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(54) **TURBINE ENGINE WITH AN AIRFOIL AND INSERT**

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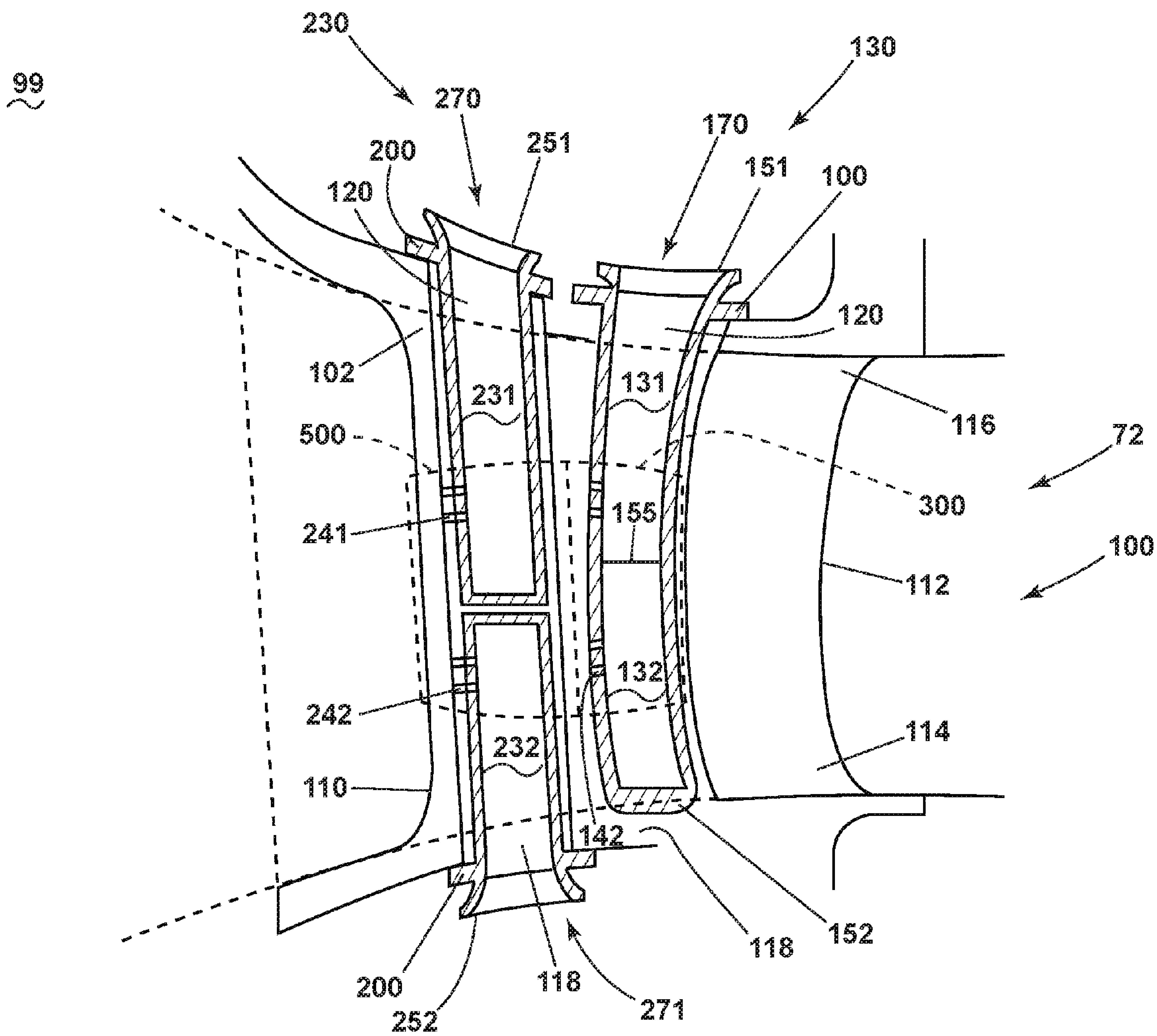
(57) **ABSTRACT**

An airfoil assembly for a turbine engine can comprise an airfoil including an outer wall extending between a root and a tip, a tip opening fluidly coupled to a first source of air, a root opening fluidly coupled to a second source of air, and an insert with impingement openings.



