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(54) **DIE CAST SYSTEM FOR FORMING A COMPONENT USABLE IN A GAS TURBINE ENGINE**

(71) Applicant: **Siemens Aktiengesellschaft**, München (DE)

(72) Inventor: **Ching-Pang Lee**, Cincinnati, OH (US)

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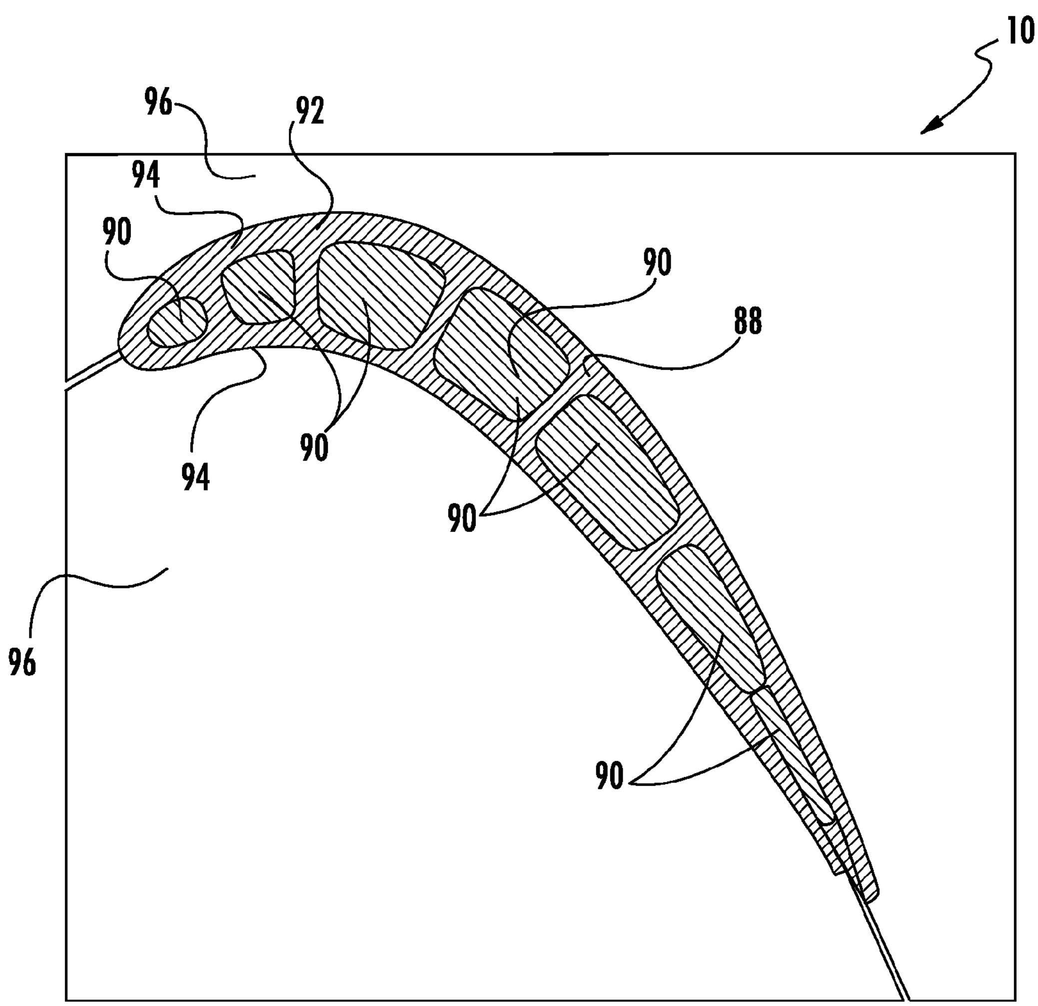
CPC *B22C 9/04* (2013.01); *B22D 17/20* (2013.01); *B22C 7/02* (2013.01); *B22C 9/10* (2013.01)

(57) **ABSTRACT**

A die cast system having an inner liner insert that enables the configuration of a component produced by the system to be easily changed by changing the inner liner insert without having to rework the die housing is disclosed. Because the inner liner insert only need be removed and replaced to change the configuration of an outer surface of a component produced by the system, the cost savings is significant in contrast with conventional systems in which the die would have to be reworked.



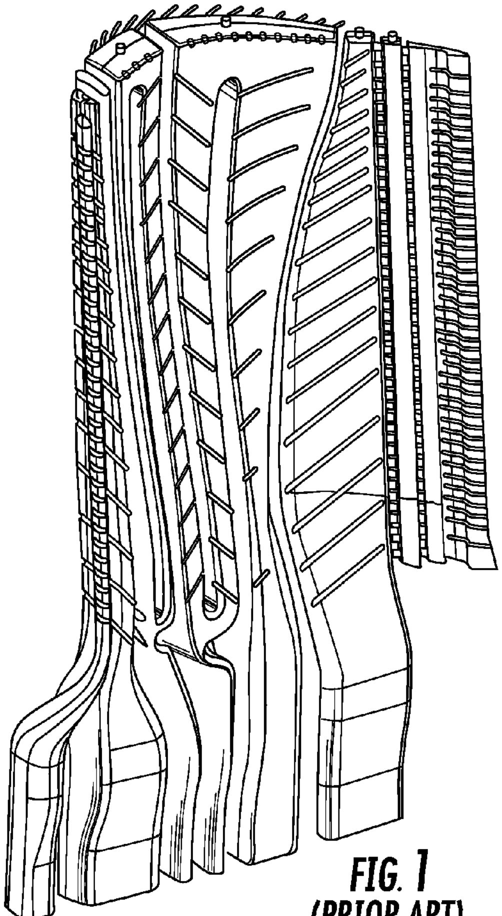


FIG. 1
(PRIOR ART)

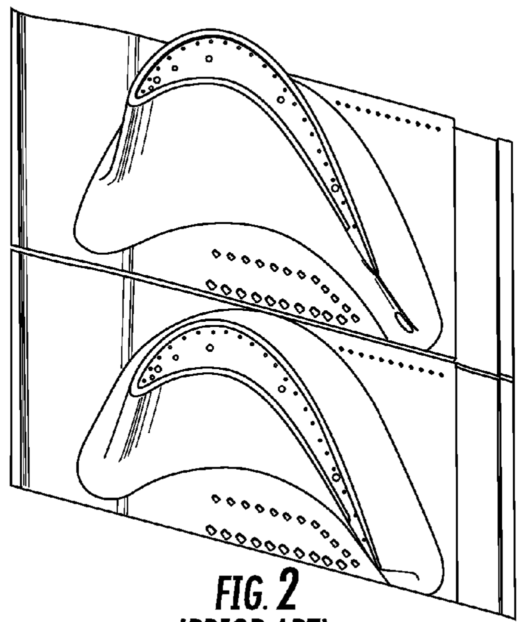


FIG. 2
(PRIOR ART)

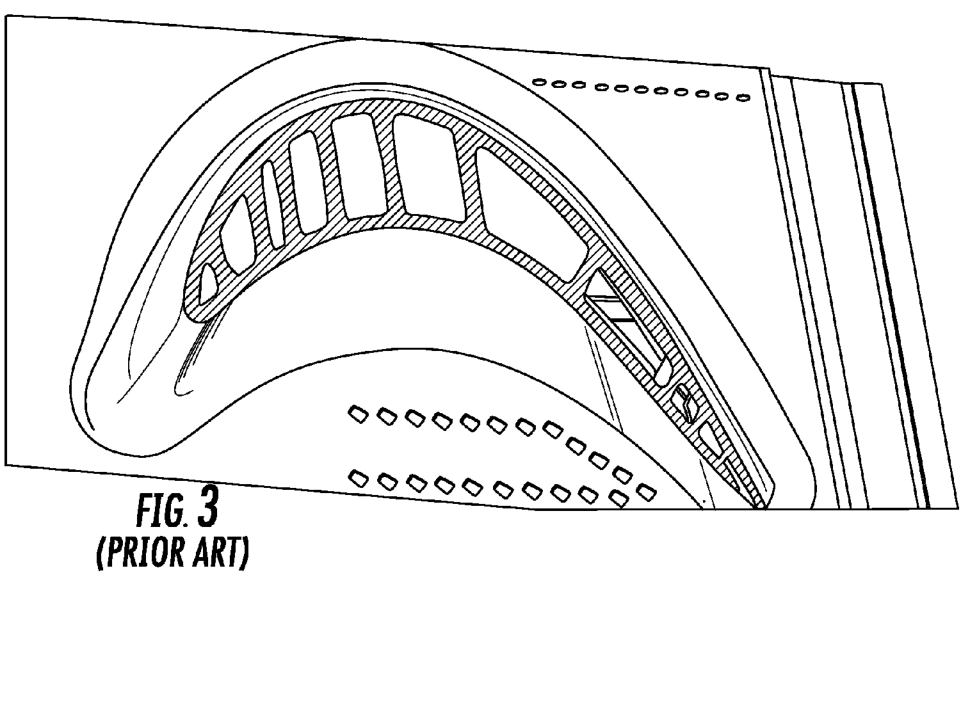


FIG. 3
(PRIOR ART)

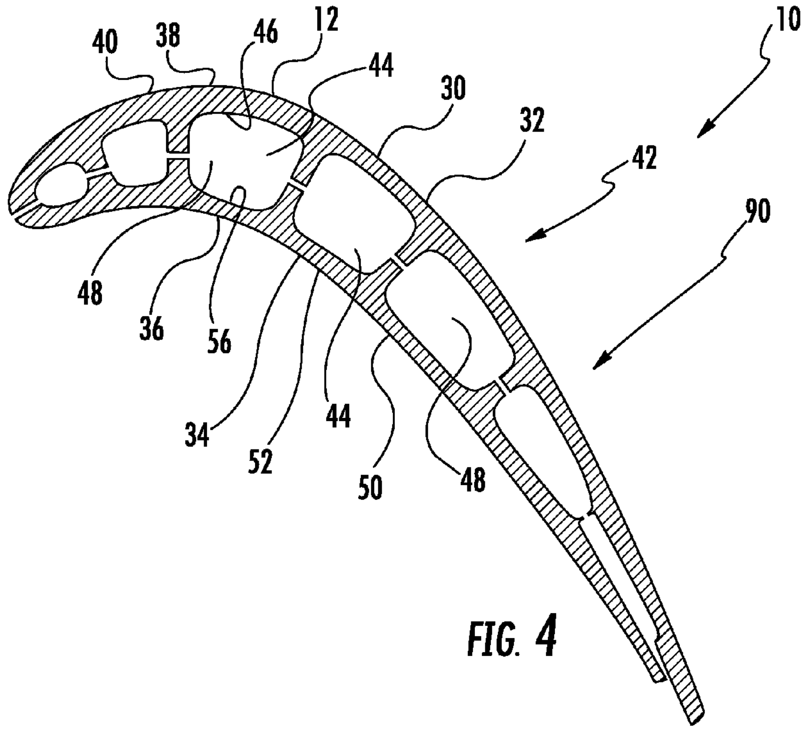

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FIG. 4

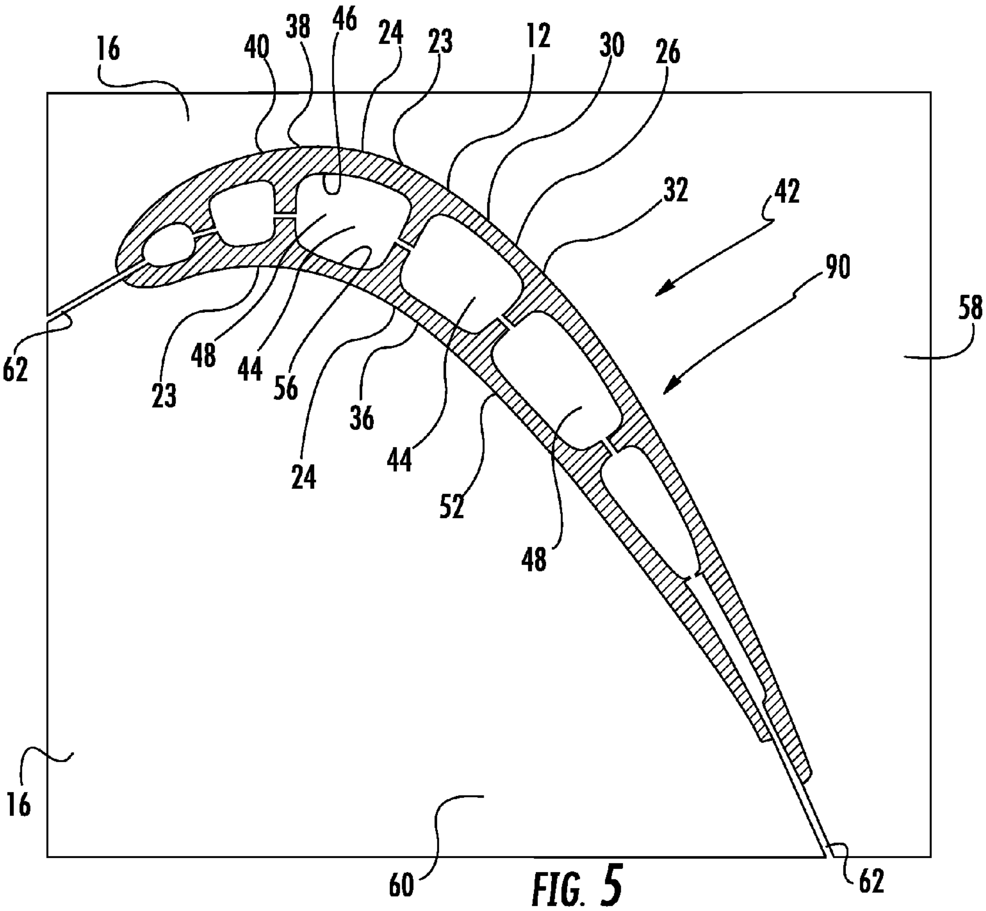
16
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FIG. 5

