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(54) **TRANSITION DUCT FOR A GAS TURBINE ASSEMBLY AND GAS TURBINE ASSEMBLY COMPRISING THIS TRANSITION DUCT**

(57) A transition duct for a gas turbine assembly and configured for guiding hot gas from a combustion chamber to a turbine, the transition duct comprising: a tubular wall structure provided with an inner surface in contact with an hot gas and an outer surface in contact with a cooling air; a connecting structure extending between the inner surface and the outer surface and configured for defining a plurality of cooling channels extending through the tubular wall structure; wherein the connecting structure is a flexible connection structure configured for allowing a circumferential movement of the outer surface whit respect to the inner surface.

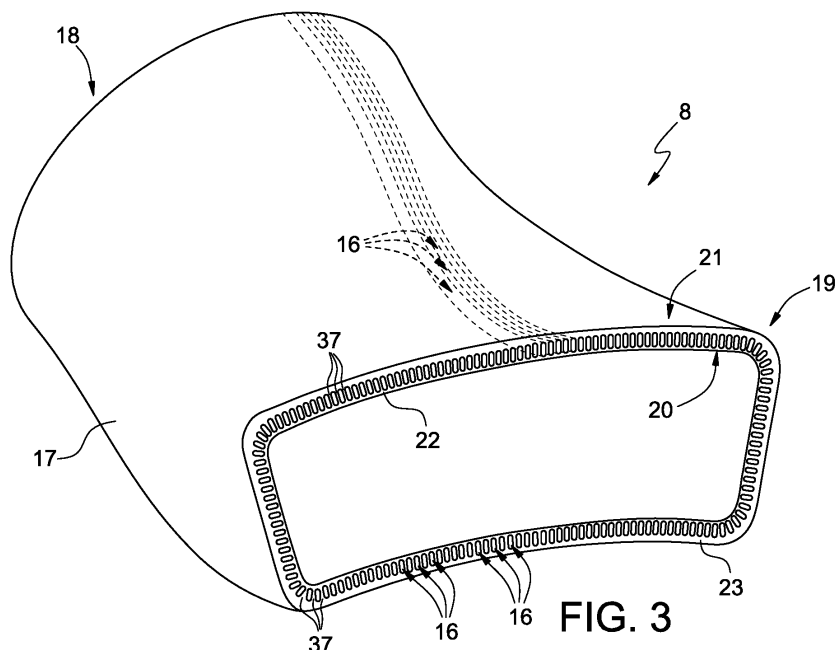


FIG. 3

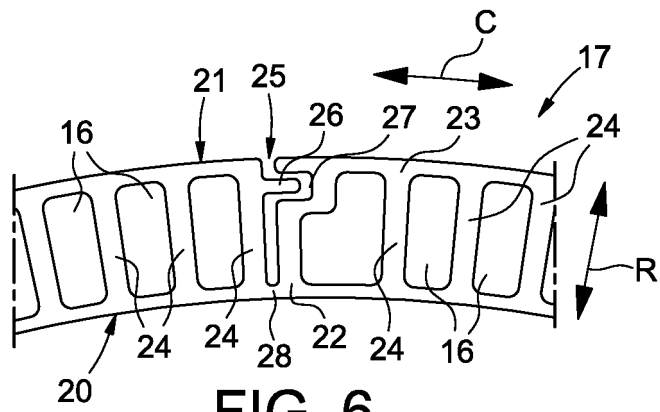


FIG. 6

Description

Field of the Invention

[0001] The present invention relates to the technical filed of the gas turbine assemblies for power plants. In particular, the present invention refers to a particular component of a gas turbine assembly, i.e. a duct (called in this field as "transition" duct) configured for guiding the hot gas leaving a combustion chamber towards a turbine inlet. More in detail, the present invention refer to the tubular wall structure of the above transition duct (called in this field as "liner").

[0002] The present invention moreover refers to a gas turbine assembly comprising the above mentioned transition duct. More in detail, the gas turbine assembly of the present invention preferably relates to the technical filed of the so called can-combustors gas turbine. In particular, each can-combustor comprises an upstream first combustor (called in this field as "premix" combustor) configured for receiving compressed air and mixing this air with fuel, a downstream second combustor (called in this field as "reheat" combustor) configured for receiving the hot gas leaving the first combustor and adding fuel into this hot gas for performing a self/spontaneous ignition and a transition duct (as foregoing mentioned) for guiding the hot gas leaving the reheat combustor to the turbine inlet. In this scenario, the liner of the present invention may be defined as a "sequential" liner. Of course, the present invention is not limited to the above filed of combustors having a reheat configuration. Indeed, the present invention may also be applied without any modification to a non-reheat combustor.

Description of prior art

[0003] As known, a gas turbine assembly for power plants (in the following only gas turbine) comprises a rotor having an axis (i.e. the gas turbine axis), a compressor, a combustor unit and at least a turbine. The compressor is configured for compressing air supplied at a compressor inlet. The compressed air leaving the compressor flows into a plenum and from there into the combustor unit. The combustor unit comprises a plurality of burners configured for injecting fuel in the compressed air flow. The mixture of fuel and compressed air flows into a combustion chamber where this mixture is combusted. The resulting hot gas leaves the combustion chamber and is expanded in the turbine performing work on the rotor. As known, the turbine comprises a plurality of stages, or rows, of rotor blades that are interposed by a plurality of stages, or rows, of stator vanes. The rotor blades are connected to the rotor whereas the stator vanes are connected to a vane carrier that is a concentric casing surrounding the turbine unit.

