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(54) **SEAL ASSEMBLY FOR A GAS TURBINE**

(57) A seal assembly for a gas turbine comprises at least one main spring configured to be at least partially housed in a seat (19) of a combustor outlet member (17), at least one flexible seal member having a plate portion disposed on an outer side of the main spring and having an outer blade configured to sealingly cooperate with a seat surface, and at least one shield seal member having a plate portion disposed on an outer side of the plate portion of the flexible seal element and a flange configured to contact axially a vane surface under the axial elastic load of the main spring. A corresponding gas turbine comprises an outer casing, a compressor, a plurality

of can combustors (10) downstream of the compressor and a turbine downstream of the can combustors (10), the compressor and turbine comprising fixed vanes (14) carried by the outer casing and rotating blades carried by a rotor. The can combustors are spaced around the rotor and produce hot gas by combusting a mixture of air and at least one fuel. The gas turbine includes, for each can combustor, a seal assembly axially interposed between an outlet member (17) of the combustor (10) and at least one turbine vane and radially interposed between an outer hot gas path (12) and an inner space containing higher-pressure cooling air.

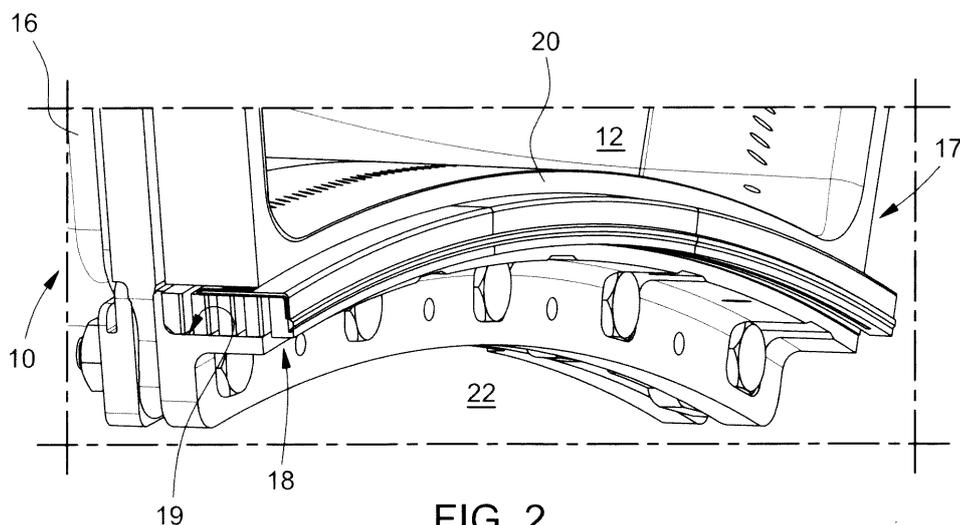


FIG. 2

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DescriptionBACKGROUND OF THE INVENTIONField of the invention

[0001] The present invention relates to a seal assembly for use in a gas turbine power plant, namely as an interface seal between an outlet of a gas combustor and a first vane range of the turbine.

Description of prior art

[0002] As is known, a gas turbine power plant (in the following, "gas turbine" only) comprises a compressor, a combustor assembly downstream of the compressor and a turbine downstream of the combustor. The gas turbine includes a rotor comprising a compressor section and a turbine section.

[0003] The terms "downstream" and "upstream" as used herein refer to the direction of the main gas flow passing through the gas turbine; the terms "axial", "radial" and derivatives refer to the direction of the rotor axis; the terms "inner" and "outer" refer to the radial position with respect to the rotor axis.

[0004] In particular, the compressor comprises an inlet supplied with air, a plurality of fixed guide vanes and a plurality of rotating blades compressing the passing air. A major part of the compressed air flows into a combustor where the compressed air is mixed with at least one fuel. This mixture is combusted in the combustor leading to a significant temperature rise. The resulting hot gas leaves the combustor and is expanded in the turbine, producing mechanical work on the rotor.

[0005] The turbine includes fixed vanes carried by the turbine housing and disposed in a plurality of axially spaced circumferential ranges, and rotating blades carried by the rotor and disposed in a plurality of axially spaced circumferential ranges, each blade range being disposed downstream of a respective vane range so that the vanes guide the gas flow in an optimal direction toward the blades.

[0006] Gas turbines are known in which the combustor is constituted by a plurality of canisters or "can combustors" that are equally spaced around the rotor, each can combustor having an outlet member facing a number of vanes of the first vane range; it is therefore necessary to seal the outlet member against the vanes facing it, so that the outer annular duct where hot combusted gases flow is sealed with respect to an inner space that conveys compressed cooling air at a lower temperature.

