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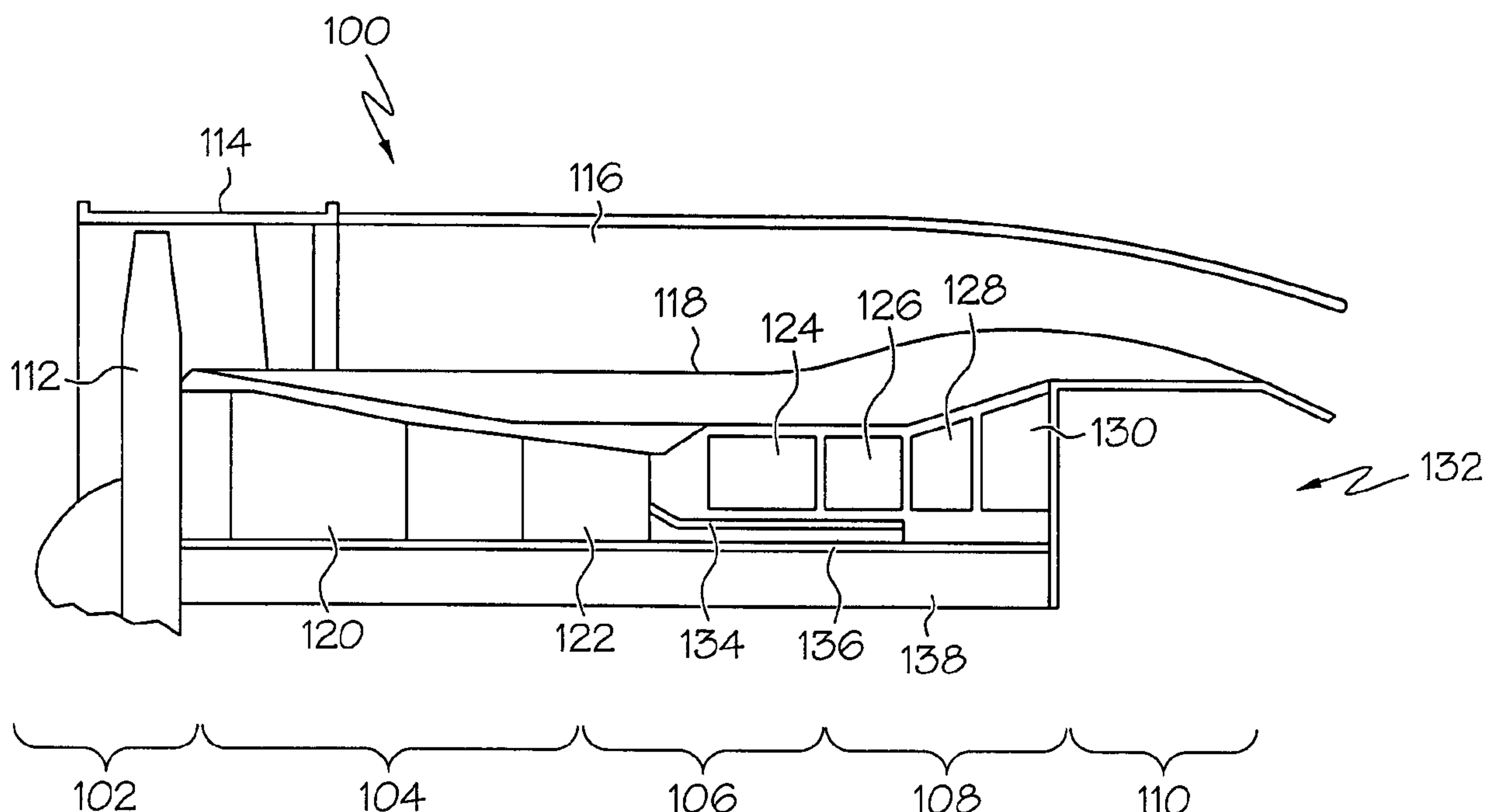
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(54) Titre : AUBAGE REDRESSEUR RECOURBE DERRIERE UN COMPRESSEUR CENTRIFUGE DANS UNE
TURBINE A GAZ

(54) Title: LEANED DESWIRL VANES BEHIND A CENTRIFUGAL COMPRESSOR IN A GAS TURBINE ENGINE



(57) Abrégé/Abstract:

A compressor (122) includes a deswirl assembly (206) to improve aerodynamic coupling with the combustor (124). The assembly (206) includes an annular housing and a plurality of vanes (224). The annular housing includes an inner and an outer annular wall (220, 222) disposed concentric to each other, and a flowpath (228) defined therebetween. The plurality of vanes (224) is disposed in the flowpath (228) in a substantially annular pattern. Each vane has a leading edge (302), a trailing edge (304), a convex surface (308), and a concave surface (306), and each of the convex and concave surfaces (308, 306) extends between the leading and trailing edges (302, 304). Additionally, each vane (224) extends between and is angled relative to the inner and the outer annular walls (220, 222) such that the concave surface (306) faces the outer annular wall (222) and the convex surface (308) faces the inner annular wall (220). The vanes (224) preferably have a uniform axial cross section for ease of manufacturing.