[0004] In order to achieve a high efficiency, a high turbine inlet temperature is required. However, in general this high temperature involves an undesired high NOx

emission level. In order to reduce this emission and to increase operational flexibility without decreasing the efficiency, the so called "sequential" gas turbines is particularly suitable. In general, a sequential gas turbine comprises two combustors or combustion stages in series wherein each combustor is provided with a plurality of burners and with at least a relative combustion chamber. Following the main gas flow direction, usually the upstream or first combustor comprises a plurality of so-called "premix" burners. The term "premix" emphasizes the fact that each burner of the first combustor is configured not only for injecting the fuel directly in the compressed air (for instance with a so called diffusion flame) but also for mixing (with a swirl) the compressed air and the fuel before injecting the mixture into the combustion chamber. The downstream or second combustor is called "reheat" or "sequential" combustor and it is fed by the hot gas leaving the first combustor. Also, the reheat combustor is provided with a plurality of reheat burners configured for injecting fuel in the hot gas coming from the first combustor. Due to the high gas temperature, the operating conditions downstream the reheat burners allow a self/spontaneous ignition of the fuel/air mixture.

[0005] Today two different kinds of sequential gas turbines are known. According to the first embodiment the premix and reheat combustors are annular shaped and are physically separated by a stage of turbine blades, called high pressure turbine. According to a second embodiment, the gas turbine is not provided with the high pressure turbine and the combustor unit is realized in form of a plurality of can-combustors. In this embodiment each can-combustor comprises a premix (first stage) and a reheat (second stage) combustor arranged directly one downstream the other inside the common can shaped casing ending with a tubular element (called in this field as "transition" duct) configured for guiding the hot gas leaving the reheat (second stage) combustor toward the turbine inlet.

[0006] As other components of gas turbine engines in contact with the hot gas, the transition duct requires cooling to avoid damages caused by overheating and in order to increase lifetime. For the purpose of cooling the transition duct, a fraction of the total airflow is usually taken from the compressor (i.e. before the combustor) and used as convective cooling air acting on the outer surface of the transition duct. Today is present the need to improve the cooling of the transition duct in order to allow further raising the firing temperature inside the transition duct itself. A common solution of this problem is to use a higher amount of cooling air. However, a higher air consumption used for cooling purpose reduces the efficiency of the gas turbine. A solution developed by the Applicant consists in providing the tubular wall of the transition duct (i.e. the liner) with a plurality of cooling channels extending through the tubular wall itself between an upstream end and a downstream end wherein these cooling channels are fed by cooling air so that the liner is cooled in a convective manner. In view of the above struc-

ture with cooling channels, the tubular wall of the transition duct comprises an inner wall portion (called in this field as "hot shell"), an outer wall portion (called in this field as "cold shell") and a plurality of ribs as partitions of adjacent cooling channels and connecting the inner wall portion and the outer wall portion. The ribs may be defined as radial ribs considering the cross section of the transition duct even if not the entire transition duct may disclose a circular cross section. These ribs act as a stiff structure, indeed for this reason it is possible to realize a thin hot shell. Moreover, these radial ribs involves a higher creep resistance with respect to a single layer design. This sequential liner (having cooling channels extending through the tubular wall divided by radial ribs) works well as long as the thermal barrier coating provided on the hot shell is not lost during the operation of the gas turbine. In case of loss of this thermal barrier coating (or in case of it is required a very high temperature difference between the hot and cold shell), due to the presence of these rigid connections (i.e. the radial ribs) a static stress level increases in the wall structure.

[0007] Today therefore there is the need to improve the above sequential liner having cooling channels extending through the tubular wall in order to allow further increase of the hot gas temperature and to guarantee a safe operation also in case of an unintended loss of the thermal barrier coating.

Disclosure of the invention

[0008] Accordingly, a primary object of the present invention is to provide a transition duct for a gas turbine configured for guiding the hot gas from the combustor to the turbine wherein this transition duct is also suitable for overcoming the prior art limits foregoing mentioned. In particular, according to the present invention a transition duct is provided wherein this transition duct comprises a tubular wall provided with a plurality of cooling channels and wherein this transition duct allows to reach an higher thermal gradient between the hot shell and the cold shell forming the wall. To reach these results, according to the present invention a transition duct for a gas turbine is provided, wherein this transition duct comprises:

- a tubular wall structure limiting the path of the hot gas leaving the combustion chamber and guiding the hot gas toward the turbine (the first turbine vane), wherein this tubular wall structure is provided with an inner surface (or inner wall portion) in contact with the hot gas and an outer surface (or outer wall portion) in contact with a cooling air (i.e. part of the compressed air leaving the compressor);
- a connecting structure extending inside the tubular wall structure between the inner surface and the outer surface and configured for defining a plurality of cooling channels extending through the tubular wall structure.

[0009] Starting from this general configuration, according to the main aspect of the invention the connecting structure is a flexible connecting structure configured for allowing a circumferential movement of the outer surface (or outer wall portion) with respect to the inner surface (or inner wall portion). The circumferential direction is defined with respect to the longitudinal axis of the duct (main hot gas flow direction) that usually comprises at least a portion having a circular cross section. Due to the fact that the outer surface can grow along the circumferential direction (instead of the rigid configuration of the prior art practice), it is possible to increase the thermal mismatch between the outer surface and the inner surface without the risk of damaging the wall structure. The main feature of the present invention has been above defined in a functional manner because the skill person may easily provide a plurality of different embodiments allowing the claimed result. In any case, in the description of the drawings some different embodiments of the invention will be described. For instance, this feature may be implemented by providing the duct with at least a groove extending from the cold shell toward the hot shell and/or with an elongated portion of the cold shell directed inside a channel toward the hot shell or directed outside the channel. The elongated portion may be preferably V-shaped, U-shaped or half-moon shaped or any similar shape allowing a circumferential movement of the cold shell. The groove and/or the elongated portion may also be provided with a passing hole for allowing the cooling air to enter a channel.

[0010] Preferably, the transition duct of the present invention is a single piece made of an additive manufacturing method, for instance a selective laser melting process.

[0011] According to a preferred embodiment, the connecting structure may also be configured for controlling another movement of the wall structure. In particular, the connecting structure may also be configured for avoiding any radial movements of the inner surface or of the wall structure in general. Therefore, according to this embodiment the radial movement of the structure is prohibited/inhibited also in case of creep. As foregoing mentioned, the radial direction is defined with respect to the longitudinal axis of the duct (or the main hot gas flow direction) that usually comprises at least a portion having a circular cross section.