[0007] A number of different technical solutions are known for this purpose.

[0008] According to a first known solution, a honeycomb seal is used, which is solidly bonded to the vane. This solution has operational limits to avoid plastic deformation of the seal and possible delamination.

[0009] Other known solutions are not optimal in terms

of life span, operation flexibility and/or ease of assembly/disassembly.

SUMMARY OF THE INVENTION

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[0010] An object of the present invention is to provide a seal assembly that ensures optimal sealing in every working condition and is free from the drawbacks of the prior art seals as specified above.

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[0011] Another object of the present invention is to provide a seal assembly that can be retrofitted to existing turbines to replace existing seals.

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[0012] According to the present invention, a seal assembly for a gas turbine is provided, which is configured to be axially interposed between an outlet member of a combustor and at least one turbine vane and radially interposed between an outer hot gas path and an inner space containing higher-pressure cooling air, the seal assembly comprising:

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- at least one main spring exerting an axial elastic load and configured to be at least partially housed in a seat of the outlet member;
- at least one flexible seal member having a plate portion disposed on an outer side of the main spring and having an outer blade configured to sealingly cooperate with a seat surface; and
- at least one shield seal member having a plate portion disposed on an outer side of the plate portion of the flexible sealing element and a flange configured to contact axially a vane surface under the axial elastic load of the main spring.

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[0013] According to the invention, each of the components of the seal assembly is aimed at a specific function and can be specifically dimensioned therefor, so as to ensure maximum performance and durability of the seal assembly in varying operation conditions. Main spring has the only function of providing axial thrust to ensure the contact between the flange of the shield seal member and the vane surface, and is subject to the cooling air temperature rather than the hot gas temperature. Shield seal member has no mechanical stress but is subject to the hot gas temperature.

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[0014] According to an embodiment, the flexible seal member includes axial slots extending from the plate portion to the outer blade of the flexible seal member.

[0015] Slots guarantee flexibility and cooling air flow; cooling air leakage may be estimated and tuned.

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[0016] According to a preferred embodiment, the main spring includes a base leaf configured to rest against the outlet member and at least one spring section including a front leaf and at least a plurality of leaves interposed between the base leaf and the front leaf and integrally connected to one another in an accordion configuration.

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[0017] Preferably, the seal assembly includes one spring section, as well as an associated flexible seal member and shield seal member, for each vane. Spring

sections operate in parallel but independently so as to adapt to individual vanes.

[0018] The present invention also relates to a gas turbine comprising an outer casing, a compressor, a plurality of can combustors downstream of the compressor and a turbine downstream of the can combustors, the compressor and turbine comprising fixed vanes carried by the outer casing and rotating blades carried by a rotor, the can combustors being spaced around the rotor and producing hot gas by combusting a mixture of air and at least one fuel, the gas turbine including, for each can combustor, a seal assembly as defined above, the seal assembly being axially interposed between an outlet member of the combustor and at least one turbine vane and radially interposed between an outer hot gas path and an inner space containing higher-pressure cooling air.

[0019] According to a preferred embodiment, the difference of pressure between the higher-pressure cooling air and the hot gas path generates a sealing force on the flange of the shield seal member against the vane surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] For a better comprehension of the present invention, a preferred embodiment thereof will be described hereafter, by way of a non-limiting example and referring to the attached drawings, where:

Figure 1 is a schematic cross section of a gas turbine power plant including seal assemblies according to the present invention;

Figure 2 is a partial perspective view of a combustor outlet member provided with the seal assembly according to the present invention;

Figure 3 a cross section of a combustor outlet/turbine inlet interface area with the seal assembly according to the invention;

Figure 4 is a perspective view of a detail of the seal according to the invention;

Figure 5 is an exploded view of the seal assembly according to the invention; and

Figure 6 is a top plan view of a main spring element of the seal assembly.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0021] Figure 1 is a schematic view of a gas turbine 1.

[0022] Gas turbine 1 comprises a compressor 2, a combustor assembly 3 and a turbine 4. Compressor 2 and turbine 4 have a common axis A and include respective sections of a rotor 5 rotatable about axis A.