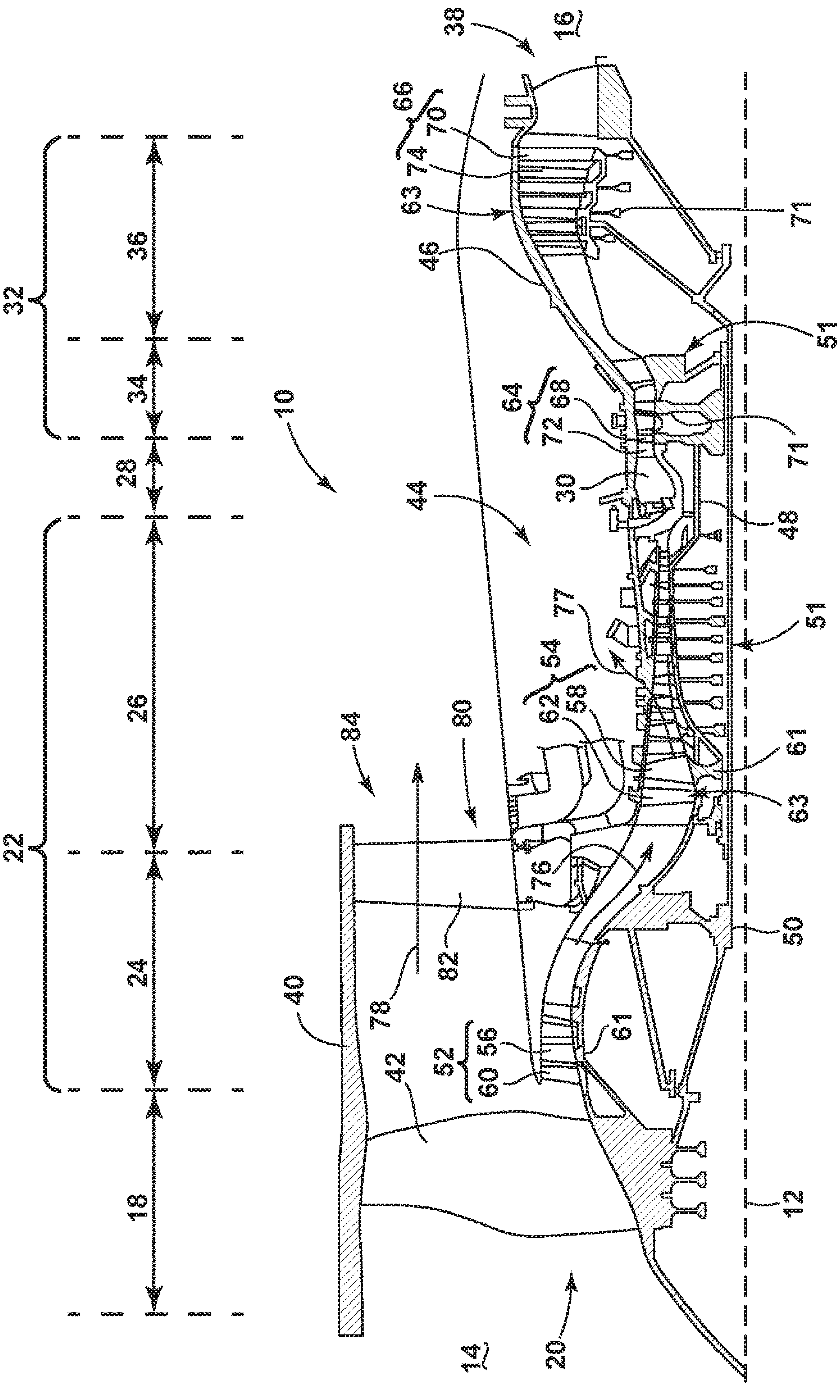


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FIG. 1

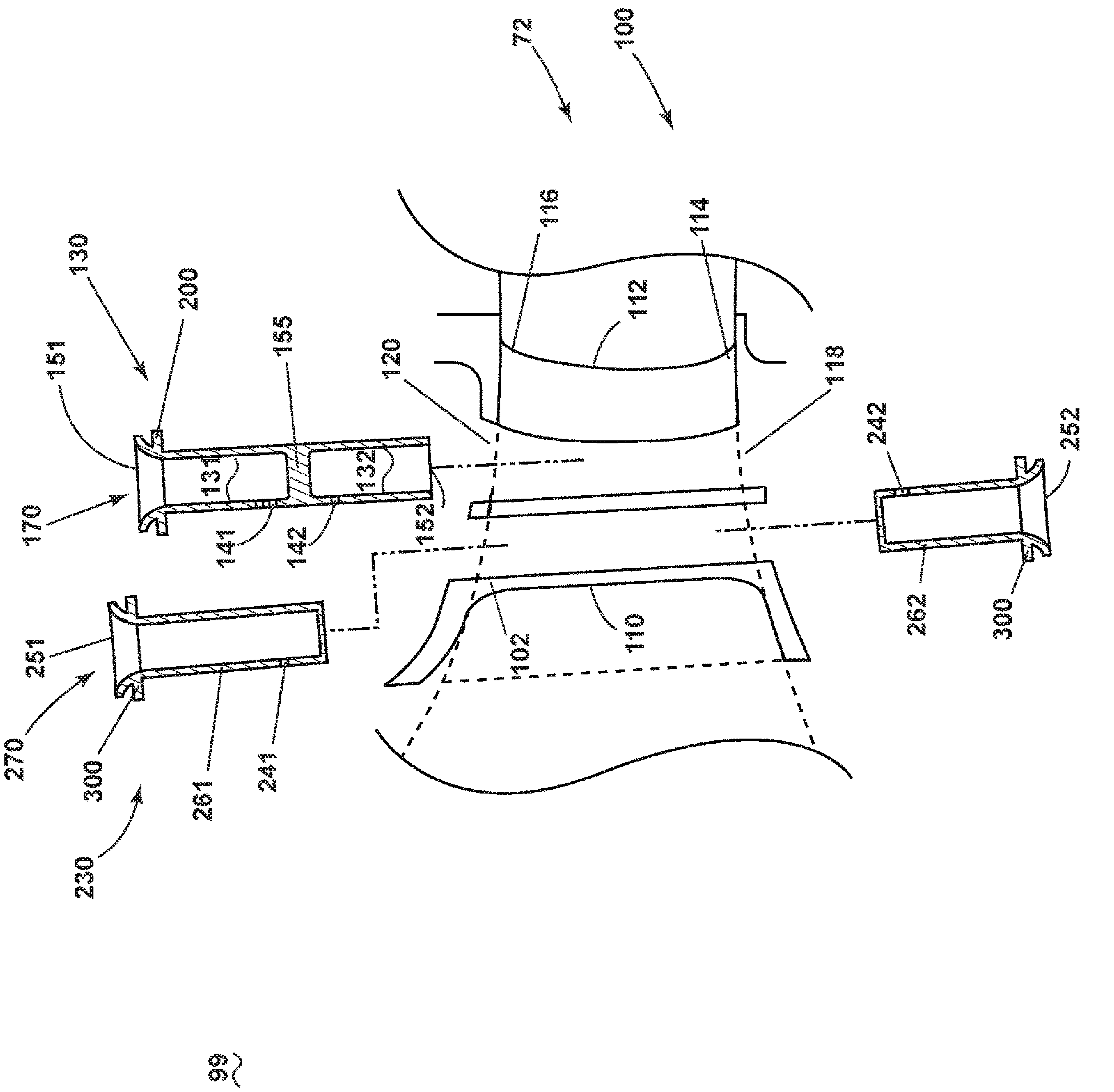
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FIG. 2

