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(54) **HOT GAS PATH COMPONENT FOR A GAS TURBINE ENGINE**

(57) A hot gas path component for a gas turbine engine includes a tubular wall structure (25) having an upstream end (28), a downstream end (29) and an inner surface (30), and a plurality of cooling channels (27) extending through the tubular wall structure (25) between the upstream end (28) and a downstream end (29). An inner portion (33) of the tubular wall structure (25), defined between the inner surface (30) and the cooling channels (27), has a first thickness (T1) and an outer portion (35) of the tubular wall structure (25), defined be-

tween the outer surface (31) and the cooling channels (27), has a second thickness (T2), greater than the first thickness (T1). The cooling channels (27) have a radial height (H) defined by a maximum radial distance across the cooling channels (27) between the inner portion (33) and the outer portion (35) of the tubular wall structure (25) and the radial height (H) of the cooling channels (27) is greater than the first thickness (T1) of the inner portion (33) of the tubular wall structure (25).

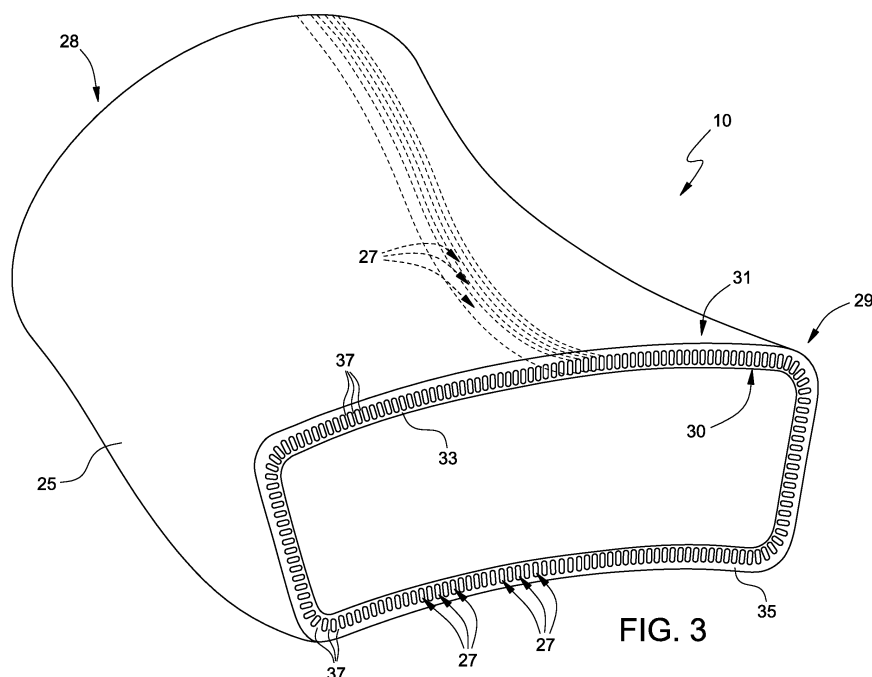


FIG. 3

Description

TECHNICAL FIELD

[0001] The present invention relates to a hot gas path component for a gas turbine engine.

BACKGROUND

[0002] As is known, a combustor of gas turbine engines comprises a hot gas path, inside which fuel is mixed with air and burnt. Hot gas thus produced is then fed to a turbine or expansion section of the gas turbine engine for conversion of thermal and kinetic energy into mechanical energy.

[0003] The hot gas path is essentially delimited by a tubular wall with an inner hot surface and an outer cold surface and may be formed by several components. The hot gas path components may comprise one or more combustion sections, defining corresponding combustion volumes (e.g. in case of sequential combustors), and a transition duct. The transition duct is configured to guide hot gas into the turbine inlet and is thus exposed to high temperatures. As other components of gas turbine engines, also components delimiting the hot gas path, and especially the transition duct, require cooling to avoid damages caused by overheating and to increase lifetime. For the purpose of cooling the hot gas path components, a fraction of the total airflow is usually taken from the compressor and fed to a cooling system through a plenum around the combustor. Several kinds of known cooling system may be used, such as impingement cooling systems, convective cooling systems or near wall cooling systems. All known systems, however, suffer from limitations that do not allow further raising the firing temperature within the hot gas paths, as would be desirable, instead, or otherwise affect operation of the gas turbine unit. Typical limitations are large loss of pressure compared to the achieved cooling effect, air consumption that reduces engine efficiency, heat pick-up that especially affects near wall cooling systems. Near wall cooling, in fact, exploits small cooling channels provided within the hot gas path wall, thus very close to the hot surface thereof and comparatively effective, in principle. However, small channels can carry only a small airflow, that heats up quickly. Therefore, known near wall cooling systems are actually efficient for cooling short portions of the hot gas path wall, but the cooling effect drops rapidly over longer distances.

[0004] Besides thermal load, the hot gas path components also need to withstand quite severe mechanical stress, caused by mechanical and/or thermoacoustic vibrations which may occur during operation of the gas turbine engines. For this reason, the hot gas wall of combustors are normally relatively thick, to provide the required mechanical resistance. However, greater thickness of the wall is in conflict with cooling efficiency of impingement and convective arrangements.

SUMMARY OF THE INVENTION

[0005] It is an aim of the present invention to provide a hot gas path component for a gas turbine engine which allows to overcome or at least attenuate the limitations described.

[0006] According to the present invention, there is provided a hot gas path component comprising:

a tubular wall structure, having an upstream end, a downstream end, an inner surface and an outer surface;

a plurality of cooling channels extending through the tubular wall structure between the upstream end and the downstream end;

wherein an inner portion of the tubular wall structure, defined between the inner surface and the cooling channels, has a first thickness and an outer portion of the tubular wall structure, defined between the outer surface and the cooling channels, has a second thickness, greater than the first thickness; and wherein the cooling channels have a radial height defined by a maximum radial distance across the cooling channels between the inner portion and the outer portion of the tubular wall structure and the radial height of the cooling channels is greater than the first thickness of the inner portion of the tubular wall structure.