[0023] As is known, ambient air 6 enters compressor 2 and is compressed. Compressed air 7 leaves compressor 2 and enters a plenum 8, i.e. a volume defined by an outer casing 9. From plenum 8, compressed air 7 enters

combustor assembly 3 that comprises a plurality of can combustors 10 annularly distributed around axis A. Here at least a fuel is injected, and the air/fuel mixture is ignited, producing hot gas 11 that is conveyed to turbine 4 along a hot gas path 12. As is well known in the art, turbine 4 includes fixed vanes 14 carried by outer casing 9 and disposed in a plurality of axially spaced circumferential ranges, of which the first two are shown in fig. 1, and rotating blades 15 carried by rotor 5 and disposed in a plurality of axially spaced circumferential ranges. Each blade range is disposed downstream of a respective vane range so that the vanes guide the gas flow in an optimal direction toward the blades.

[0024] As is better shown in figure 2, each combustor 10 includes a tubular combustion chamber 16 terminating in an outlet member 17 in the form of a frame of generally rectangular shape or, more precisely, an annulus section facing a plurality of vanes 14 of the first range; in the example shown, each outlet member 17 faces three vanes 14.

[0025] A seal assembly 18 according to the present invention is housed in a front curved elongated seat 19 provided in an arcuate radially inner side 20 of the outlet member 17. Seal assembly 18 projects towards vanes 14 and is configured to sealingly rest against a correspondingly arcuate plane front surface 21 of vanes 14, thereby sealing the hot gas path 12 from an inner space 22 which communicates with plenum 8 and thus contains compressed air (at a higher pressure than the hot gas path) which can be used as a cooling fluid.

[0026] Seal assembly 18 (figures 3, 5) includes a main spring 24 and, for each vane 14, a flexible seal member 25 and a shield seal member 26.

[0027] Main spring 24 has an arcuate, elongated shape so as to be partially housed inside seat 19 and includes a plain base leaf 27 configured to rest against a bottom shoulder 23 of seat 19 and a plurality of spring sections 28 extending axially from the base leaf 27 and partially projecting axially out of seat 19 towards respective vanes 14.

[0028] In the present embodiment, there are three spring sections 28 extending each for substantially one third of the base leaf 27, being only slightly spaced from one another. Although only one flexible seal member 25 and one shield seal member 26 are shown in figure 5, each spring section 28 has an associated flexible seal member 25 and a shield seal member 26.

[0029] Each spring section 28 comprises a plane front leaf 29 parallel to, and axially spaced from, base leaf 27, and two multiple-leaf spring sets 30 arranged in parallel with one another and extending between base leaf 27 and front leaf 29. Spring sets 30 are symmetrical with respect to a median plane of the spring section 28.

[0030] Specifically, each spring set 30 extends for substantially one longitudinal half of the spring section 28 and is formed by a plurality of leaves 31 integrally connected in series to one another at their ends in an "accordion" or "bellows" fashion. More specifically, each leaf

31 is spaced from the adjacent ones in an axial direction (i.e. parallel to axis A), and is slightly inclined so as to diverge axially from the preceding so as to form a zigzag pattern. The end leaves 31 of each spring set 30 are joined to base leaf 27 and front leaf 29, respectively, at lateral ends of the spring section 28.

[0031] Main spring 24 finally includes a plurality of positioning pins 32 that project axially from base leaf 27 and are configured to engage corresponding bores (not shown) in outlet member 17.

[0032] Flexible seal members 25 (figures 3-5) comprise, each, a substantially rectangular plate portion 34 elongated in circumferential direction and curved so as to follow the radially outer contour of main spring 24. An outer blade 35 is bent back axially from one circumferential side of plate 34 and extends parallel thereto. More specifically, outer blade 35 is formed by two radially offset portions, namely a spring portion 36 that is joined to plate 34 at end bend 37, and a seal portion 38 that is joined to spring portion 36 at an intermediate step 39 so as to be parallel to plate 34 and spaced therefrom more than spring portion 36.

[0033] Flexible seal member 25 includes an end flange 44 extending perpendicularly inward, i.e. on the opposite side of outer blade 35, from an end side of plate 34 opposite to end bend 37.

[0034] Flexible seal member 25 is finally provided with a plurality of axial slots 45 that are preferably equally spaced along its width. Slots 45 are provided in the form of axial cuts extending along most of plate 34 (except for a portion thereof adjacent end flange 44), end bend 37, spring portion 36, intermediate step 39 and part of seal portion 38.

[0035] In use, plate 34 rests on the outer contour of a respective spring section 28 of main spring 24, and end flange 44 rests axially against front leaf 29 of spring section 28 (figure 3).

[0036] Shield seal member 26 (figures 3-5) includes a substantially rectangular plate 46 elongated in circumferential direction, which rests against plate 34 of flexible seal member 25, is tightly inserted between plate 34 and spring portion 36, and forms a gap 40 with seal portion 38 of outer blade 35 of flexible seal member 25. Shield member 26 also includes an end flange 47 extending perpendicularly inward from an end side of plate 46 in axial contact against end flange 44 of flexible seal member 26. Preferably, flange 47 has a sealing lip 48 configured to rest against front surface 21 of vanes 14.

