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(54) HOT GAS PATH COMPONENT FOR TURBINE SYSTEM

(75) Inventors: **Benjamin Paul Lacy**, Greer, SC (US); **Brian Gene Brzek**, Clifton Park, NY (US); **Rebecca Christine Malish**, Schenectady, NY (US)

(73) Assignee: **GENERAL ELECTRIC COMPANY**, Schenectady, NY (US)

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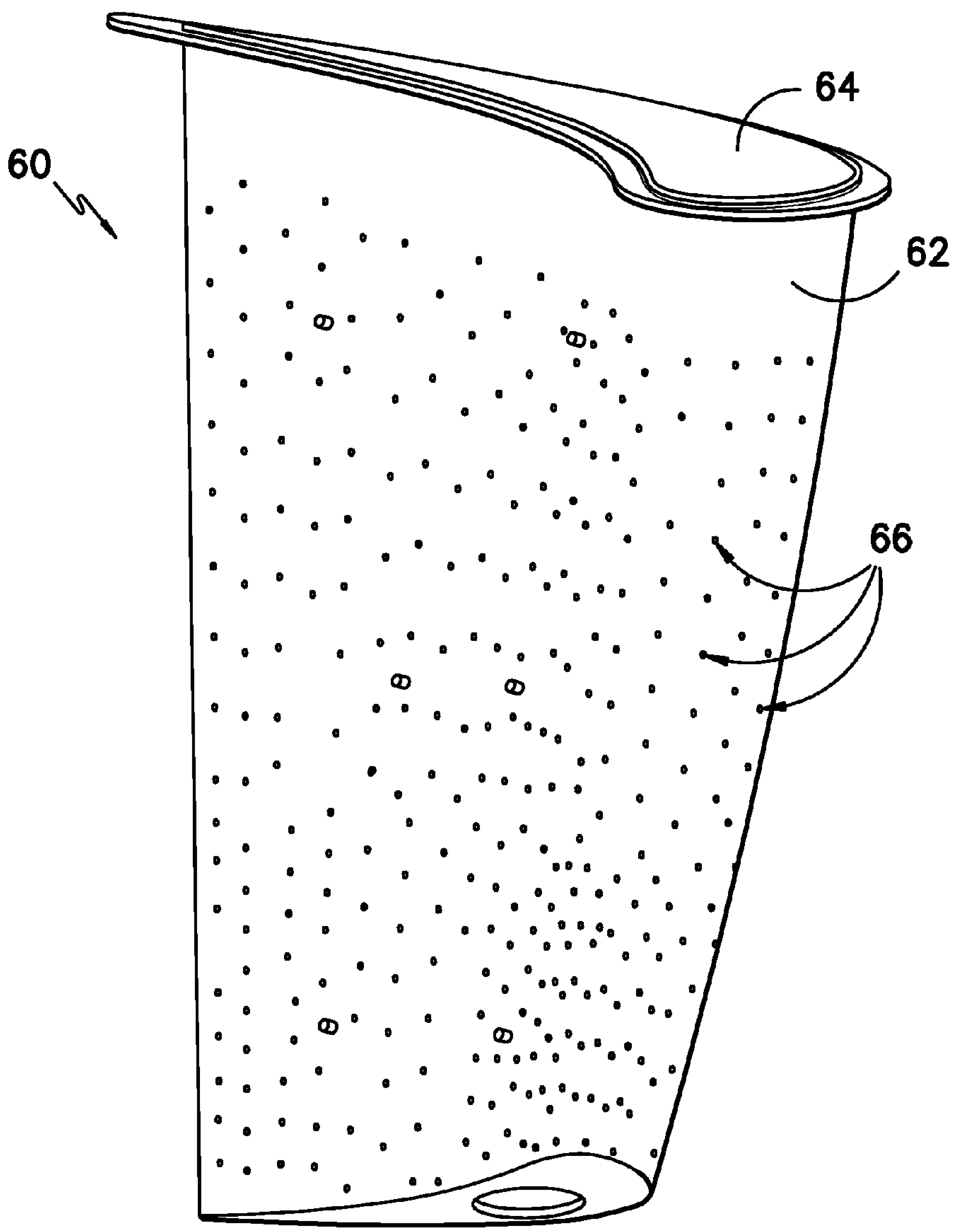
(57) ABSTRACT

A hot gas path component for a turbine system is disclosed. The hot gas path component includes a shell having an exterior surface and an interior surface. The hot gas path component further includes a porous medium having an exterior surface and an interior surface, the exterior surface positioned adjacent to the interior surface of the shell. The porous medium is configured for flowing a cooling medium therethrough.