[0012] Also this additional feature of the connecting structure has been above defined in a functional manner because the skill person may easily provide a plurality of different embodiments allowing this added result. In any case, in the description of the drawings some different embodiments provided with this feature will be described. For instance this feature may be implemented by providing the duct with a circumferential indentation housed in a circumferential seat or extending as a lip above a portion of the cold shell.

[0013] Preferably, the new connecting structure of the present invention does not affect the shape, geometry or

configuration of inner surface of the duct. Therefore, the implementation of the present invention does not interfere with the thermal barrier coating applied on the inner surface.

[0014] The present invention also refers to a gas turbine for power plant wherein this gas turbine has an axis and comprises:

- a compressor for compressing air;
- a combustor sector for mixing the compressed with at least a fuel and combusting this mixture;
- at least a turbine for expanding the combusted hot gas flow leaving the combustor sector and for performing work on a rotor.

[0015] In particular, the combustor sector of the present invention comprises a plurality can combustors, wherein each can combustor may comprise a single combustion stage or in series a first combustor a second combustor. Each can combustor comprise also a transition duct that is realized according to the enclosed claims for guiding the hot gas from the combustor to the turbine.

[0016] It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed. Other advantages and features of the invention will be apparent from the following description, drawings and claims.

[0017] The features of the invention believed to be novel are set forth with particularity in the appended claims.

Brief description of drawings

[0018] Further benefits and advantages of the present invention will become apparent after a careful reading of the detailed description with appropriate reference to the accompanying drawings.

[0019] The invention itself, however, may be best understood by reference to the following detailed description of the invention, which describes an exemplary embodiment of the invention, taken in conjunction with the accompanying drawings, in which:

- Figure 1 is a side elevation view, cut along an axial, longitudinal plane, of a gas turbine assembly that can be provided with the transition duct according to the present invention;
- Figure 2 is a an enlarged view of the portion labeled with the reference II in figure 1;
- Figures 3 and 4 are respectively a front view and a rear view of a transition duct having a tubular wall provided with a plurality of cooling channels;
- Figure 5A is a an enlarged view of the portion labeled with the reference V in figure 4, in particular figure 5A discloses a transition duct wall structure according to the prior art practice;
- Figure 5B is a diagram disclosing the static stress load acting on the transition duct wall structure of

figure 5A during operation due to the thermal mismatch between the hot shell and the cold shell.

- Figures 6-11 are schematic views of some different embodiments of a transition duct wall structure according to the present invention.

Detailed description of preferred embodiments of the invention

[0020] In cooperation with attached drawings, the technical contents and detailed description of the present invention are described hereinafter according to preferred embodiments, being not used to limit its executing scope. Any equivalent variation and modification made according to appended claims is all covered by the claims claimed by the present invention.

[0021] Reference will now be made to the drawing figures to describe the present invention in detail.

[0022] Reference is made to figure 1 which is a side elevation view, cut along an axial, longitudinal plane, of a gas turbine assembly that can be provided with the transition duct according to the present invention. In particular, figure 1 discloses a simplified view of a gas turbine assembly, designated as whole with reference 1. The gas turbine assembly 1 comprises a compressor 2, a combustor assembly 3 and a turbine 4. The compressor 2 and the turbine 5 extend along a main axis A. The combustor assembly 3 disclosed in the example of figure 1 is a can combustor 5 that may be a sequential combustor or a single-stage combustor. Therefore, in this embodiment, the combustor assembly 3 comprises a plurality of sequential can combustors 5 circumferentially arranged about the main axis A. As known, the compressor 2 of the gas turbine engine 1 provides a compressed airflow, which is added with fuel and burned in the can combustors 5. Part of the airflow delivered by the compressor 2 is also supplied to the combustor assembly 3 and to the turbine section 4 for the purpose of cooling.

[0023] Reference is now made to figure 2 that is an enlarged view of the portion labelled with the reference II in figure 1. In particular, figure 2 discloses a can combustor 5 of the gas turbine assembly 1 of figure 1. The can combustors 5 disclosed in figure 2 comprises a first-stage combustor 6 and a second-stage combustor 7 and a transition duct 8, sequentially arranged and defining a hot gas path. More specifically, the first-stage combustor 6 comprises a first-stage burner unit 9 and a first-stage combustion chamber 10. The second-stage combustor 7 is arranged downstream of the first-stage combustor 6 and comprises a second-stage burner unit 17 and a second-stage combustion chamber 18. The second-stage combustor 7 is furthermore coupled to the turbine 4, here not shown, through the transition duct 8. The second-stage combustion chamber 12 extends along an axial direction downstream of the first-stage combustor 6. In this embodiment, the second-stage combustion chamber 12 comprises an outer liner 13 and an inner liner 14 wherein the outer liner 13 surrounds the inner liner 14 at

a distance therefrom, so that a convective cooling channel 15 is defined between the outer liner 13 and the inner liner 14.

[0024] Reference is now made to figures 3 and 4 that are respectively a front view and a rear view of the transition duct 8 of figure 2. As known, the disclosed transition duct 8 is the component of the hot gas path suffering the most severe thermal stress. Therefore, for cooling purpose the transition duct 8 comprises a tubular wall structure 17 provided with a plurality of cooling channels 16 fed by cooling air. The tubular wall structure 17 has an upstream end 18 having a circular cross section, a downstream end 19 having a substantially rectangular cross section, an inner surface 20 and an outer surface 21. The upstream end 18 is joined to the second-stage combustion chamber 12, whereas the downstream end 19 faces the turbine 4. The inner surface 20 delimits a hot gas flow volume through which hot gas flows to reach the turbine 4. The inner surface 20 is therefore directly exposed to hot gas flowing through the hot gas path. In view of the above the inner surface may be coated at least in part by a thermal barrier coating. The cooling channels 16 extend through the tubular wall structure 17 between the upstream end 18 and the downstream end 19 and are uniformly distributed in a circumferential direction of the tubular wall structure 17. At the upstream end 18, the cooling channels 16 are in fluid communication with the convective cooling channel 15 of the second-stage combustion chamber 12. In this embodiment, the cooling channels 16 extend in an axial longitudinal direction of the tubular wall structure 17.

