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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

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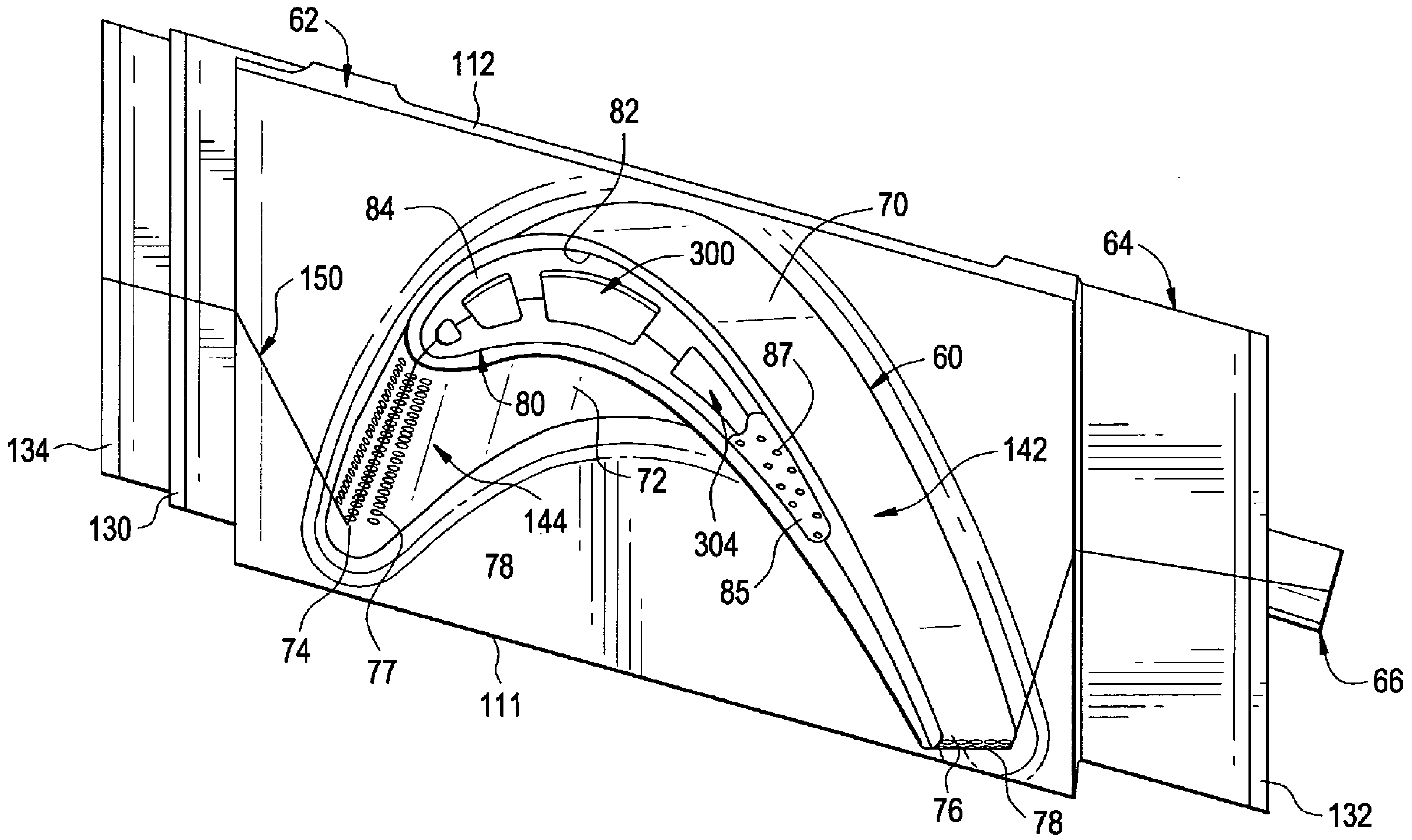
(57) **ABSTRACT**

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.