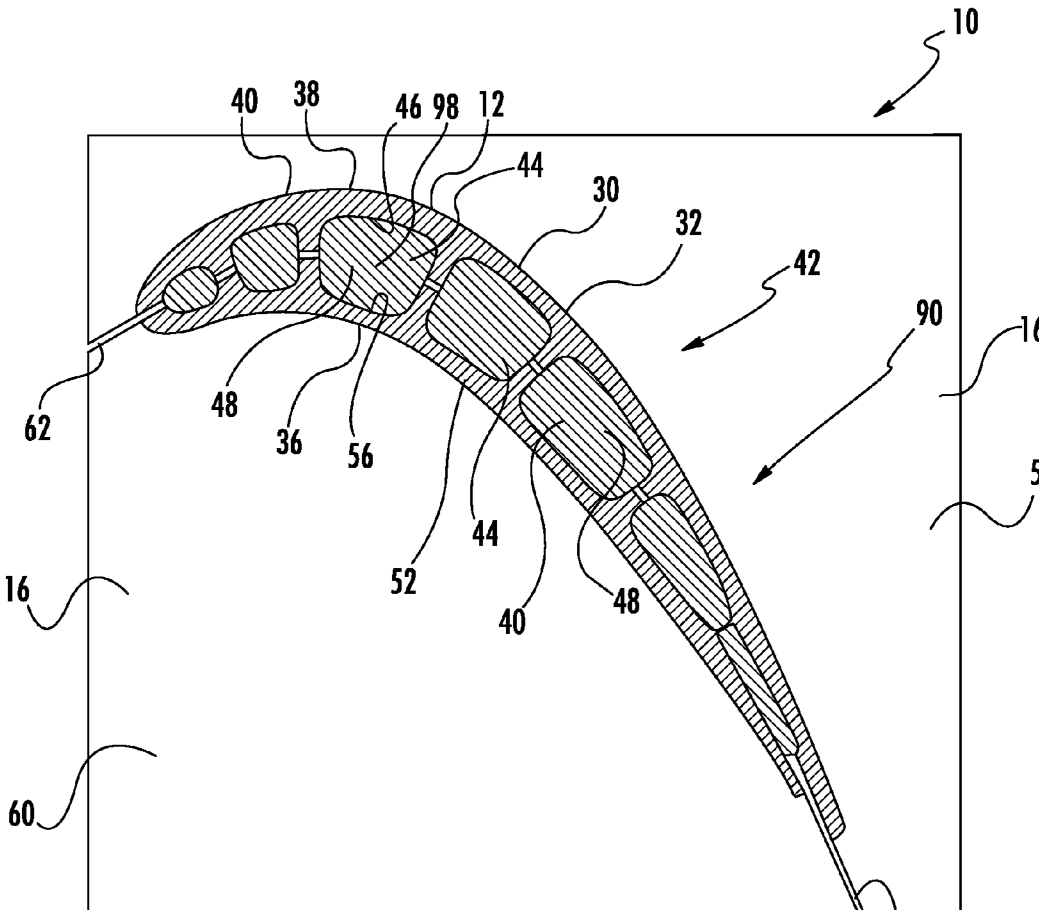
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FIG. 6

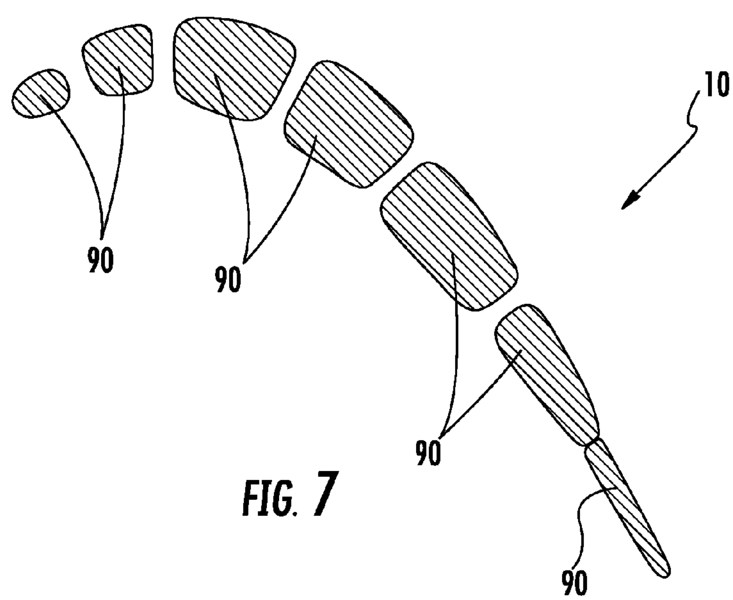
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FIG. 7