[0025] Reference is now made to figure 5A that is an enlarged view of the portion labelled with the reference V in figure 4. This figure 5A discloses a wall 17 according to the prior art practice (rigid connection). As disclosed in figure 5A, the cooling channels 16 separate different portions of the tubular wall structure 17. In particular it is possible to define an inner wall portion 22 or hot shell of the tubular wall structure 17 that is the portion of the wall between the inner surface 20 and the cooling channels 16. Accordingly, an outer wall portion 23 or cold shell of the tubular wall structure 17 may be defined as the portion of the wall between the outer surface 21 and the cooling channels 16. Adjacent cooling channels 16 are separated by diaphragms or partitions in form or radial ribs 24 extending between the inner wall portion 22 and to the outer wall portion 23 of the tubular wall structure 17. During the operation, the temperature of the hot shell (inner wall portion 22) increases by some 100K more with respect to the temperature of the cold shell (outer wall portion 23). Of course, any further increase of heat load or the loss of the thermal barrier coating applied on the hot shell lead to a parallel increase on this temperature difference. Due to the rigid connection of the prior art provided by the ribs extending between the hot shell and cold shell, the above temperature difference involves a high static stress load acting on the wall structure. In particular, since the hot shell wants to circumfer-

entially expand more than the cold shell, the cold shell has to resist to a high static stress load acting along the circumferential direction. Beside the figure 5A the direction references A, R e C are disclosed wherein the direction A is the axial direction (main hot gas flow direction), the direction C is the circumferential direction and the direction R is the radial direction. The diagram of figure 5B schematically discloses the static stress load acting on the wall structure.

[0026] As described in the chapter relating the general definition of the invention, in order to allow an increase of the thermal load and to guarantee a safe operation also in case of loss of the foregoing mentioned thermal barrier coating, the proposed solution is to provide the wall 17 with a flexibility feature configured for allowing the cold shell 23 to grow in the circumferential direction. In this way the stress level acting on the cold shell due to the thermal mismatch is reduced and compensated by this circumferential movement. The following description of the figures 6-11 will refer to some particular embodiments of the invention, i.e. embodiments wherein the rigid prior art connection between the hot shell and the cold shell (radial ribs) has been modified to allow the cold shell to freely grow in the circumferential direction. In any case, in all disclosed embodiments the radial movement of the hot shell is prohibited/inhibited also in case of creep.

[0027] Reference is now made to figures 6 that is a schematic view of a first embodiment of a transition duct wall structure according to the present invention. According to this embodiment the transition duct wall structure 17 comprises at least a radial groove or slot 25 (axially extending at least in part along the duct) realized inside a rib 24 and extending from the cold shell 23 towards the hot shell 22. Therefore, at this radial groove 25 the thickness of the transition duct wall structure 17 is reduced to the sole hot shell 22. In other words, at this radial groove or slot 25 along the circumferential direction the integrity of the transition duct wall structure 17 is performed only at a point the hot shell 22 acting as a hinge 28 for the structure. In the contrary at the radial groove or slot 25 the cold shell 23 discloses two separated facing edges allowing the cold shell to move along the circumferential direction C. In order to avoid movements of the structure along the radial direction R (in particular to prevent any radial movement of the hot shell), a middle portion of groove or slot 25 along the radial direction is provided at one side with a circumferential indentation 26 and at the opposite side with a circumferential seat 27 housing at least in part the circumferential indentation 26.

[0028] Reference is now made to figures 7 that is a schematic view of an alternative embodiment of a transition duct wall structure according to the present invention. This embodiment differs from the previous for the position of the circumferential indentation 26 along the radial direction of the groove or slot 25. As disclosed, in figure 7 the indentation 26 is extending outside the groove or slot 25, in particular outwardly the cold shell 23 radially covering (spaced) the groove or slot 25. Also in this case

the indentation 26 allows to prevent any radial movement of the hot shell.

[0029] Reference is now made to figures 8 that is a schematic view of an alternative embodiment of a transition duct wall structure according to the present invention. According to this embodiment the transition duct wall structure 17 comprises at least a V shaped groove or lowered portion 29 of the cold shell 23 at a channel 16 wherein this V shaped portion is directed towards the hot shell 22. Also a bridge 30 may be provided for connecting the apex of the V shaped portion 29 to the hot shell 22. At the V shaped portion 29 the stiffness of the cold shell is reduced to allow the cold shell itself to move along the circumferential direction.

[0030] Reference is now made to figures 9 that is a schematic view of an alternative embodiment of a transition duct wall structure according to the present invention. This embodiment differs from the previous for the fact that the V shaped portion 29' is not extending towards the hot shell 23 but outside the channel 16. Also in this case at the V shaped portion 29' the stiffness of the cold shell 23 is reduced to allow the cold shell itself to move along the circumferential direction.

[0031] Reference is now made to figures 10 that is a schematic view of an alternative embodiment of a transition duct wall structure according to the present invention. This embodiment comprises all features of the embodiment of figure 6 and moreover it discloses at least a cooling hole 30 connecting the groove 25 to an adjacent channel 16. In order to maximize the cooling effect of the hot shell 22, the cooling hole 30 is realized at the end of the groove 25 opposite to the cold shell 23. The arrow F in figure 10 represent the cooling flow passing inside the groove 25 and the hole 30 for entering a channel 16.