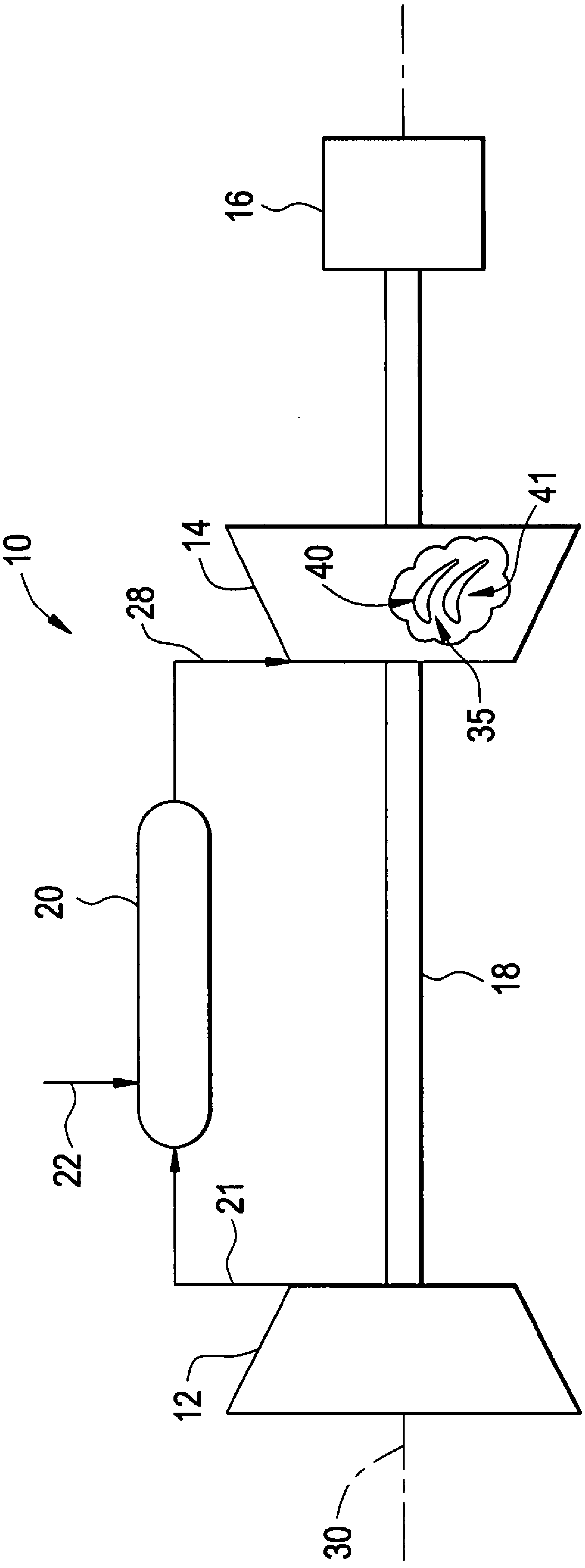