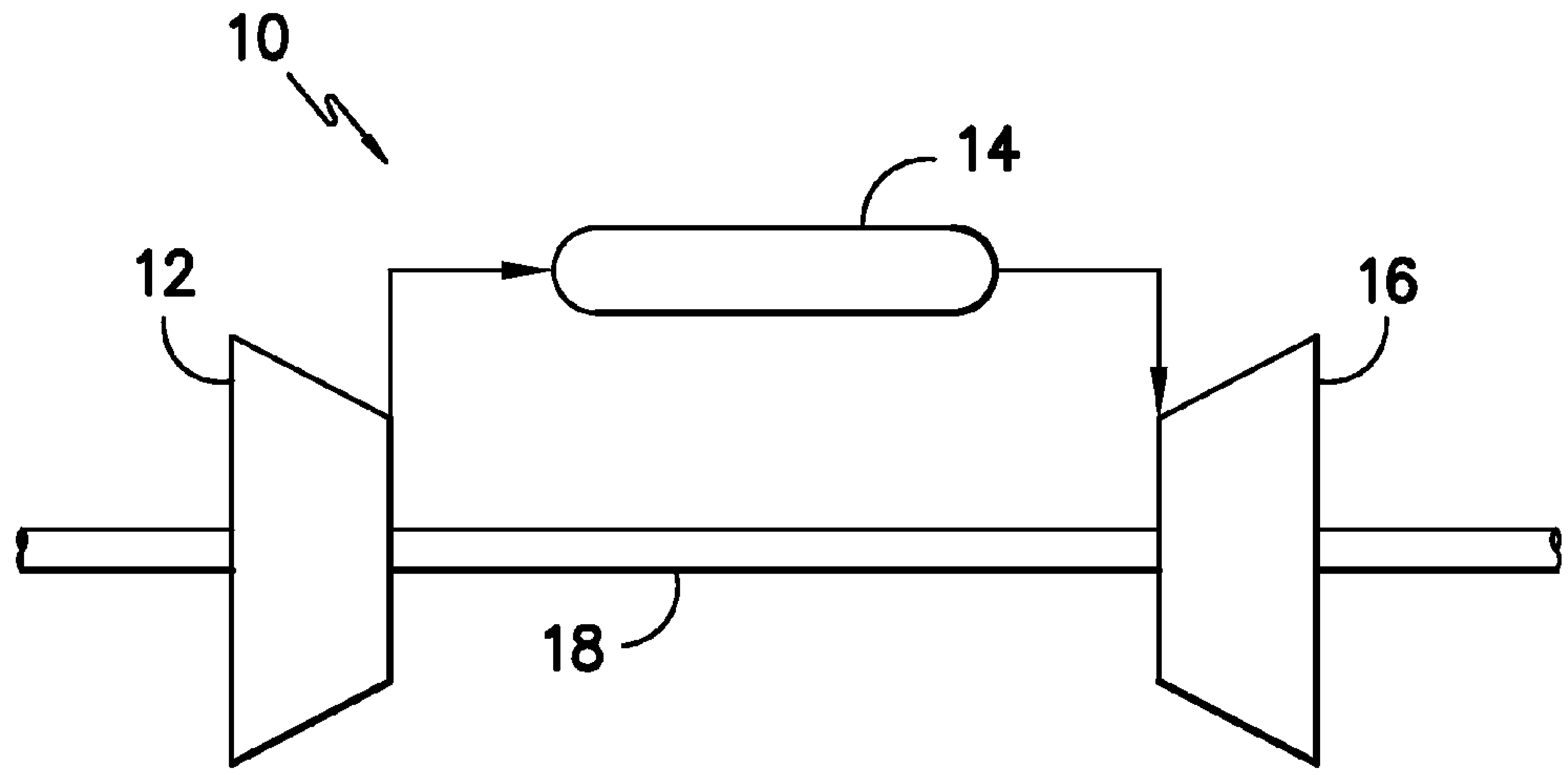


FIG. -1-

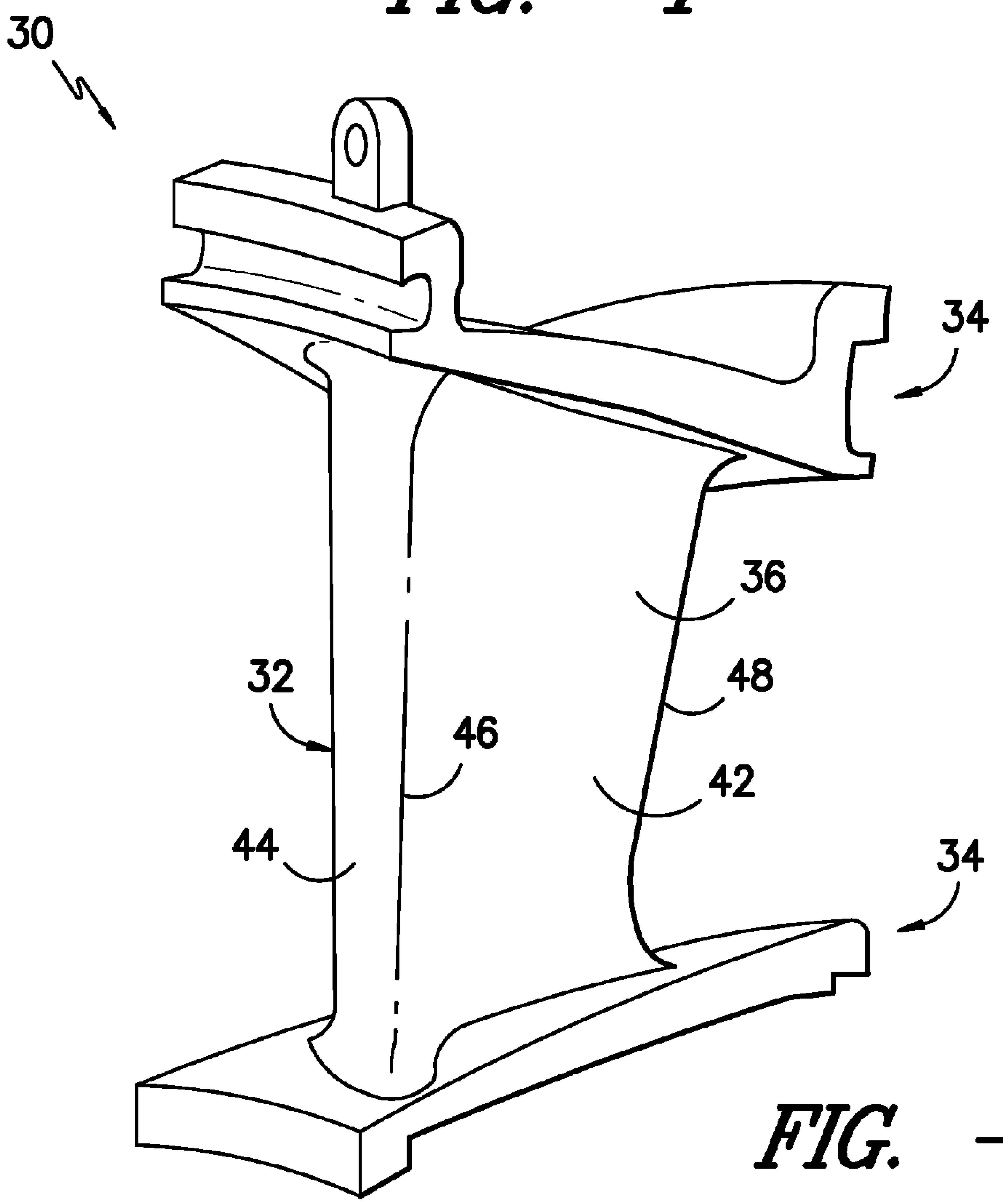


FIG. -2-

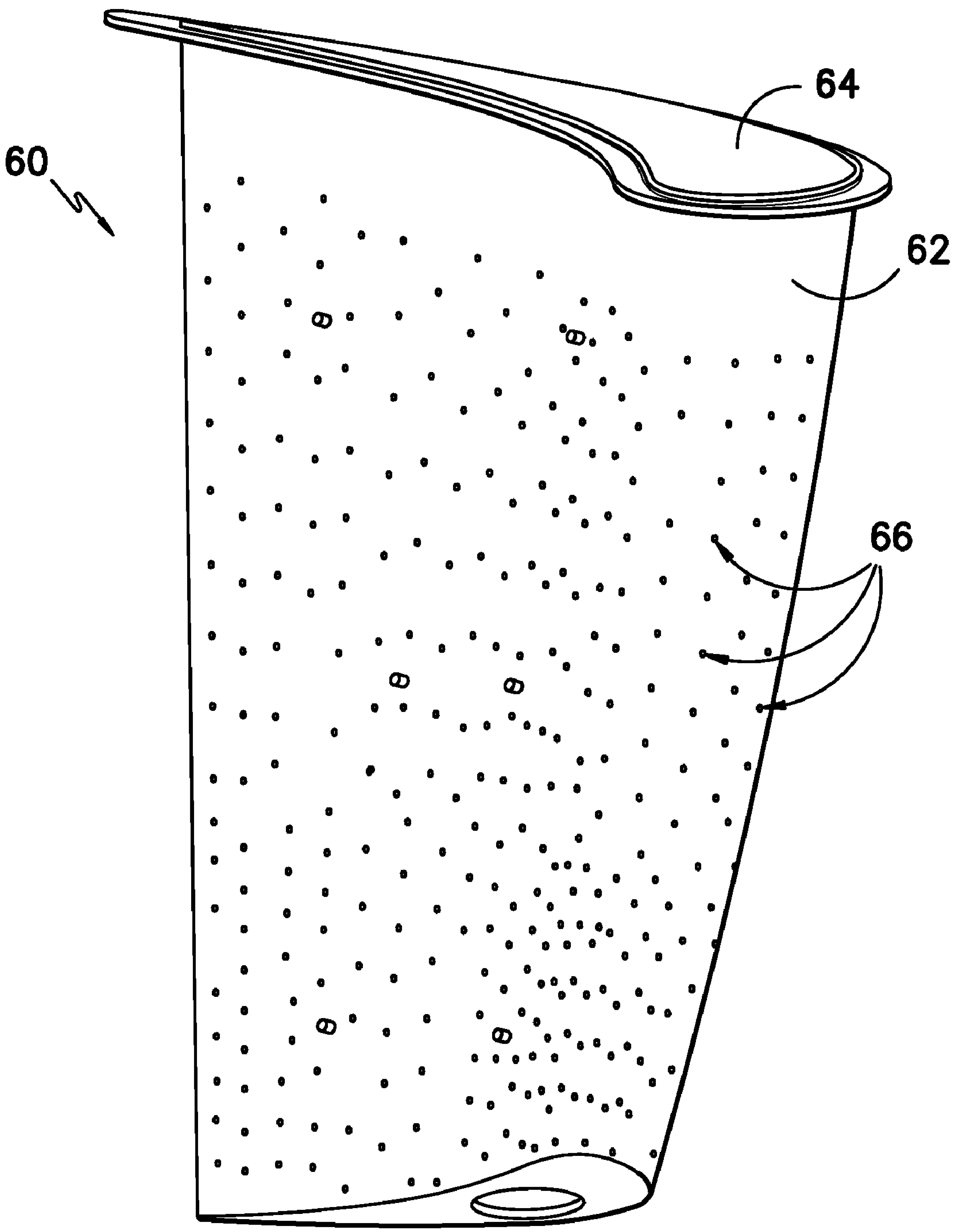


FIG. –3–