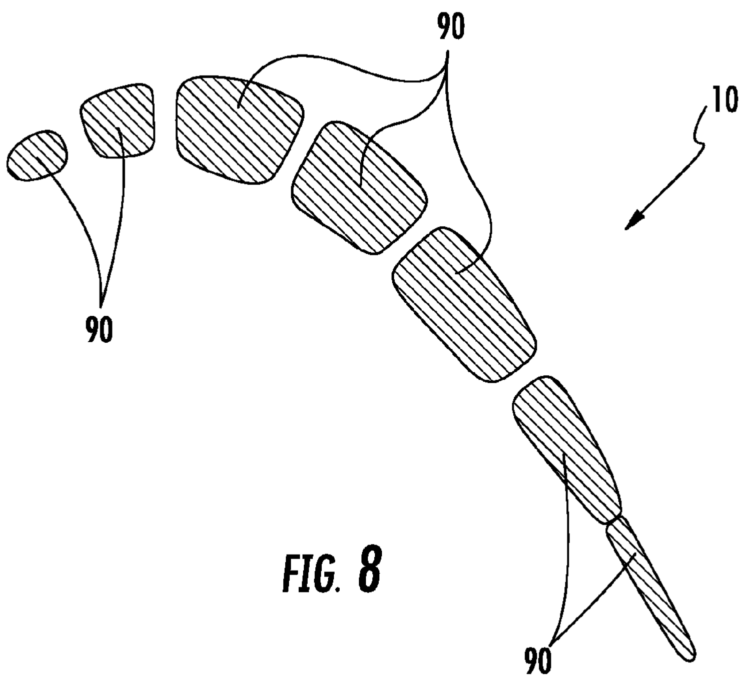

FIG. 8

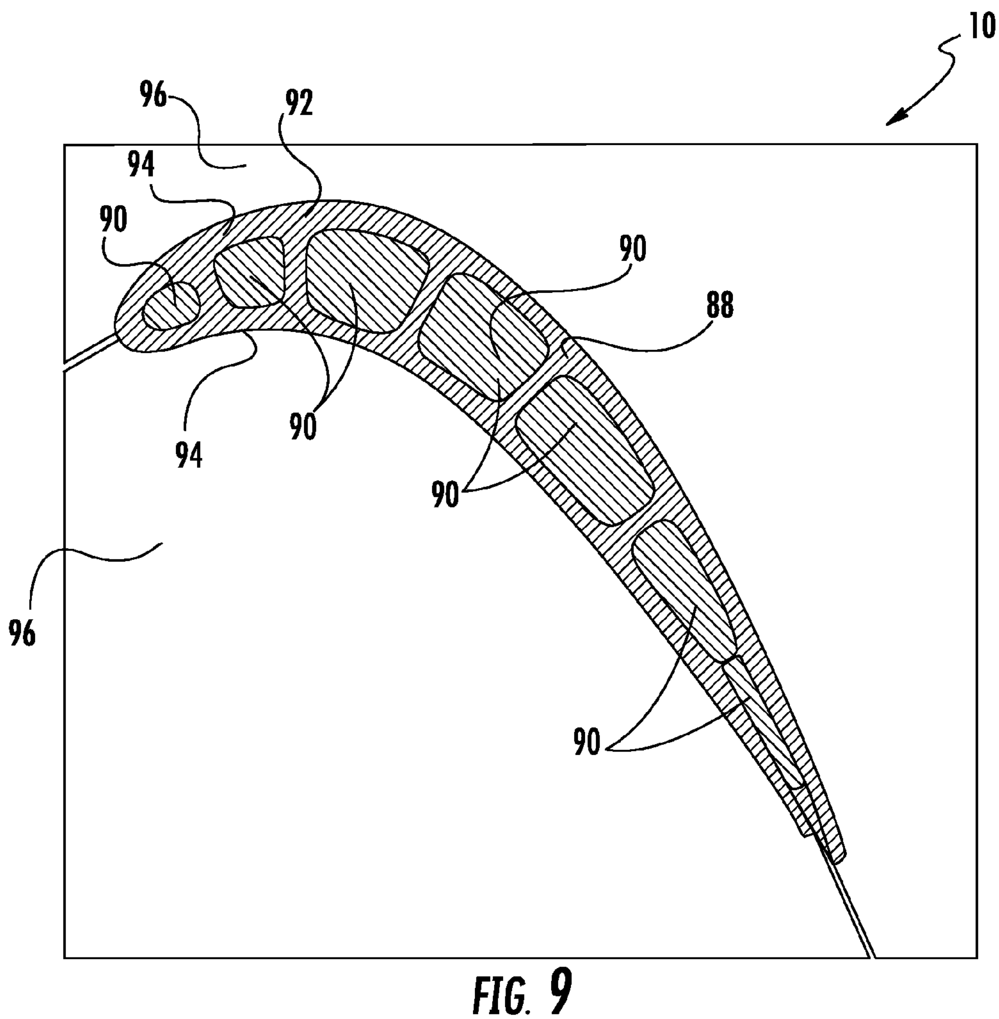

FIG. 9

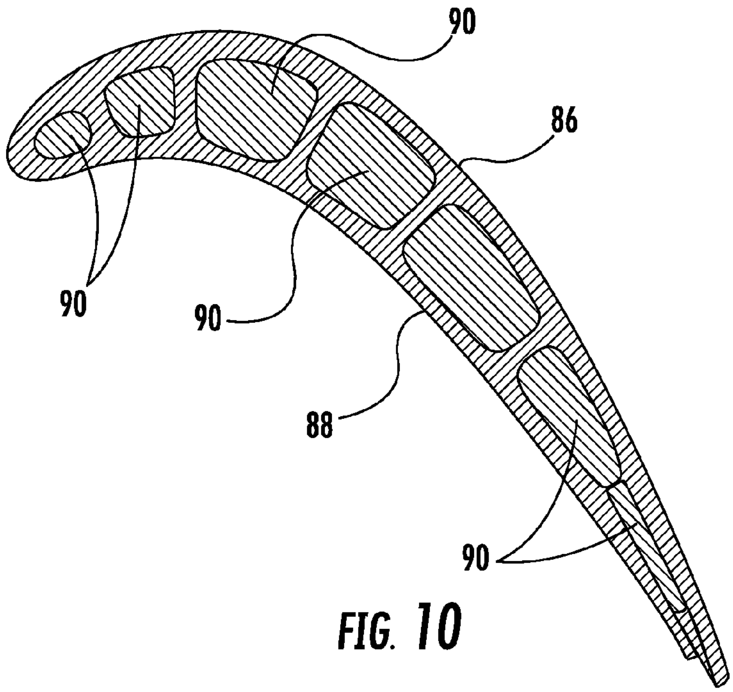

FIG. 10

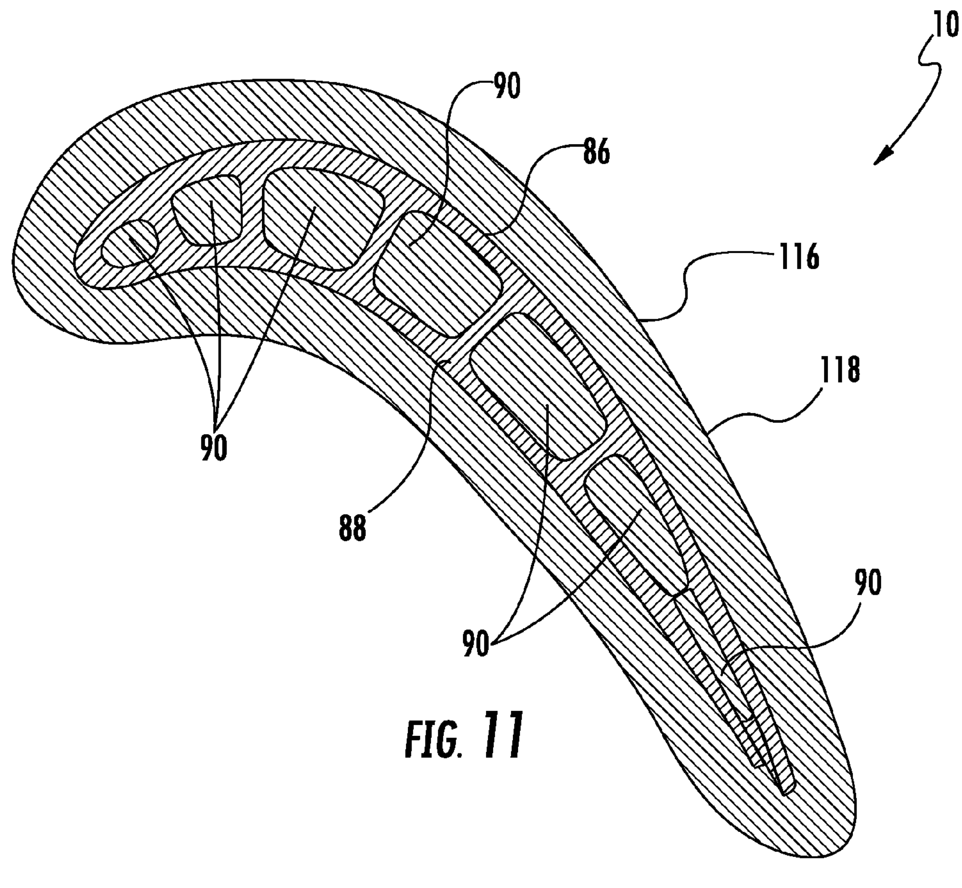

FIG. 11

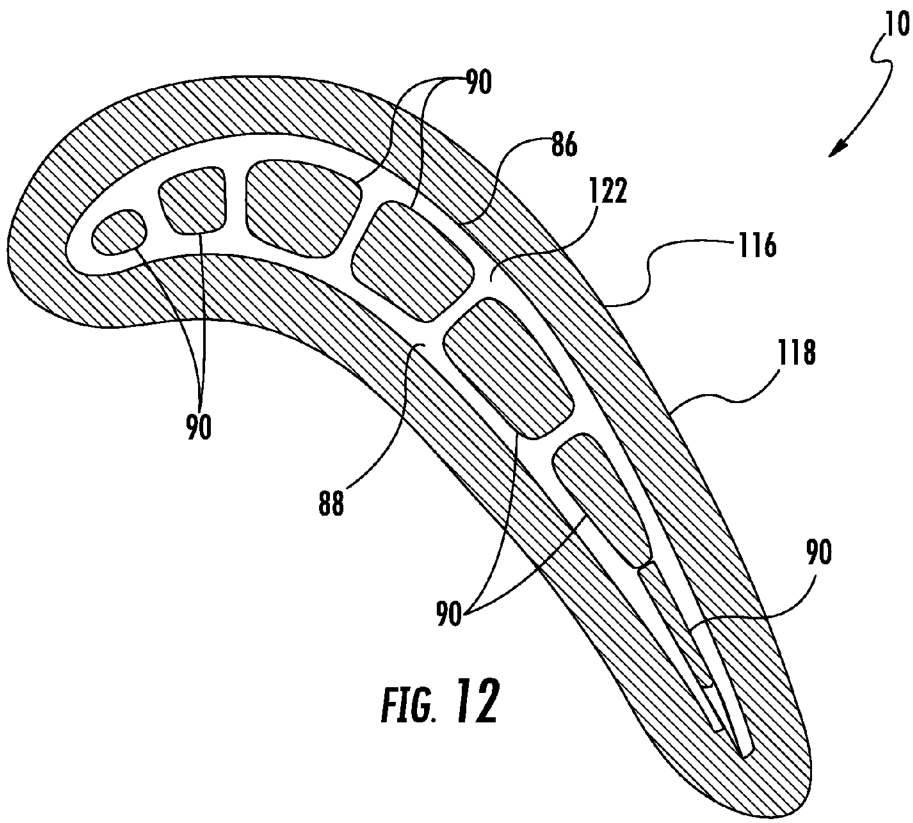

FIG. 12

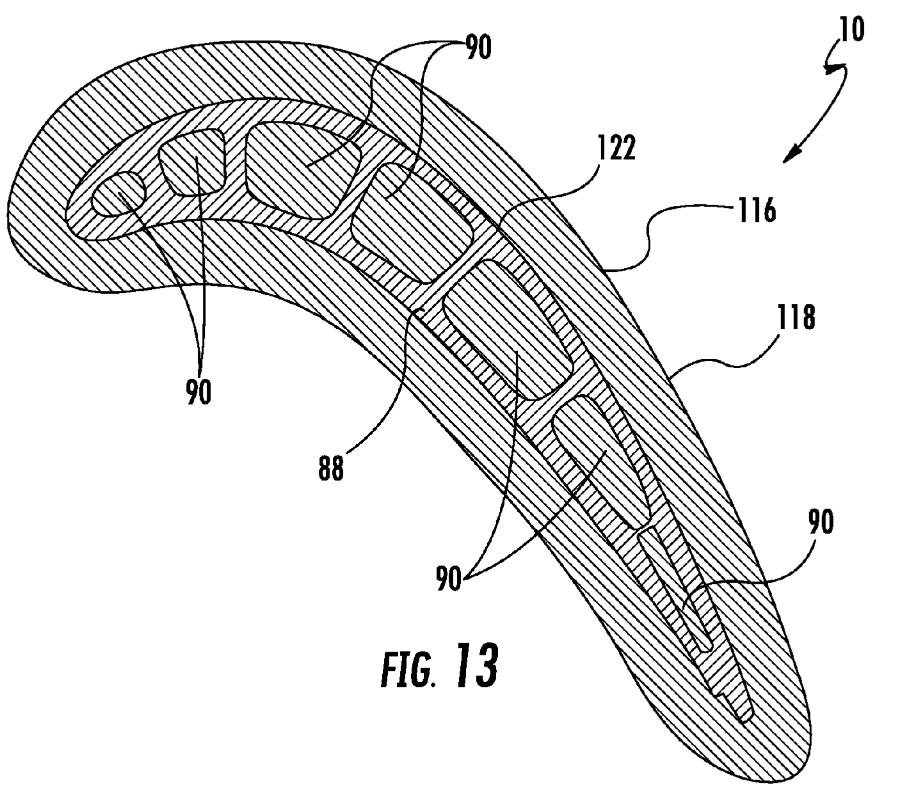

FIG. 13

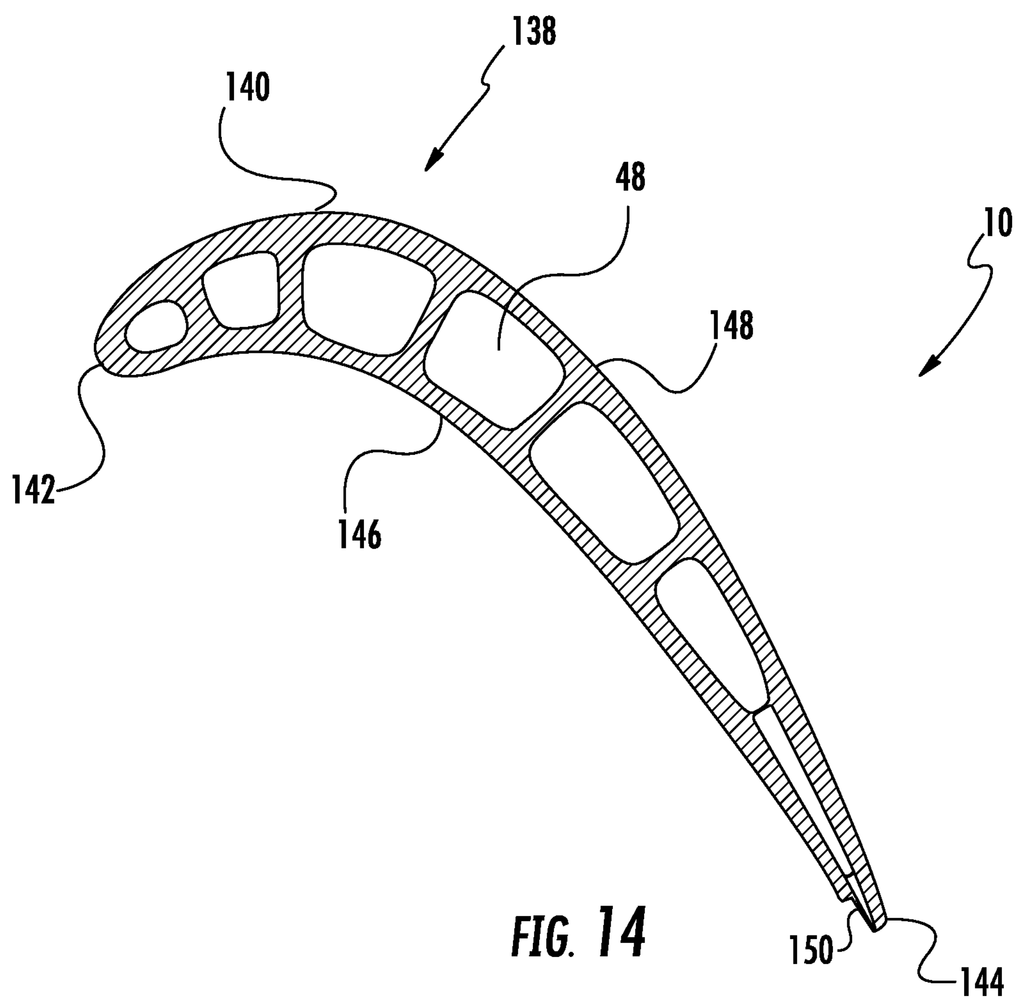

FIG. 14

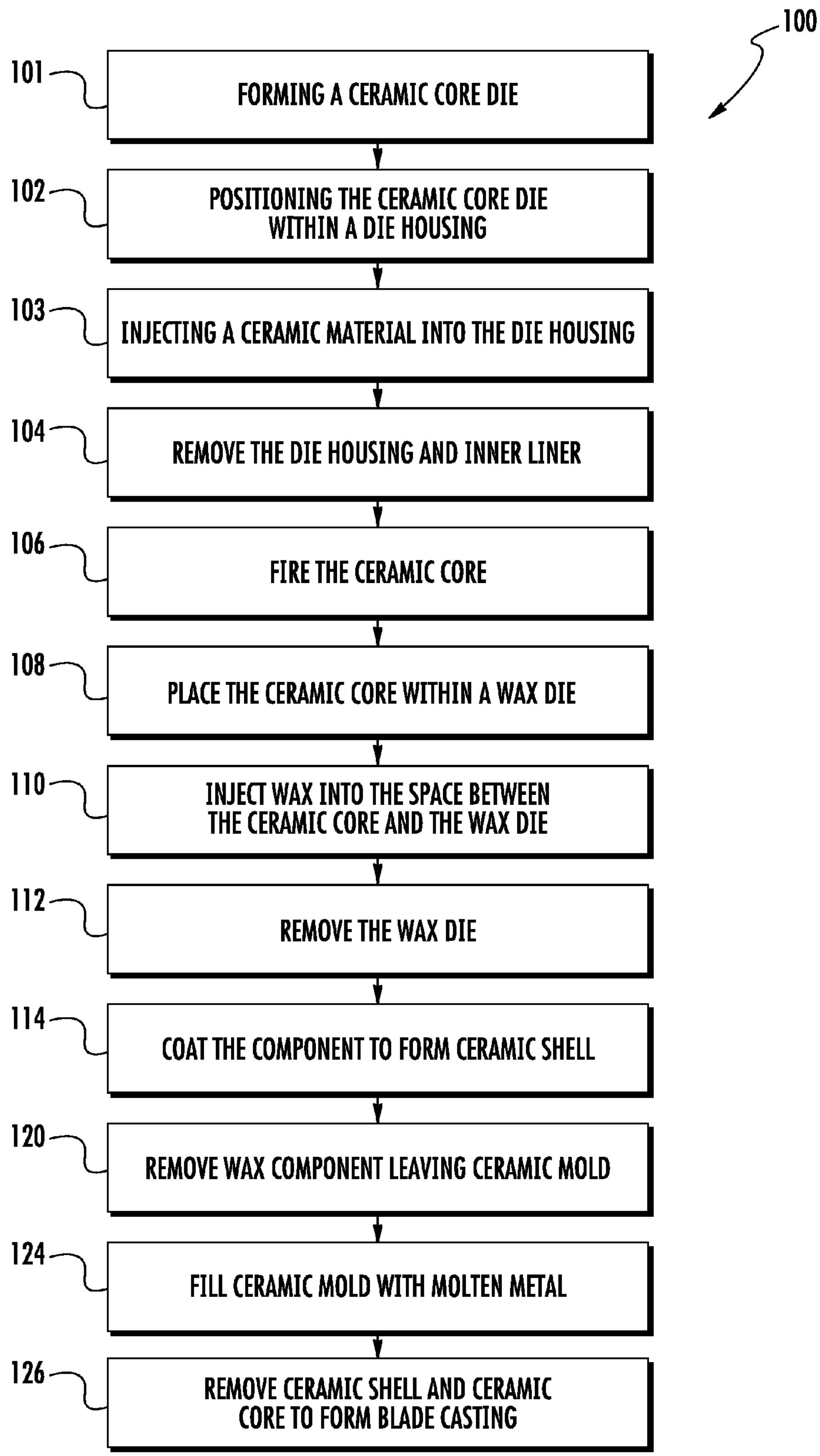
100
101
FORMING A CERAMIC CORE DIE
102
POSITIONING THE CERAMIC CORE DIE WITHIN A DIE HOUSING
103
INJECTING A CERAMIC MATERIAL INTO THE DIE HOUSING
104
REMOVE THE DIE HOUSING AND INNER LINER
106
FIRE THE CERAMIC CORE
108
PLACE THE CERAMIC CORE WITHIN A WAX DIE
110
INJECT WAX INTO THE SPACE BETWEEN THE CERAMIC CORE AND THE WAX DIE
112
REMOVE THE WAX DIE
114
COAT THE COMPONENT TO FORM CERAMIC SHELL
120
REMOVE WAX COMPONENT LEAVING CERAMIC MOLD
124
FILL CERAMIC MOLD WITH MOLTEN METAL
126
REMOVE CERAMIC SHELL AND CERAMIC CORE TO FORM BLADE CASTING