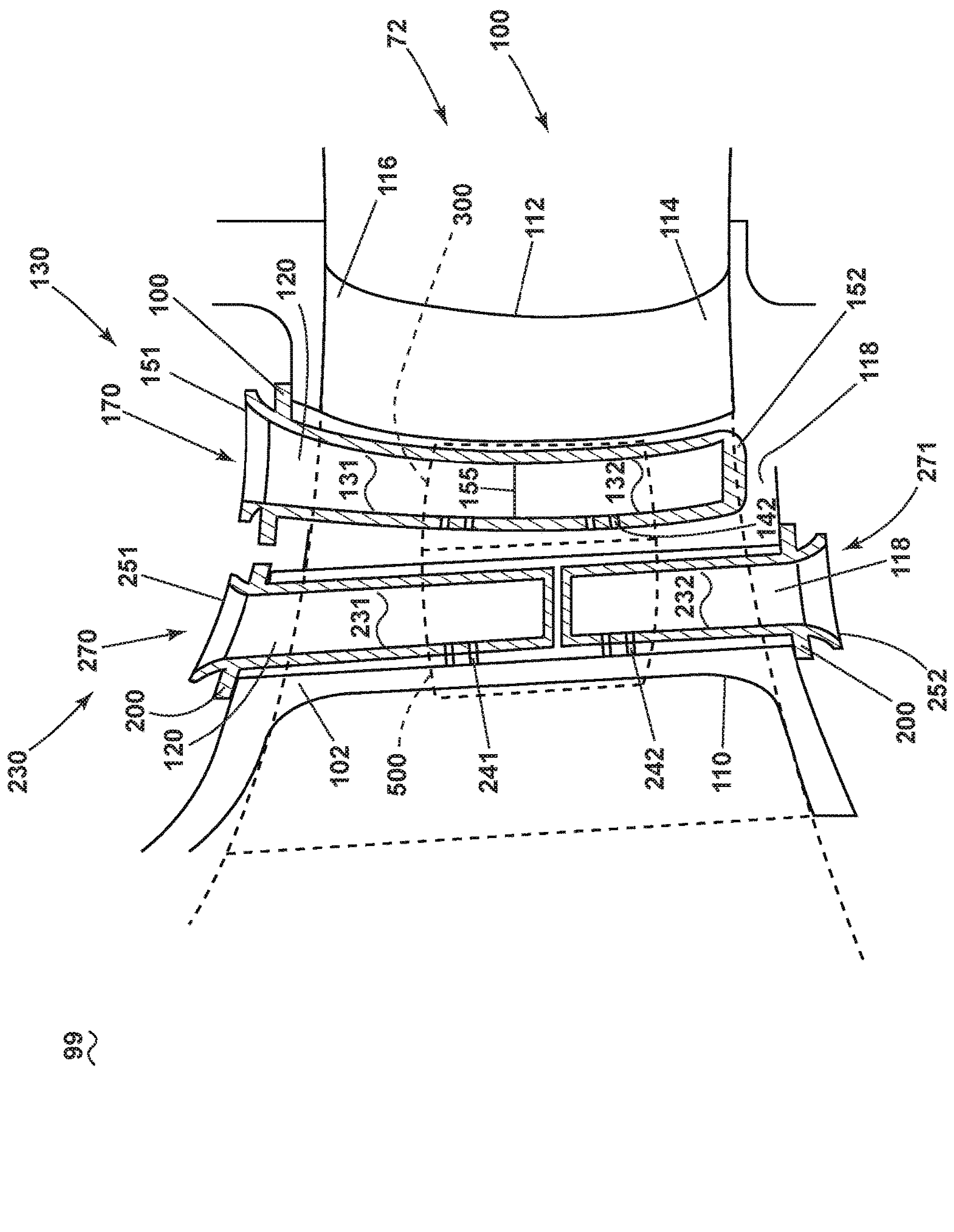
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FIG. 3