LEANED DESWIRL VANES BEHIND A CENTRIFUGAL COMPRESSOR IN A
GAS TURBINE ENGINE

ABSTRACT OF THE DISCLOSURE

A compressor (122) includes a deswirl assembly (206) to improve aerodynamic coupling with the combustor (124). The assembly (206) includes an annular housing and a plurality of vanes (224). The annular housing includes an inner and an outer annular wall (220, 222) disposed concentric to each other, and a flowpath (228) defined therebetween. The plurality of vanes (224) is disposed in the flowpath (228) in a substantially annular pattern. Each vane has a leading edge (302), a trailing edge (304), a convex surface (308), and concave surface (306), and each of the convex and concave surfaces (308, 306) extends between the leading and trailing edges (302, 304). Additionally, each vane (224) extends between and is angled relative to the inner and the outer annular walls (220, 222) such that the concave surface (306) faces the outer annular wall (222) and the convex surface (308) faces the inner annular wall (220). The vanes (224) preferably have a uniform axial cross section for ease of manufacturing.

LEANED DESWIRL VANES BEHIND A CENTRIFUGAL COMPRESSOR IN A GAS TURBINE ENGINE

TECHNICAL FIELD

[0001] The present invention relates to a gas turbine engine and, more particularly, to a deswirl assembly having leaned deswirl vanes for use in the gas turbine engine.

BACKGROUND

[0002] A gas turbine engine may be used to power various types of vehicles and systems. A typical gas turbine engine includes a fan section, a compressor section, a combustor section, a turbine section, and an exhaust section. The fan section induces air from the surrounding environment into the engine and accelerates a fraction of the air toward the compressor section. The compressor section compresses the pressure of the air to a relatively high level and directs the air to the combustor section. A steady stream of fuel is injected into the combustor section, and the injected fuel is ignited to significantly increase the energy of the compressed air. The high-energy compressed air then flows into and through the turbine section, causing rotationally mounted turbine blades therein to rotate and generate energy. The air exiting the turbine section is exhausted from the engine via the exhaust section, and the energy remaining in the exhaust air aids the thrust generated by the air flowing through a bypass plenum.

[0003] In some engines, the compressor section is implemented with a centrifugal compressor. A centrifugal compressor typically includes at least one impeller that is rotationally mounted to a rotor and surrounded by a shroud. When the impeller rotates, it compresses and imparts tangential velocity to the air received from the fan section and the shroud directs the air radially outward into a diffuser. The diffuser

decreases the radial and tangential velocity of the air and increases the static pressure of the air and directs the air into a deswirl assembly. The deswirl assembly includes an annular housing having a plurality of straight radially extending vanes mounted therein that straighten and reduce the tangential velocity component of the air flow before it enters the combustor section. The combustor section in some engines is implemented with an axial through-flow combustor that includes an annular combustor disposed within a combustor housing that defines a plenum. The straightened air enters the plenum and travels axially through the annular combustor where it is mixed with fuel and ignited.

[0004] Recently, conventional deswirl assemblies have included downcanted outlets to improve aerodynamic coupling between the diffuser and combustor. However, it has been found that these deswirl assemblies generate greater flow angle variation across the span of the flowpath at the deswirl vane leading edge and therefore may not adequately condition air flow to a sufficiently low mach number in an acceptably efficient manner unless the overall axial length and/or radial envelope of the assembly is increased. Because engines are continually designed to be smaller, the size increase may not be acceptable in newer aircraft. As a result, the configuration of the deswirl assembly has had to be redesigned. One preferred configuration includes vanes that are shaped so that the vane can accept a large variation in air angle at its leading edge. The vanes may also be configured such that the pressure side of each vane faces radially inwardly. However, although this configuration optimizes airflow through the deswirl assembly, manufacture of the assembly is relatively time-consuming and costly because each vane may need to be individually formed and shaped.

[0005] Hence, there is a need for an improved downcanted deswirl assembly that includes a plurality of vanes that are configured to aerodynamically couple a centrifugal compressor and an axial through-flow combustor. Additionally, it is desirable for the deswirl assembly to be relatively inexpensive and simple to

manufacture. Moreover, it is desirable for the deswirl assembly to suitably direct and condition the air flowing therethrough for optimal engine performance.

BRIEF SUMMARY

[0006] The present invention provides a deswirl assembly for receiving air flow from a diffuser. The deswirl assembly includes an annular housing and a plurality of vanes. The annular housing includes an inner annular wall, an outer annular wall disposed concentric to the inner annular wall, and a flowpath defined therebetween. The plurality of vanes is disposed in the flowpath in a substantially annular pattern. Each vane has a leading edge, a trailing edge, a convex surface, and concave surface, and each of the convex and concave surfaces extends between the leading and trailing edges. Additionally, each vane extends between and is angled relative to the inner and the outer annular walls such that the concave surface faces the outer annular wall and the convex surface faces the inner annular wall.