[0032] Reference is now made to figures 11 that is a schematic view of an alternative embodiment of a transition duct wall structure according to the present invention. This embodiment is quite similar to the embodiment disclosed in figure 7. However, the embodiment of figure 11 comprises a cooling hole 30 for connecting the groove 25 to a channel 16 (as the previous example) and it is not provided with the indentation 26 covering the groove 25. Indeed, this indentation 26 may limit the air flow entering the groove 25.

[0033] Although the invention has been explained in relation to its preferred embodiment(s) as mentioned above, it is to be understood that many other possible modifications and variations can be made without departing from the scope of the present invention. It is, therefore, contemplated that the appended claim or claims will cover such modifications and variations that fall within the true scope of the invention.

Claims

1. A transition duct (8) for a gas turbine assembly (1) and configured for guiding hot gas from a combustion

chamber to a turbine, the transition duct (8) comprising:

- a tubular wall structure (17) provided with an inner surface (20) in contact with a hot gas and an outer surface (21) in contact with a cooling air;
- a connecting structure extending between the inner surface (20) and the outer surface (21) and configured for defining a plurality of cooling channels (16) extending through the tubular wall structure (17);

characterized in that

the connecting structure is a flexible connecting structure configured for allowing a circumferential movement of the outer surface (20) with respect to the inner surface (21).

2. A transition duct (8) as claimed in claim 1, wherein the transition duct (8) is a single piece.
3. A transition duct (8) as claimed in claim 2, wherein the transition duct (8) is made of an additive manufacturing method.
4. A transition duct (8) as claimed in any one of the foregoing claims, wherein the connecting structure is also configured for avoiding radial movements of the inner surface (21).
5. A transition duct (8) as claimed in any one of the foregoing claims, wherein the connecting structure does not affect the inner surface (21).
6. A transition duct (8) as claimed in any one of the foregoing claims, wherein the connecting structure comprises a plurality of ribs (24) extending from the outer surface (21) to the inner surface (20) for separating adjacent channels (16).
7. A transition duct (8) as claimed in claim 6, wherein the transition duct (8) comprises at least a groove (25) extending inside a rib (24) from the outer surface (21) towards the inner surface (20).
8. A transition duct (8) as claimed in claim 7, wherein a middle portion of the groove (25) is provided with an indentation (26) configured for avoiding radial movements of the inner surface (21).
9. A transition duct (8) as claimed in claim 7, wherein the outer surface (21) is provided with a lip portion outwardly covering the groove (25).
10. A transition duct (8) as claimed in in any one of the foregoing claims from 6 to 9, wherein the outer surface (21) comprises an elongated portion (29') extending inside a channel (16) towards the inner sur-

face (20).

11. A transition duct (8) as claimed in claim 10, wherein a bridge (30) connecting the elongated portion (29') and the inner surface (20) is provided. 5
12. A transition duct (8) as claimed in claim 10, wherein the outer surface (21) comprises an elongated portion (29') extending outside a channel (16). 10
13. A transition duct (8) as claimed in any one of the foregoing claims from 7 to 12, wherein the groove (25) or the elongated portion comprises at least a hole (30) connecting the groove (25) or the elongated portion to a channel (16). 15
14. A transition duct (8) as claimed in claim 13, wherein the hole (30) is provided at the end of the groove (25) opposite to the outer surface (21). 20
15. A gas turbine for power plant; the gas turbine (1) having an axis (A) and comprising following the gas flow direction:
 - a compressor (2) for compressing air, 25
 - a combustor sector (3) for mixing and combusting the compressed with at least a fuel
 - a turbine (4) for expanding the combusted hot gas flow leaving the combustors (3); 30wherein the combustor (4) comprises a plurality of can combustors (5), each can combustor houses a single combustor or in series a first combustor (6) a second combustor (7) and a transition duct (8), the transition duct (8) being realized according to any one of the foregoing claims. 35

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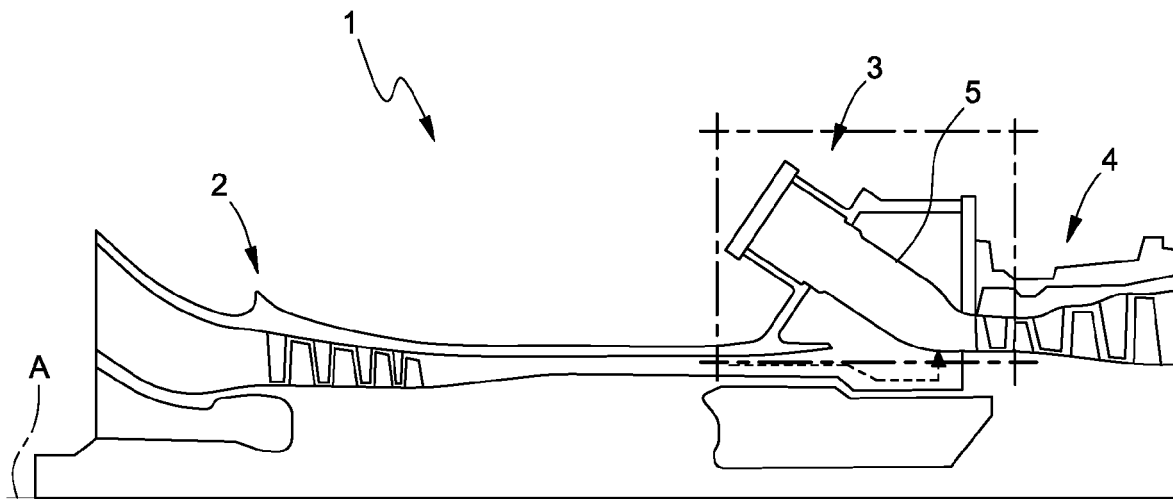