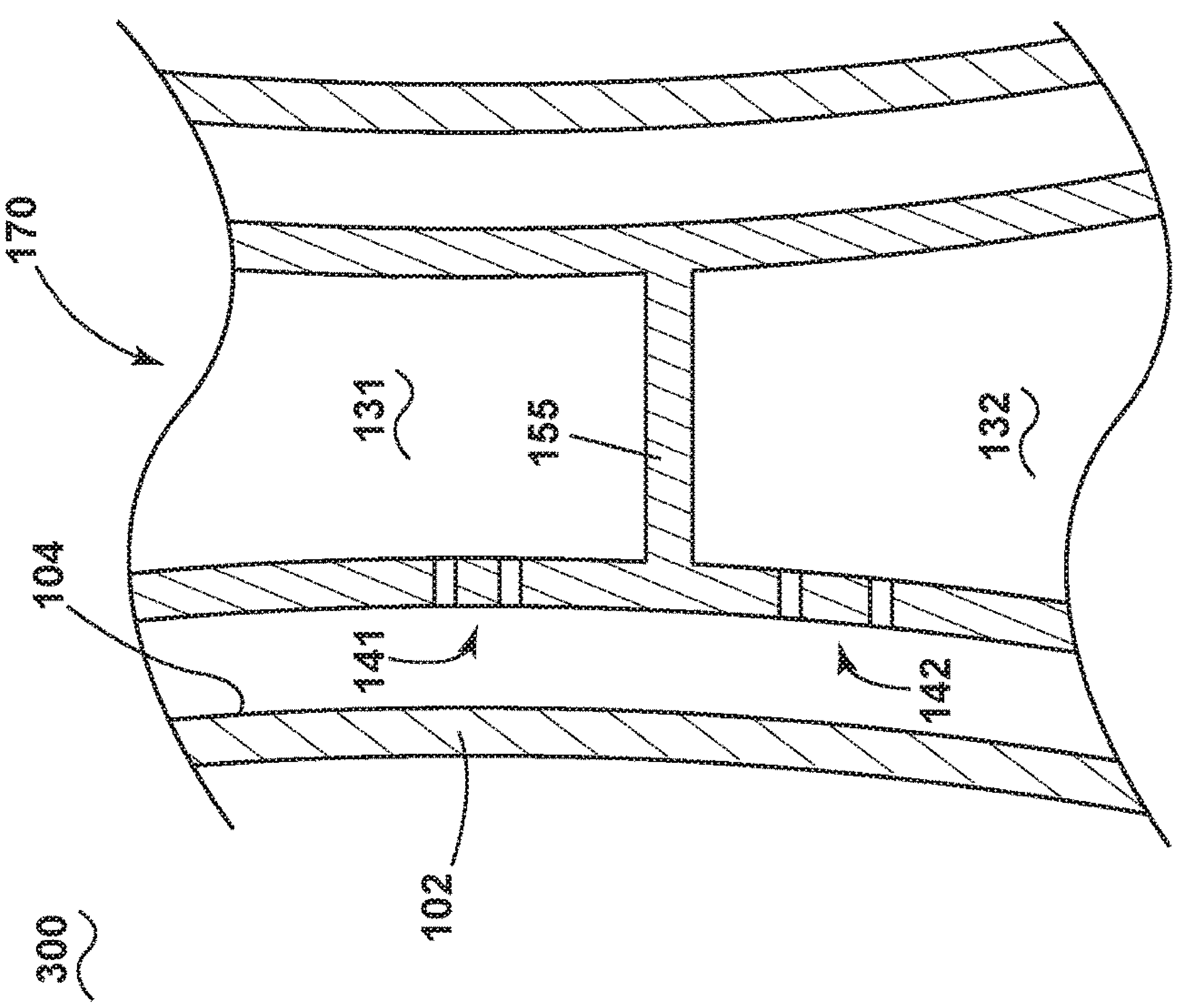

FIG. 4

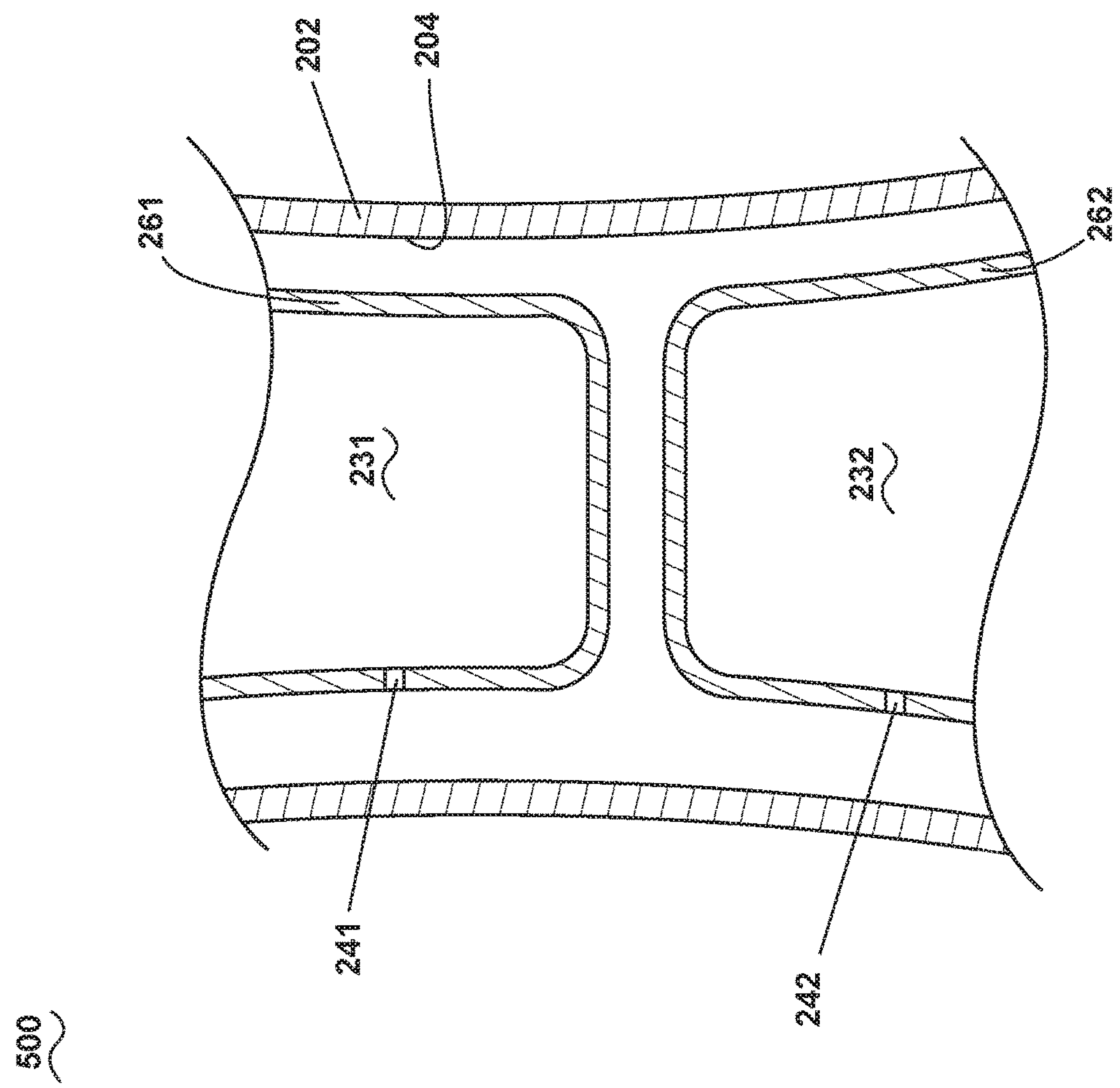

FIG. 5

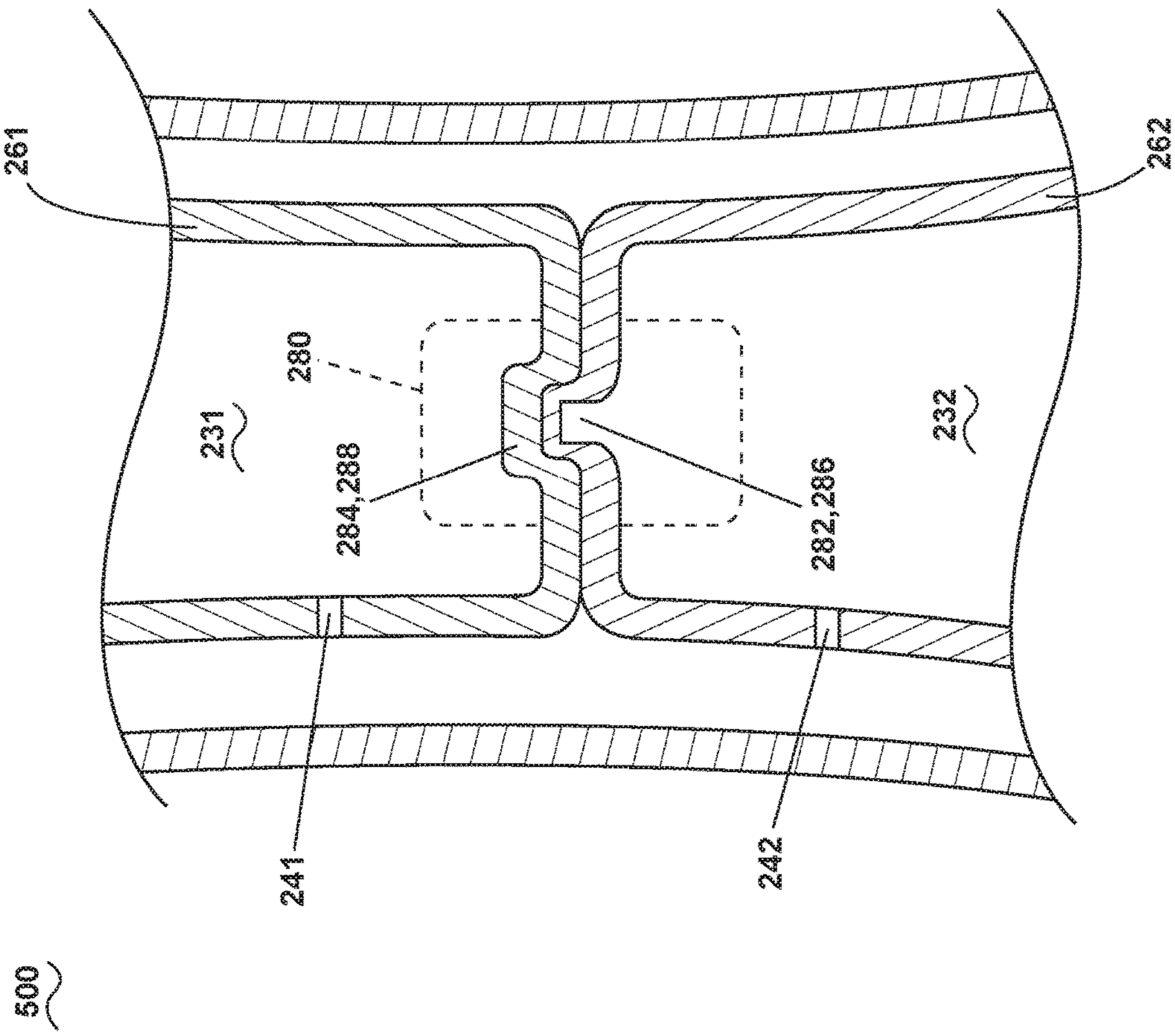

FIG. 6

TURBINE ENGINE WITH AN AIRFOIL AND INSERT

BACKGROUND OF THE INVENTION

[0001] Turbine engines, and particularly gas or combustion turbine engines, are rotary engines that extract energy from a flow of combusted gases passing through the engine onto a multitude of rotating turbine blades.

[0002] Gas turbine engines for aircraft are designed to operate at high temperatures to maximize engine efficiency, so cooling of certain engine components, such as the high pressure turbine and the low pressure turbine, can be beneficial. Typically, cooling is accomplished by ducting cooler air from the high and/or low pressure compressors to the engine components that require cooling. Temperatures in the high pressure turbine are around 1000° C. to 2000° C. and the cooling air from the compressor is around 500° C. to 700° C. While the compressor air is a high temperature, it is cooler relative to the turbine air, and can be used to cool the turbine.

[0003] Contemporary turbine blades generally include one or more interior cooling circuits for routing the cooling air through the blade to cool different portions of the blade, and can include dedicated cooling circuits for cooling different portions of the blade, such as the leading edge, trailing edge and tip of the blade.

BRIEF DESCRIPTION OF THE INVENTION

[0004] In one aspect, an airfoil assembly for a turbine engine comprises an outer wall bounding an interior and extending between a leading edge and a trailing edge to define a chord-wise direction and between a root and a tip to define a span-wise direction, a tip opening located at the tip and fluidly coupled to a first source of air, a root opening located at the root and fluidly coupled to a second source of air, and an impingement insert with impingement openings located within the interior and having a first chamber fluidly coupling the first source of air to a first set of the impingement openings, and a second chamber fluidly coupling the second source of air to a second set of the impingement openings.

[0005] In another aspect, a component for a turbine engine comprises a wall bounding an interior and having a first opening fluidly coupled to a first source of air and a second opening fluidly coupled to a second source of air, and an impingement insert with impingement openings located within the interior and having a first chamber fluidly coupling the first source of air to a first set of the impingement openings, and a second chamber fluidly coupling the second source of air to a second set of the impingement openings.

[0006] In another aspect, a method of impingement cooling an interior of a component for a turbine engine comprises supplying a first source of air into a first impingement insert located within the interior, and supplying a second source of air, separate from the first source of air, into a second impingement insert located within the interior, wherein the first and second sources of air have at least one different property.

