second cooling flow passages are shown to be similar, various other configurations could also be employed without detracting from the invention. Also, while the component is described as being cast from aluminum, other metals including super alloys and non-metals can also be used depending on the particular application of the engine. It should also be understood that while described as a rotor blade, various other engine components such as vanes, buckets, nozzles and the like could also be formed by the present invention. Finally, the component could be cast in any number of parts and should not be seen as being limited to the two component sections as shown. In general, the invention is only intended to be limited by the scope of the following claims.

Claims

1. A multi -part cast component for a turbine engine comprising:

a first component section having a main body portion including at least one cooling flow passage section; and

a second component section having a main body portion including at least one cooling flow passage section, said second component sec-

- tion being joined to the first component section along a parting line to form a turbine engine component with the at least one cooling flow passage section of the first component section aligning with the at least one cooling flow passage section of the second component section to form a cooling flow channel. 5
2. The multi-part cast component according to claim 1, wherein the first and second component sections are joined to form a two-part turbine engine component. 10
3. The multi-part cast component according to claim 1 or claim 2, wherein the first component section is a first rotor blade section and the second component section is a second rotor blade section, said first and second rotor blade sections being joined along the parting line to form a turbine rotor blade. 15
4. The multi-part cast component according to any one of the preceding claims, wherein the at least one cooling flow passage section of the first component section includes first and second cooling flow passage sections. 20
5. The multi-part cast component according to claim 3, wherein the at least one cooling flow passage section of the second component section includes third and fourth cooling flow passage sections, said first and third cooling flow passage sections being joined to form a first cooling flow channel and said second and fourth cooling flow passage sections being joined to form a second cooling flow channel. 25 30
6. A method of forming a multi-part cast component for a turbine engine comprising: 35
- forming a first component section;
creating at least one cooling flow passage section in the first component section; 40
forming a second component section;
creating at least one cooling flow passage section in the second component section; and
joining the first and second component section along a parting line to form a turbine engine component with said at least one cooling flow passage section of the first component section joining to the at least one cooling flow passage section of the second component section to form a cooling flow channel in the turbine component. 45 50
7. The method of claim 6, wherein the turbine engine component is a turbine rotor blade.
8. The method of claim 6 or claim 7, further comprising: 55
- forming first and second cooling flow passage sections in the first component section; and
- forming third and fourth cooling flow passage sections in the second component section wherein, upon joining the first and second component sections along the parting line, said first cooling flow passage section registers with the third cooling flow passage section to establish a first cooling flow channel and said second cooling flow passage section registers with the fourth cooling flow passage section to establish a second cooling flow channel in the turbine component.
9. The method of any one of claims 6 to 8, wherein the at least one cooling flow passage section is machined from corresponding ones of the first and second component sections.
10. The method of any one of claims 6 to 9, wherein the at least one cooling flow passage section is molded into corresponding ones of the first and second component sections.
11. The method of any one of claims 6 to 10, wherein the turbine engine component is formed in two parts.