FIG. 15

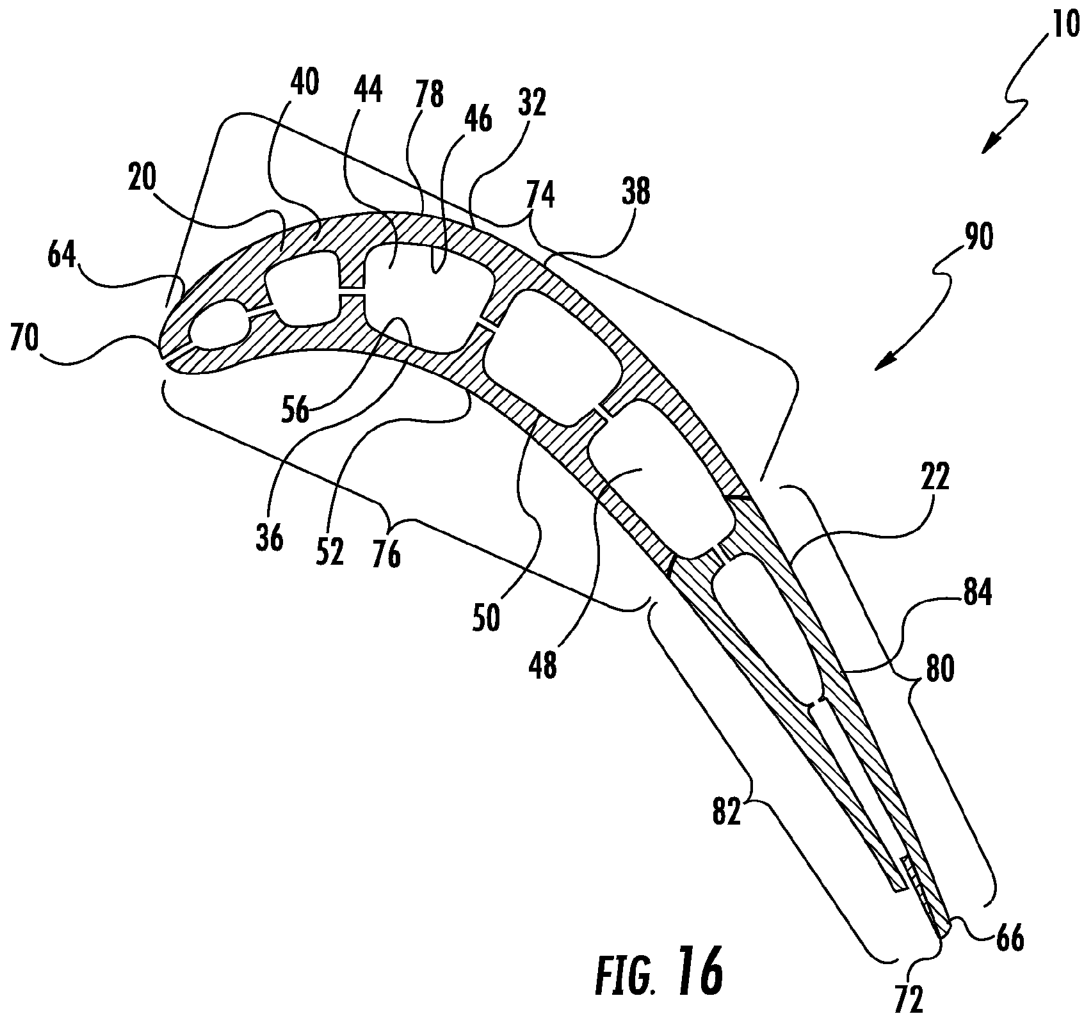

FIG. 16

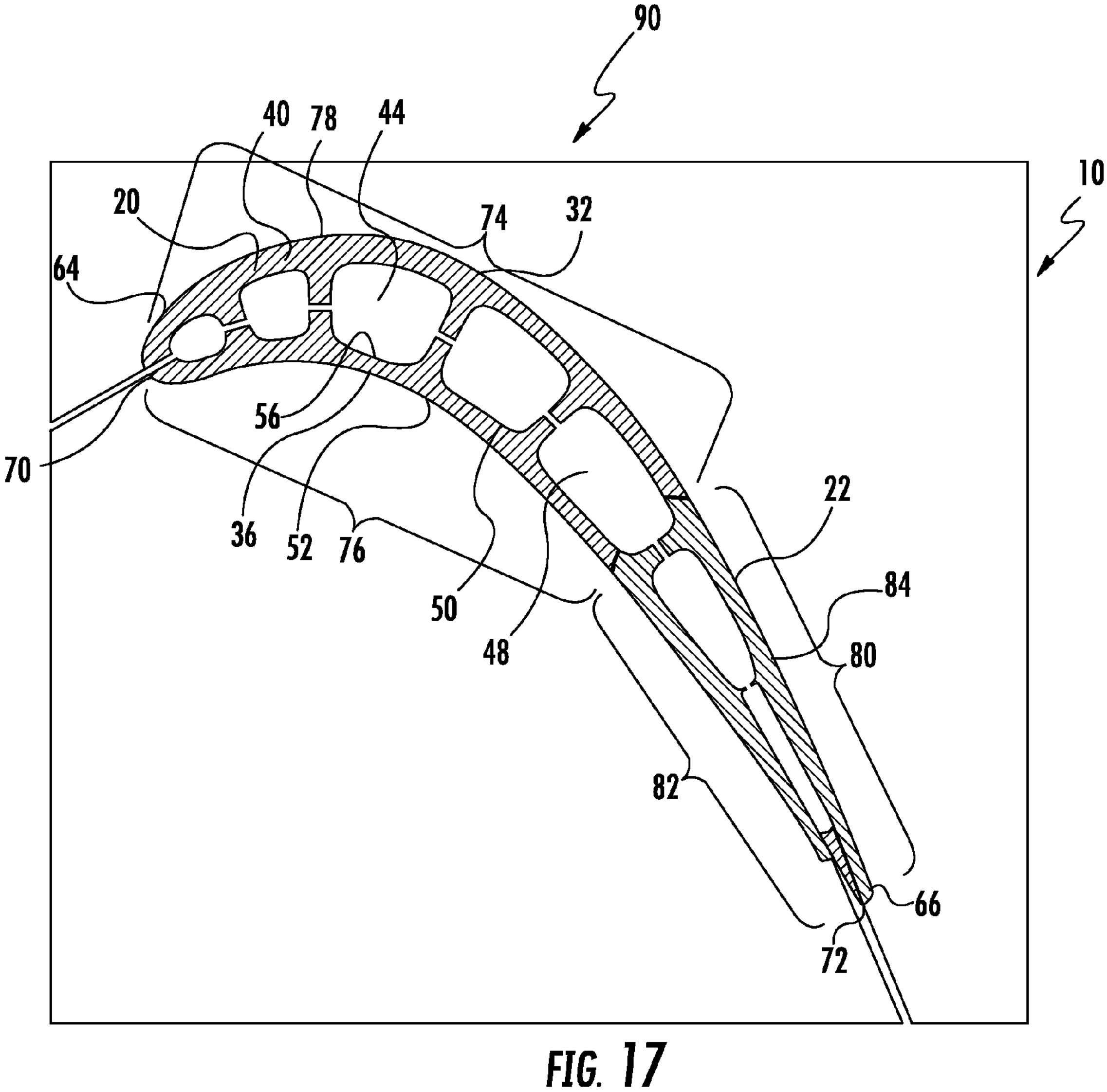

FIG. 17

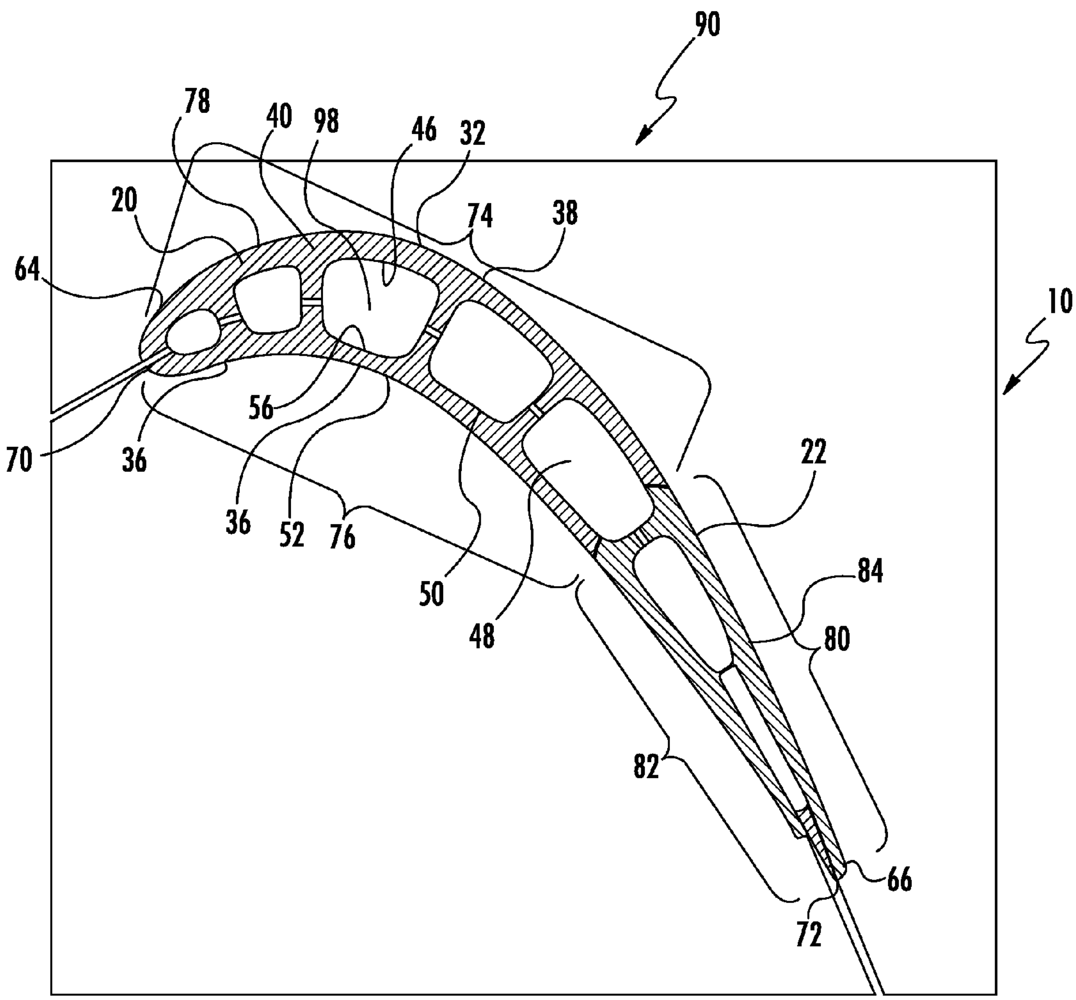
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FIG. 18