[0007] The hot gas path component thus combines effective cooling action and mechanical strength to withstand both severe thermal and mechanical loads. On the one hand, in fact, the cooling channels may be provided at a short distance from the inner surface of the tubular wall structure, which is directly exposed to hot gas. Heat dissipation is therefore efficient. On the other hand, the cooling channels radially extend through a substantial amount of the overall thickness of the tubular wall structure, thus favoring passage of a sufficient flow of cooling air. Thus, not only the cooling channels may run very near to the inner surface, but also heat pick-up can be kept low. At the same time, the outer portion of the tubular wall structure is thick enough to provide the required mechanical resistance, without affecting heat dissipation.

[0008] According to another aspect of the invention, the second thickness is between two and five times greater than the first thickness.

[0009] The ratio of the first and second thicknesses indicated above helps ensure both cooling effect at the inner surface and mechanical resistance.

[0010] According to another aspect of the invention, the radial height of the cooling channels is at least three times greater than the first thickness of the inner portion of the tubular wall structure.

[0011] The ratio of the radial height and the first thicknesses indicated above helps ensure low heat pick-up in the cooling airflow.

[0012] According to another aspect of the invention,

the radial height is greater than a width of the cooling channels.

[0013] According to another aspect of the invention, adjacent cooling channels are separated from one another by diaphragms transverse to the inner portion and to the outer portion of the tubular wall structure.

[0014] The diaphragms provide a twofold function of mechanical connecting the inner and the outer portion of the tubular wall structure and dissipating heat, acting as dissipating fins.

[0015] According to another aspect of the invention, the diaphragms are substantially perpendicular to the inner portion and to the outer portion of the tubular wall structure.

[0016] According to another aspect of the invention, the diaphragms form angles between 30 ° and 90 ° with the inner portion and the outer portion of the tubular wall structure.

[0017] Angled diaphragms add flexibility to the tubular wall structure, thus reducing sensitivity to vibrations and mechanical stress in general.

[0018] According to another aspect of the invention, the diaphragms are tapered from the inner portion to the outer portion of the tubular wall structure or from the outer portion to the inner portion of the tubular wall structure.

[0019] Tapered diaphragms allow to achieve satisfactory tradeoff of mechanical and thermal properties of the tubular wall structure. Thicker portions of the diaphragms increase stiffness and conductive heat transfer, whereas thinner portions cause thermal decoupling. Thus, thicker or thinner portions of the diaphragms may be provided either at the inner or at the outer portions of the tubular wall structure to optimize heat dissipation, thermal decoupling and mechanical resistance as desired.

[0020] According to another aspect of the invention, the cooling channels have rectangular or parallelogram or trapezoidal cross-section, with or without rounded corners, or oval cross-section.

[0021] The shape and aspect of the cross-section can be selected to optimize airflow and cooling effect as desired.

[0022] According to another aspect of the invention, the hot gas path component comprises at least one fin extending longitudinally along at least one of the cooling channels from the inner portion of the tubular wall structure.

[0023] Fins in the cooling channel further improve heat dissipation and cooling effectiveness.

[0024] According to another aspect of the invention, the cooling channels are uniformly distributed in a circumferential direction of the tubular wall structure.

[0025] In this way, even cooling effect is achieved over the whole component.

[0026] According to another aspect of the invention, the cooling channels extend in an axial longitudinal direction of the tubular wall structure or along a spiral path around a longitudinal axis of the tubular wall structure.

[0027] Design of the cooling channels may be thus se-

lected to optimize the cooling effect as required.

[0028] According to another aspect of the invention, there is provided a hot gas path assembly for a gas turbine engine comprising a hot gas path component as defined above.

[0029] According to another aspect of the invention, the hot gas path component is a transition duct.

[0030] The transition ducts are normally among the most critical components because they are exposed to the highest temperatures in the hot gas path. Applying the invention to transition ducts is thus particularly beneficial.

[0031] According to another aspect of the invention, there is provided a gas turbine engine assembly comprising:

a compressor section, extending along a main axis;
a plurality of can combustors, circumferentially arranged about the main axis;
a turbine section;
wherein at least one of the can combustors comprises a hot gas wall component as defined above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] The present invention will now be described with reference to the accompanying drawings, which show some nonlimiting embodiment thereof, in which:

- Figure 1 is a side elevation view, cut along an axial, longitudinal plane, of a gas turbine engine;
- Figure 2 is a side elevation view of a hot gas path of the a gas turbine engine of figure 1;
- Figure 3 is a perspective view of a hot gas path component of the hot gas path of figure 2, in accordance with an embodiment of the present invention;
- Figure 4 is a rear elevation view of the hot gas path component of figure 2;
- Figure 5 is a rear elevation view of a detail of the hot gas path component of figure 2;
- Figure 6 is a perspective view of a hot gas path component, in accordance with another embodiment of the present invention;
- Figure 7 is a perspective view of a hot gas path component, in accordance with another embodiment of the present invention;
- Figure 8 is a rear elevation view of a detail of a hot gas path component, in accordance with another embodiment of the present invention;
- Figure 9 is a rear elevation view of a detail of a hot gas path component, in accordance with another embodiment of the present invention;
- Figure 10 is a rear elevation view of a detail of a hot gas path component, in accordance with another embodiment of the present invention; and
- Figure 11 is a rear elevation view of a detail of a hot gas path component, in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0033] Figure 1 shows a simplified view of a gas turbine engine, designated as whole with numeral 1. The gas turbine engine 1 comprises a compressor section 2, a combustor assembly 3 and a turbine section 5. The compressor section 2 and the turbine section 5 extend along a main axis A. The combustor assembly 3 may be a sequential combustor assembly, as in the example of figure 1, or a single-stage combustor assembly. In one embodiment, the combustor assembly 3 comprises a plurality of sequential can combustors 7, circumferentially arranged about the main axis A.

[0034] The compressor section 3 of the gas turbine engine 1 provides a compressed airflow, which is added with fuel and burned in the can combustors 7. The airflow delivered by the compressor section 2 is supplied to the combustor assembly 3 and to the turbine section 5 for the purpose of cooling.

[0035] Each of the can combustors 7, one of which is shown in figure 2, comprises a first-stage combustor 8 and a second-stage combustor 9 and a transition duct 10, sequentially arranged and defining a hot gas path 12.

[0036] More specifically, the first-stage combustor 8 comprises a first-stage burner unit 14 and a first-stage combustion chamber 15.

[0037] The second-stage combustor 9 is arranged downstream of the first-stage combustor 8 and includes a second-stage burner unit 17 and a second-stage combustion chamber 18. The second-stage combustor 9 is furthermore coupled to the turbine section 5, here not shown, through the transition duct 10.