FIG. 1

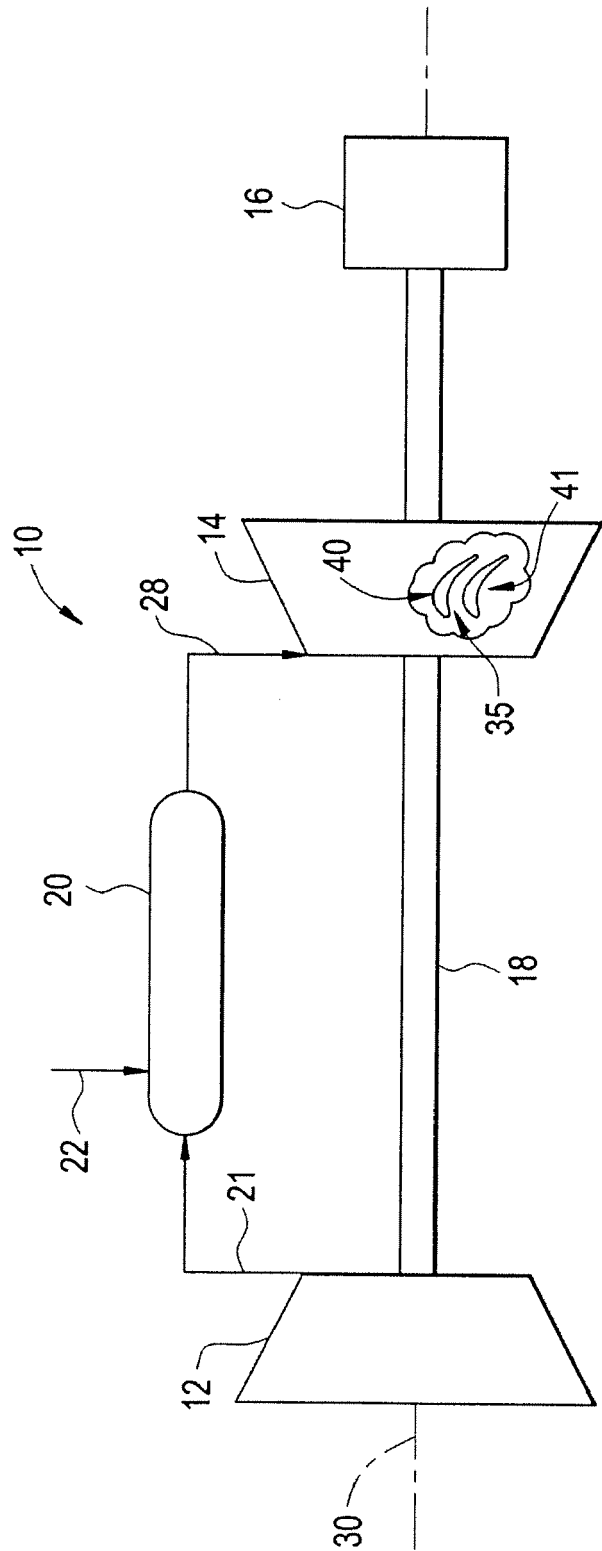


FIG. 2

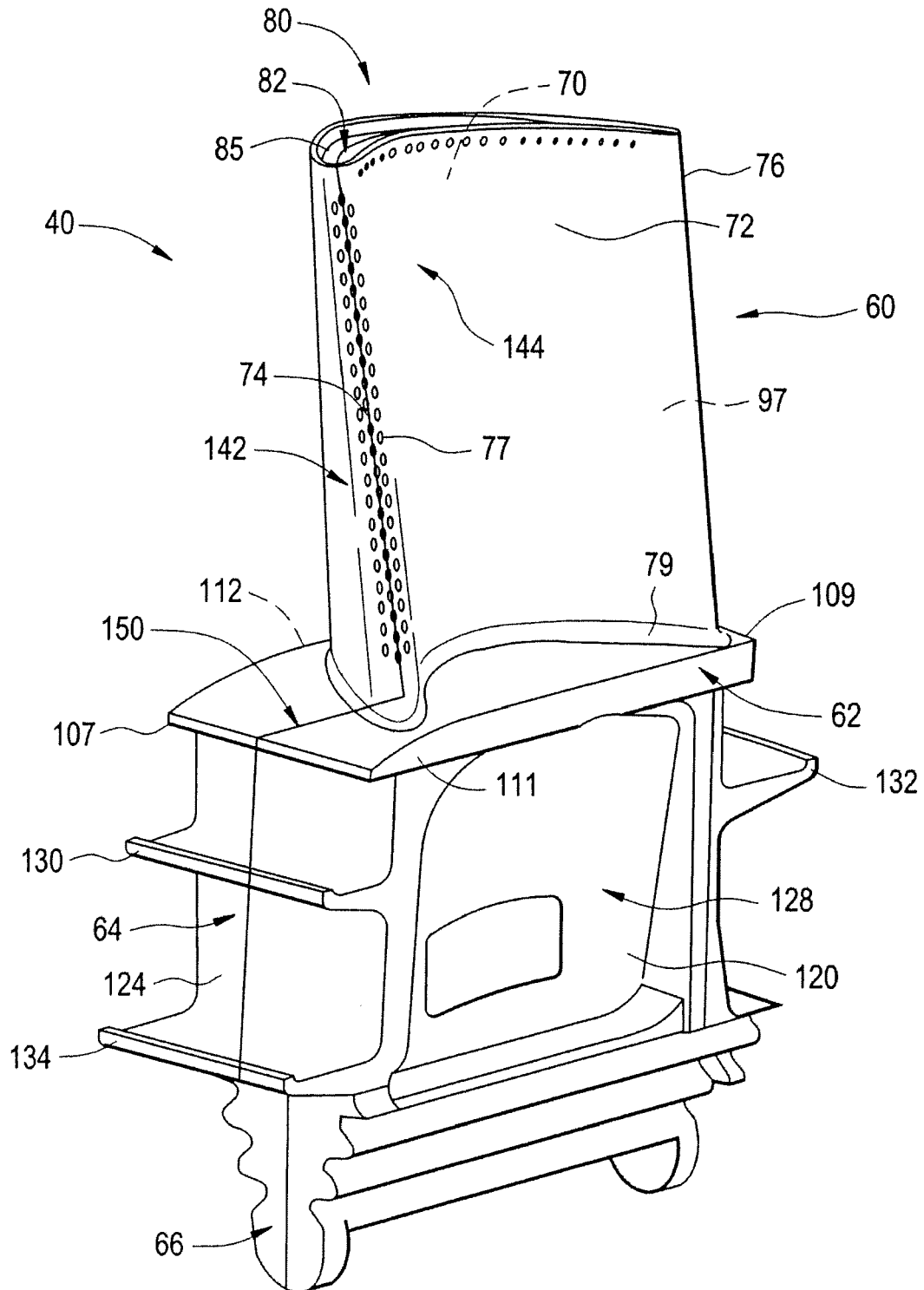