[0007] In one embodiment, and by way of example only, the deswirl assembly including an annular housing, and a first and a second plurality of vanes. The annular housing includes an inner annular wall, an outer annular wall disposed concentric to the inner annular wall, and a flowpath defined therebetween. The first plurality of vanes is disposed in the flowpath in a substantially annular pattern, and each vane has a leading edge, a trailing edge, a convex surface, and concave surface, each of the convex and concave surfaces extending between the leading and trailing edges, each vane extends between and is angled relative to the inner and the outer annular walls such that the concave surface faces the outer annular wall and the convex surface faces the inner annular wall and each vane has an axial cross section shape, and each axial cross section shape is substantially the same. The second plurality of vanes is disposed in the flowpath in a substantially annular pattern downstream of the first plurality of vanes. Each vane has a leading edge, a trailing edge, a convex surface, and concave surface, each of the convex and concave surfaces extends between the

leading and trailing edges, and each vane extends between and is angled relative to the inner and the outer annular walls such that the concave surface faces the outer annular wall and the convex surface faces the inner annular wall. Additionally, each vane of the second plurality of vanes has an axial cross section shape, and each axial cross section shape is substantially the same.

[0008] In still another embodiment, a system is provided for aerodynamically coupling air flow from a centrifugal compressor to an axial combustor, where the compressor and combustor are disposed about a longitudinal axis. The system includes a diffuser, a deswirl assembly, combustor inner and outer annular liners, a combustor dome, and a curved annular plate. The diffuser has an inlet, an outlet and a flow path extending therebetween, where the diffuser inlet is in flow communication with the centrifugal compressor, and the diffuser flow path extends radially outward from the longitudinal axis. The deswirl assembly includes an annular housing and a plurality of vanes. The annular housing includes an inner annular wall, an outer annular wall disposed concentric to the inner annular wall, and a flowpath defined therebetween. The plurality of vanes is disposed in the flowpath in a substantially annular pattern. Each vane has a leading edge, a trailing edge, a convex surface, and concave surface, and each of the convex and concave surfaces extends between the leading and trailing edges. Additionally, each vane extends between and is angled relative to the inner and the outer annular walls such that the concave surface faces the outer annular wall and the convex surface faces the inner annular wall. The combustor inner annular liner is disposed about the longitudinal axis, and the inner annular liner has an upstream end. The combustor outer annular liner is disposed concentric to the combustor inner annular liner and forms a combustion plenum therebetween. The outer annular liner has an upstream end. The combustor dome is coupled to and extends between the combustor inner and outer annular liner upstream ends. The curved annular plate is coupled to the combustor inner and outer annular liner upstream ends to form a combustor subplenum therebetween, and the curved annular plate has a first opening and a second opening formed therein. The first

opening is aligned with the deswirl assembly outlet to receive air discharged therefrom.

[0009] Other independent features and advantages of the preferred deswirl assembly will become apparent from the following detailed description, taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a simplified cross section side view of an exemplary multi-spool turbofan gas turbine jet engine according to an embodiment of the present invention;

[0011] FIG. 2 is a cross section view of a portion of an exemplary combustor that may be used in the engine of FIG. 1;

[0012] FIG. 3 is a cutaway view of a portion of an exemplary deswirl assembly that may be implemented into the combustor shown in FIG. 2 forward looking aft;

[0013] FIG. 4 is the portion of the exemplary deswirl assembly shown in FIG. 3 aft looking forward; and

[0014] FIG. 5 is a top view of the exemplary deswirl assembly shown in FIG. 3.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0015] Before proceeding with the detailed description, it is to be appreciated that the described embodiment is not limited to use in conjunction with a particular type of turbine engine. Thus, although the present embodiment is, for convenience of explanation, depicted and described as being implemented in a multi-spool turbofan

gas turbine jet engine, it will be appreciated that it can be implemented in various other types of turbines, and in various other systems and environments.

[0016] An exemplary embodiment of a multi-spool turbofan gas turbine jet engine 100 is depicted in FIG. 1, and includes an intake section 102, a compressor section 104, a combustion section 106, a turbine section 108, and an exhaust section 110. The intake section 102 includes a fan 112, which is mounted in a fan case 114. The fan 112 draws air into the intake section 102 and accelerates it. A fraction of the accelerated air exhausted from the fan 112 is directed through a bypass section 116 disposed between the fan case 114 and an engine cowl 118, and provides a forward thrust. The remaining fraction of air exhausted from the fan 112 is directed into the compressor section 104.

[0017] The compressor section 104 includes two compressors, an intermediate pressure compressor 120, and a high pressure compressor 122. The intermediate pressure compressor 120 raises the pressure of the air directed into it from the fan 112, and directs the compressed air into the high pressure compressor 122. The high pressure compressor 122 compresses the air still further, and directs the high pressure air into the combustion section 106. In the combustion section 106, which includes an annular combustor 124, the high pressure air is mixed with fuel and combusted. The combusted air is then directed into the turbine section 108.