[0038] The second-stage combustion chamber 18 extends along an axial direction downstream of the first-stage combustor 8. In one embodiment, the second-stage combustion chamber 20 comprises an outer liner 21 and inner liner 22. The outer liner 21 surrounds the inner liner 22 at a distance therefrom, so that a convective cooling channel 23 is defined between the outer liner 21 and the inner liner 22.

[0039] The transition duct 10, which is the component of the hot gas path 12 suffering the most severe thermal stress, is illustrated in greater detail in figures 3 and 4. The transition duct 10 comprises a plurality of cooling channels 27.

[0040] The tubular wall structure 25 has an upstream end 28, a downstream end 29, an inner surface 30 and an outer surface 31. The upstream end 28 is joined to the second-stage combustion chamber 19, whereas the downstream end 29 faces the turbine section 5. The inner surface 30 delimits a hot gas flow volume through which hot gas passes to reach the turbine section 5. The inner surface 30 is therefore directly exposed to hot gas flowing through the hot gas path 12.

[0041] The cooling channels 27 extend through the tubular wall structure 25 between the upstream end 28 and the downstream end 29 and are uniformly distributed in

a circumferential direction of the tubular wall structure 25. At the upstream end 28, the cooling channels 27 are in fluid communication with the convective cooling channel 23 of the second-stage combustion chamber 18. In one embodiment, the cooling channels 27 extend in an axial longitudinal direction of the tubular wall structure 25.

[0042] The cooling channels 27 also separate different portions of the tubular wall structure 25. As also shown in figure 5, an inner portion 33 of the tubular wall structure 25 is defined between the inner surface 30 and the cooling channels 27 and has a first thickness T1, i.e. a minimum distance between the inner surface 30 and the cooling channels 27. An outer portion 35 of the tubular wall structure 25 is defined between the outer surface 31 and the cooling channels 27 and has a second thickness T2. The second thickness T2 of the outer portion is greater than the first thickness T1 of the inner portion 33. In particular, the second thickness T2 may be two to five times greater than the first thickness T1.

[0043] The cooling channels 27 have a radial height H which is defined by a maximum radial distance across the cooling channels 27 between the inner portion 33 and the outer portion 35 of the tubular wall structure 25. The radial height H of the cooling channels is significantly greater than the first thickness T1 of the inner portion 33 of the tubular wall structure 25. The cooling channels 27 thus have quite a large cross section and allow passage of cooling airflow sufficient to avoid that the cooling action may be seriously affected by heat pick-up. Specifically, the radial height H may be at least three times and up to twenty times greater than the first thickness T1 of the inner portion 33 of the tubular wall structure 25.

[0044] The radial height H is also greater than a width W of the cooling channels.

[0045] Adjacent cooling channels 27 are separated from one another by diaphragms 37 which extend transverse to the inner portion 33 and to the outer portion 35 of the tubular wall structure 25. In the embodiment of figures 3-5, in particular, the diaphragms 37 are substantially perpendicular to the inner portion 33 and to the outer portion 35 of the tubular wall structure 25. In this case, the diaphragms 37 have uniform thickness and join the inner portion 33 and to the outer portion 35 of the tubular wall structure 25 through smooth rounded transitions. As a result, the cooling channels 27 have substantially oval cross section, with substantially straight sides.

[0046] The cooling channels may have any suitable path between the upstream end and the downstream end of the transition duct in order to provide desired cooling action. In the embodiment of figure 6, for example, a transition duct has a tubular wall structure, here designated by numeral 125, with an upstream end 128, a downstream end 129, an inner surface 130, an outer surface 131, an inner portion 133 and an outer portion 135 substantially as already described. Cooling channels 127, also having aspect ratio and dimension as already described, run along a spiral path around a longitudinal axis B of the tubular wall structure 125.

[0047] In one embodiment, illustrated in figure 7, a transition duct 225 has a tubular wall structure 225 with an upstream end 228, a downstream end 229, an inner surface 230, an outer surface 231, an inner portion 233 and an outer portion 235 substantially as already described. Cooling channels 227 extend between the upstream end 228 and the downstream end 229 and are separated from one another by diaphragms 237. The diaphragms 237 are discontinuous and are interrupted by indentations 238, that may be aligned in a substantially circumferential direction of the tubular wall structure 225, as in figure 7, or otherwise staggered as desired in other embodiments not shown. Indentations 238 of the diaphragms 238 help reduce mechanical stress caused by thermal expansion.

[0048] In another embodiment, figure 8, a transition duct has a tubular wall structure 325 with cooling channels 327 as already described except in that the cross-section of the cooling channels 327 is substantially rectangular, possibly with rounded corners. Dissipating fins 340 extend longitudinally along the cooling channels 327 from the inner portion 333 of the tubular wall structure 325. In other embodiments (not shown), only some of the cooling channels may be provided with dissipating fins, in accordance with specific requirements.

[0049] In the embodiment of figure 9, a transition duct has tubular wall structure 425 with cooling channels 427 mutually separated by diaphragms 437. The diaphragms 437 form angles α between 30° and 90° with the inner portion 433 and the outer portion 435 of the tubular wall structure 425. As a result, cross-section of the cooling channels 427 is in the form of a parallelogram.

[0050] Another embodiment is illustrated in figure 10. In this case, a transition duct has tubular wall structure 525 with cooling channels 527 mutually separated by diaphragms 537. The diaphragms 537 are tapered from the outer portion 535 to the inner portion 533 of the tubular wall structure 525. As a result, the cooling channels 527 have trapezoidal cross-section, with wider base at the outer portion 535 and smaller base at the inner portion 533 of the tubular wall structure 525.

[0051] In the embodiment of figure 11, a transition duct has tubular wall structure 625 with cooling channels 627 mutually separated by diaphragms 637. The diaphragms 637 are tapered from the inner portion 633 to the outer portion 635 of the tubular wall structure 625. Also in this case the cooling channels have trapezoidal cross-section, but with wider base at the inner portion 633 and smaller base at the outer portion of the tubular wall structure 625.

[0052] Finally, it is evident that the described transition duct may be subject to modifications and variations, without departing from the scope of the present invention, as defined in the appended claims.