FIG. 3

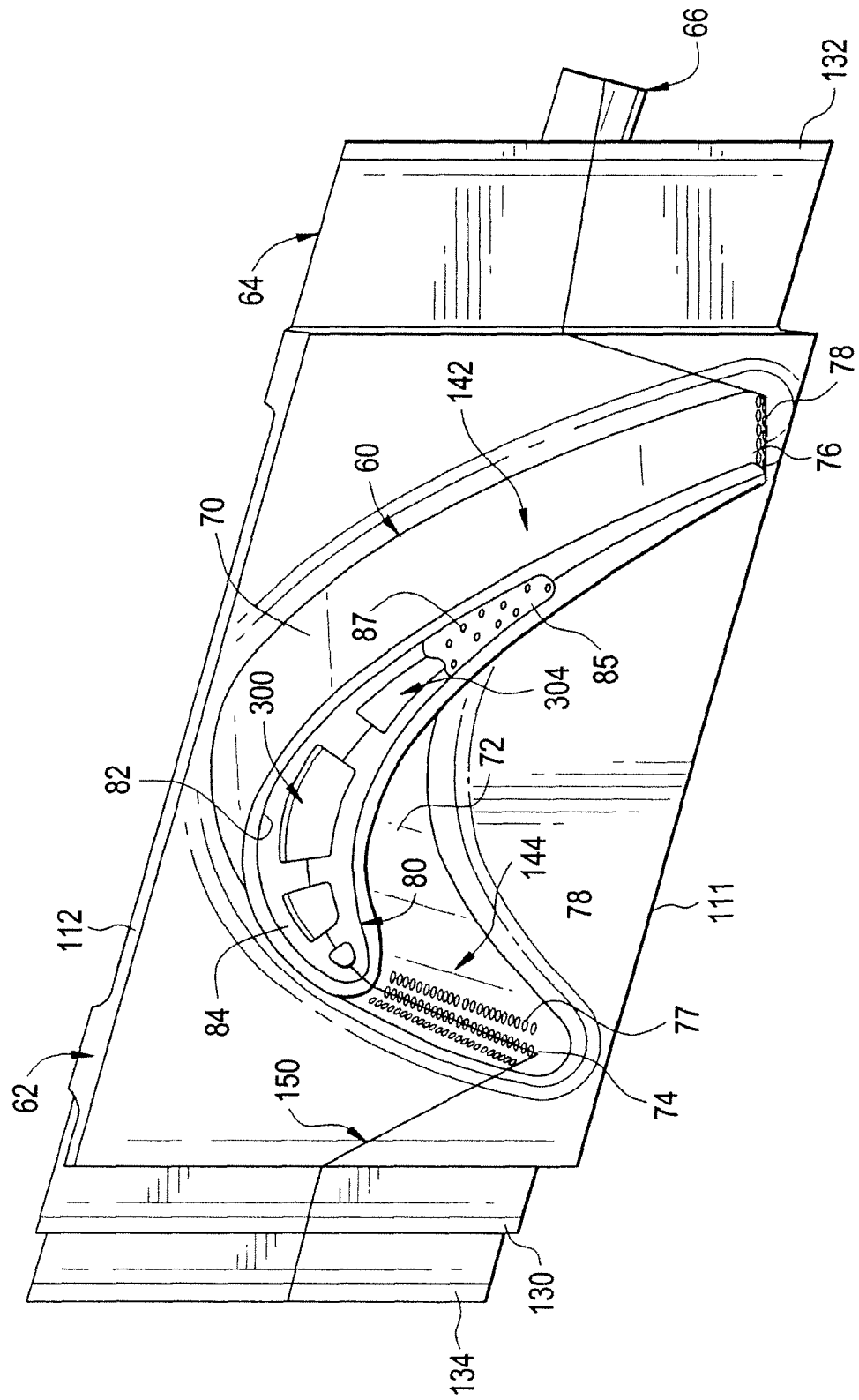


FIG. 4