[0007] In another aspect, a method of assembling an airfoil for a turbine engine comprises inserting a first insert at least partially into the airfoil, inserting a second insert at least partially into the airfoil, and coupling the first insert to the second insert.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In the drawings:

[0009] FIG. **1** is a schematic cross-sectional diagram of a turbine engine for an aircraft including an airfoil assembly.

[0010] FIG. **2** is a partially-exploded view of the airfoil assembly of FIG. **1** including an airfoil with inserts according to various aspects of the disclosure.

[0011] FIG. **3** is a perspective view of the airfoil assembly of FIG. **2**.

[0012] FIG. **4** is a schematic cross-sectional view of a portion of the insert of FIG. **2** according to a first embodiment of the disclosure.

[0013] FIG. **5** is a schematic cross-sectional view of a portion of the insert of FIG. **2** according to a second embodiment in a first configuration.

[0014] FIG. **6** is a schematic cross-sectional view of a portion of the insert of FIG. **2** according to a second embodiment in a second configuration.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0015] The described embodiments of the present disclosure are directed to an airfoil for a turbine engine. For purposes of illustration, the present disclosure will be described with respect to the turbine section for an aircraft turbine engine. It will be understood, however, that the disclosure is not so limited and may have general applicability within an engine, including in compressors, as well as in non-aircraft applications such as other mobile applications and non-mobile industrial, commercial, and residential applications.

[0016] As used herein, the term "forward" or "upstream" refers to moving in a direction toward the engine inlet, or a component being relatively closer to the engine inlet as compared to another component. The term "aft" or "downstream" used in conjunction with "forward" or "upstream" refers to a direction toward the rear or outlet of the engine or being relatively closer to the engine outlet as compared to another component.

[0017] Additionally, as used herein, the terms "radial" or "radially" refer to a dimension extending between a center longitudinal axis of the engine and an outer engine circumference, and "a set" as used herein can include any number including only one.

[0018] All directional references (e.g., radial, axial, proximal, distal, upper, lower, upward, downward, left, right, lateral, front, back, top, bottom, above, below, vertical, horizontal, clockwise, counterclockwise, upstream, downstream, forward, aft, etc.) are only used for identification purposes to aid the reader's understanding of the present disclosure, and do not create limitations, particularly as to the position, orientation, or use of the disclosure. Connection references (e.g., attached, coupled, connected, and joined) are to be construed broadly and can include intermediate members between a collection of elements and relative movement between elements unless otherwise indicated. As such, connection references do not necessarily infer that two elements are directly connected and in fixed relation to one another. The exemplary drawings are for purposes of illustration only and the dimensions, positions, order and relative sizes reflected in the drawings attached hereto can vary.