[0053] In particular, any other component of the hot gas path may have the structure described above, with a tubular wall structure and relatively large cooling channels extending across the tubular wall structure. In one embodiment not illustrated, for example, the second-

stage combustion chamber may have the same structure as the transition duct, with the cooling channels of the second-stage combustion chamber fluidly coupled to respective cooling channels of the transition duct. The second-stage combustion chamber and the transition duct may be formed in a single monolithic body.

Claims

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

a tubular wall structure (25; 225; 325; 425; 525; 625), having an upstream end (28; 228), a downstream end (29; 229), an inner surface (30; 230) and an outer surface (31; 231);

a plurality of cooling channels (27; 227; 327; 427; 527; 627) extending through the tubular wall structure (25; 225; 325; 425; 525; 625) between the upstream end (28; 228) and the downstream end (29; 229);

wherein an inner portion (33; 233; 333; 433; 533; 633) of the tubular wall structure (25; 225; 325; 425; 525; 625), defined between the inner surface (30; 230) and the cooling channels (27; 227; 327; 427; 527; 627), has a first thickness (T1) and an outer portion (35; 235; 335; 435; 535; 635) of the tubular wall structure (25; 225; 325; 425; 525; 625), defined between the outer surface (31; 231) and the cooling channels (27; 227; 327; 427; 527; 627), has a second thickness (T2), greater than the first thickness (T1); and wherein the cooling channels (27; 227; 327; 427; 527; 627) have a radial height (H) defined by a maximum radial distance across the cooling channels (27; 227; 327; 427; 527; 627) between the inner portion (33; 233; 333; 433; 533; 633) and the outer portion (35; 235; 335; 435; 535; 635) of the tubular wall structure (25; 225; 325; 425; 525; 625) and the radial height (H) of the cooling channels (27; 227; 327; 427; 527; 627) is greater than the first thickness (T1) of the inner portion (33; 233; 333; 433; 533; 633) of the tubular wall structure (25; 225; 325; 425; 525; 625).

2. The hot gas path component according to claim 1, wherein the second thickness (T2) is between two and five times greater than the first thickness (T1).
3. The hot gas path component according to claim 1 or 2, wherein the radial height (H) of the cooling channels (27; 227; 327; 427; 527; 627) is at least three times greater than the first thickness (T1) of the inner portion (33; 233; 333; 433; 533; 633) of the tubular wall structure (25; 225; 325; 425; 525; 625).

4. The hot gas path component according to any one of the preceding claims, wherein the radial height (H) is greater than a width (W) of the cooling channels (27; 227; 327; 427; 527; 627).
5. The hot gas path component according to any one of the preceding claims, wherein adjacent cooling channels (27; 227; 327; 427; 527; 627) are separated from one another by diaphragms (37; 237; 337; 437; 537; 637) transverse to the inner portion (33; 233; 333; 433; 533; 633) and to the outer portion (35; 235; 335; 435; 535; 635) of the tubular wall structure (25; 225; 325; 425; 525; 625).
6. The hot gas path component according to claim 5, wherein the diaphragms (37; 237; 337; 437; 537; 637) are substantially perpendicular to the inner portion (33; 233; 333; 433; 533; 633) and to the outer portion (35; 235; 335; 435; 535; 635) of the tubular wall structure (25; 225; 325; 425; 525; 625) or the diaphragms (437) form angles between 30° and 90° with the inner portion (433) and the outer portion (435) of the tubular wall structure (425).
7. The hot gas path component according to claim 5 or 6, wherein the diaphragms (537; 637) are tapered from the inner portion (533; 633) to the outer portion (535; 635) of the tubular wall structure (525; 625) or from the outer portion (535; 635) to the inner portion (533; 633) of the tubular wall structure (525; 625).
8. The hot gas path component according to any one of claims 5 to 7, wherein the diaphragms (237) are discontinuous and are interrupted by indentations (238).
9. The hot gas path component according to any one of the preceding claims, wherein the cooling channels (27; 227; 327; 427; 527; 627) have rectangular or parallelogram or trapezoidal cross-section, with or without rounded corners, or oval cross-section.
10. The hot gas path component according to any one of the foregoing claims, comprising at least one fin (340) extending longitudinally along at least one of the cooling channels (327) from the inner portion (333) of the tubular wall structure (325).
11. The hot gas path component according to any one of the foregoing claims, wherein the cooling channels (27; 227; 327; 427; 527; 627) are uniformly distributed in a circumferential direction of the tubular wall structure (25; 225; 325; 425; 525; 625).
12. The hot gas path component according to any one of the foregoing claims, wherein the cooling channels (27; 227) extend in an axial longitudinal direction of the tubular wall structure (25) or along a spiral path around a longitudinal axis of the tubular wall structure (125).
13. A hot gas path assembly for a gas turbine engine comprising a hot gas path component according to any one of the preceding claims.
14. The hot gas path assembly according to claim 13, wherein the hot gas path component is a transition duct.
15. A gas turbine engine comprising:
 - a compressor section (2), extending along a main axis (A) ;
 - a plurality of can combustors (7), circumferentially arranged about the main axis (A);
 - a turbine section (5);
 - wherein at least one of the can combustors (7) comprises a hot gas wall component according to any one of the preceding claims.