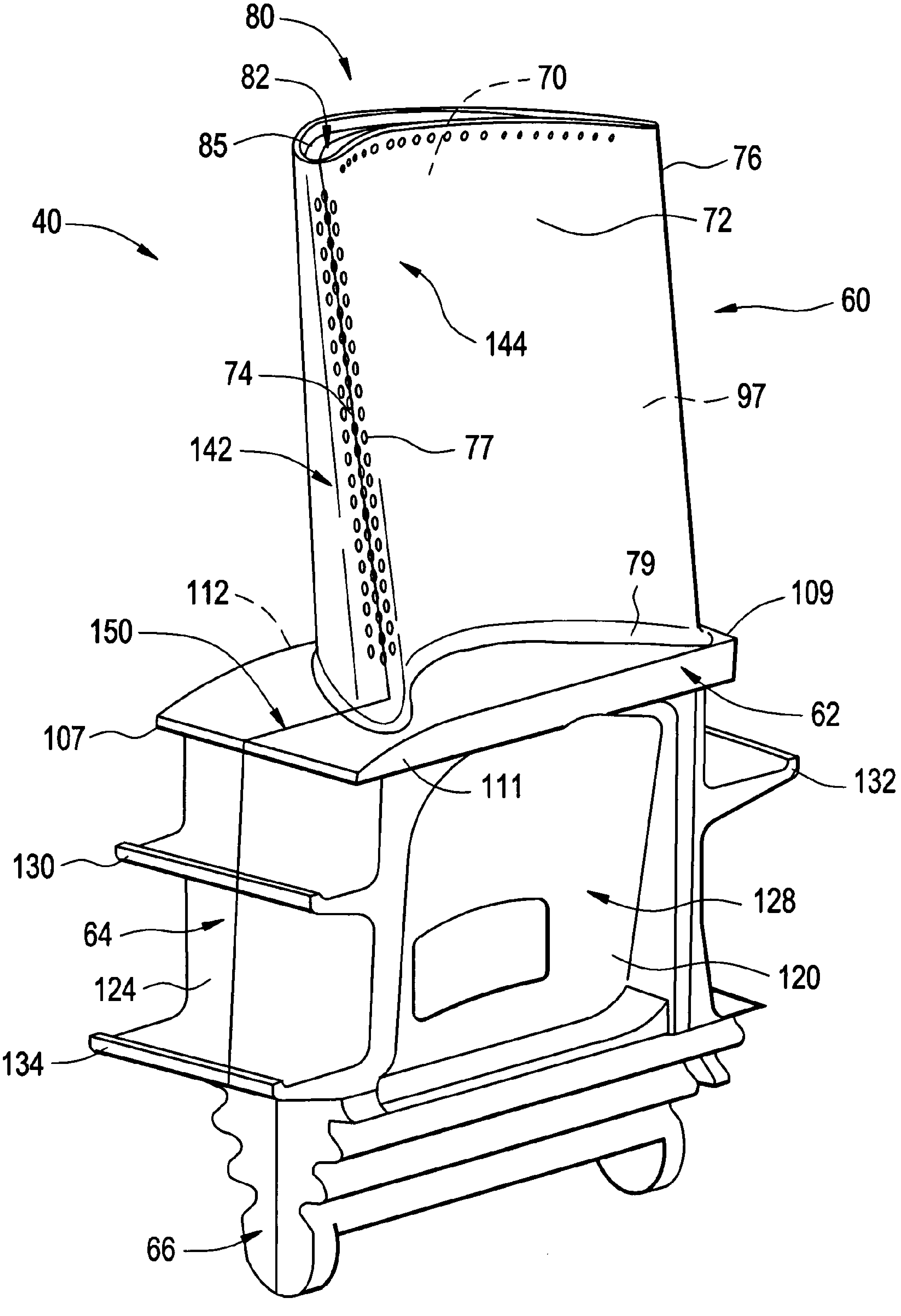