[0018] The turbine section 108 includes three turbines disposed in axial flow series, a high pressure turbine 126, an intermediate pressure turbine 128, and a low pressure turbine 130. The combusted air from the combustion section 106 expands through each turbine, causing it to rotate. The air is then exhausted through a propulsion nozzle 132 disposed in the exhaust section 110, providing additional forward thrust. As the turbines rotate, each drives equipment in the engine 100 via concentrically disposed shafts or spools. Specifically, the high pressure turbine 126 drives the high pressure compressor 122 via a high pressure spool 134, the intermediate pressure turbine 128 drives the intermediate pressure compressor 120 via

an intermediate pressure spool 136, and the low pressure turbine 130 drives the fan 112 via a low pressure spool 138.

[0019] Turning now to FIG. 2, an exemplary cross section of the area between the high pressure compressor 122 and annular combustor 124 is illustrated. In addition to the compressor 122 and combustor 124, FIG. 2 depicts a diffuser 204 and a deswirl assembly 206, each disposed about a longitudinal axis 207. The high pressure compressor 122 is preferably a centrifugal compressor and includes an impeller 208 and a shroud 210 disposed in a compressor housing 211. The impeller 208, as alluded to above, is driven by the high pressure turbine 126 and rotates about the longitudinal axis 207. The shroud 210 is disposed around the impeller 208 and defines an impeller discharge flow passage 212 therewith that extends radially outwardly.

[0020] The diffuser 204 is coupled to the shroud 210 and is configured to decrease the velocity and increase the static pressure of air that is received therefrom. In this regard, any one of numerous conventional diffusers 204 suitable for operating with a centrifugal compressor may be employed. In any case, the diffuser 204 includes an inlet 214, an outlet 216, and a flow path 218 that each communicates with the passage 212, and the flow path 218 is configured to direct the received air flow radially outwardly.

[0021] The deswirl assembly 206 communicates with the diffuser 204 and is configured to substantially remove swirl from air received therefrom, to thereby decrease the Mach number of the air flow. The deswirl assembly 206 includes an inner annular wall 220, an outer annular wall 222, and two pluralities of vanes 224, 226 disposed therebetween. The walls 220, 222 define a flow path 228 that is configured to redirect the air from its radially outward direction to a radially inward and axially downstream direction. In this regard, the walls 220, 222 are formed such that the flow path 228 extends between an inlet 230 and outlet 232 in an arc 233 so that when the air exits the outlet 232, it is directed at an angle and toward the longitudinal axis 207 and the annular combustor 124. As the angle of the arc 233 is

increased the variation of the air angle between the inner wall 220 and out wall 222 is increased.

[0022] As briefly mentioned above, the two pluralities of vanes 224, 226 are disposed between the walls 220, 222. To secure the vanes 224, 226 to the assembly 206, each wall 220, 222 includes two sets of slots 234, 236, 238, 240 that are formed in annular patterns along two axial positions. Preferably, the slots 234, 236, 238, 240 are formed downstream of the arc 233. Each of the vanes 224, 226 includes at least a top 242, 244 and a bottom 246, 248 that extend through the slots 234, 236, 238, 240. The vanes 226, 228 may be secured to the walls 220, 222 in any one of numerous fashions, such as, for example, by brazing.

[0023] To condition the airflow to a sufficiently low Mach number, each vane preferably has a substantially identical predetermined shape and is positioned in the flow path 228 at a predetermined angle relative to the walls 220, 222. Exemplary vanes 300, which are shown as being implemented into the two pluralities of vanes 224, 226, are depicted in FIGs. 3 and 4. As briefly mentioned above, FIG. 3 is a cutaway view of the deswirl assembly 200 looking at the vanes 300 from forward to aft, while FIG. 4 is the deswirl assembly shown in FIG. 3 looking at the vanes 300 from aft to forward.

[0024] Each vane 300 includes a leading edge 302 and a trailing edge 304. A concave pressure surface 306 and a convex suction surface 308 extend between the leading and trailing edges 302, 304. The vanes 300 preferably each have a uniformly shaped curved axial cross-section from top 310 to bottom 312. In this regard, a number of the vanes 300 having substantially identical shapes may be mass produced from a single sheet of material. Specifically, the sheet of material may be suitably pressed into an appropriate curve shape to form the concave and convex surfaces 306, 308 and a plurality of the vanes 300 may be cut from the single sheet of material.

[0025] As mentioned previously, each vane 300 of the two pluralities of vanes 224, 226 is disposed at an angle relative to the walls 220, 222. Preferably, the vanes 300

are each placed such that the concave pressure surface 306 faces outwardly toward the outer annular wall 222 and the convex suction surface 308 faces inwardly toward the inner annular wall 220. Angling the vanes 300 in this preferred embodiment reduces the variation in air angle between the walls 220,222. In one exemplary embodiment, the vanes 300 are disposed such that an angle between the concave pressure surface 308 the inner annular wall 220 is about 110.8° . However, it will be appreciated that the particular angle at which the vanes 224, 226 are disposed depends on the overall configuration of the walls 220, 222.