[0019] FIG. 1 is a schematic cross-sectional diagram of a gas turbine engine 10 for an aircraft. The engine 10 has a generally longitudinally extending axis or centerline 12 extending forward 14 to aft 16. The engine 10 includes, in downstream serial flow relationship, a fan section 18 including a fan 20, a compressor section 22 including a booster or low pressure (LP) compressor 24 and a high pressure (HP) compressor 26, a combustion section 28 including a combustor 30, a turbine section 32 including a HP turbine 34, and a LP turbine 36, and an exhaust section 38.

[0020] The fan section 18 includes a fan casing 40 surrounding the fan 20. The fan 20 includes a plurality of fan blades 42 disposed radially about the centerline 12. The HP compressor 26, the combustor 30, and the HP turbine 34 form a core 44 of the engine 10, which generates combustion gases. The core 44 is surrounded by core casing 46, which can be coupled with the fan casing 40.

[0021] A HP shaft or spool 48 disposed coaxially about the centerline 12 of the engine 10 drivingly connects the HP turbine 34 to the HP compressor 26. A LP shaft or spool 50, which is disposed coaxially about the centerline 12 of the engine 10 within the larger diameter annular HP spool 48, drivingly connects the LP turbine 36 to the LP compressor 24 and fan 20. The spools 48, 50 are rotatable about the engine centerline and couple to a plurality of rotatable elements, which can collectively define a rotor 51.

[0022] The LP compressor 24 and the HP compressor 26 respectively include a plurality of compressor stages 52, 54, in which a set of compressor blades 56, 58 rotate relative to a corresponding set of static compressor vanes 60, 62 to compress or pressurize the stream of fluid passing through the stage. In a single compressor stage 52, 54, multiple compressor blades 56, 58 can be provided in a ring and can extend radially outwardly relative to the centerline 12, from a blade platform to a blade tip, while the corresponding static compressor vanes 60, 62 are positioned upstream of and adjacent to the rotating blades 56, 58. It is noted that the number of blades, vanes, and compressor stages shown in FIG. 1 were selected for illustrative purposes only, and that other numbers are possible.

[0023] The blades 56, 58 for a stage of the compressor can be mounted to (or integral to) a disk 61, which is mounted to the corresponding one of the HP and LP spools 48, 50. The vanes 60, 62 for a stage of the compressor can be mounted to the core casing 46 in a circumferential arrangement.

[0024] The HP turbine 34 and the LP turbine 36 respectively include a plurality of turbine stages 64, 66, in which a set of turbine blades 68, 70 are rotated relative to a corresponding set of static turbine vanes 72, 74 (also called a nozzle) to extract energy from the stream of fluid passing through the stage. In a single turbine stage 64, 66, multiple turbine blades 68, 70 can be provided in a ring and can extend radially outwardly relative to the centerline 12 while the corresponding static turbine vanes 72, 74 are positioned upstream of and adjacent to the rotating blades 68, 70. It is noted that the number of blades, vanes, and turbine stages shown in FIG. 1 were selected for illustrative purposes only, and that other numbers are possible.

[0025] The blades 68, 70 for a stage of the turbine can be mounted to a disk 71, which is mounted to the corresponding one of the HP and LP spools 48, 50. The vanes 72, 74 for a stage of the compressor can be mounted to the core casing 46 in a circumferential arrangement.

[0026] Complementary to the rotor portion, the stationary portions of the engine 10, such as the static vanes 60, 62, 72, 74 among the compressor and turbine section 22, 32 are also referred to individually or collectively as a stator 63. As such, the stator 63 can refer to the combination of non-rotating elements throughout the engine 10.

[0027] In operation, the airflow exiting the fan section 18 is split such that a portion of the airflow is channeled into the LP compressor 24, which then supplies pressurized air 76 to the HP compressor 26, which further pressurizes the air. The pressurized air 76 from the HP compressor 26 is mixed with fuel in the combustor 30 and ignited, thereby generating combustion gases. Some work is extracted from these gases by the HP turbine 34, which drives the HP compressor 26. The combustion gases are discharged into the LP turbine 36, which extracts additional work to drive the LP compressor 24, and the exhaust gas is ultimately discharged from the engine 10 via the exhaust section 38. The driving of the LP turbine 36 drives the LP spool 50 to rotate the fan 20 and the LP compressor 24.

[0028] A portion of the pressurized airflow 76 can be drawn from the compressor section 22 as bleed air 77. The bleed air 77 can be drawn from the pressurized airflow 76 and provided to engine components requiring cooling. The temperature of pressurized airflow 76 entering the combustor 30 is significantly increased. As such, cooling provided by the bleed air 77 is necessary for operating of such engine components in the heightened temperature environments.

[0029] A remaining portion of the airflow 78 bypasses the LP compressor 24 and engine core 44 and exits the engine assembly 10 through a stationary vane row, and more particularly an outlet guide vane assembly 80, comprising a plurality of airfoil guide vanes 82, at the fan exhaust side 84. More specifically, a circumferential row of radially extending airfoil guide vanes 82 are utilized adjacent the fan section 18 to exert some directional control of the airflow 78.

[0030] Some of the air supplied by the fan 20 can bypass the engine core 44 and be used for cooling of portions, especially hot portions, of the engine 10, and/or used to cool or power other aspects of the aircraft. In the context of a turbine engine, the hot portions of the engine are normally downstream of the combustor 30, especially the turbine section 32, with the HP turbine 34 being the hottest portion as it is directly downstream of the combustion section 28. Other sources of cooling fluid can be, but are not limited to, fluid discharged from the LP compressor 24 or the HP compressor 26.

[0031] A component 99 of the engine 10, illustrated as an airfoil assembly 100, can include at least one airfoil such as the HP turbine vane 72 as shown in FIG. 2. The vane 72 can comprise an outer wall 102 bounding an interior and extending from a leading edge 110 to a trailing edge 112 in a chord-wise direction, as well as extending from a root 114 to a tip 116 in a span-wise direction. The root 114 can include at least one root opening 118 fluidly coupled to a first source of air; similarly, the tip 116 can include at least one tip opening 120 fluidly coupled to a second source of air. It should be understood that while illustrated herein as the vane 72, the airfoil in the assembly 100 can comprise any airfoil within the engine 10 including in the fan section 18, compressor section 22, or turbine section 32, including at least one vane in a pair of vanes forming a nozzle in the compressor section 22 or turbine section 32, in non-limiting examples.