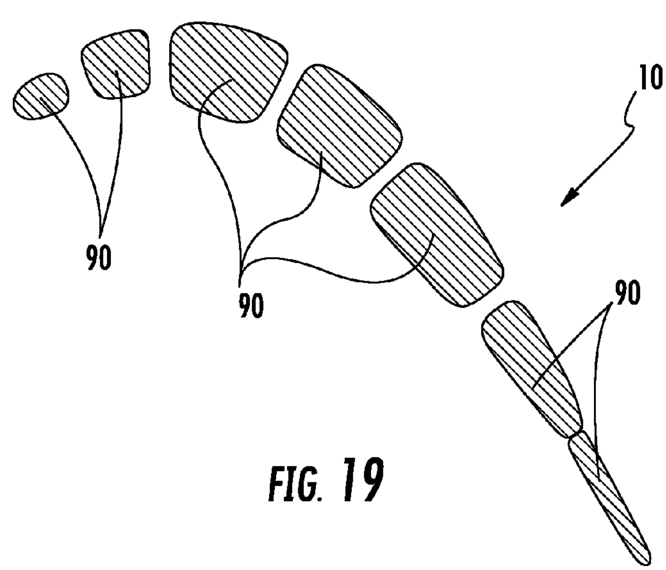
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FIG. 19