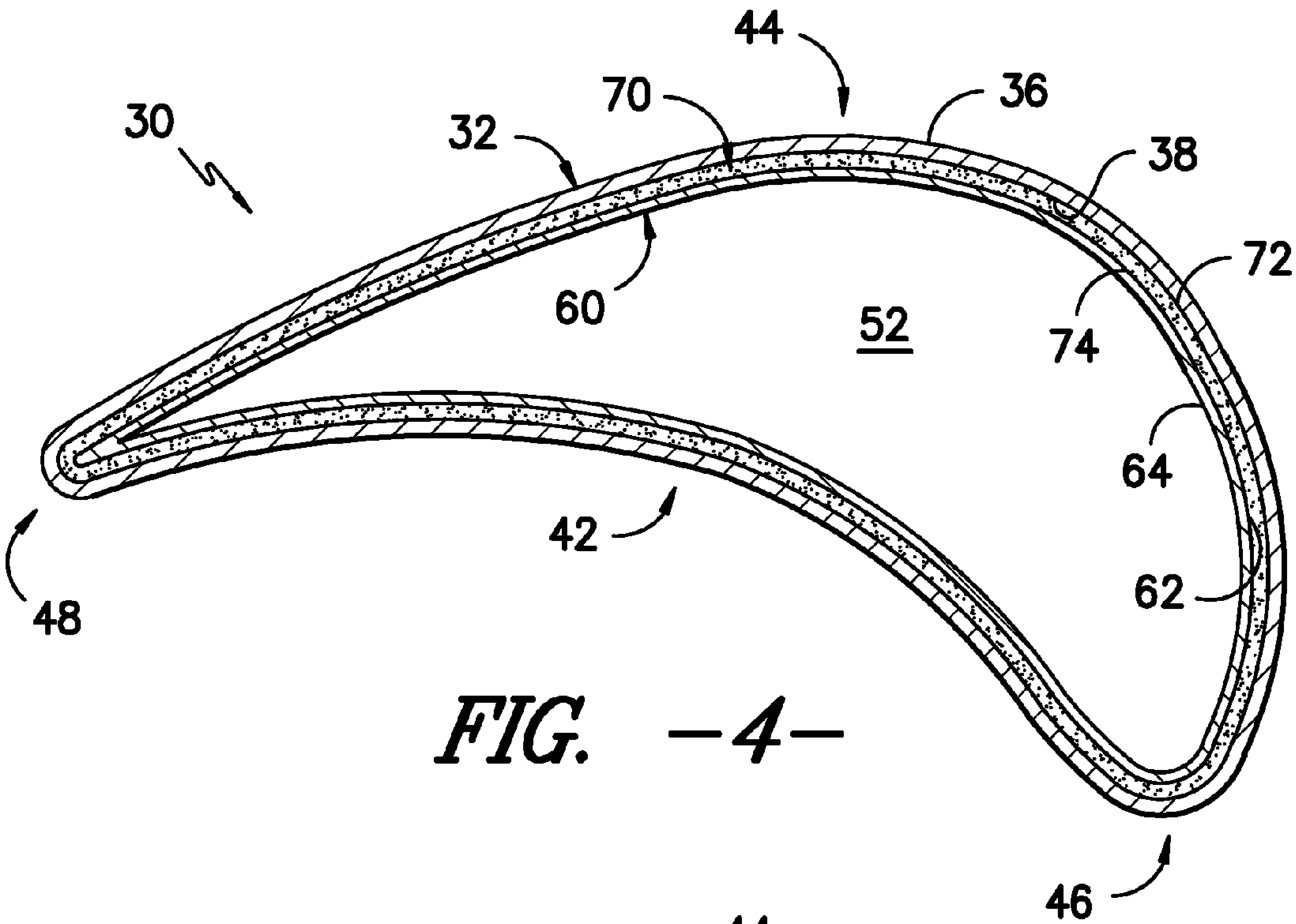

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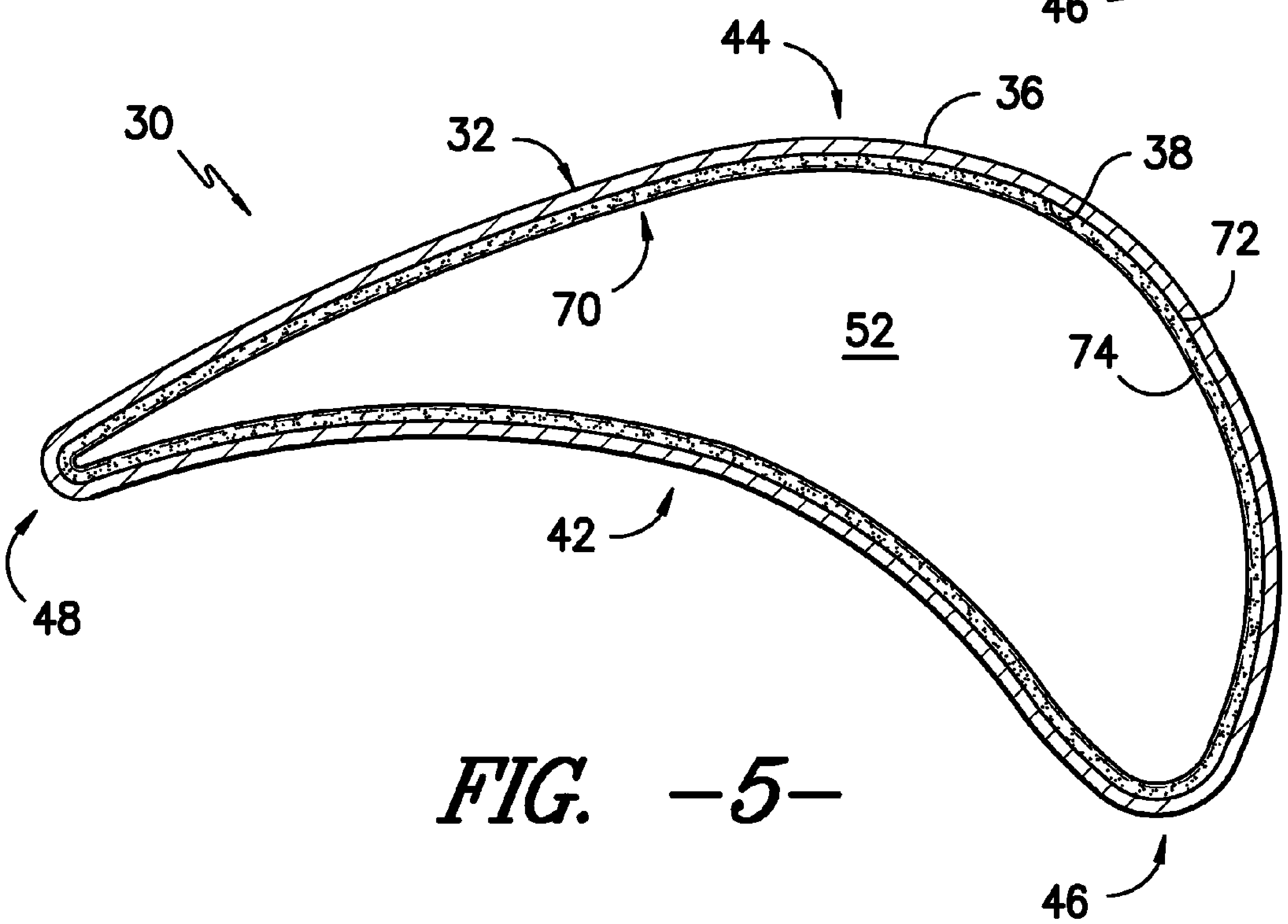
FIG. -4-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74
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48
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FIG. -5-