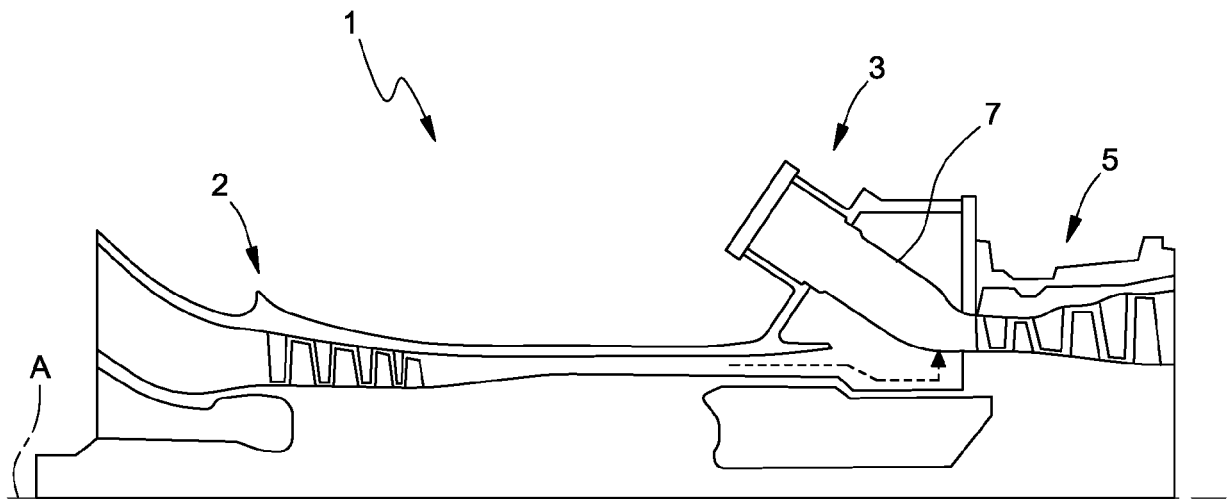


FIG. 1

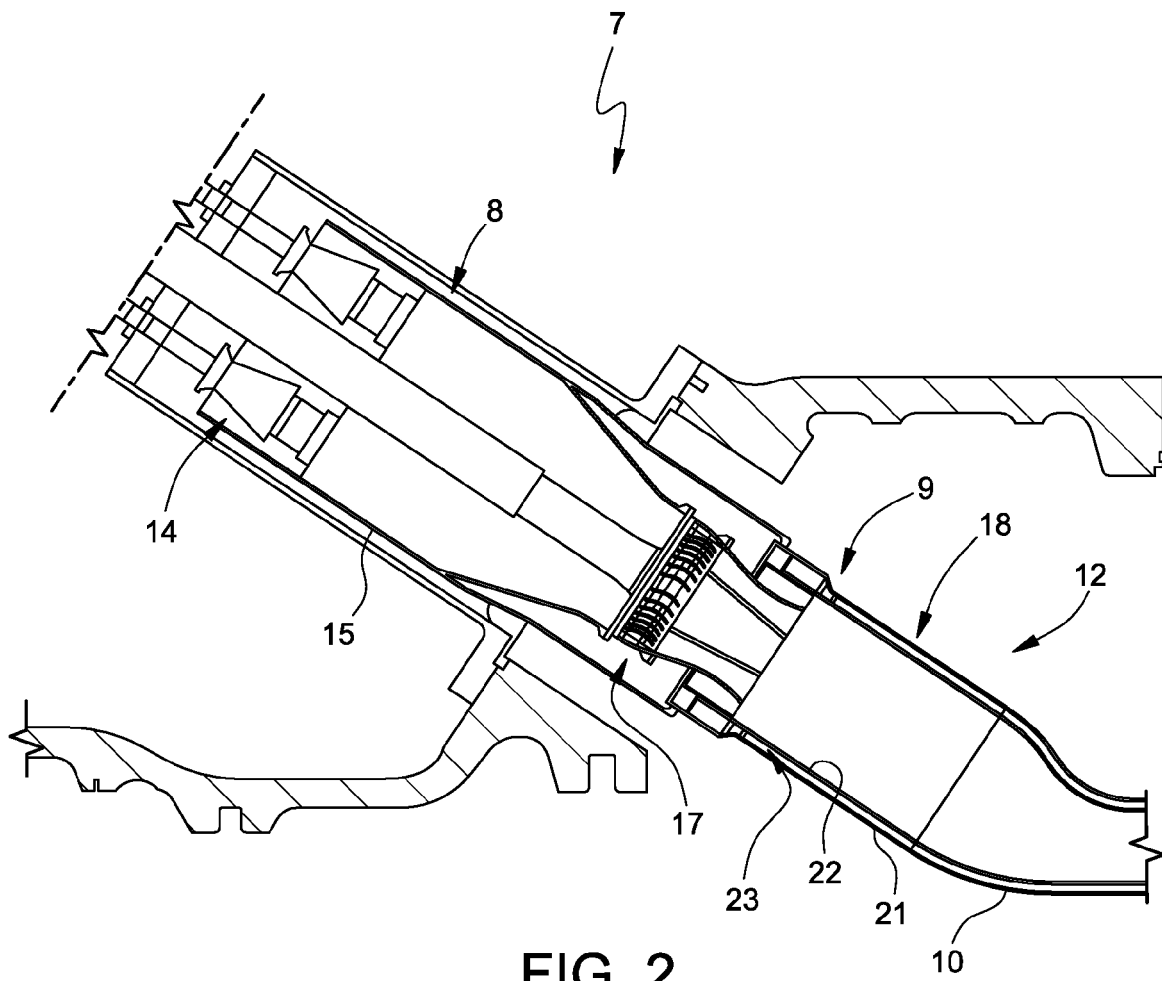