[0032] The airfoil assembly **100** can also comprise an impingement insert **130** including a first chamber **131** and a second chamber **132**, as well as first and second sets of impingement openings **141**, **142** as shown. It is contemplated that the insert **130** can comprise a monolithic structure that can be internally divided into the first and second chambers **131**, **132** as shown. For assembly, the insert **130** can be sized for insertion into the interior of the vane **72** through either the root opening **118** or tip opening **120** (illustrated here as being inserted through the tip opening **120**), and a stop **200** can be included with the insert **130** for abutment with the tip **116** once fully inserted. It is contemplated that a stop or set of stops **200** may also be provided for abutment with the outer wall **102** or root **114** to limit the insertion of the impingement insert **130** as desired, and the stop **200** can be of any suitable geometry such as a collar circumscribing the insert **130**.

[0033] The impingement insert **130** can further comprise a tubular structure with a first insert opening **151** and a second insert opening **152** such that a passage **170** can be defined through the insert **130**. A dividing wall **155** can also be included within the insert **130**, closing and dividing the passage **170** into the first and second chambers **131**, **132** as shown wherein the first chamber **131** has the first insert opening **151** and the second chamber **132** has the second insert opening **152**.

[0034] The airfoil assembly **100** can further comprise another impingement insert **230** according to a second embodiment of the disclosure. The insert **230** is similar to the insert **130**, therefore, like parts will be identified with like numerals increased by **100**, with it being understood that the description of the like parts of the first embodiment applies to the second embodiment, unless otherwise noted.

[0035] The impingement insert **230** can comprise a first insert **261** and second insert **262**, where in a non-limiting example the first and second inserts **261**, **262** can be inserted into the vane **72** through a tip opening **120** and root opening **118**, respectively. A stop **300** can be included with either or both of the first insert **261** and second insert **262**, and the stop **300** can abut the root **114** or tip **116** of the vane **72**. In addition, the first insert **261** can include a first chamber **231**, first set of impingement openings **241** and first insert opening **251**, and the second insert **262** can include a second chamber **232**, second set of impingement openings **242** and second insert opening **252** as shown.

[0036] When assembled, the first insert openings **151**, **251** can be in registry with the tip openings **120**, and the second insert openings **152**, **252** can be in registry with the root openings **118** as shown in FIG. **3**. In this manner, the first chambers **131**, **231** can be coupled to a first source of air through the tip openings **120**, and the second chambers **132**, **232** can be coupled to a second source of air through the root openings **118**. It can be seen that the first source of air can be fluidly coupled to the first set of impingement openings **141**, **241**, and the second source of air can be fluidly coupled to the second set of impingement openings **142**, **242**.

[0037] It can be appreciated that the size of the chambers **131**, **132** in the impingement insert **130** can be determined by the position of the dividing wall **155**, and further, that the size of the chambers **231**, **232** in the insert **230** can be determined by the overall size of the first and second inserts **261**, **262**; in non-limiting examples, the first chambers **131**, **231** can have a greater volume than that of the second chambers **132**, **232**, or the first chambers **131**, **231** can have an equal volume to that of the second chambers **132**, **232**. In addition, the inserts **130**, **230** are also contemplated for use near the trailing edge **112** or anywhere else within the vane **72** as desired, and combinations such as the use of a sole insert **130**, a sole insert **230**, or group of inserts **130**, **230** are also contemplated for use in the airfoil assembly **100**, in non-limiting examples.

[0038] In operation, cooling air from a first source can flow through the first insert opening **151** and tip opening **120**, enter the first chamber **131**, and exit through the first set of impingement openings **141**, while cooling air from a second source can flow through the second insert opening **152** and root opening **118**, enter the second chamber **132**, and exit through the second set of impingement openings **142**, providing cooling air to the interior of the vane **72**. It should be appreciated that the interior of the vane **72** can provide a common chamber for the first and second sources of air.

[0039] The first source of air can have a different pressure from that of the second sources of air, and as both are fluidly connected with the interior of the vane **72**, the differing air pressures can cause more air to be drawn into the vane **72** from one source than another. By way of non-limiting example, if the first source of air were at a higher pressure than the second source of air, the first chamber **131**, **231** could be chosen to be larger than the second chamber **132**, **232** to compensate, allowing for a balancing of the air pressures in the first chambers **131**, **231** and second chambers **132**, **232** to take in equal amounts of cooling air from the first and second sources.

[0040] A portion **400** of the vane **72** and impingement insert **130** is illustrated in FIG. **4**. It is contemplated that the insert **130** can be spaced from an inner surface **104** of the vane **72**, and that the first and second sets of impingement openings **141**, **142** can fluidly couple the first and second chambers **131**, **132** to the space between the insert **130** and the inner surface **104** such that air flowing from the chambers **131**, **132** can be used to cool the vane **72**.

[0041] A similar portion **500** of the impingement insert **230** is illustrated in FIG. **5**, where the first and second inserts **261**, **262** are illustrated in a first configuration. It is also contemplated that the inserts **261**, **262** can be spaced from the inner surface **104** of the outer wall **102**; when assembled, the first and second inserts **261**, **262** can be spaced apart or contact one another as desired. It is further contemplated that the inserts **261**, **262** can be coupled via a connector **280** as shown in FIG. **6**, preventing relative movement of the first and second inserts **261**, **262**. The connector can comprise a key **282** on the second insert **262** that can be inserted into a keyway **284** on the first insert **261**; it will be understood that the key **282** and keyway **284** can also be provided on the first and second inserts **261**, **262**, respectively. It is further contemplated that the connector **280** can comprise a strike **286** and catch **288** mechanism provided on the first or second inserts **286**, **288** in a similar manner as the key **282** and keyway **284**.

[0042] A method of impingement cooling the interior of the component **99** for the turbine engine **10**, such as the vane **72**, can comprise supplying the first source of air into the first impingement insert **261** and supplying the second source of air, separate from the first source of air, into the second impingement insert **262**, where the first and second inserts **261**, **262** are located within the interior of the vane **72**. The first and second sources of air can have at least one different property, such as different temperatures, pressures, or Mach numbers in non-limiting examples. It is contemplated that the amount of air supplied to the first and second inserts **261**, **262** can be proportionally controlled based on the property (temperature, pressure, Mach number) as described above.

[0043] A method of assembling the component **99** for the turbine engine **10**, such as the vane **72**, can comprise inserting the first insert **261** at least partially into the vane **72**, inserting the second insert **262** at least partially into the vane **72**, and coupling the first and second inserts **261**, **262**. As shown in FIG. **2**, the first insert **261** can be inserted into the vane **72** through a first end, such as the tip opening **120**, and the second insert **262** can be inserted through another end such as the root opening **118**. The connector can comprise the strike **286** and catch **288**, or key **282** and keyway **284**, as described in FIG. **5**. It will be understood that inserts **261**, **262** can be inserted into the vane **72** in any desired order, and that the method of assembling the component **99** can include the assembly of a newly-produced component **99**, a repaired component **99**, or a refurbished component **99**.