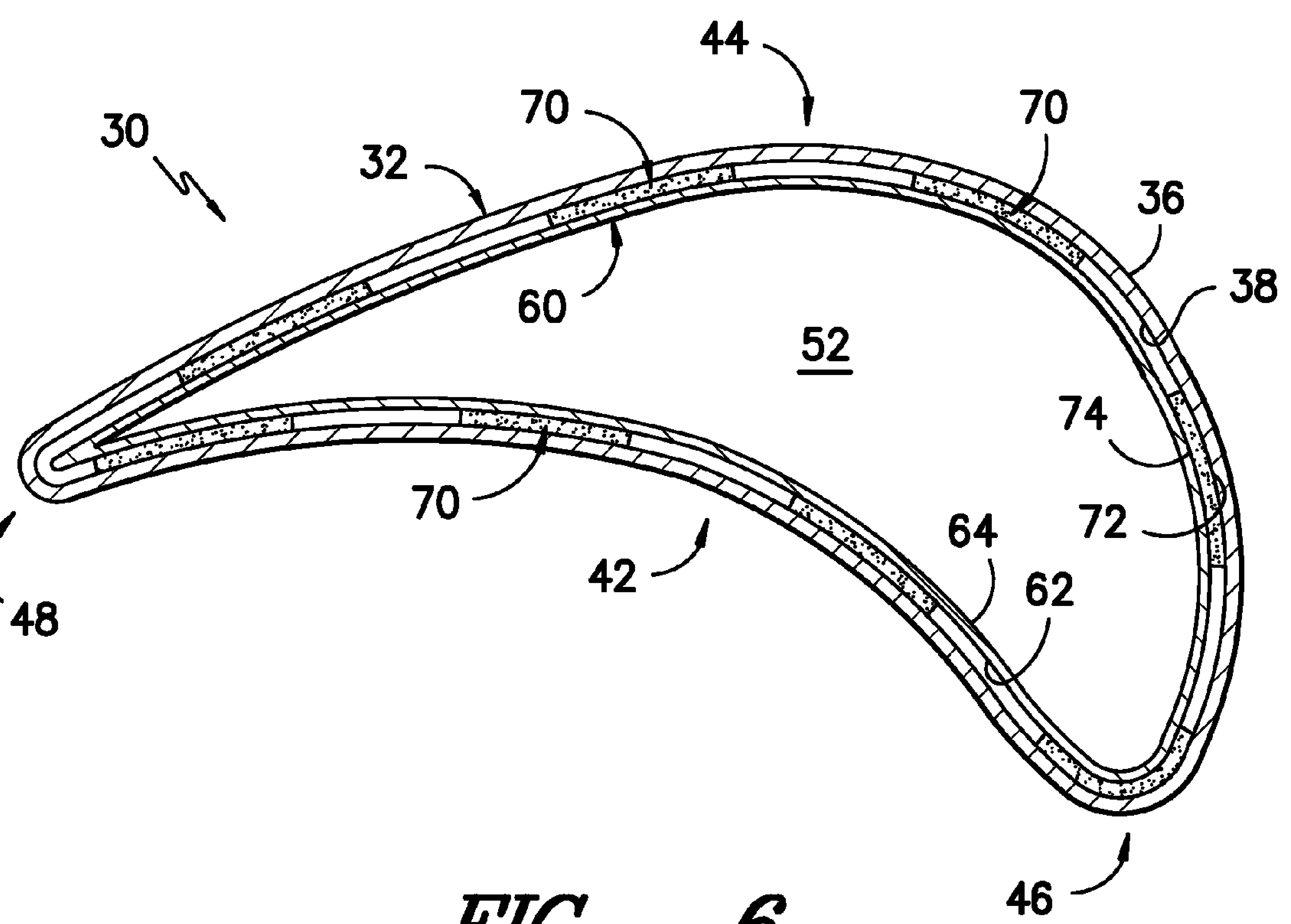
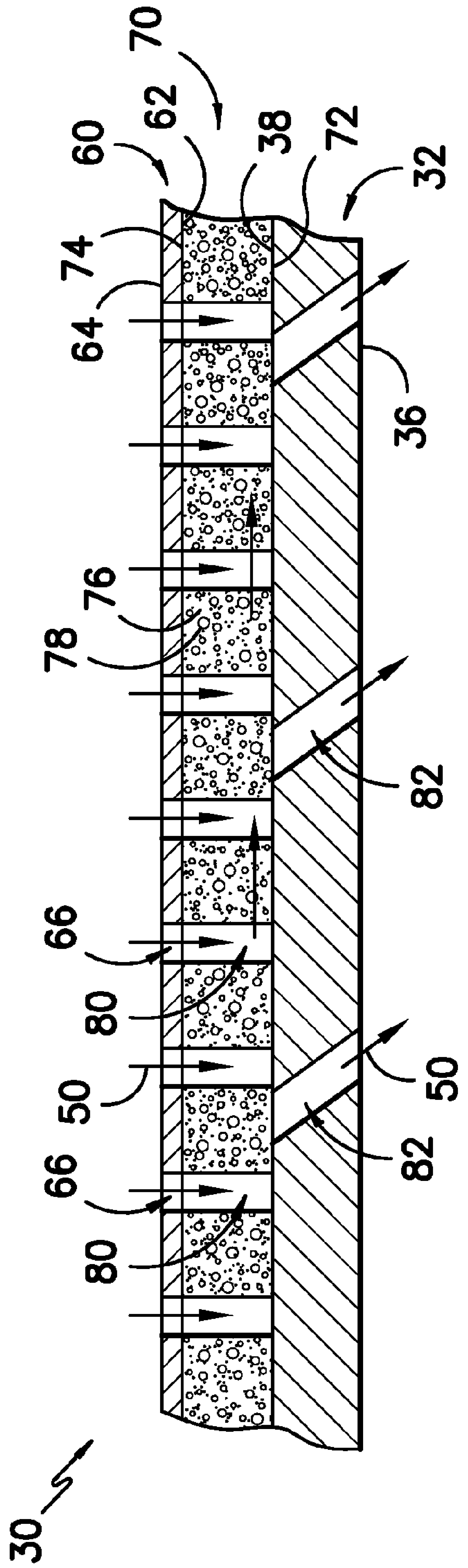


FIG. –6–


70
60
62
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72
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74
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36
76
78
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66
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50
66
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80
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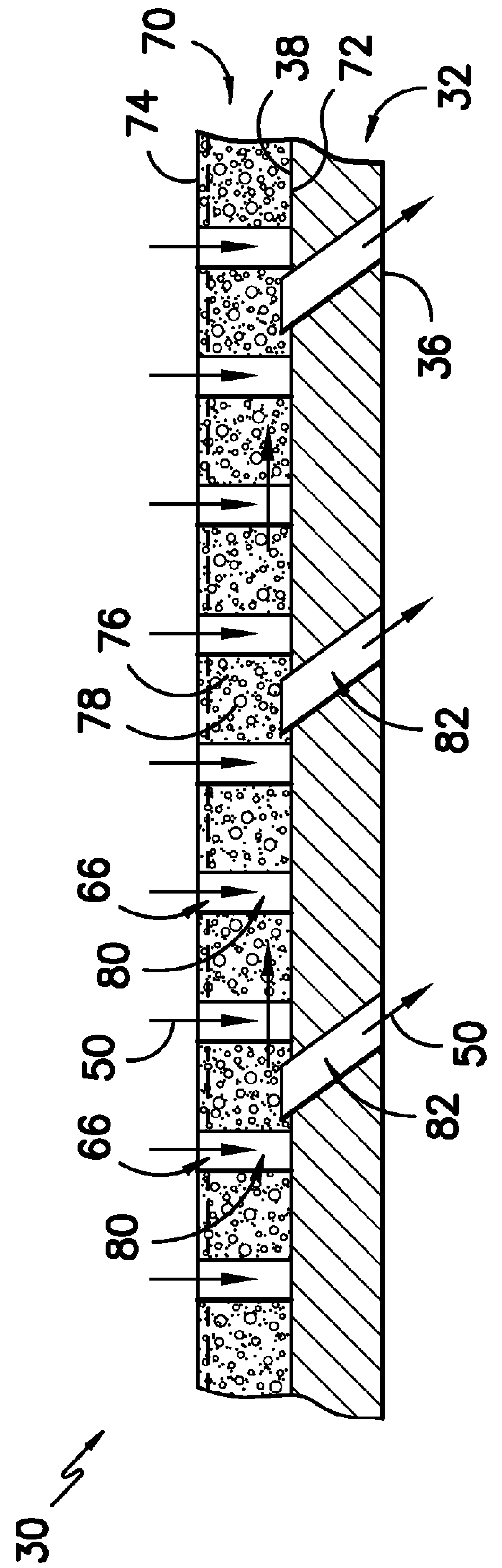
FIG. -7-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82
80
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FIG. -8-