FIG. 2

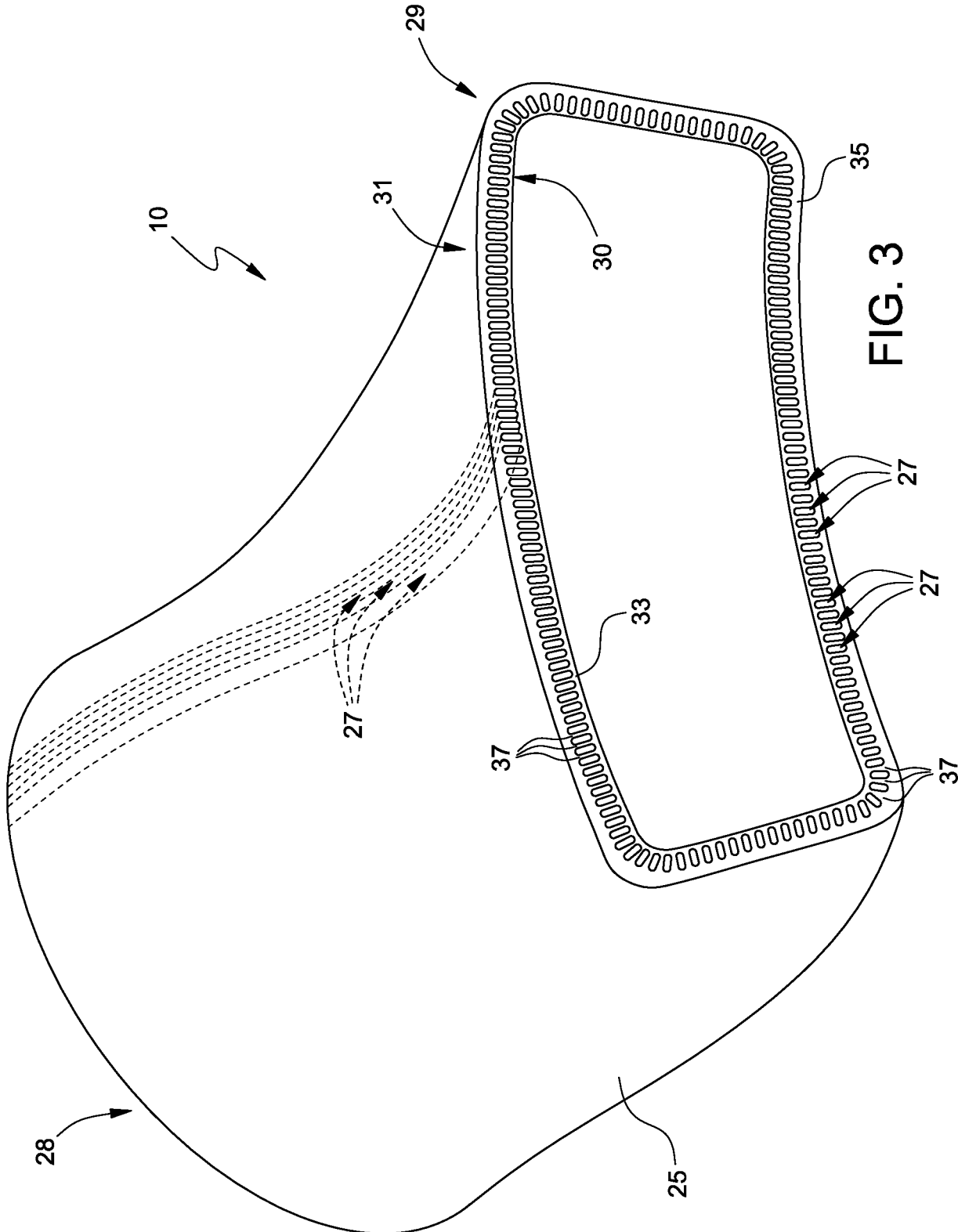
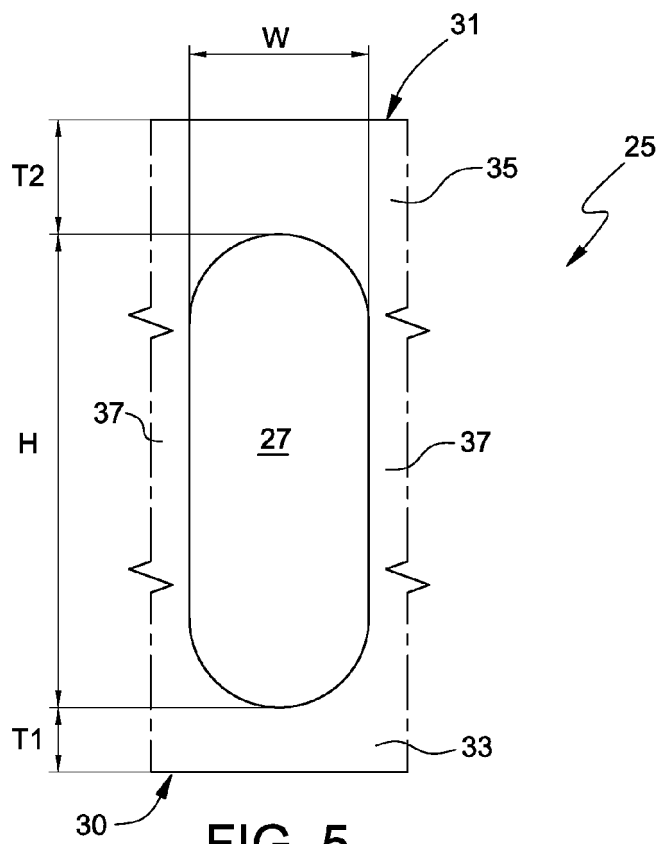