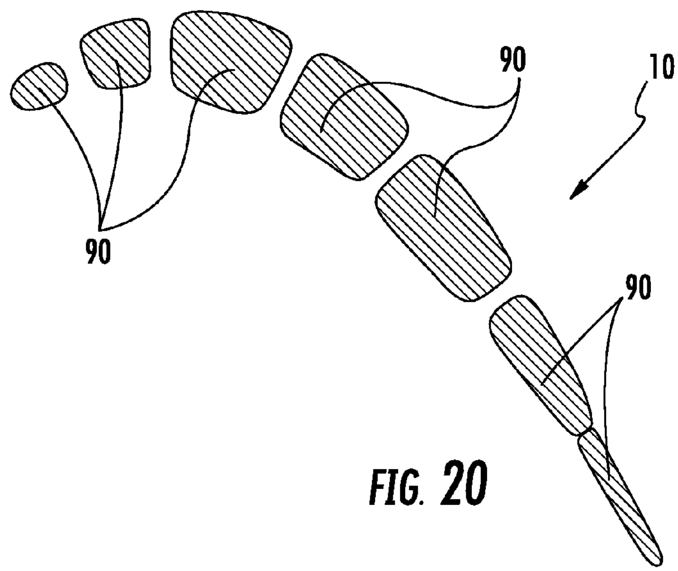

FIG. 20

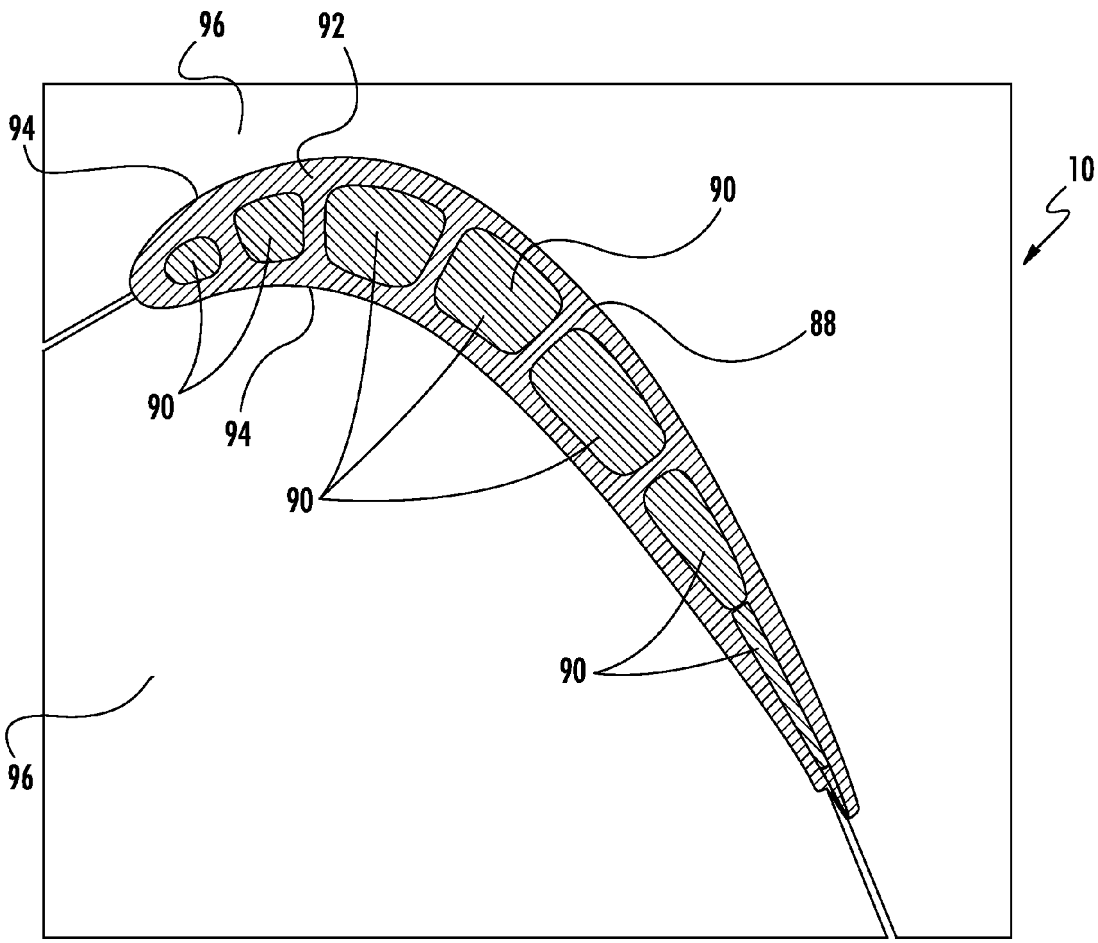

FIG. 21

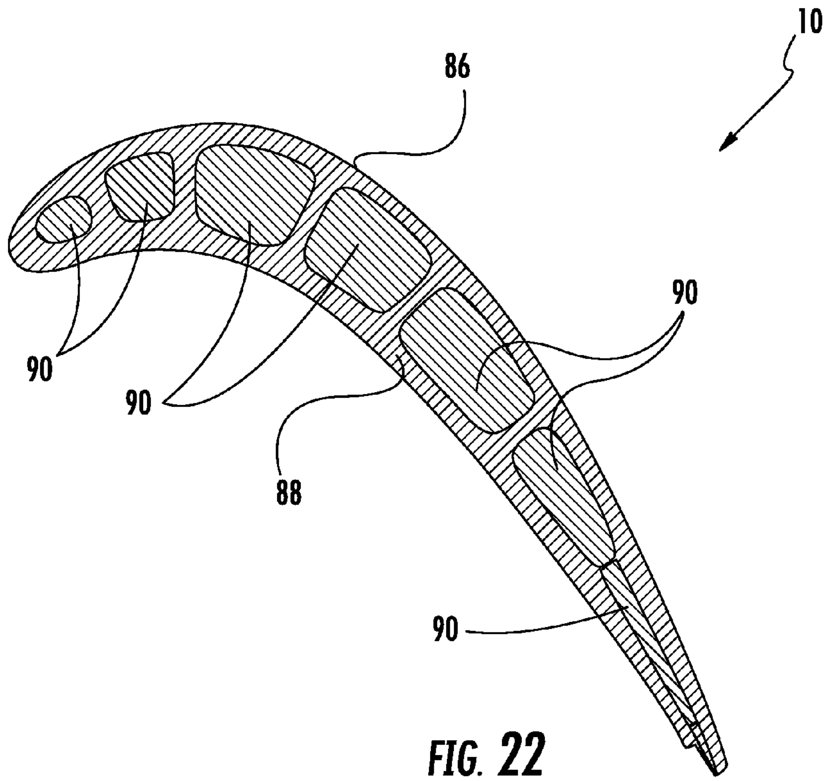

FIG. 22

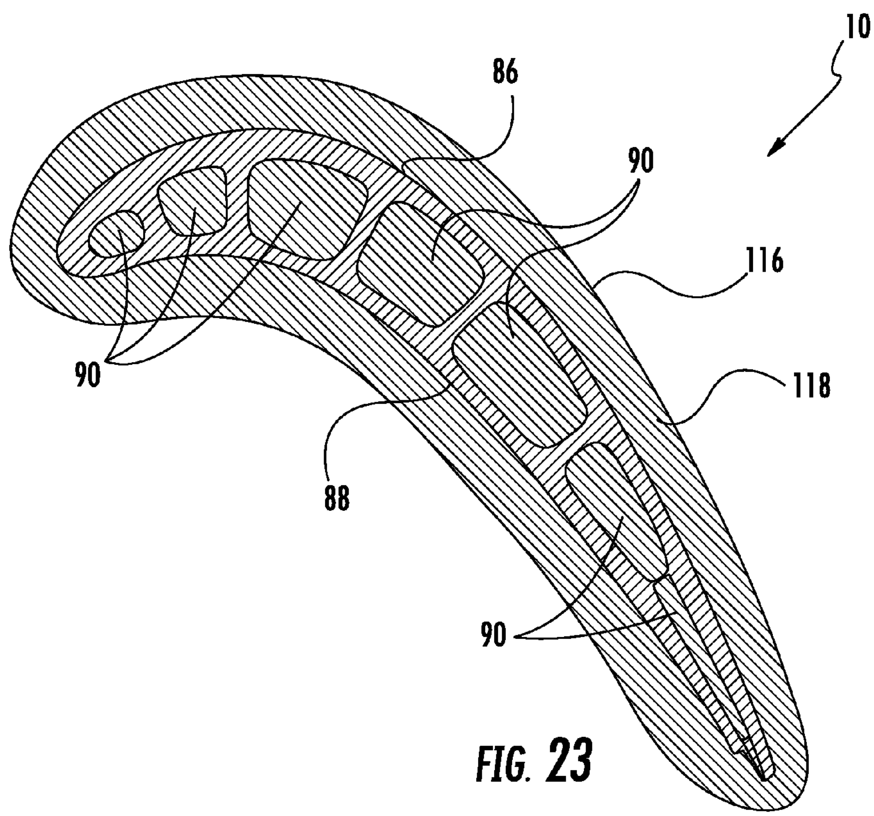

FIG. 23

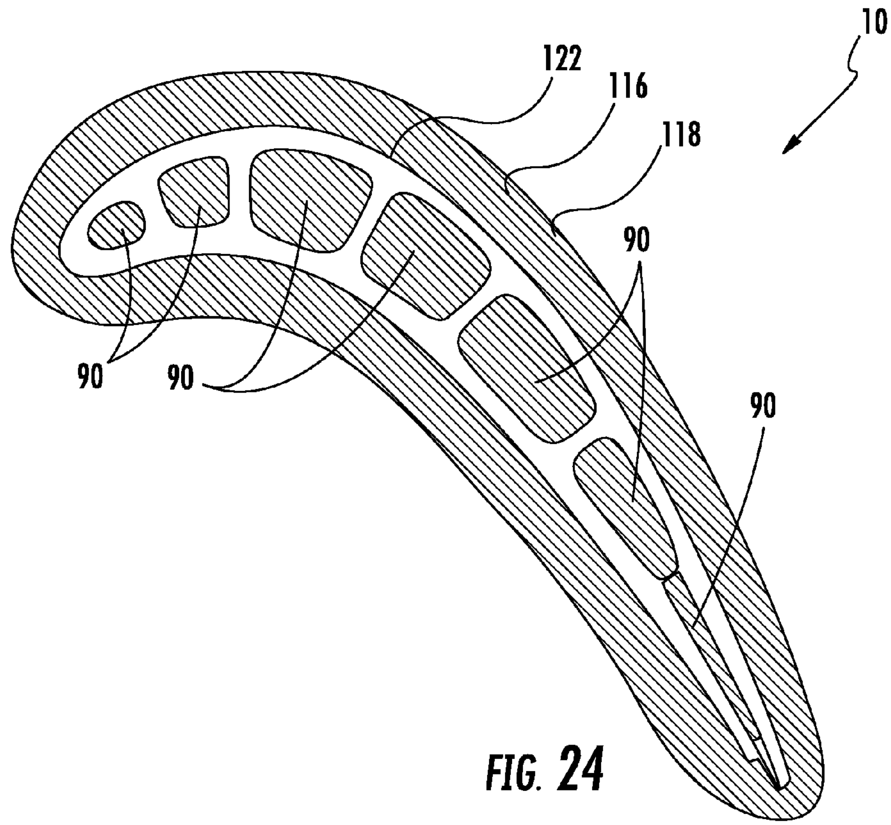

FIG. 24

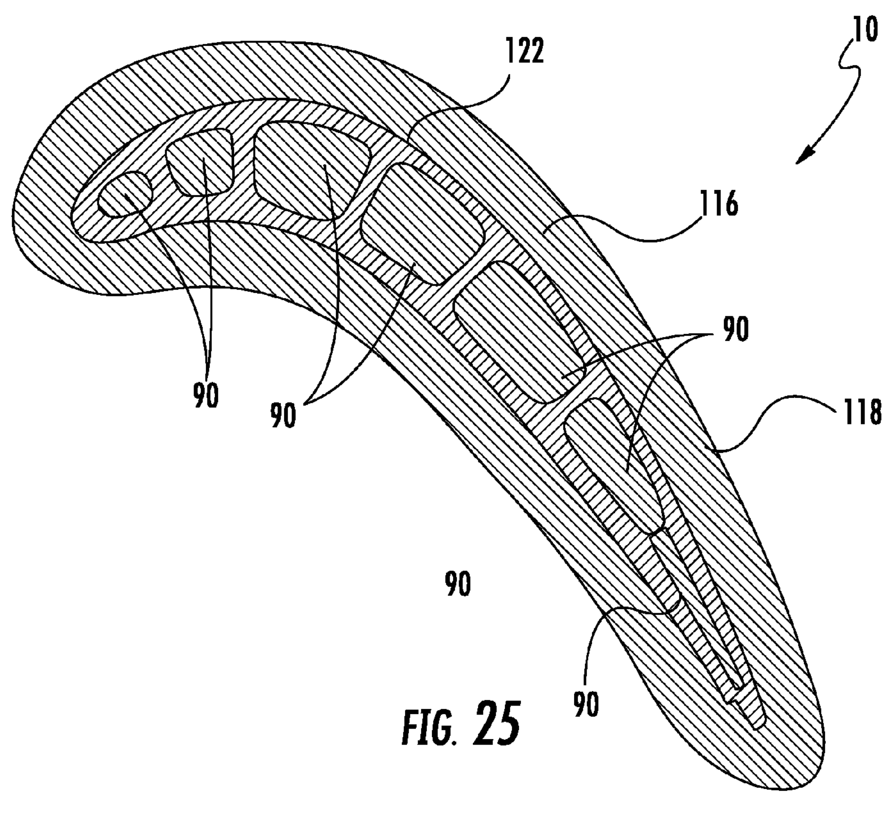

FIG. 25

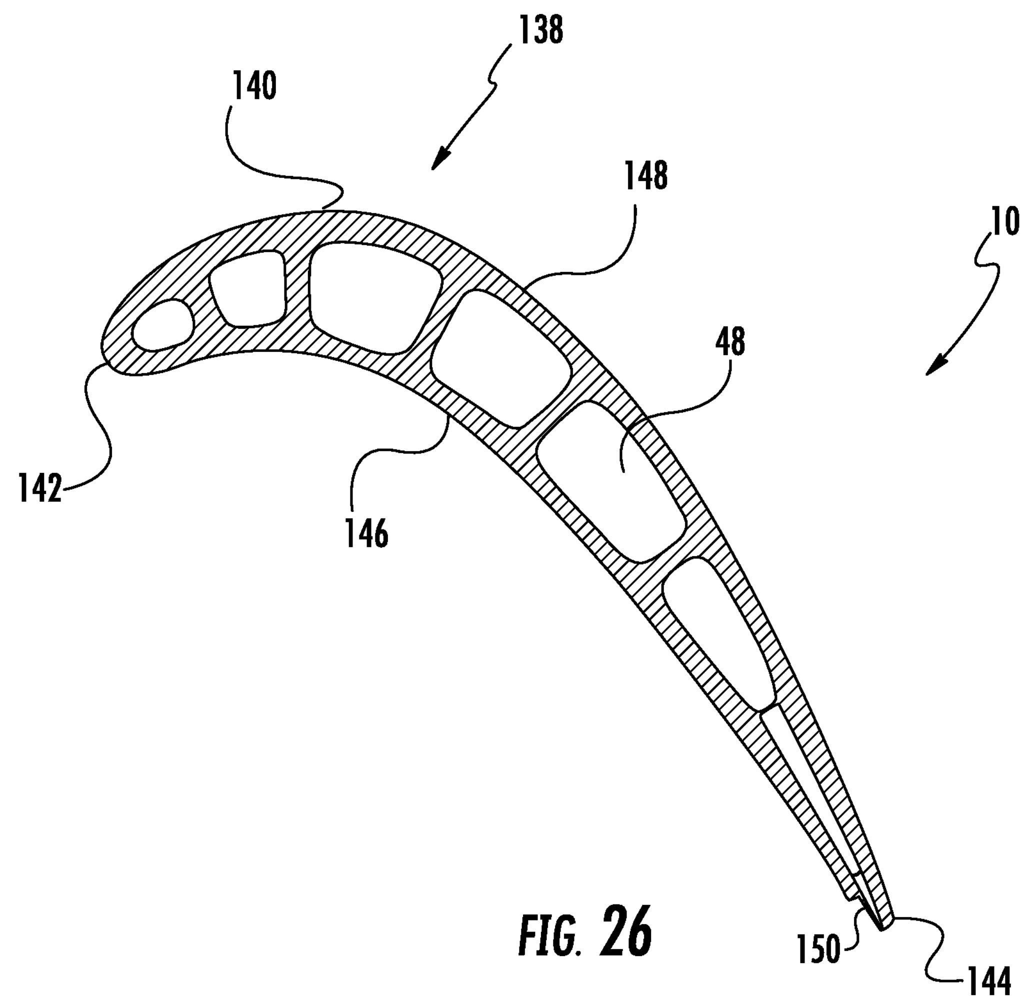

FIG. 26

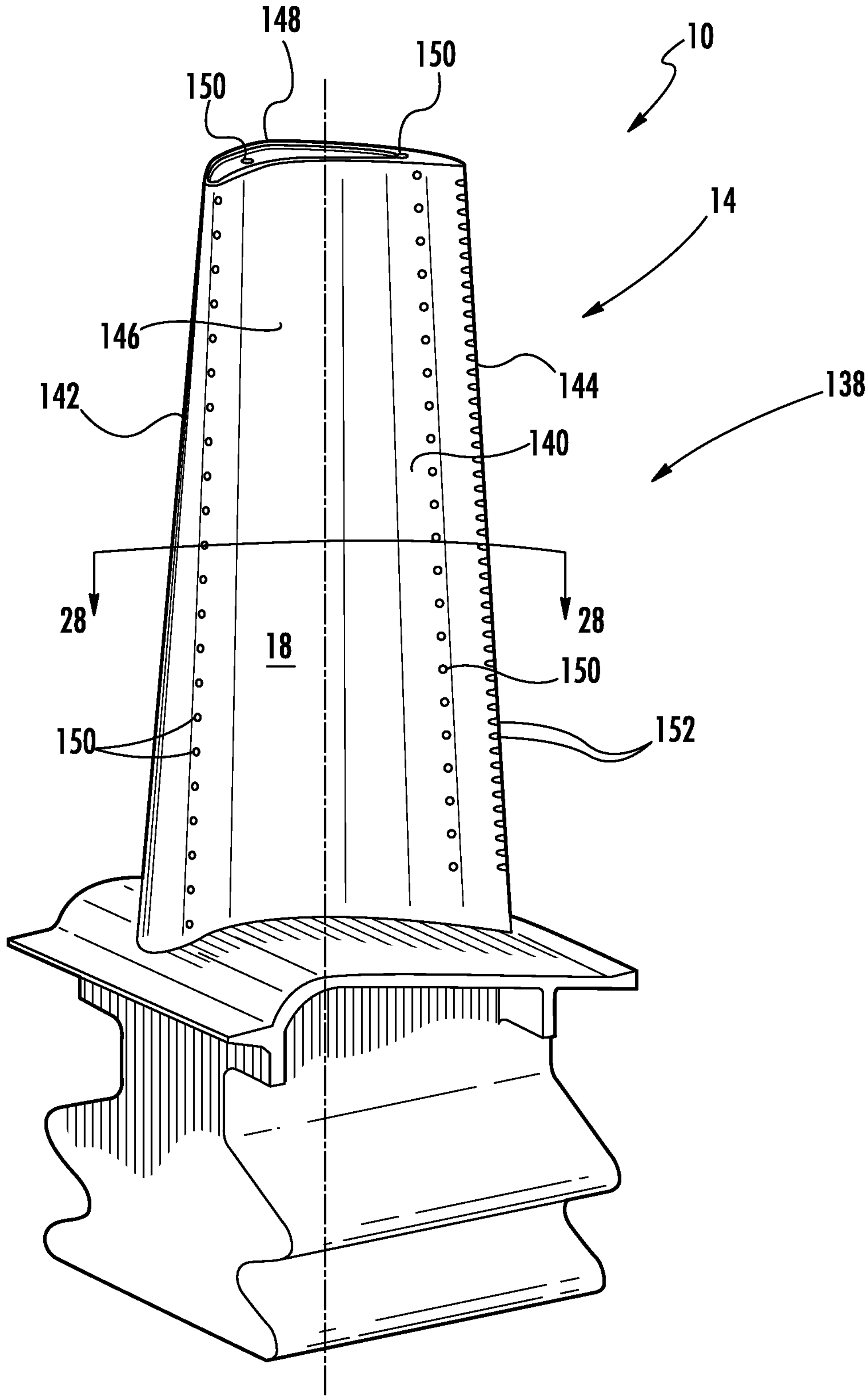

FIG. 27

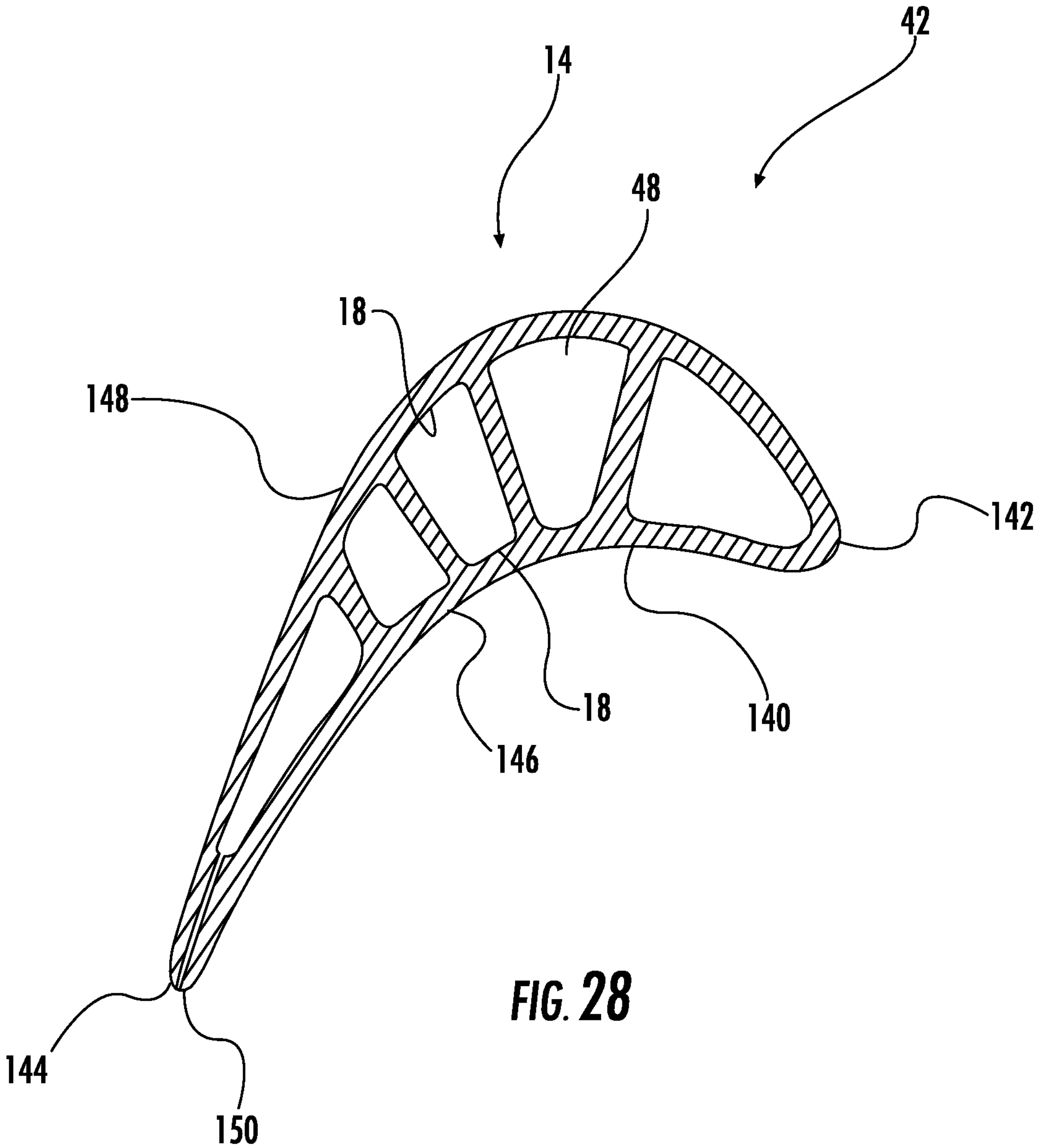

FIG. 28

DIE CAST SYSTEM FOR FORMING A COMPONENT USABLE IN A GAS TURBINE ENGINE

FIELD OF THE INVENTION

[0001] This invention is directed generally to die cast systems, and more particularly to manufacturing methods for turbine airfoils usable in turbine engines.