FIG. 1

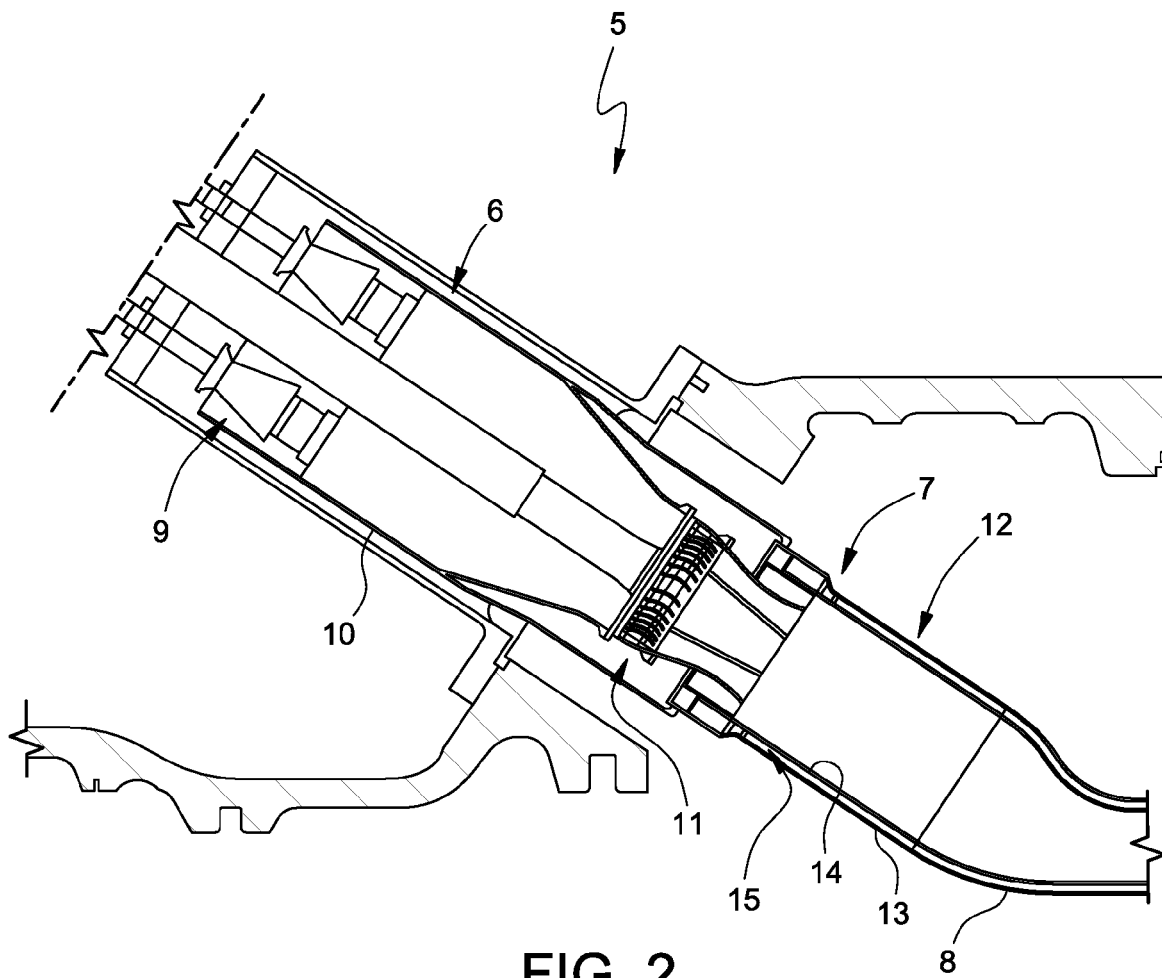