[0037] In use, seal assembly 18 is partially housed within seat 19, with seal portion 38 of the flexible seal member 25 in radial elastic contact against the radially outer side of seat 19 due to the elastic deformation of spring portion 36, and sealing lip 48 against vane surface 21.

[0038] The distance D between surface 21 and shoulder 23 (figure 3) is such that spring sections 28 are axially pre-compressed during assembly, so as to exert an axial load against flanges 44, 47 and ensure that the latter

contacts surface 21 with sealing lip 48 under an elastic load. This load, however, is not the main force ensuring sealing; in fact, in use there is a pressure difference between the inner space including compressed cooling air and the hot gas path, which pressure difference presses flange 47 against surface 21.

[0039] Such pressure difference also ensures that cooling air flows in a controlled manner through slots 45, which form cooling channels connecting the inner space 22 to gap 40 which axially communicates with hot gas path 12, thereby cooling main spring 24, flexible seal member 25 and shield seal member 26.

[0040] According to the present invention, and as opposed to the prior art, seal assembly 18 is constituted by a plurality of elements, each of which is used in optimal mechanical and temperature conditions so as to ensure perfect sealing in variable operational conditions and over a long life span. Moreover, relatively large displacements can be accommodated.

[0041] Main spring 24 is configured to maintain the contact of seal assembly 18 with front surface 21 of vanes 14, and is subject to cooling air pressure and temperature. Spring sections 28 are pre-compressed and operate in parallel but independently so as to adapt to individual vanes 14.

[0042] Flexible seal member 25 is aimed at ensuring sealing against the outlet member 17, adapting to thermal deformations. Slots 45 guarantee flexibility and cooling air flow; cooling air leakage may be estimated and tuned.

[0043] Shield seal member 26, which is the only element of seal assembly 18 that is subject to the hot gas path temperature, is free from mechanical stress and has a very simple design that provides for the main component of sealing pressure.

[0044] Although the invention has been explained in relation to its preferred embodiment as mentioned above, it is to be understood that modifications and variations can be made without departing from the scope of the appended claims.

Claims

1. Seal assembly for a gas turbine configured to be axially interposed between an outlet member (17) of a combustor (10) and at least one turbine vane (14) and radially interposed between an outer hot gas path (12) and an inner space (22) containing higher-pressure cooling air, the seal assembly comprising:

- at least one main spring (24) exerting an axial elastic load and configured to be at least partially housed in a seat (19) of the outlet member (17);
- at least one flexible seal member (25) having a plate portion (34) disposed on an outer side of the main spring (24) and having an outer blade (35) configured to sealingly cooperate with a seat surface; and