FIG. 1

FIG. 2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82
70
85
76
40
72
60
144
74
97
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112
109
150
62
107
111
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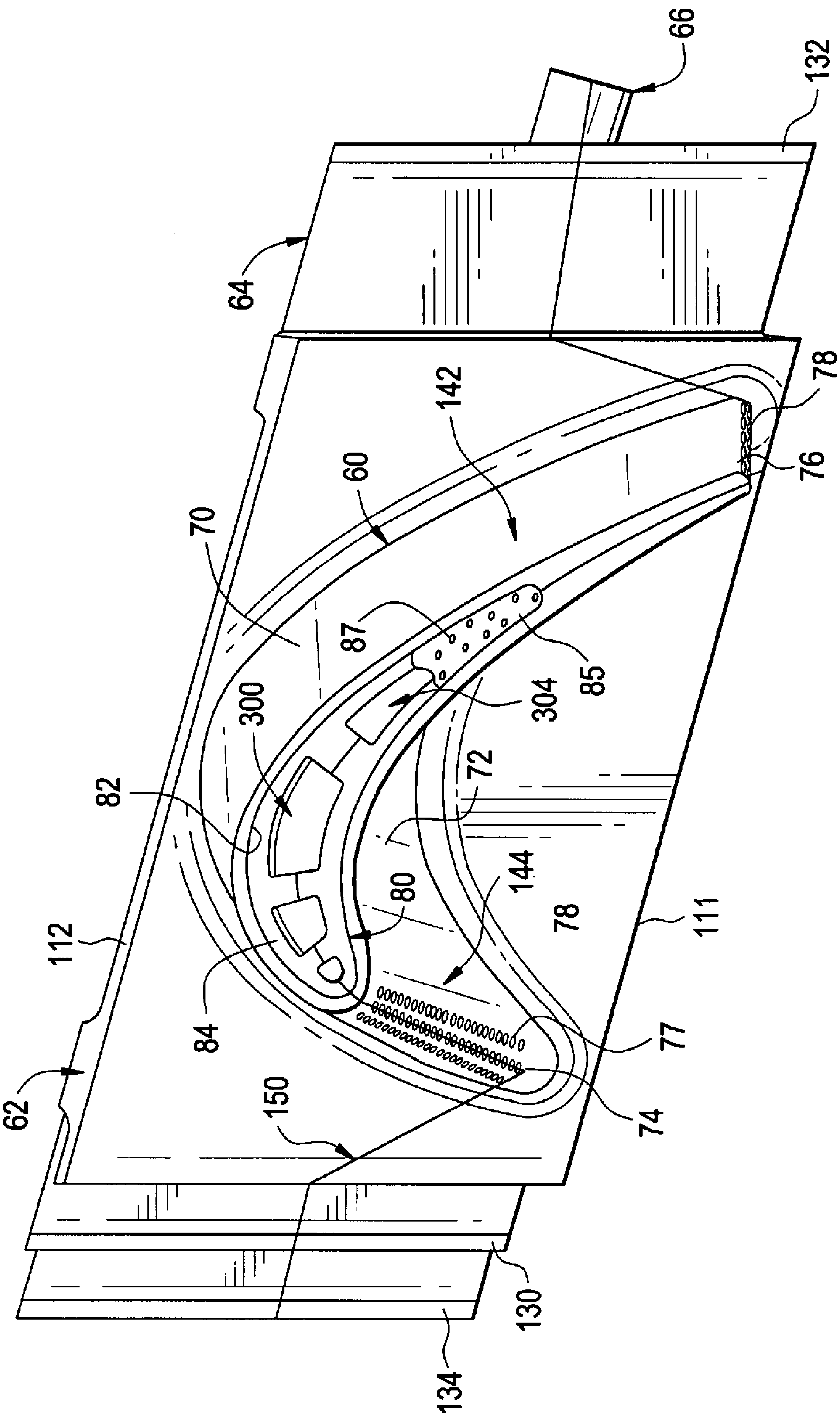
128
64
120
124
134
66