[0026] The degree to which the vanes 224, 226 are angled may also determine how the two pluralities of vanes 224, 226 are placed relative to each another. In one example, as shown in FIGs. 3 and 4, the vanes of the first plurality of vanes 224 are equally spaced apart from one another and the trailing edge of each vane is disposed around a first circumferential position 242 around the inner annular wall 220, while the vanes of the second plurality of vanes 226 are also equally spaced apart from one another but the leading edge of each is disposed around a second circumferential position 244. Although the first and second circumferential positions 242, 244 are shown in this embodiment as non-overlapping and the first circumferential position 242 is disposed upstream of the second circumferential position 244, the first circumferential position 242 may alternatively be disposed downstream of the second circumferential position 244, or may overlap.

[0027] Additionally, the second plurality of vanes 226 are preferably staggered between the first plurality of vanes 224. For instance, as shown in FIG. 5 viewing the vanes 300 from forward 250 to aft 252, one vane 226b of the second plurality of vanes 226 is preferably disposed between two vanes 224a, 224b of the first plurality of vanes 224 and biased toward the pressure surface 306 of vane 224b. In one exemplary embodiment, a distance 254 between vane 226b of the second plurality of vanes 226 and vane 224b of the first plurality of vanes 224 is about 35% of the distance 256 between vanes 224a, 224b of the first plurality of vanes 224. It will be

appreciated, however, that the particular distances between all of the vanes may largely depend on the angling thereof relative to the walls 220, 222.

[0028] It will further be appreciated that although two pluralities of vanes 226, 228 are included in the embodiment shown in FIG. 2, the deswirl assembly 200 may alternatively only include a single plurality of vanes. In still other embodiments, more than two pluralities of vanes 226, 228 may need to be employed.

[0029] An improved downcanted deswirl assembly has now been provided that includes a plurality of vanes that are configured to aerodynamically couple a centrifugal compressor and an axial through-flow combustor. Additionally, the deswirl assembly is relatively inexpensive and simple to manufacture and is capable of directing and conditioning the air flowing therethrough for optimal engine performance

[0030] While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt to a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS

WE CLAIM:

1. A deswirl assembly (206) for receiving air flow from a diffuser, the deswirl assembly (206) comprising:
an annular housing including an inner annular wall (220), an outer annular wall (222) disposed concentric to the inner annular wall (220), and a flowpath (228) defined therebetween; and
a plurality of vanes (224) disposed in the flowpath (228) in a substantially annular pattern, each vane (224) having a leading edge (302), a trailing edge (304), a convex surface (308), and concave surface (306), each of the convex and concave surfaces (308, 306) extending between the leading and trailing edges (302, 304), each vane (224) extending between and angled relative to the inner and the outer annular walls (220, 222) such that the concave surface (306) faces the outer annular wall (222) and the convex surface (308) faces the inner annular wall (220).
2. The deswirl assembly (206) of claim 1, wherein each vane (224) has an axial cross section shape, and each axial cross section shape is substantially the same.
3. The deswirl assembly (206) of claim 1, further comprising a second plurality of vanes (226) disposed in the flowpath (228) in a substantially annular pattern downstream of the first plurality of vanes (224).
4. The deswirl assembly (206) of claim 1, wherein the trailing edges (304) of the vanes of the first plurality of vanes (224) are disposed around a first circumferential position (242) around the inner annular wall (220) and the leading edges (302) of the vanes of the second plurality of vanes (226) are disposed around a second circumferential position (244) around the inner annular wall (220).

5. The deswirl assembly (206) of claim 4, wherein the first and second circumferential positions (242, 244) do not overlap.

6. The deswirl assembly (206) of claim 4, wherein the first circumferential position (242) is disposed downstream of the second circumferential position (244).

7. The deswirl assembly (206) of claim 4, wherein the vanes of the second plurality of vanes (226) are each staggered between vanes of the first plurality of vanes (224).

8. The deswirl assembly (206) of claim 7, wherein at least one vane (226b) of the second plurality of vanes (226) is disposed between two vanes (224a, 224b) of the first plurality of vanes (224) and a first distance (254) between the at least one vane (226b) of the second plurality of vanes and one (224b) of the two vanes (224a, 224b) of the first plurality of vanes (224) is less than a second distance (256) between the two vanes (224a, 224b) of the first plurality of vanes (224).