- at least one shield seal member (26) having a plate portion (46) disposed on an outer side of the plate portion (34) of the flexible seal element (25) and a flange (47) configured to contact axially a vane surface (21) under the axial elastic load of the main spring (24) .
2. Seal assembly as claimed in claim 1, wherein the outer blade (35) and the plate portion (34) of the flexible seal member (25) are integrally connected by an end bend (37), the plate portion (46) of the shield seal member (26) being housed between the plate portion (34) and the outer blade (35) of the flexible seal element (25).
 3. Seal assembly as claimed in claim 1 or 2, wherein the flexible seal member (25) includes axial slots (45) extending from the plate portion (34) to the outer blade (35) of the flexible seal member (25).
 4. Seal assembly as claimed in any of the preceding claims, wherein the outer blade (35) includes a spring portion (36) adjacent to the end bend (37) and a seal portion (38) connected to the spring portion (36) by an intermediate step (39), the plate portion (46) of the shield seal member (26) being tightly inserted between the plate portion (34) and the spring portion (36) of the flexible seal member (25), so as to form a gap (40) with the plate portion (34) of the shield seal member (26).
 5. Seal assembly as claimed in claim 4, **characterized in that** the flexible seal member (25) includes an end flange (44) interposed between the main spring (24) and the flange (47) of the shield seal member (26).
 6. Seal assembly as claimed in any of the preceding claims, wherein the main spring (24) includes a base leaf (27) configured to rest against the outlet member (17) and at least one spring section (28) including a front leaf (29) and at least a plurality of leaves (31) interposed between the base leaf (27) and the front leaf (29) and connected to one another in an accordion configuration.
 7. Seal assembly as claimed in claim 6, **characterized in that** said front leaf (29) contacts the end flange (44) of the flexible seal member (25).
 8. Seal assembly as claimed in claim 6 or 7, **characterized in that** the at least one spring section (28) includes two sets (30) of leaf springs (31) interposed between the base leaf (27) and the front leaf (29) and connected to one another in an accordion configuration, the two sets (30) of leaf springs (31) being symmetrical with respect to a median plane of said spring section (28).
 9. Seal assembly as claimed in any of the preceding claims, **characterized in that** said flange of the shield seal member includes a lip (48) configured to contact a surface of a respective vane (14).
 10. Seal assembly as claimed in any of the preceding claims, **characterized by** including a plurality of spring sections (28) spaced along the base leaf, and a corresponding plurality of flexible seal members (25) and shield seal members (26) associated, each, to a respective spring section (28) .
 11. A gas turbine comprising an outer casing (9), a compressor (2), a plurality of can combustors (10) downstream of the compressor (2) and a turbine (4) downstream of the can combustors (10), the compressor (2) and turbine (4) comprising fixed vanes (14) carried by the outer casing (9) and rotating blades (15) carried by a rotor (5), the can combustors (10) being spaced around the rotor (5) and producing hot gas by combusting a mixture of air and at least one fuel, the gas turbine (1) including, for each can combustor (10), a seal assembly (18) as claimed in any of the preceding claims, the seal assembly (18) being axially interposed between an outlet member (17) of the combustor (10) and at least one turbine vane (14) and radially interposed between an outer hot gas path (12) and an inner space containing higher-pressure cooling air.
 12. A gas turbine as claimed in claim 11, wherein the at least one main spring (24) is at least partially housed in a seat (19) of the outlet member (17) and exerts an axial elastic load so as to maintain the flange (47) of the shield seal member (26) in axial contact with a vane surface (21).
 13. A gas turbine as claimed in claim 11 or 12, wherein said slots (45) define a plurality of cooling channels allowing a controlled flow of cooling air from the inner space (22) to the hot gas path (12).
 14. A gas turbine as claimed in claim 13, **characterized in that** said cooling channels connect the inner cooling air space to the gap (40) formed between the seal portion (38) of the flexible seal member (25) and the plate portion (46) of the shield seal member (26).
 15. A gas turbine as claimed in any of claims 11 to 14, **characterized in that** the outlet member (17) of each can combustor (10) faces a plurality of vanes (14), said seal assembly including a plurality of spring sections (28) spaced along the base leaf (27) and, for each spring section (28), a flexible seal member (25) and a shield seal member (26) contacting the respective vane (14).