BACKGROUND

[0002] Turbine blade airfoils typically have internal cooling systems formed from a plurality of cooling channels, as shown in FIGS. **2** and **3**. To form these cooling channels inside of a blade, a casting mold is often used and includes an internal ceramic core and external ceramic shell. The ceramic core, as shown in FIG. **1**, is manufactured to include detail features on the core die surface in order to form efficient cooling devices inside the blade casting. The core dies typically used to form cores are most often formed from hard steel, which are expensive to manufacture. The core die surfaces are typically in direct contact with the ceramic core material during the high pressure injection process. The core die will wear out after sufficient injections and lead to non-conforming casting. To maintain accurate casting dimensions, the core die needs to be reworked or replaced when a core die becomes worn, which is an expensive endeavor. Even a small improvement on an internal surface requires that a completely new die be made. Thus, a need exists for a more robust, less expensive system.

SUMMARY OF THE INVENTION

[0003] A die cast system having an inner liner insert that enables the configuration of a component produced by the system to be easily changed by changing the inner liner insert without having to rework the die housing is disclosed. Because the inner liner insert only need be removed and replaced to change the configuration of an outer surface of a component produced by the system, the cost savings is significant in contrast with conventional systems in which the die would have to be reworked. The die cast system may also include an inner liner formed from first and second end sub-inner liners, whereby the first end sub-inner liner may be from a first material that is less compliant than a material forming the second end sub-inner liner enabling more intricate cooling systems to be created by the second end sub-inner liner that is formed from a more compliant material.

[0004] In at least one embodiment, the die cast system may include a die housing having one or more inner chambers forming an insert receiving chamber and one or more inner liners positioned within the insert receiving chamber of the inner chamber of the die housing. The inner liner may have an inner surface defining boundaries useful to form an inner surface of a turbine component, whereby the inner liner may be formed via a selective laser melting process. The inner liner may be formed from a first side sub-inner liner forming a first side of the turbine component and a second side sub-inner liner forming a second side of the turbine component. The first side sub-inner liner may form an outer wall of a suction side of an airfoil usable in a gas turbine engine and may include at least one cavity on an inner side of the outer wall that is configured to form at least a portion of an internal airfoil cooling system. The second side sub-inner liner may form an outer wall of a pressure side of an airfoil usable in a gas turbine engine and may include one or more cavities on an inner side of the outer wall that is configured to form at least a portion of an internal airfoil cooling system.

[0005] In at least one embodiment, the inner liner may be formed from a non-ceramic, flexible material. The inner liner may be formed from a different material than the die housing. The die housing may be formed from a first sub-die housing and a second sub-die housing having a mateable interface positioned therebetween such that the first and second sub-die housings are mateable at the mateable interface.

[0006] In another embodiment, the inner liner may be formed from a first end sub-inner liner forming a first end of the turbine component and a second end sub-inner liner forming a second end of the turbine component. The first end sub-inner liner may be formed from a first material that is less compliant than a material forming the second end sub-inner liner. The second end sub-inner liner being more compliant may be used to form intricate aspects to the internal cooling system. The first end sub-inner liner may be configured to form a leading edge of an airfoil usable in a turbine engine and second end sub-inner liner is configured to form a trailing edge of the airfoil usable in the turbine engine.

[0007] In at least one embodiment, the first end sub-inner liner may be formed from a first end, first side sub-inner liner and a first end, second side sub-inner liner. The first end, first side sub-inner liner may form a suction side outer wall of an upstream portion of a suction side of an airfoil usable in a gas turbine engine and may include one or more cavities on an inner side of the suction side outer wall that is configured to form at least a portion of an internal airfoil cooling system. The first end, second side sub-inner liner may form a pressure side outer wall of a pressure side of the upstream portion of an airfoil usable in a gas turbine engine and may include one or more cavities on an inner side of the pressure side outer wall that is configured to form at least a portion of an internal airfoil cooling system.

[0008] The second end sub-inner liner may be formed from a second end, first side sub-inner liner and a second end, second side sub-inner liner. The second end, first side sub-inner liner may form a suction side outer wall of a downstream portion of a suction side of an airfoil usable in a gas turbine engine and may include one or more cavities on an inner side of the suction side outer wall that is configured to form at least a portion of an internal airfoil cooling system. The second end, second side sub-inner liner may form a pressure side outer wall of a pressure side of the downstream portion of an airfoil usable in a gas turbine engine and may include one or more cavities on an inner side of the pressure side outer wall that is configured to form at least a portion of an internal airfoil cooling system.

[0009] A method of forming a turbine component is disclosed. The method may include injecting a ceramic material into at least one inner cavity formed within a composite die cast system, wherein the die cast system may be formed from a die housing having one or more inner chambers forming an insert receiving chamber and one or more inner liners positioned within the insert receiving chamber of the inner chamber of the die housing. The inner liner may have an inner surface defining boundaries useful to form an inner surface of a turbine component. The inner liner may be formed via a selective laser melting process. The method may also include removing the die cast system thereby revealing a ceramic core.

[0010] The method may include firing the ceramic core, placing the ceramic core within an inner cavity formed by an inner surface of a wax die, and injecting wax into one or more openings formed between the ceramic core and the inner surface of the wax die. The method may also include removing the wax die to reveal a wax component, coating the wax component with a ceramic coating to form a ceramic shell with a ceramic core positioned therein and removing the wax component within the ceramic coating leaving one or more cavities within the ceramic coating. The method may also include filling the cavity within the ceramic coating with a molten metal and removing the ceramic shell and the ceramic core to form a cast component.

[0011] An advantage of the composite die cast system is that because the inner liner insert only need be removed and replaced to change the configuration of an inner surface of a component produced by the system, a significant cost savings is captured in contrast with conventional systems in which the die would have to be reworked.

[0012] Another advantage of the hybrid die cast system is that use of the hybrid die cast system will reduce time and effort required to create a core die in a conventional casting process.

[0013] Yet another advantage of the hybrid die cast system is that the inner liner may be formed from different portions formed from different materials, thereby enabling portions of the inner liner proximate to aspects of the core where intricate aspects of an internal cooling system are located, to be formed from more compliant material enabling those intricate aspects of the internal cooling system to be formed.

[0014] These and other embodiments are described in more detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying drawings, which are incorporated in and form a part of the specification, illustrate embodiments of the presently disclosed invention and, together with the description, disclose the principles of the invention.

[0016] FIG. **1** is a perspective view of a conventionally formed core.

[0017] FIG. **2** is a cross-sectional view of two adjacent conventional turbine airfoils.

[0018] FIG. **3** is a cross-sectional view of a conventional turbine airfoil with an internal cooling system.

[0019] FIG. **4** is a cross-sectional view of an inner liner of the die cast system.

[0020] FIG. **5** is a cross-sectional view of an inner liner positioned within a die housing of the die cast system.

[0021] FIG. **6** is a cross-sectional view of a ceramic material injected within the inner liner positioned within a die housing of the die cast system.

[0022] FIG. **7** is a cross-sectional view of a ceramic core.

[0023] FIG. **8** is a cross-sectional view of a ceramic core after firing.

[0024] FIG. **9** is a cross-sectional view of a ceramic core after firing placed in a wax die and wax injected into the openings between the ceramic core and the wax die.

[0025] FIG. **10** is a cross-sectional view of a wax pattern with the ceramic core and with the wax die removed.

[0026] FIG. **11** is a cross-sectional view of the wax pattern with a ceramic shell formed around the wax pattern.

[0027] FIG. **12** is a cross-sectional view of the ceramic shell and ceramic core with the wax pattern removed.

[0028] FIG. **13** is a cross-sectional view of the ceramic shell and ceramic core with molten metal in the ceramic casting mold.

[0029] FIG. **14** is a casting of a component with the ceramic shell and ceramic core removed.

[0030] FIG. **15** is a flow chart of a method of forming a casting component, such as, but not limited to, an airfoil from cast metal.

[0031] FIG. **16** is a cross-sectional view of an alternative inner liner of the die cast system.

[0032] FIG. **17** is a cross-sectional view of the alternative inner liner of FIG. **16** positioned within a die housing of the die cast system.

[0033] FIG. **18** is a cross-sectional view of a ceramic material injected within the alternative inner liner of FIG. **16** positioned within a die housing of the die cast system.

[0034] FIG. **19** is a cross-sectional view of a ceramic core.

[0035] FIG. **20** is a cross-sectional view of a ceramic core after firing.

[0036] FIG. **21** is a cross-sectional view of a ceramic core after firing placed in a wax die and wax injected into the openings between the ceramic core and the wax die.

[0037] FIG. **22** is a cross-sectional view of a wax pattern with the ceramic core and with the wax die removed.

[0038] FIG. **23** is a cross-sectional view of the wax pattern with a ceramic shell formed around the wax pattern.

[0039] FIG. **24** is a cross-sectional view of the ceramic shell and ceramic core with the wax pattern removed.

[0040] FIG. **25** is a cross-sectional view of the ceramic shell and ceramic core with molten metal in the ceramic casting mold.

[0041] FIG. **26** is a casting of a component with the ceramic shell and ceramic core removed.

[0042] FIG. **27** is a perspective view of a turbine airfoil formed with the die cast system of FIGS. **4-14** and **16-26** and via the method of using the system shown in FIG. **15**.

[0043] FIG. **28** is a cross-sectional view of the turbine airfoil taken along section line **28-28** in FIG. **27**.

DETAILED DESCRIPTION OF THE INVENTION

[0044] As shown in FIGS. **4-28**, a die cast system **10** having an inner liner insert **12** that enables the configuration of a component **14** produced by the system **10** to be easily changed by changing the inner liner insert **12** without having to rework the die housing **16** is disclosed. Because the inner liner insert **12** only need be removed and replaced to change the configuration of an inner surface **18** of a component **14** produced by the system **10**, the cost savings is significant in contrast with conventional systems in which the die would have to be reworked. The die cast system **10** may also include an inner liner **12** formed from first and second end sub-inner liners **20**, **22**, whereby the first end sub-inner liner **20** may be from a first material that is less compliant than a material forming the second end sub-inner liner **22** enabling more intricate cooling systems to be created by the second end sub-inner liner **22**, which is more compliant than the first end inner liner **20**.

[0045] In at least one embodiment, the die cast system **10** may include a die housing **16** may have one or more inner chambers **23** forming an insert receiving chamber **24**. The die cast system **10** may also include one or more inner liners **12** positioned within the insert receiving chamber **24** of the inner chamber **24** of the die housing **16**. The inner liner **12** may have an inner surface **26** defining boundaries useful to form an inner surface **18** of a turbine component **14**. In at least one embodiment, the inner surface **26** of the inner liner **12** may be configured to form an airfoil **138** usable in a gas turbine engine. The airfoil **138** may be formed from a generally elongated, hollow airfoil **140** having a leading edge **142** on an opposite side from a trailing edge **144** and separated by a concave pressure side **146** and a convex suction side **148**. The generally elongated, hollow airfoil **60** may have one or more film cooling holes **150** at one or more of the leading edge **142** forming a showerhead, concave pressure side **146**, the convex suction side **148** or the trailing edge **144**, or any combination thereof.

[0046] In at least one embodiment, the inner liner **12** may be formed via a selective laser melting process, with a material such as, but not limited to, iron. The inner liner **12** may be formed from a first side sub-inner liner **30** forming a first side **32** of the turbine component **14** and a second side sub-inner liner **34** forming a second side **36** of the turbine component **14**. In at least one embodiment, as shown in FIG. **4-6**, the first side sub-inner liner **30** may be formed from an outer wall **38** of a suction side **40** of an airfoil shaped core **42** and may include one or more cavities **44** on an inner side **46** of the outer wall **38** that is configured to form at least a portion of an internal airfoil cooling system **48**. The second side sub-inner liner **34** may form an outer wall **50** of a pressure side **52** of the airfoil shaped core **42** and may include one or more cavities **44** on an inner side **56** of the outer wall **50** that is configured to form at least a portion of an internal airfoil cooling system **48**. In at least one embodiment, as shown in FIGS. **4-6**, the first side sub-inner liner **30** and the second side sub-inner liner **34** may together form a plurality of inner cavities **44** forming the internal airfoil cooling system **48**.