HOT GAS PATH COMPONENT FOR TURBINE SYSTEM

[0001] This invention was made with government support under contract number DE-FC26-05NT42643 awarded by the Department of Energy. The government has certain rights in the invention.

FIELD OF THE INVENTION

[0002] The subject matter disclosed herein relates generally to turbine systems, and more specifically to hot gas path components for turbine systems.

BACKGROUND OF THE INVENTION

[0003] Turbine systems are widely utilized in fields such as power generation. For example, a conventional gas turbine system includes a compressor, a combustor, and a turbine. During operation of the gas turbine system, various components in the system are subjected to high temperature flows, which can cause the components to fail. Since higher temperature flows generally result in increased performance, efficiency, and power output of the gas turbine system, the components that are subjected to high temperature flows must be cooled to allow the gas turbine system to operate at increased temperatures, increased efficiency, and/or reduced emissions.

[0004] Various strategies are known in the art for cooling various gas turbine system components. For example, a cooling medium may be routed from the compressor and provided to various components. In the compressor and turbine sections of the system, the cooling medium may be utilized to cool various compressor and turbine components.

[0005] Nozzles are one example of a hot gas path component that must be cooled. For example, various parts of the nozzle, such as the airfoil, are disposed in a hot gas path and exposed to relatively high temperatures, and thus require cooling.

[0006] One solution for cooling a nozzle is to include an impingement sleeve inside the airfoil. Cooling medium is flowed to the interior of the nozzle, and then flowed through the impingement sleeve and onto an interior surface of the airfoil. This approach facilitates impingement cooling of the airfoil. However, while impingement sleeves do provide adequate cooling of nozzles, increased cooling efficiency is desired. Such increased efficiency would allow for a reduction in the cooling medium required to cool the nozzles, and thus a reduction in emission and/or increase in firing temperature.

[0007] Accordingly, an improved hot gas path component, such as an improved nozzle, for a turbine system is desired in the art. For example, a hot gas path component with improved cooling features would be advantageous.

BRIEF DESCRIPTION OF THE INVENTION

[0008] Aspects and advantages of the invention will be set forth in part in the following description, or may be obvious from the description, or may be learned through practice of the invention.

[0009] In one embodiment, a hot gas path component for a turbine system is disclosed. The hot gas path component includes a shell having an exterior surface and an interior surface. The hot gas path component further includes a porous medium having an exterior surface and an interior surface, the exterior surface positioned adjacent to the interior surface of the shell. The porous medium is configured for flowing a cooling medium therethrough.

[0010] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

[0012] FIG. **1** is a schematic illustration of a gas turbine system according to one embodiment of the present disclosure;

[0013] FIG. **2** is a perspective view of a nozzle according to one embodiment of the present disclosure;

[0014] FIG. **3** is a perspective view of an impingement sleeve according to one embodiment of the present disclosure;

[0015] FIG. **4** is a top cross-sectional view of a nozzle according to one embodiment of the present disclosure;

[0016] FIG. **5** is a top cross-sectional view of a nozzle according to another embodiment of the present disclosure;

[0017] FIG. **6** is a top cross-sectional view of a nozzle according to another embodiment of the present disclosure;

[0018] FIG. **7** is a close-up cross-sectional view of a hot gas path component according to one embodiment of the present disclosure; and

[0019] FIG. **8** is a close-up cross-sectional view of a hot gas path component according to another embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0020] Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0021] FIG. **1** is a schematic diagram of a gas turbine system **10**. The system **10** may include a compressor **12**, a combustor **14**, and a turbine **16**. The compressor **12** and turbine **16** may be coupled by a shaft **18**. The shaft **18** may be a single shaft or a plurality of shaft segments coupled together to form shaft **18**.

[0022] The turbine **16** may include a plurality of turbine stages. For example, in one embodiment, the turbine **16** may have three stages. A first stage of the turbine **16** may include a plurality of circumferentially spaced nozzles and buckets. The nozzles may be disposed and fixed circumferentially about the shaft **18**. The buckets may be disposed circumferentially about the shaft and coupled to the shaft **18**. A second stage of the turbine **16** may include a plurality of circumferentially spaced nozzles and buckets. The nozzles may be disposed and fixed circumferentially about the shaft **18**. The buckets may be disposed circumferentially about the shaft **18** and coupled to the shaft **18**. A third stage of the turbine **16** may include a plurality of circumferentially spaced nozzles and buckets. The nozzles may be disposed and fixed circumferentially about the shaft **18**. The buckets may be disposed circumferentially about the shaft **18** and coupled to the shaft **18**. The various stages of the turbine **16** may be at least partially disposed in the turbine **16** in, and may at least partially define, a hot gas path. It should be understood that the turbine **16** is not limited to three stages, but rather that any number of stages are within the scope and spirit of the present disclosure.

[0023] Similarly, the compressor **12** may include a plurality of compressor stages (not shown). Each of the compressor **12** stages may include a plurality of circumferentially spaced nozzles and buckets.