9. The deswirl assembly of claim 8, wherein the first distance (254) is about 35% of the second distance (256).

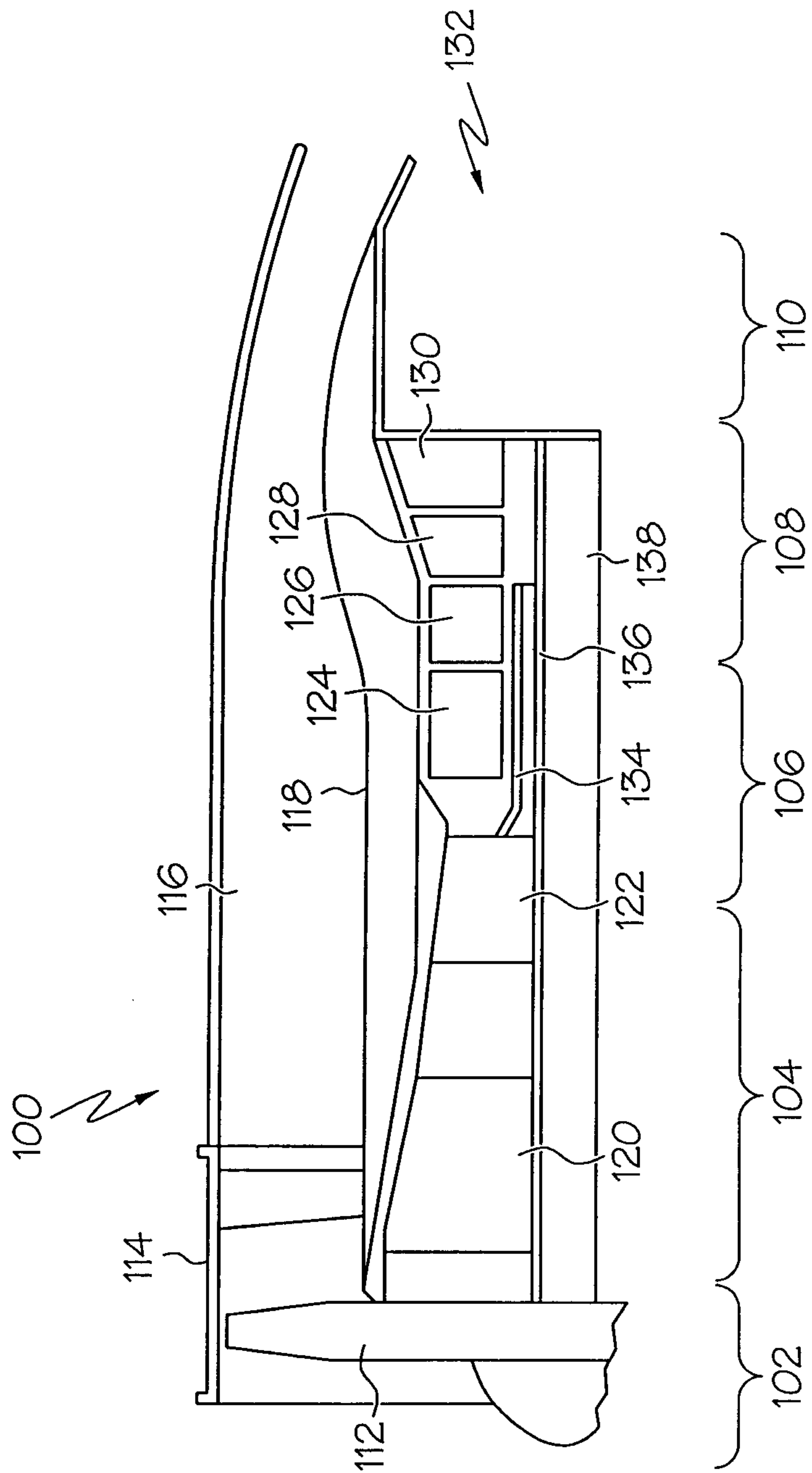
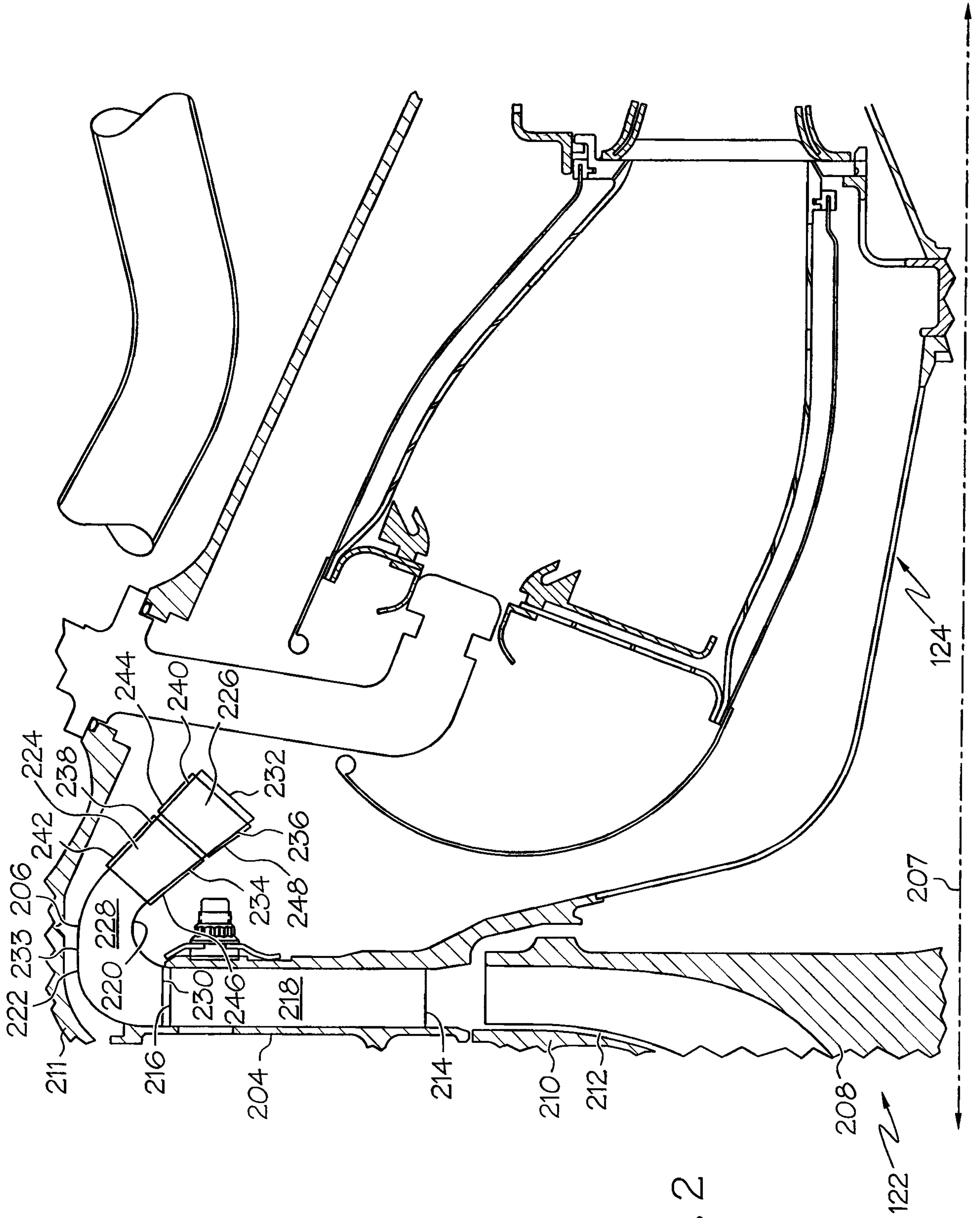