[0044] It can be appreciated that by taking in air from both sides of the insert **130**, **230**, the flow velocity or Mach number can be reduced within the chambers which can reduce an amount of pressure drop needed from the compressor to provide cooling air into the chambers. Such a case can facilitate the implementation of a low-pressure-drop combustor in the turbine engine **10**, which can improve the power output and reduce fuel consumption. In addition, the use of multiple chambers within the insert **130**, **230** can balance a pressure differential that may exist in the first and second sources of air to allow the provision of equal amounts of cooling air taken in from the first and second sources of air. Further, the use of multiple airfoil inserts can improve insertability during assembly, which can allow for the use of more efficient airfoils with complicated geometric structures where a single insert may be prohibitively difficult to assemble within the airfoil.

[0045] It should be understood that application of the disclosed design is not limited to turbine engines with fan and booster sections, but is applicable to turbojets and turboshaft engines as well.

[0046] To the extent not already described, the different features and structures of the various embodiments can be used in combination, or in substitution with each other as desired. That one feature is not illustrated in all of the embodiments is not meant to be construed that it cannot be so illustrated, but is done for brevity of description. Thus, the various features of the different embodiments can be mixed and matched as desired to form new embodiments, whether or not the new embodiments are expressly described. All combinations or permutations of features described herein are covered by this disclosure.

[0047] 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 have 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. An airfoil assembly for a turbine engine comprising:

an outer wall bounding an interior and extending between a leading edge and a trailing edge to define a chord-wise direction and between a root and a tip to define a span-wise direction;

a tip opening located at the tip and fluidly coupled to a first source of air;

a root opening located at the root and fluidly coupled to a second source of air; and

an impingement insert with impingement openings located within the interior and having a first chamber fluidly coupling the first source of air to a first set of the impingement openings, and a second chamber fluidly coupling the second source of air to a second set of the impingement openings.

2. The airfoil assembly of claim **1** wherein the impingement insert comprises a monolithic structure divided into the first and second chambers.

3. The airfoil assembly of claim **2** wherein the monolithic structure comprises a tubular structure having opposing first and second insert openings defining a passage with a dividing wall closing the passage and dividing the passage into the first chamber having the first insert opening and the second chamber having the second insert opening.

4. The airfoil assembly of claim **3** wherein the dividing wall evenly divides the passage in at least one of length and volume.

5. The airfoil assembly of claim **3** wherein the dividing wall unevenly divides the passage in at least one of length and volume.

6. The airfoil assembly of claim **2** wherein the impingement insert is sized to be inserted into the interior through one of the tip opening and root opening.

7. The airfoil assembly of claim **6** wherein the impingement insert comprises a stop abutting at least one of the outer wall, tip, or root to limit the insertion of the impingement insert.

8. The airfoil assembly of claim **7** wherein the stop is a collar circumscribing the monolithic structure.

9. The airfoil assembly of claim **1** wherein the impingement insert comprises a first insert inserted through the tip opening and a second insert inserted through the root opening.

10. The airfoil assembly of claim **9** further comprising a connector coupling the first and second inserts once inserted.

11. The airfoil assembly of claim **10** wherein the connector comprises at least one of:

a) a strike on one of the first and second inserts and a catch on the other of the first and second inserts, or

b) a key on one of the first and second inserts and a keyway on the other of the first and second inserts.

12. The airfoil assembly of claim **1** wherein the impingement insert is spaced from an inner surface of the outer wall when the impingement insert is located within the interior.

13. The airfoil assembly of claim **1** wherein the airfoil assembly is a nozzle assembly with at least two vanes, and at least one of the vanes defines the outer wall.

14. A component for a turbine engine comprising:

a wall bounding an interior and having a first opening fluidly coupled to a first source of air and a second opening fluidly coupled to a second source of air; and an impingement insert with impingement openings located within the interior and having a first chamber fluidly coupling the first source of air to a first set of the impingement openings, and a second chamber fluidly coupling the second source of air to a second set of the impingement openings.

15. The component of claim **14** wherein the impingement insert comprises a monolithic structure divided into the first and second chambers.

16. The component of claim **15** wherein the monolithic structure comprises a tubular structure having opposing first and second insert openings defining a passage with a dividing wall closing the passage and dividing the passage into a first chamber having the first insert opening and a second chamber having the second insert opening.

17. The component of claim **16** wherein the dividing wall unevenly divides the passage in at least one of length and volume.

18. The component of claim **14** wherein the impingement insert is sized to be inserted into the interior through one of the first and second openings.

19. The component of claim **18** wherein the impingement insert comprises a stop abutting at least one of an outer wall, tip, or root to limit the insertion of the impingement insert.

20. The component of claim **14** wherein the impingement insert comprises a first insert inserted through the first opening and a second insert inserted through the second opening.

21. The component of claim **20** further comprising a connector coupling the first and second inserts once inserted.

22. The component of claim **14** wherein the impingement insert is spaced from an inner surface of the outer wall when the impingement insert is located within the interior.

23. A method of impingement cooling an interior of a component for a turbine engine, the method comprising:

supplying a first source of air into a first impingement insert located within the interior; and

supplying a second source of air, separate from the first source of air, into a second impingement insert located within the interior;

wherein the first and second sources of air have at least one different property.

24. The method of claim **23** wherein the at least one different property comprises at least one of: temperature, pressure, Mach number.

25. The method of claim **23** wherein the supplying the first and second sources of air comprises proportionally controlling the amount of first and second sources based on the at least one different property.

26. A method of assembling an airfoil for a turbine engine, the method comprising:

inserting a first insert at least partially into the airfoil;

inserting a second insert at least partially into the airfoil; and

coupling the first insert to the second insert.

27. The method of claim **26** wherein the coupling comprises mechanically coupling the first and second inserts.

28. The method of claim **26** wherein inserting the first insert comprises inserting the first insert into a first end of the airfoil.

29. The method of claim **28** wherein inserting the second insert comprises inserting the second insert into a second end of the airfoil.

30. The method of claim **29** wherein the first end is opposite the second end.

31. The method of claim **30** wherein the first end is at least one of a tip or root of the airfoil and the second end is the other of a tip or root of the airfoil.

32. The method of claim **26** wherein one of first and second inserts is inserted into the airfoil before the other of the first and second inserts.

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