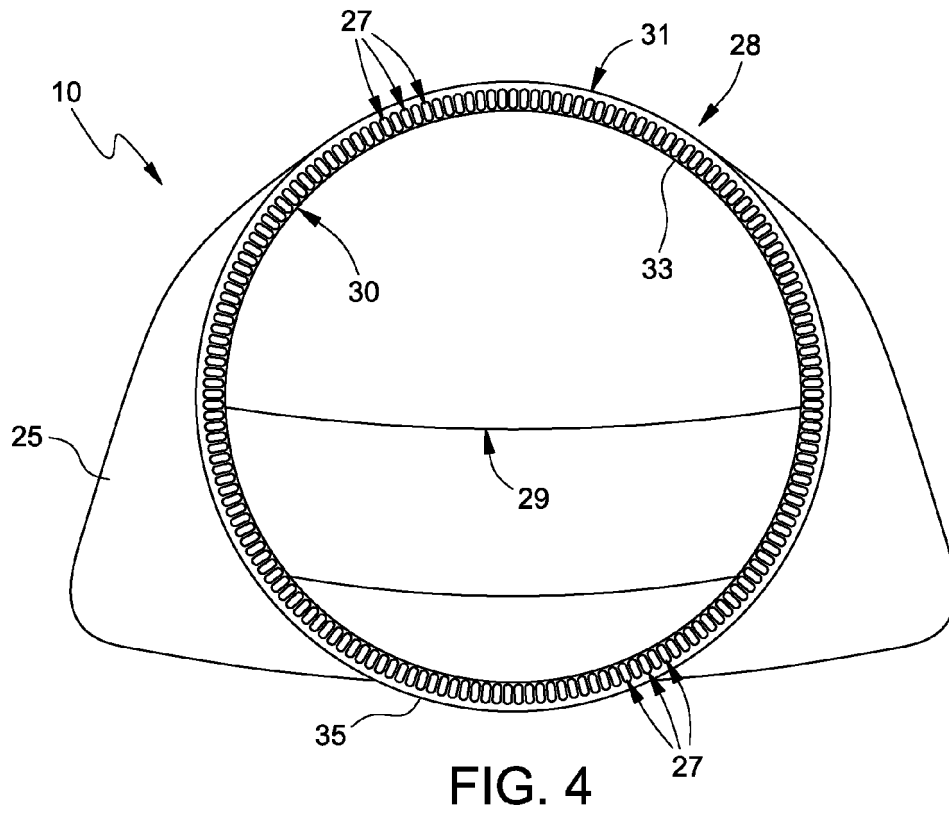
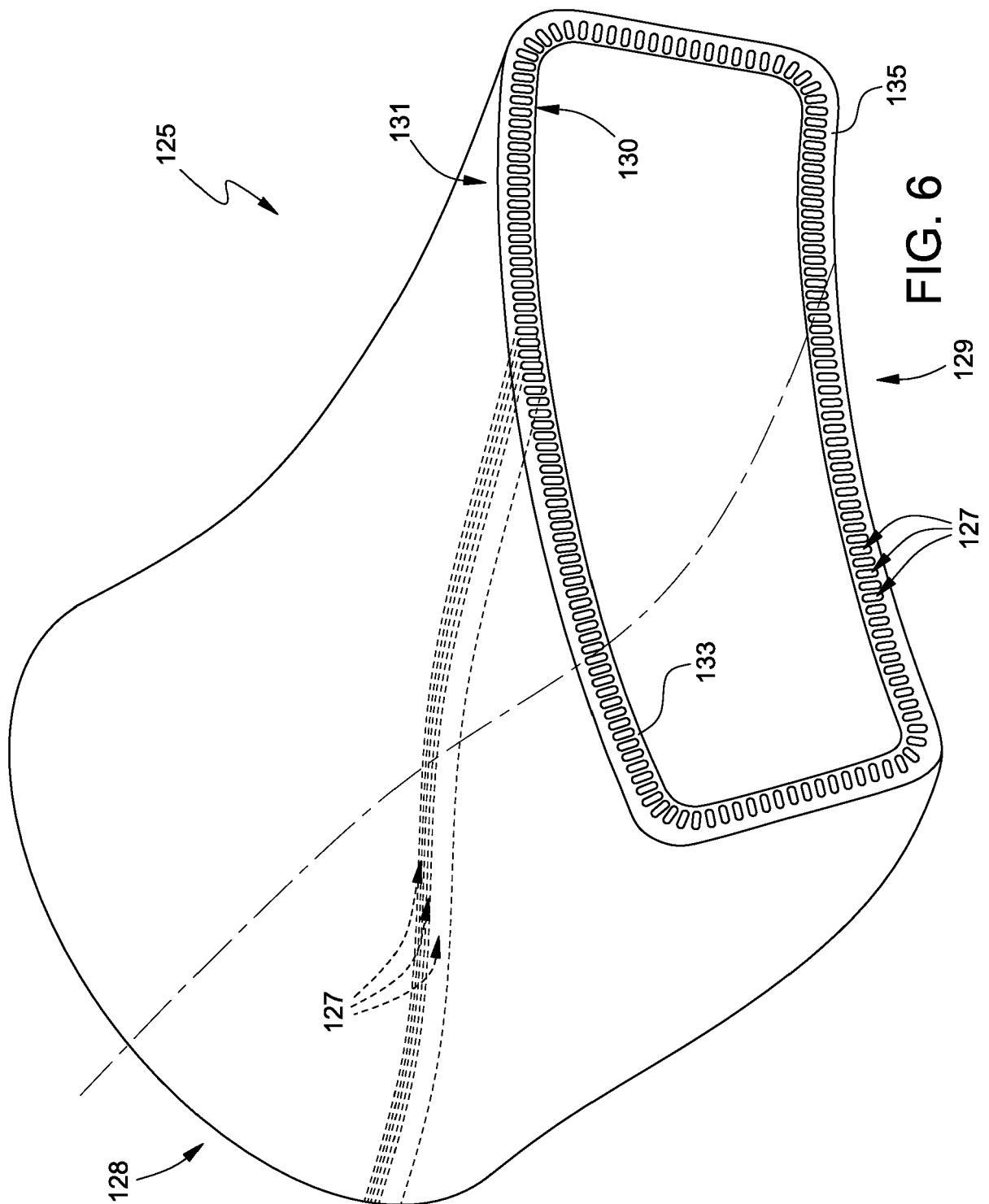