FIG. 1



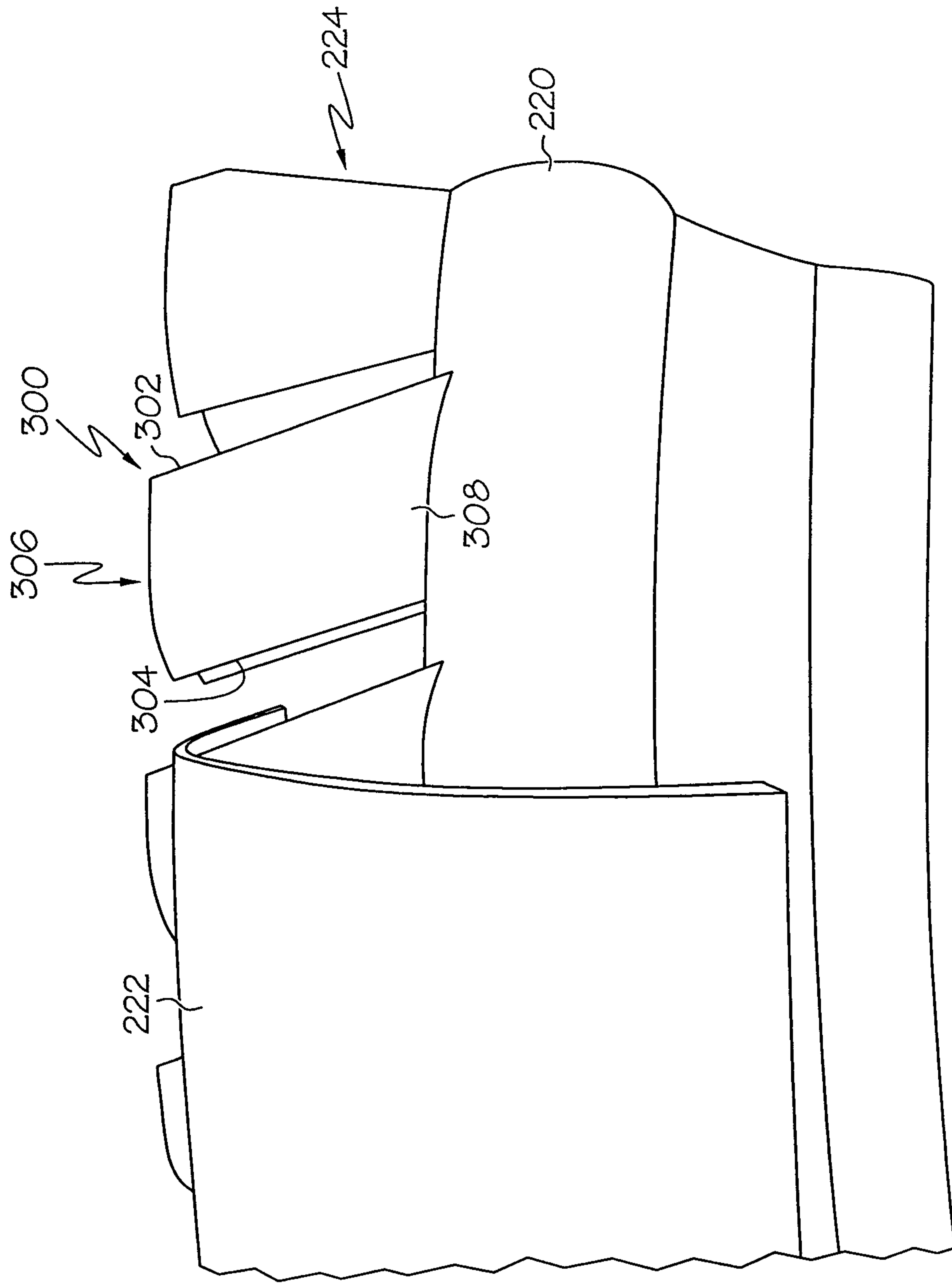