[0047] In at least one embodiment, the inner liner **12** may be formed from a non-ceramic material, such as, but not limited to, iron, or another appropriate material. The inner liner **12** may be formed from a different material than the die housing **16**. The die housing **16** may be formed from a first sub-die housing **58** and a second sub-die housing **60** having a mateable interface **62** positioned therebetween such that the first and second sub-die housings **58**, **60** are mateable at the mateable interface **62**.

[0048] In at least one embodiment, as shown in FIGS. **16-18**, the inner liner **12** may be formed from a first end sub-inner liner **20** forming a first end **64** of the turbine component **14** and a second end sub-inner liner **22** forming a second end **66** of the turbine component **14**. The first end sub-inner liner **20** may be formed from a first material that is less compliant than a material forming the second end sub-inner liner **22**. As such, that less compliant material may be used to form intricate aspects of the internal cooling system **48**. In at least one embodiment, the second end sub-inner liner **22** form from the less compliant material may be formed by processes employed by Mikro Systems of Charlottesville, VA. The first end sub-inner liner **20** may be configured to form a leading edge **70** of an airfoil shaped core **42** usable in a turbine engine, and second end sub-inner liner **22** may be configured to form a trailing edge **72** of the airfoil shaped core **42** usable in the turbine engine.

[0049] In at least one embodiment, as shown in FIGS. **16-18**, the first end sub-inner liner **20** may be formed from a first end, first side sub-inner liner **74** and a first end, second side sub-inner liner **76**. The first end, first side sub-inner liner **74** may form a suction side outer wall **38** of an upstream portion **78** of a suction side **40** of an airfoil shaped core **42**. The first end, first side sub-inner liner **74** may include one or more cavities **44** on an inner side **46** of the suction side outer wall **38** that is configured to form at least a portion of an internal airfoil cooling system **48**. The first end, second side sub-inner liner **76** may form a pressure side outer wall **50** of a pressure side **52** of the upstream portion **78** of an airfoil shaped core **42**. The first end, second side sub-inner liner **76** may include one or more cavities **44** on an inner side **56** of the pressure side outer wall **50** that is configured to form at least a portion of the internal airfoil cooling system **48**.

[0050] Similarly, the second end sub-inner liner **22** may be formed from a second end, first side sub-inner liner **80** and a second end, second side sub-inner liner **82**. The second end, first side sub-inner liner **80** may form a suction side outer wall **38** of a downstream portion **84** of a suction side **40** of an airfoil shaped core **42** and may include one or more cavities **44** on an inner side **46** of the suction side outer wall **38** that is configured to form at least a portion of an internal airfoil cooling system **48**. The second end, second side sub-inner liner **82** may form a pressure side outer wall **50** of a pressure side **52** of the downstream portion **84** of the airfoil shaped core **42** and may include one or more cavities **44** on an inner side **56** of the pressure side outer wall **50** that is configured to form at least a portion of the internal airfoil cooling system **48**.

[0051] As shown in FIG. **15**, a method **100** of forming a turbine component **14** may include forming a ceramic core die **90** at **101** and FIGS. **4** and **16** via a selective laser melting process. The die **90** may be positioned within a die housing **16** at **102** and FIGS. **5** and **17**. The method **100** may also include injecting a ceramic material **98** at **103** and FIGS. **6** and **18** into one or more inner cavities **44** formed within a die cast system **10** in which the die cast system **10** may be formed from a die housing **16** having one or more inner chambers **23** forming an insert receiving chamber **24**. The die cast system **10** may also include one or more inner liners **12** positioned within the insert receiving chamber **24** of the inner chamber **23** of the die housing **16**. The inner liner **12** may have an inner surface **26** defining boundaries useful to form an inner surface **18** of a turbine component **14**. The inner liner **12** may be formed via a selective laser melting process. The method may include removing the die cast system **10** at **104** and FIGS. **7** and **19** thereby revealing a ceramic core **90**.

[0052] The method may also include firing the ceramic core **90** at **106** and FIGS. **8** and **20** and placing the ceramic core **90** at **108** within an inner cavity **92** formed by an inner surface **94** of a wax die **96**. The method may also include injecting wax **88** at **110** and FIGS. **9** and **21** into at least opening **92** formed between the ceramic core **90** and the inner surface **94** of the wax die **96**. The method may include removing the wax die **96** at **112** and FIGS. **10** and **22** to reveal a wax component **86** and coating the wax component **86** at **114** and FIGS. **11** and **23** with a ceramic coating **116** to form a ceramic shell **118** with a ceramic core **90** positioned therein. The method may include removing the wax component **86** at **120** and FIGS. **12** and **24** within the ceramic coating **116** leaving one or more cavities **122** within the ceramic coating **116**. The method may include filling the cavity **122** at **124** and FIGS. **13** and **25** within the ceramic coating **116** with a molten metal and removing the ceramic shell **118** and the ceramic core **90** at **126** and FIGS. **14** and **26** to form a cast component **14**.

[0053] The step of injection a ceramic material at **102** may include injecting a ceramic material into at least one inner cavity **122** formed within the composite die cast system **10**, wherein the inner liner **12** is formed from a first side sub-inner liner **30** forming a first side **32** of the turbine component **14** and a second side sub-inner liner **34** forming a second side **36** of the turbine component **14**. The step of injection a ceramic material at **102** may include injecting a ceramic material into at least one inner cavity **122** formed within the composite die cast system **10**, wherein the first side sub-inner liner **30** may form an outer wall **38** of a suction side **40** of an airfoil shaped core **42** and may include one or more cavities **44** on an inner side **46** of the outer wall **38** that is configured to form at least a portion of an internal airfoil cooling system **48**. The second side sub-inner liner **34** may form an outer wall **50** of a pressure side **52** of an airfoil shaped core **42** and may include one or more cavities **44** on an inner side **56** of the outer wall **50** that is configured to form at least a portion of an internal airfoil cooling system **48**.

[0054] The step of injection a ceramic material at **102** may include injecting a ceramic material into at least one inner cavity **122** formed within the composite die cast system **10**, wherein the inner liner **12** may be formed from a first end sub-inner liner **20** forming a first end **64** of the turbine component **14** and a second end sub-inner liner **22** forming a second end **66** of the turbine component **14**, wherein the first end sub-inner liner **20** may be formed from a first material having a less compliant than a material forming the second end sub-inner liner **22**.

[0055] The step of injection a ceramic material at **102** may include injecting a ceramic material into at least one inner cavity **122** formed within the composite die cast system **10**, wherein the first end sub-inner liner **20** may be formed from a first end, first side sub-inner liner **74** and a first end, second side sub-inner liner **76**, and wherein the first end, first side sub-inner liner **74** may form a suction side outer wall **38** of an upstream portion **78** of a suction side **40** of an airfoil shaped core **42** and may include one or more cavities **44** on an inner side **46** of the suction side outer wall **38** that is configured to form at least a portion of an internal airfoil cooling system **48**. The first end, second side sub-inner liner **76** may form a pressure side outer wall **50** of a pressure side **52** of the upstream portion **78** of an airfoil shaped core **42** and may include one or more cavities **44** on an inner side **56** of the pressure side outer wall **50** that is configured to form at least a portion of an internal airfoil cooling system **48**.

[0056] The step of injection a ceramic material at **102** may include injecting a ceramic material into at least one inner cavity **122** formed within the composite die cast system **10**, wherein the second end sub-inner liner **22** may be formed from a second end, first side sub-inner liner **80** and a second end, second side sub-inner liner **82**, and wherein the second end, first side sub-inner liner **80** may form a suction side outer wall **38** of a downstream portion **84** of a suction side **40** of an airfoil shaped core **42** and may include one or more cavities **44** on an inner side **46** of the suction side outer wall **38** that is configured to form at least a portion of an internal airfoil cooling system **48**. The second end, second side sub-inner liner **82** may form a pressure side outer wall **50** of a pressure side **52** of the downstream portion **84** of an airfoil shaped core **42** and may include one or more cavities **44** on an inner side **56** of the pressure side outer wall **50** that is configured to form at least a portion of an internal airfoil cooling system **48**.

[0057] The foregoing is provided for purposes of illustrating, explaining, and describing embodiments of this invention. Modifications and adaptations to these embodiments will be apparent to those skilled in the art and may be made without departing from the scope or spirit of this invention.

We claim:

1-13. (canceled)

14. A core die cast system comprising:

a die housing having an insert receiving chamber;

at least one inner liner formed via selective laser melting and positioned within the insert receiving chamber of the die housing, wherein the at least one inner liner has an inner surface corresponding to an inner surface of a turbine component.

15. The core die cast system of claim **14**, characterized in that the at least one inner liner comprises a first side sub-inner liner having a body shape corresponding to a first side of the turbine component and a second side sub-inner liner having a body shape corresponding to a second side of the turbine component.

16. The core die cast system of claim **15**, characterized in that the first side sub-inner liner comprises a body shape corresponding to an outer wall of a suction side of an airfoil in a gas turbine engine, and wherein the second side sub-inner liner comprises a body shape corresponding to an outer wall of a pressure side of an airfoil in a gas turbine engine.

17. The core die cast system of claim **14**, characterized in that the at least one inner liner comprises a non-ceramic material.

18. The core die cast system of claim **14**, characterized in that the at least one inner liner comprises a different material than the die housing.

19. The core die cast system of claim **14**, characterized in that the die housing comprises a first sub-die housing and a second sub-die housing having a mateable interface positioned therebetween such that the first and second sub-die housings are mateable at the mateable interface.

20. The core die cast system of claim **14**, characterized in that the inner liner comprises a first end sub-inner liner having a body shape corresponding to a first end of the turbine component and a second end sub-inner liner having a body shape corresponding to a second end of the turbine component.

21. The core die cast system of claim **20**, characterized in that the first end sub-inner liner comprises a first material less compliant than a material of the second end sub-inner liner.

22. The core die cast system of claim **20**, characterized in that the first end sub-inner liner comprises a body shape corresponding to a leading edge of an airfoil in a turbine engine and second end sub-inner liner comprises a body shape corresponding to a trailing edge of the airfoil in the turbine engine.

23. The core die cast system of claim **20**, characterized in that the first end sub-inner liner comprises a first end, first side sub-inner liner and a first end, second side sub-inner liner.

24. The core die cast system of claim **23**, characterized in that the first end, first side sub-inner liner comprises a body shape corresponding to a suction side outer wall of an upstream portion of a suction side of an airfoil in a gas turbine engine and includes at least one cavity defined by the first end, first side sub-inner liner, and wherein the first end, second side sub-inner liner comprises a body shape corresponding to a pressure side outer wall of a pressure side of an upstream portion of an airfoil in a gas turbine engine and includes at least one cavity defined by the first end, second side sub-inner liner.

25. The core die cast system of claim **20**, characterized in that the second end sub-inner liner comprises a second end, first side sub-inner liner and a second end, second side sub-inner liner.

26. The core die cast system of claim **25**, characterized in that the second end, first side sub-inner liner comprises a body shape corresponding to a suction side outer wall of a downstream portion of a suction side of an airfoil usable in a gas turbine engine and includes at least one cavity defined by the second end, first side sub-inner liner, and wherein the second end, second side sub-inner liner comprises a body shape corresponding to a pressure side outer wall of a pressure side of the downstream portion of an airfoil in a gas turbine engine and includes at least one cavity defined by the the second end, second side sub-inner liner.

27. A method of forming a turbine component comprising:

injecting a ceramic material into at least one inner cavity formed within a core die cast system, wherein the core die cast system comprises:

a die housing having an insert receiving chamber;

at least one inner liner formed via selective laser melting and positioned within the insert receiving chamber of the die housing, wherein the at least one inner liner has an inner surface corresponding to an inner surface of the turbine component;

removing the die cast system to reveal one or more ceramic cores;

firing the one or more ceramic cores;

placing the one or more ceramic cores within an inner cavity formed by an inner surface of a wax die; and

injecting wax into one or more openings formed between the one or more ceramic cores and the inner surface of the wax die;

removing the wax die to reveal a wax component;

coating the wax component with a ceramic coating to form a ceramic shell with a ceramic core positioned therein;

removing the wax component within the ceramic coating leaving one or more cavities within the ceramic coating;

filling the one or more cavities within the ceramic coating with a molten metal; and

removing the ceramic shell and the one or more ceramic cores to form the turbine component with the inner surface.

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