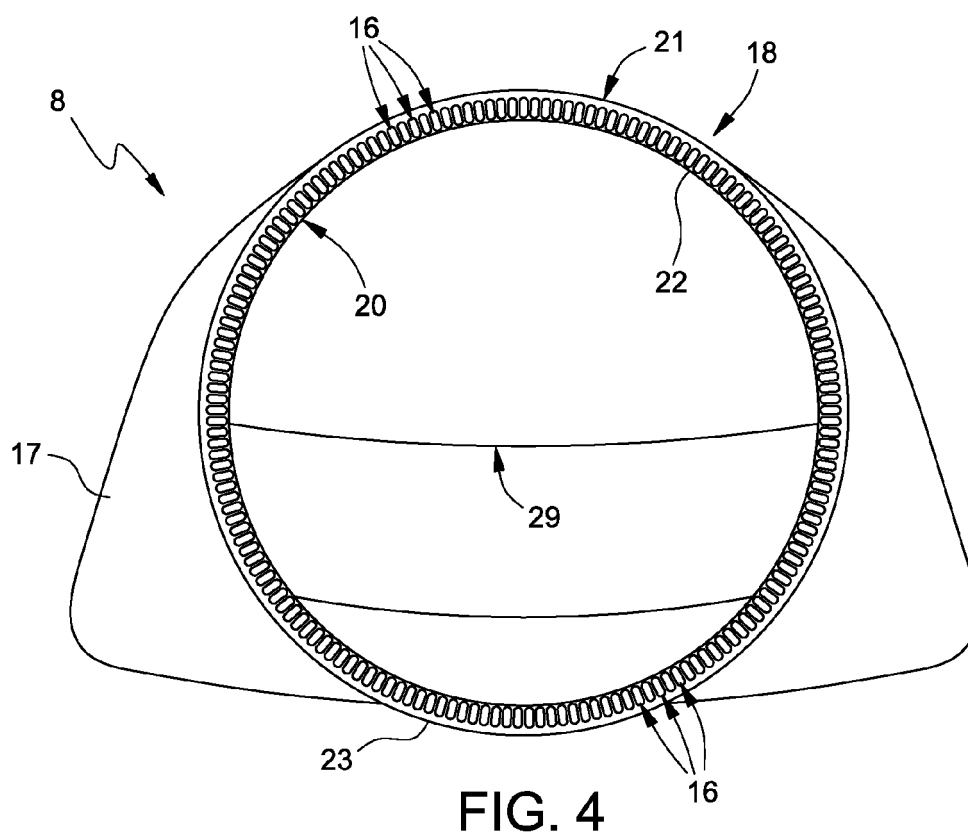
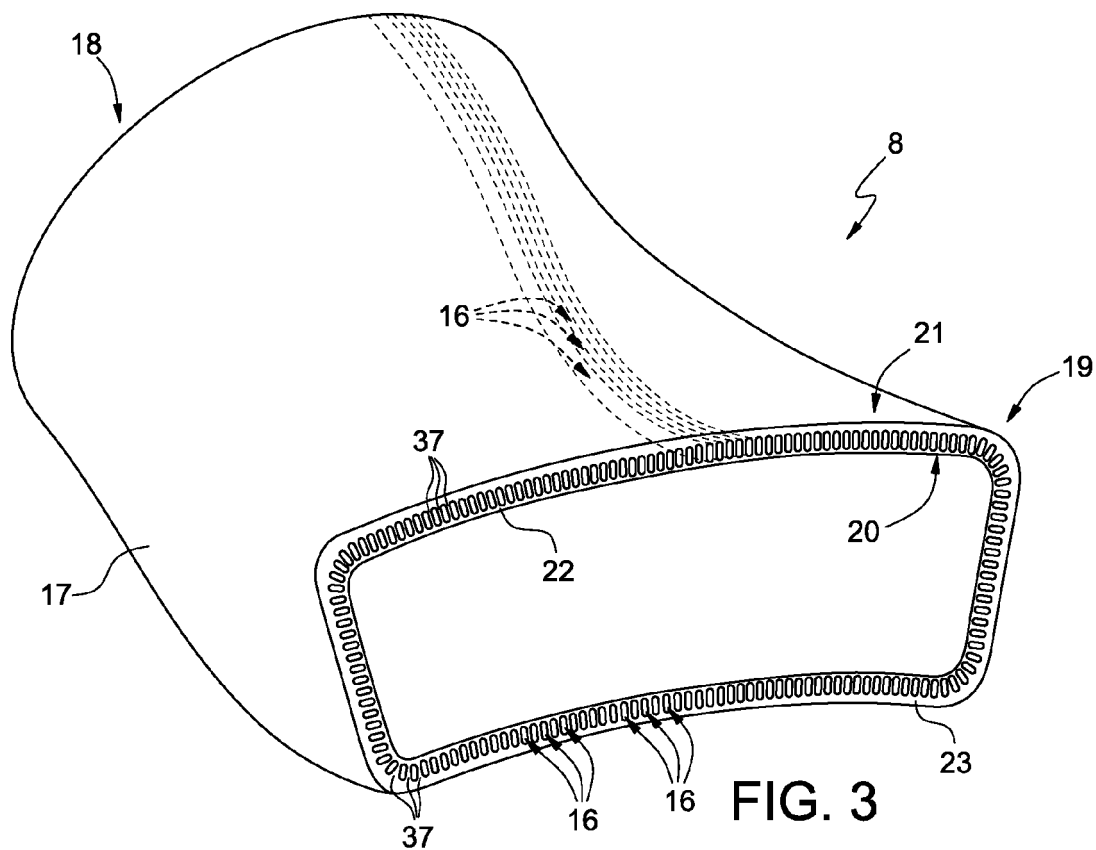