[0024] An exemplary hot gas path component, which may be included in the turbine **16** and/or the compressor **12**, is shown by reference numeral **30** in FIG. **2**. In exemplary embodiments as shown, the hot gas path component **30** is a nozzle. Alternatively, however, a hot gas path component **30** according to the present disclosure may be a bucket, a shroud block, or any other suitable component that may be disposed in the path of hot gases flowing through a turbine system **10**. The nozzle **30** may include a shell **32**. In exemplary embodiments, the shell **32** may be an airfoil that extends between end caps **34**. In embodiments wherein the shell **32** is an airfoil, it may have a generally aerodynamic contour. For example, the shell **32** may have an exterior surface **36** and an interior surface **38**. In embodiments wherein the shell **32** is an airfoil, the exterior surface **36** may define a pressure side **42** and suction side **44** each extending between a leading edge **46** and a trailing edge **48**, or any other suitable aerodynamic contour. One or more of the end caps **34** may define an opening (not shown). The opening may allow cooling medium **50** to flow to the interior **52** of the shell **32**, defined by the interior surface **38**, as is generally known in the art.

[0025] In some embodiments, the hot gas path component **30** may further include an impingement sleeve **60**, as shown in FIGS. **3**, **4**, **6** and **7**. The impingement sleeve **60** may be disposed at least partially within the interior **52** of the shell **32**, and spaced from the interior surface **38**. The impingement sleeve may have an exterior surface **62** and interior surface **64**, and may have a contour similar to that of the shell **32**. Further, the impingement sleeve **60** may define one or more impingement passages **66** extending between the interior surface **64** and the exterior surface **62**. Cooling medium **50** flowed into the interior **52** of the shell **32** may be flowed through these impingement passages **66**. In other embodiments, the hot gas path component **30** may include any suitable sleeve therein. For example, a sleeve may include a plurality of spaced apart plates which allow cooling medium **50** to flow therebetween.

[0026] As shown in FIGS. **4** through **8**, a hot gas path component **30** according to the present disclosure further includes one or more porous media **70**. A porous medium **70** according to the present disclosure has an exterior surface **72** and an interior surface **74**. The exterior surface **72** is positioned adjacent the interior surface **38** of the shell **32**. In embodiments wherein the hot gas path component **30** includes an impingement sleeve **60** or other suitable sleeve, the porous media **70** are positioned between the hot gas path component **30** and impingement sleeve **60** or other suitable sleeve, such that the exterior surface **62** of the impingement sleeve **60** is positioned adjacent the interior surfaces **64** of the porous media **70**.

[0027] The porous media **70** according to the present disclosure may advantageously allow improved cooling of the hot gas path component **30**, such as of the shell **32**. For example, in exemplary embodiments, the porous media **70** allow for conductive heat transfer from the shell **32** due to the cooling medium **50** flowing generally through the porous media **70**. In further embodiments, as discussed below, the porous media **70** may additionally allow for impingement cooling of the shell **32**, thus further improving cooling of the hot gas path component **30**.

[0028] A porous medium **70** according to the present disclosure may be formed from any suitable porous material or materials having a matrix **76** and one or more voids **78**. For example, in some embodiments, a porous medium **70**, such as the matrix **76** thereof, may be formed from a metal or metal alloy foam, a ceramic foam, such as a ceramic matrix composite foam, or a carbon fiber foam. A foam is typically formed by mixing a material, such as a metal, ceramic, or carbon fiber, with another substance and then melting the substance away, leaving a porous foam. In other embodiments, the porous medium **70** may be formed from, for example, a plurality of packed together beads of a suitable material, or any other suitable material or materials. The porous medium **70** may thus be configured for flowing cooling medium **50** therethrough. The cooling medium **50** may flow through the voids **78** in a porous medium **70** before contacting the interior surface **38** of the shell **32**, thus in exemplary embodiments facilitating convection cooling.

[0029] As shown in FIGS. **4** and **5**, in some embodiments, the hot gas path component **30** may include one porous medium **70**. In exemplary embodiments, the porous medium **70** is continuous in the direction of the contour, such as the aerodynamic contour, of the shell **32**, such that substantially all of a cross-sectional profile of the interior surface **38** is adjacent to the porous medium **70**. In other embodiments, only a portion of a cross-sectional profile of the interior surface **38** may be adjacent to the porous medium.

[0030] As shown in FIG. **6**, in other embodiments, the hot gas path component **30** may include more than one porous medium **70**. Each of the plurality of porous mediums **70** may be spaced apart from others of the plurality of porous mediums **70**, such as in the direction of the contour, such as the aerodynamic contour, of the shell **32** as shown or in any other suitable direction, or may abut or otherwise contact others of the plurality of porous mediums **70**.

[0031] As discussed above, in some embodiments as shown in FIGS. **4**, **6** and **7**, an impingement sleeve **60** may be positioned adjacent the interior surface **74** of a porous medium **70**. In these embodiments, cooling medium **50** may be flowed through the impingement passages **66** of the impingement sleeve **60** to the porous medium **70**. In other embodiments, as shown in FIGS. **5** and **8**, no impingement sleeve **60** may be included in the hot gas path component **30**.

[0032] As further shown in FIGS. **5** and **8**, in some embodiments, the interior surfaces **74** of the porous media **70** may be treated. Such treating may seal the interior surface **74**, such that voids **78** defined in a porous medium **70** do not extend to the interior surface **74**. Passages, such as impingement passages, may then be formed through such treated interior surface **74**, as discussed below, to allow cooling medium **50** to flow therethrough. Treating of the interior surface **74** may include grinding, filling, brazing, welding, soldering, or any other suitable treating technique that would suitably seal the interior surface **74**.

[0033] In exemplary embodiments, as shown in FIGS. **4** through **8**, a porous medium **70** may be in contact with the shell **32** and/or optional impingement sleeve **60**. Thus, the exterior surface **72** of the porous medium **70** may contact the interior surface **38** of the shell **32**. The interior surface **74** of the porous medium **70** may contact the exterior surface **62** of the impingement sleeve **60**. In some embodiments wherein the porous medium **70** contacts the shell **32** and/or the impingement sleeve **60**, the porous medium **70** may be press-fit, bonded such as through a suitable adhesive or bonding process, or otherwise connected to the shell **32** and/or impingement sleeve **60**. In other embodiments, a porous medium **70** may be spaced from the shell **32** and/or the impingement sleeve **60**. Thus, a porous medium **70** according to the present disclosure may be in contact with both an shell **32** and an impingement sleeve **60**, may be spaced from both a shell **32** and an impingement sleeve **60**, or may be in contact with one of an shell **32** or an impingement sleeve **60** and spaced from the other of an shell **32** or an impingement sleeve **60**.