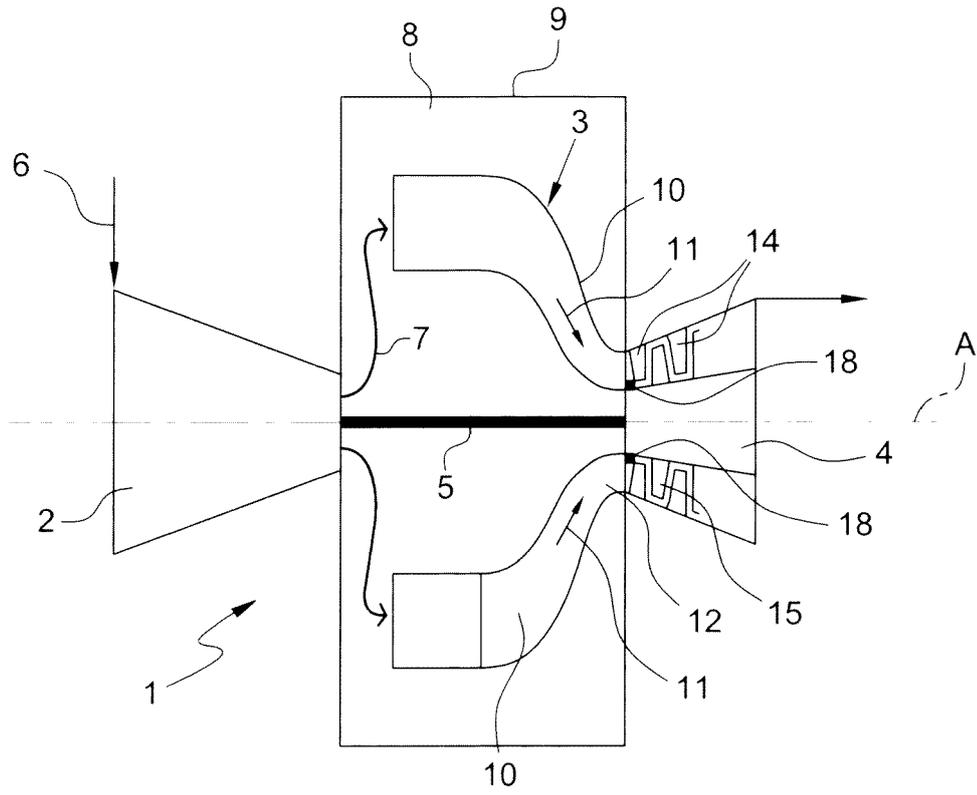


FIG. 1

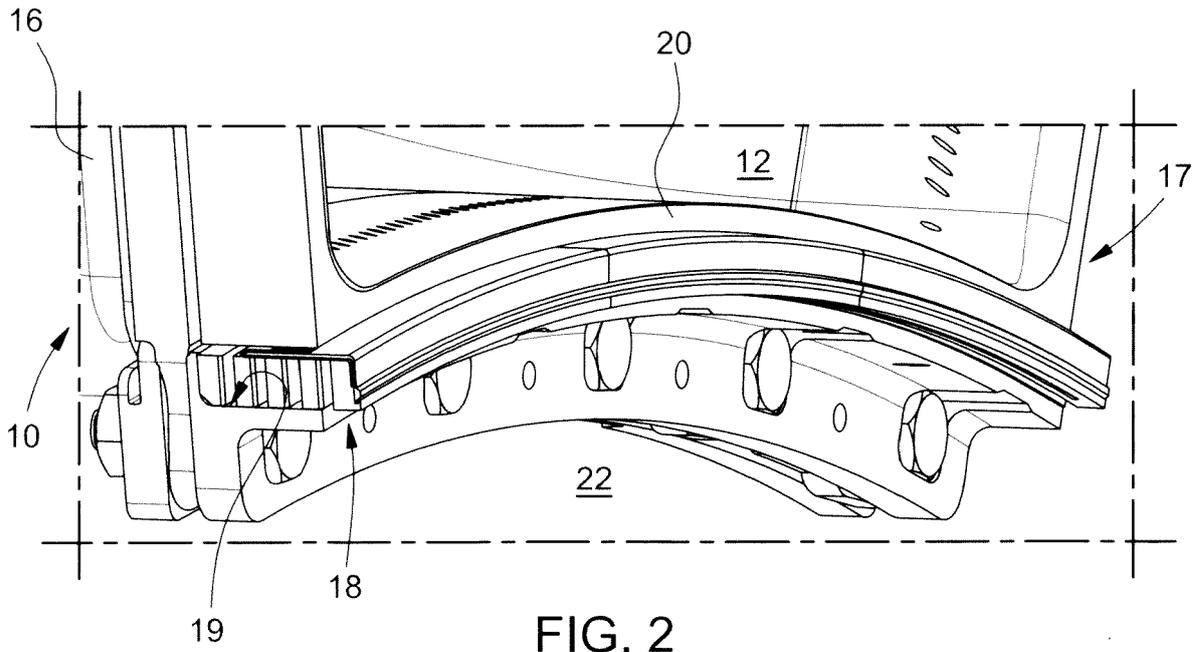


FIG. 2

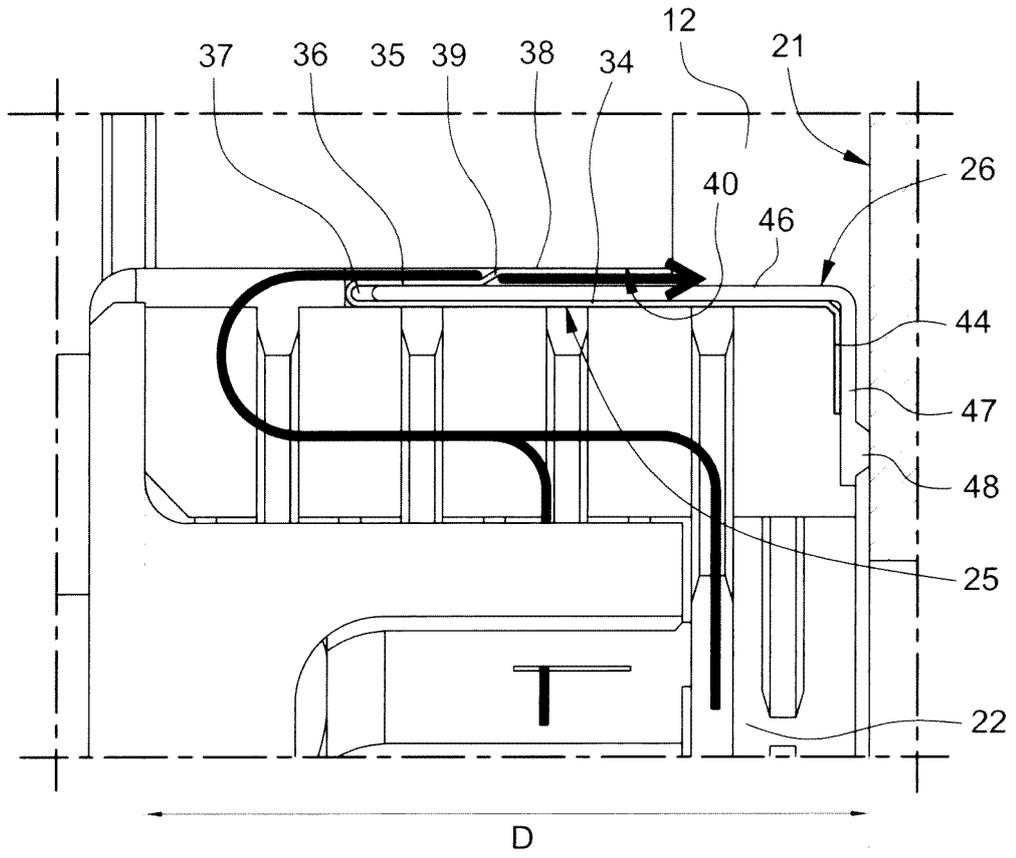


FIG. 3

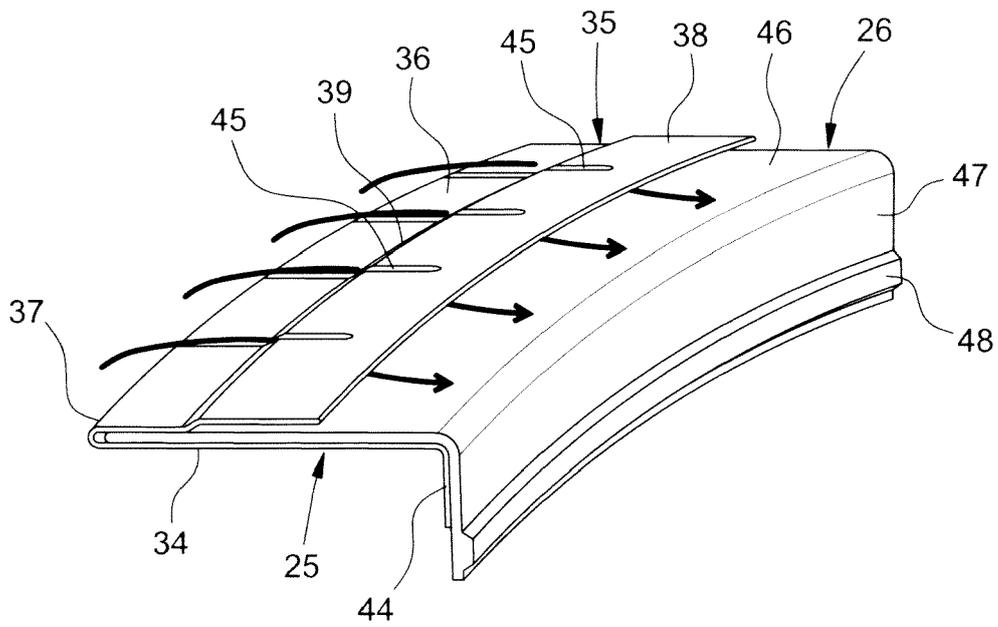


FIG. 4

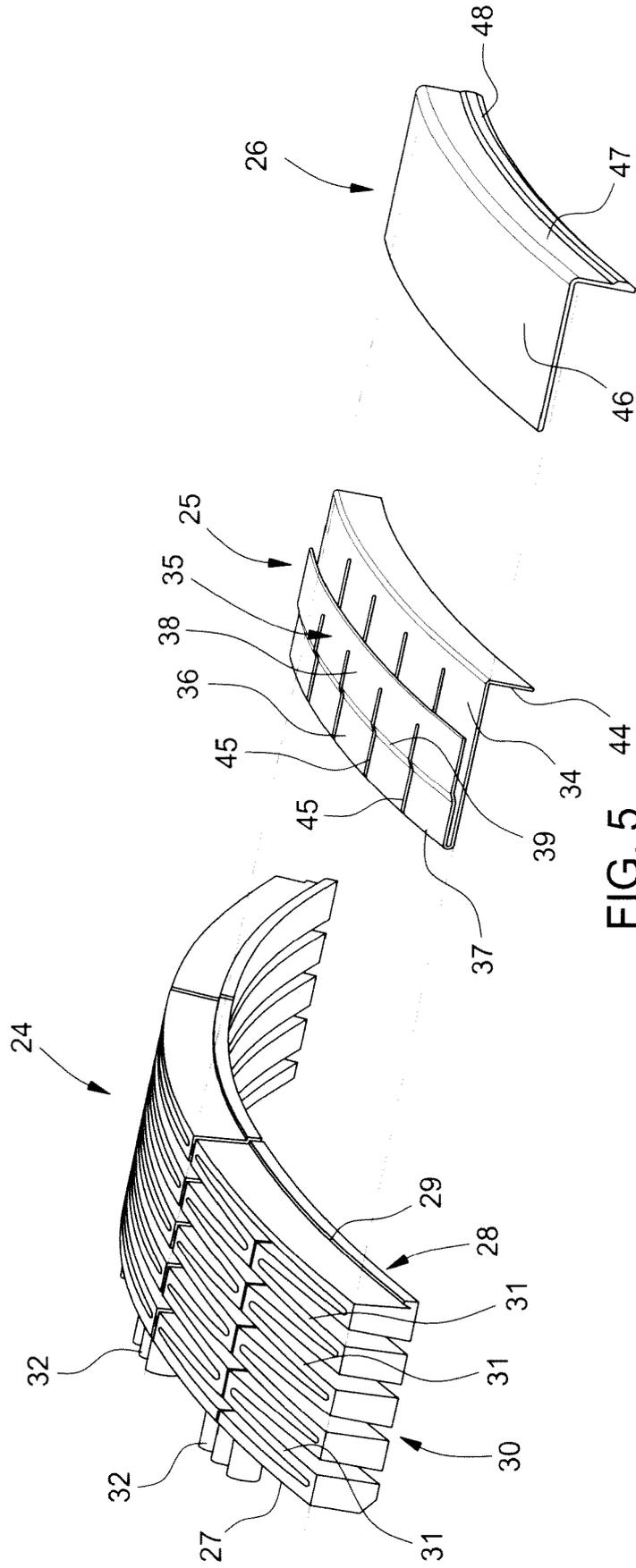