FIG. 3

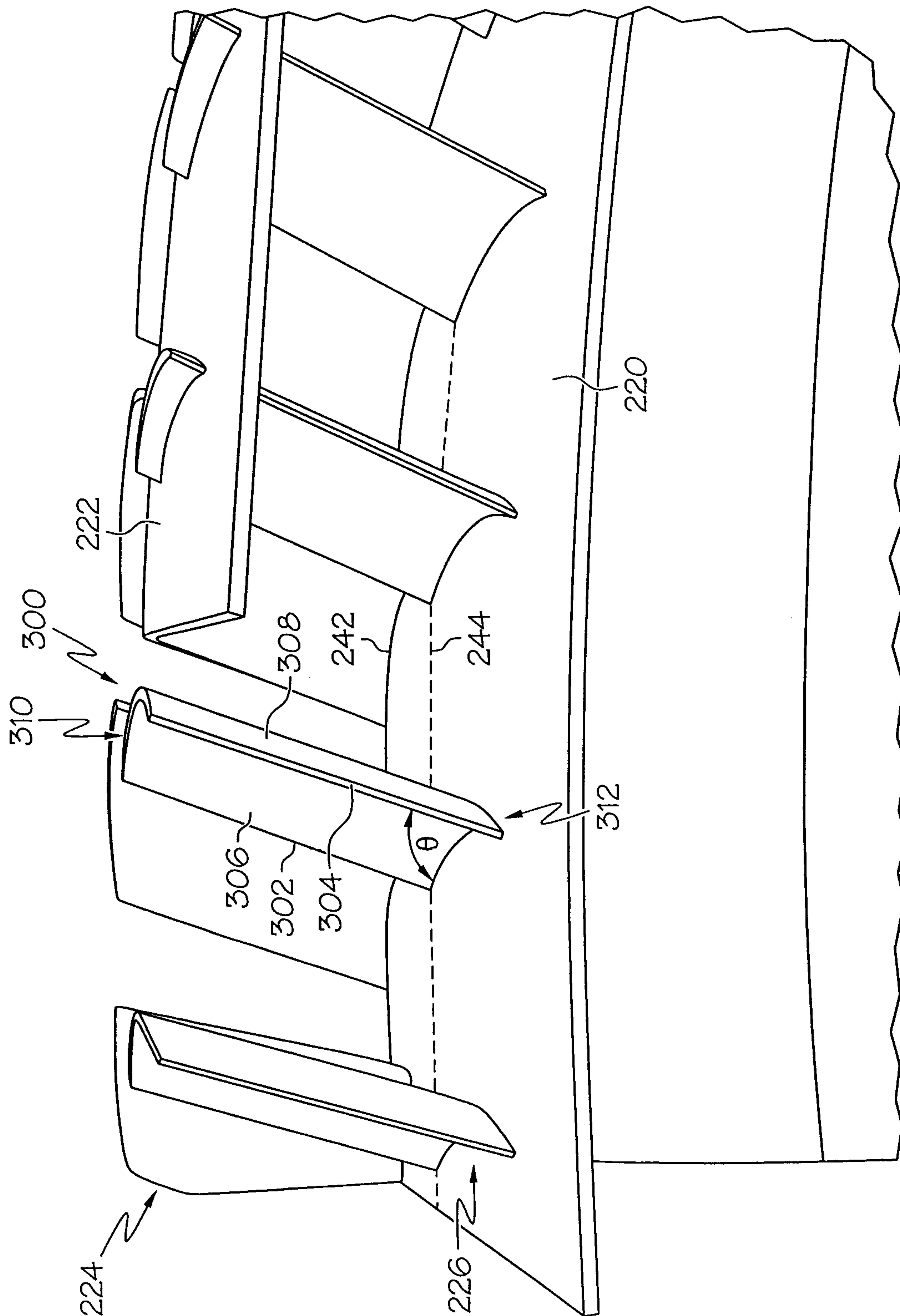


FIG. 4