FIG. 3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142
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144
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112
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84
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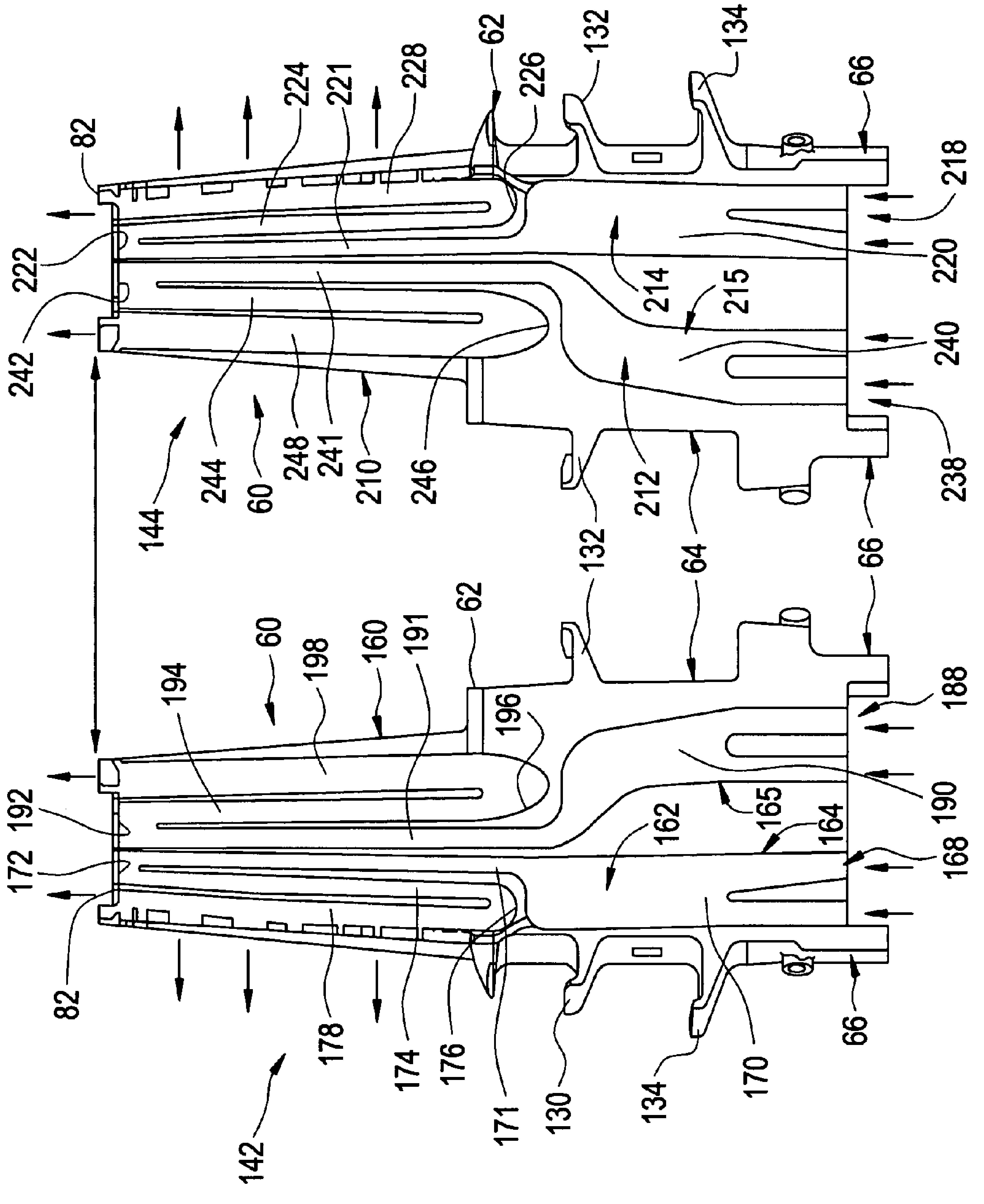
62
150
74
130
134

FIG. 4


82
222
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144
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134
132
226
62
228
221
224
82
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192
194
198
60
160
191
62
196
132
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190
165
162
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168
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134
130
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176
174
178
142
66
82

MULTI-PART CAST TURBINE ENGINE COMPONENT HAVING AN INTERNAL COOLING CHANNEL AND METHOD OF FORMING A MULTI-PART CAST TURBINE ENGINE COMPONENT

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, casting 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 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] FIG. **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] FIG. **2** is an enlarged perspective view of the rotor blade of FIG. **1**;

[0009] FIG. **3** is an end view of the rotor blade of FIG. **1**; and

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

DETAILED DESCRIPTION OF THE INVENTION

[0011] With initial reference to FIG. **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 rotatably 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 FIGS. **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 chord-wise 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 FIG. **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 FIGS. **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, rotor 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 FIG. **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 a 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 a 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 manufacturing 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.

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 section 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.

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.

3. The multi-part cast component according to claim **1**, 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.

4. The multi-part cast component according to claim **1**, wherein the at least one cooling flow passage section of the first component section includes first and second cooling flow passage sections.

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.

6. A method of forming a multi-part cast component for a turbine engine comprising:

forming a first component section;

creating at least one cooling flow passage section in the first component section;

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.

7. The method of claim **6**, wherein the turbine engine component is a turbine rotor blade.

8. The method of claim **6**, further comprising:

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 claim **6**, 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 claim **6**, 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 claim **5**, wherein the turbine engine component is formed in two parts.

* * * * *