FIG. 2



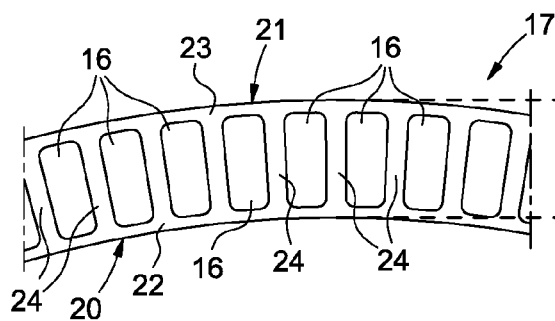


FIG. 5A

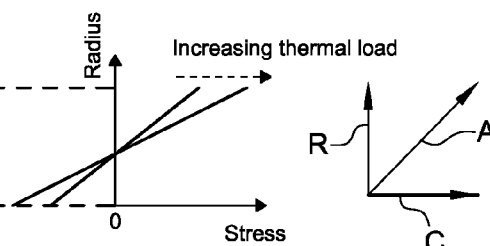


FIG. 5B

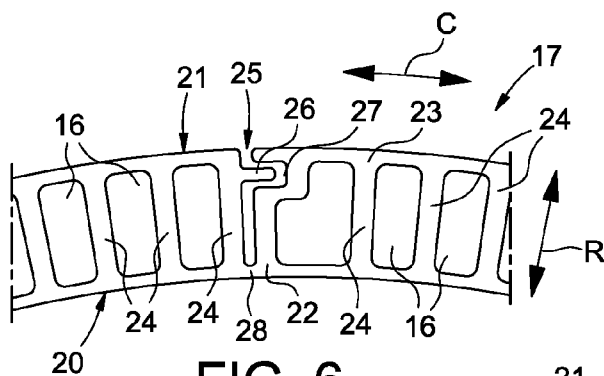


FIG. 6

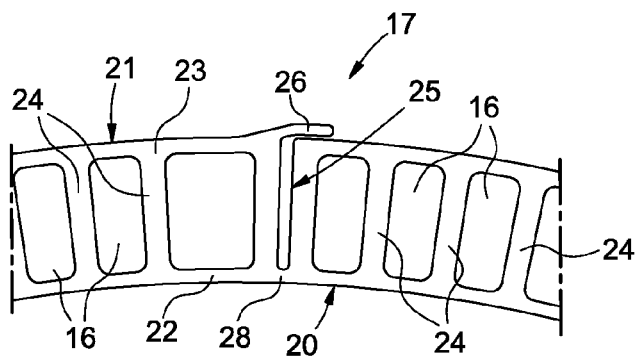


FIG. 7

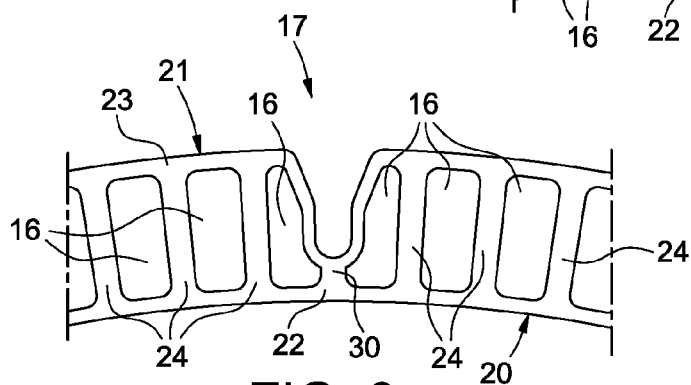


FIG. 8

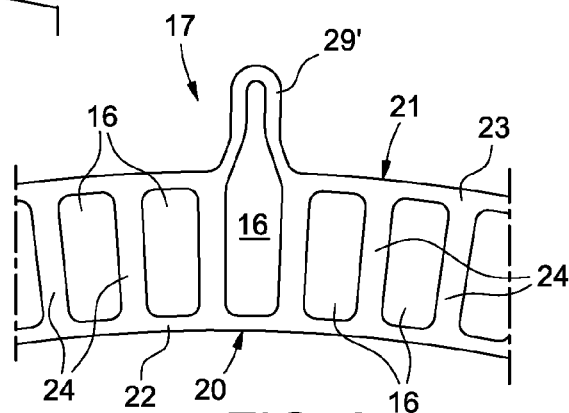


FIG. 9

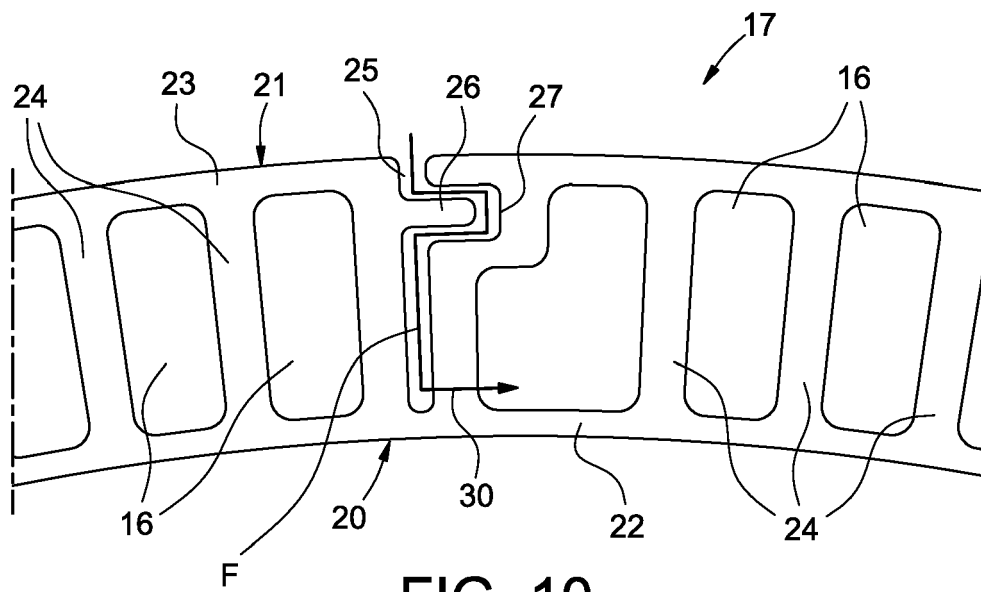


FIG. 10

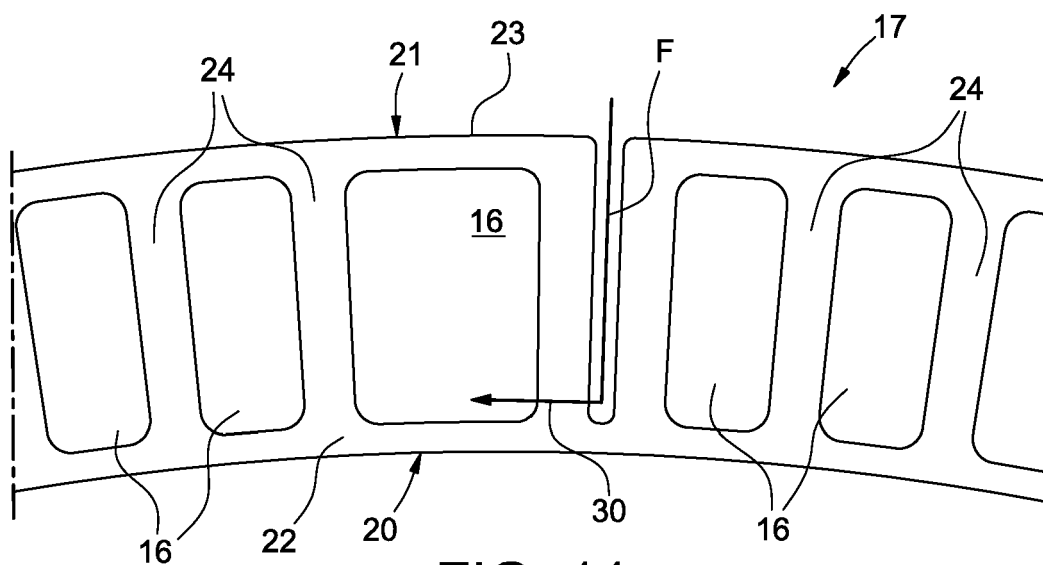


FIG. 11



EUROPEAN SEARCH REPORT

Application Number
EP 19 17 0045

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 206 886 A2 (GEN ELECTRIC [US]) 14 July 2010 (2010-07-14)	1,4-6,15	INV. F01D9/02 F01D25/12 F23R3/00
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