[0034] In further exemplary embodiments, as shown in FIGS. **7** and **8**, one or more impingement passages **80** may be defined in a porous medium **70**. The impingement passages **80** may extend between the interior surface **74** and the exterior surface **72** of the porous medium **70**. Such impingement passages **80** may allow for cooling medium **50** to flow therethrough and impinge on the inner surface **38** of the shell **32**, thus impingement cooling the shell **32**. Further, portions of the cooling medium **50** may enter the impingement passages **80** and then flow from the impingement passages **80** through the voids **78** in the porous medium **70**, thus otherwise facilitating cooling of the shell **32**.

[0035] Such impingement passages **80** may have any suitable cross-sectional shape, such as circular or oval-shaped, square or rectangle shaped, triangular, or having any other suitable polygonal shape. For example, in some exemplary embodiments, the impingement passages **80** may have generally circular cross-sectional shapes, while in others the impingement passages **80** may have generally rectangular cross-sectional shapes and be characterized as slots. The impingement passages **80** may have cross-sectional areas that are larger than, identical to, or smaller than those of the impingement passages **66**.

[0036] Further, the impingement passages **80** may have any suitable cross-sectional area, and this cross-sectional area may be constant throughout the length of the passage **80** or may vary. For example, in some embodiments, a passage **80** may taper, or may have a constricted portion or a relatively larger portion.

[0037] Still further, the impingement passages **80** may be linear, curvilinear, or have any other suitable path. For example, in some embodiments, an impingement passage **80** may be curvilinear, having a generally serpentine path. In other embodiments, an impingement passage **80** may simply have a linear path.

[0038] An impingement passage **80** according to the present disclosure may be drilled or otherwise formed into a porous medium **70**. In embodiments wherein an impingement sleeve **60** is adjacent to the porous medium **70**, the impingement passages **66** in the impingement sleeve **60** may generally align with the impingement passages **80** of the porous medium **70**. In embodiments wherein the interior surface **74** of a porous medium **70** is treated, the impingement passages **80** may extend through this treated surface.

[0039] A shell **32** according to the present disclosure may further define one or more cooling passage **82**, as shown in FIGS. **7** and **8**. The cooling passages **80** may extend between the interior surface **38** and the exterior surface **36** of the shell **32**. Such cooling passages **80** may have any suitable cross-sectional shape, cross-sectional area, and cross-sectional path, as discussed above. Further, in some embodiments, the cooling passages **80** may be film cooling passages, and may be angled and formed such that cooling medium **50** flowed therethrough and exhausted therefrom then provides film cooling to the exterior surface **36** of the shell **32**.

[0040] A cooling passage **82** may be aligned with a porous medium **70**, as shown, or with an impingement passage **80** defined therein. Cooling medium **50** flowing through the impingement passages **80** and porous medium **70** may flow into and through the cooling passage **82**. In some embodiments, as shown in FIG. **7**, a cooling passage **82** extends only through the shell **32** between the interior surface **38** and exterior surface **36**. In other embodiments, as shown in FIG. **8**, a cooling passage **82** may further extend at least partially into and be at least partially defined in a porous medium **70**. For example, a cooling passage **82** may extend through the exterior surface **72** of a porous medium **70**, as shown.

[0041] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A hot gas path component for a turbine system, comprising:

a shell having an exterior surface and an interior surface; and

a porous medium having an exterior surface and an interior surface, the exterior surface positioned adjacent to the interior surface of the shell, the porous medium configured for flowing a cooling medium therethrough.

2. The hot gas path component of claim **1**, further comprising an impingement sleeve positioned adjacent the interior surface of the porous medium.

3. The hot gas path component of claim **1**, wherein the interior surface of the porous medium is treated.

4. The hot gas path component of claim **1**, wherein the porous medium defines an impingement passage extending between the interior surface and the exterior surface.

5. The hot gas path component of claim **1**, wherein the exterior surface of the porous medium is in contact with the interior surface of the shell.

6. The hot gas path component of claim **1**, wherein the shell defines a cooling passage extending between the interior surface and the exterior surface.

7. The hot gas path component of claim **6**, wherein the cooling passage further extends at least partially into the porous medium.

8. The hot gas path component of claim **1**, wherein the porous medium is formed from one of a metal foam, a ceramic foam, or a carbon fiber foam.

9. The hot gas path component of claim **1**, further comprising a plurality of porous mediums, and wherein an exterior surface of each of the plurality of porous mediums is positioned adjacent to the interior surface of the shell.

10. The hot gas path component of claim **1**, wherein the hot gas path component is a nozzle.

11. A turbine system, comprising:

a compressor;

a turbine coupled to the compressor; and

a plurality of hot gas path components disposed in at least one of the compressor or the turbine, at least one of the hot gas path components comprising:

a shell having an exterior surface and an interior surface; and

a porous medium having an exterior surface and an interior surface, the exterior surface positioned adjacent to the interior surface of the shell, the porous medium configured for flowing a cooling medium therethrough.

12. The turbine system of claim **11**, further comprising an impingement sleeve positioned adjacent the interior surface of the porous medium.

13. The turbine system of claim **11**, wherein the interior surface of the porous medium is treated.

14. The turbine system of claim **11**, wherein the porous medium defines an impingement passage extending between the interior surface and the exterior surface.

15. The turbine system of claim **11**, wherein the exterior surface of the porous medium is in contact with the interior surface of the shell.

16. The turbine system of claim **11**, wherein the shell defines a cooling passage extending between the interior surface and the exterior surface.

17. The turbine system of claim **16**, wherein the cooling passage further extends at least partially into the porous medium.

18. The turbine system of claim **11**, wherein the porous medium is formed from one of a metal foam, a ceramic foam, or a carbon fiber foam.

19. The turbine system of claim **11**, further comprising a plurality of porous mediums, and wherein an exterior surface of each of the plurality of porous mediums is positioned adjacent to the interior surface of the shell.

20. The turbine system of claim **11**, wherein the hot gas path component is a nozzle.

* * * * *