FIG. 5

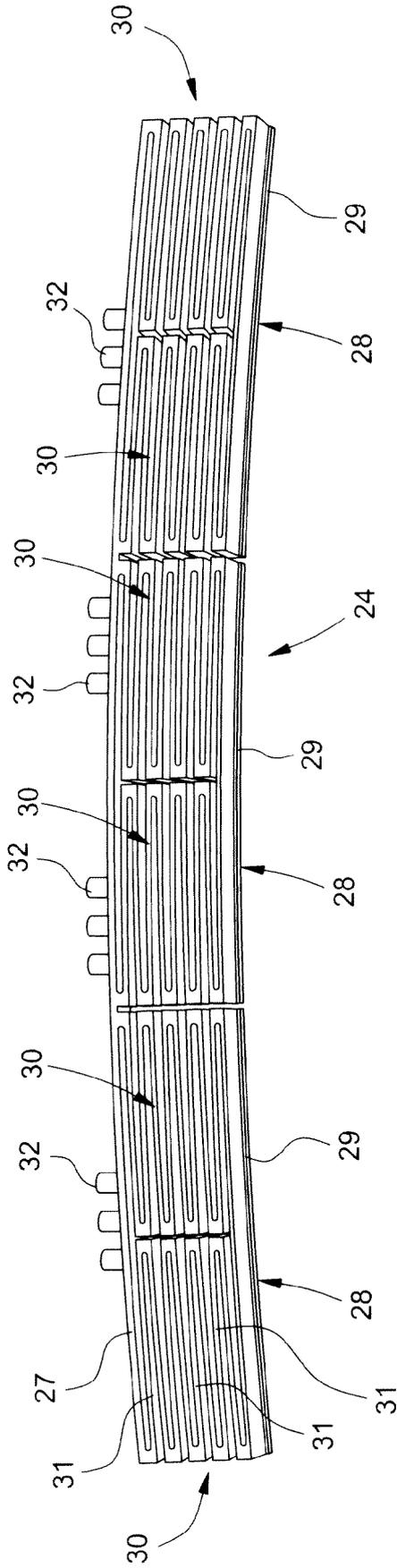


FIG. 6



EUROPEAN SEARCH REPORT

Application Number
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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 10 July 2019	Examiner Dreyer, Christoph
CATEGORY OF CITED DOCUMENTS		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	
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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