FIG. 3





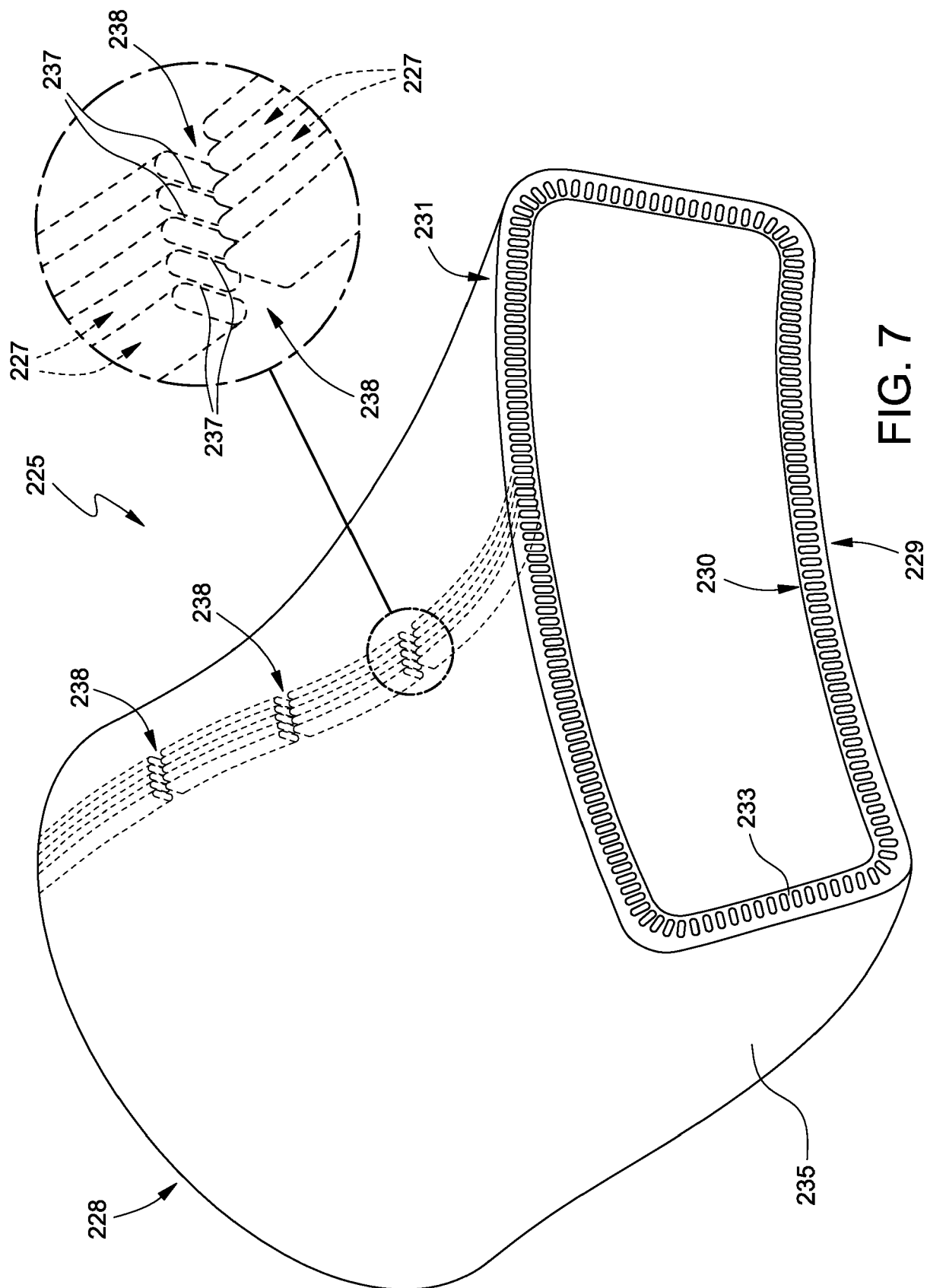
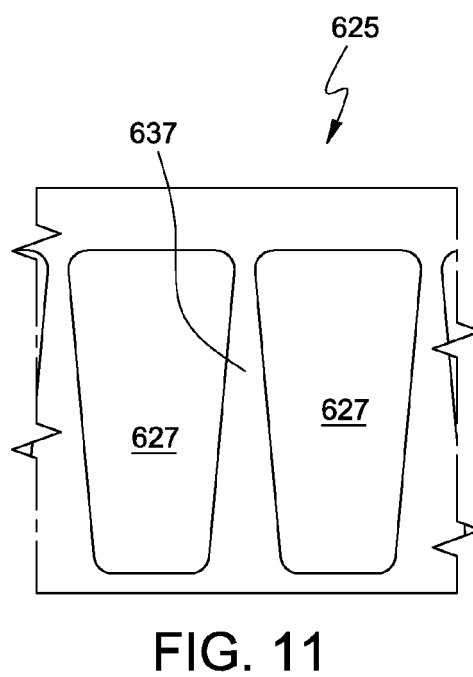
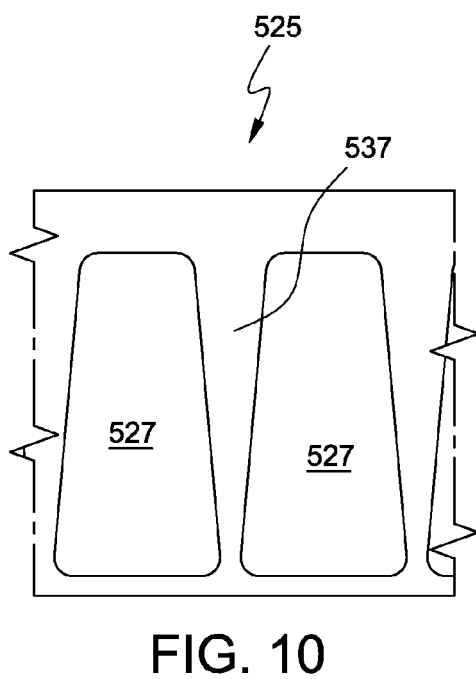
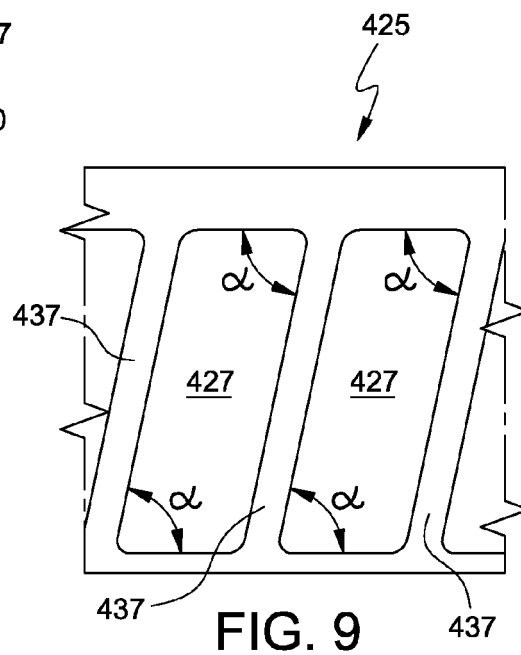
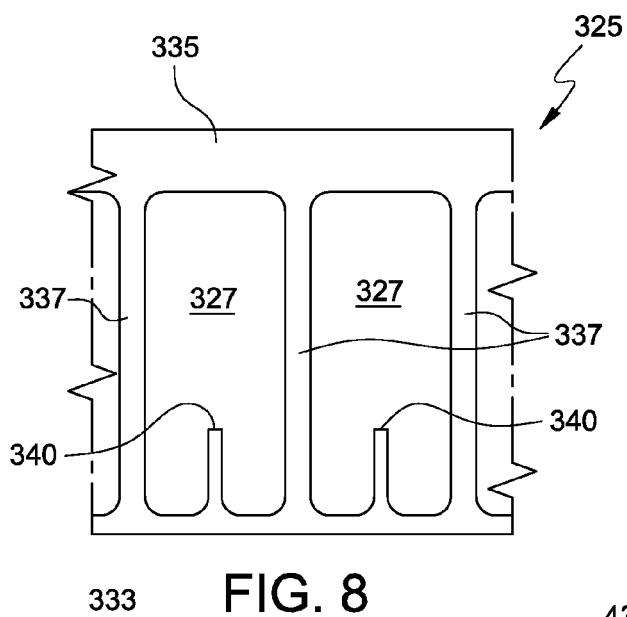


FIG. 7





EUROPEAN SEARCH REPORT

Application Number
EP 17 20 1913

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 March 2018	Examiner Dreyer, Christoph
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03/02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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