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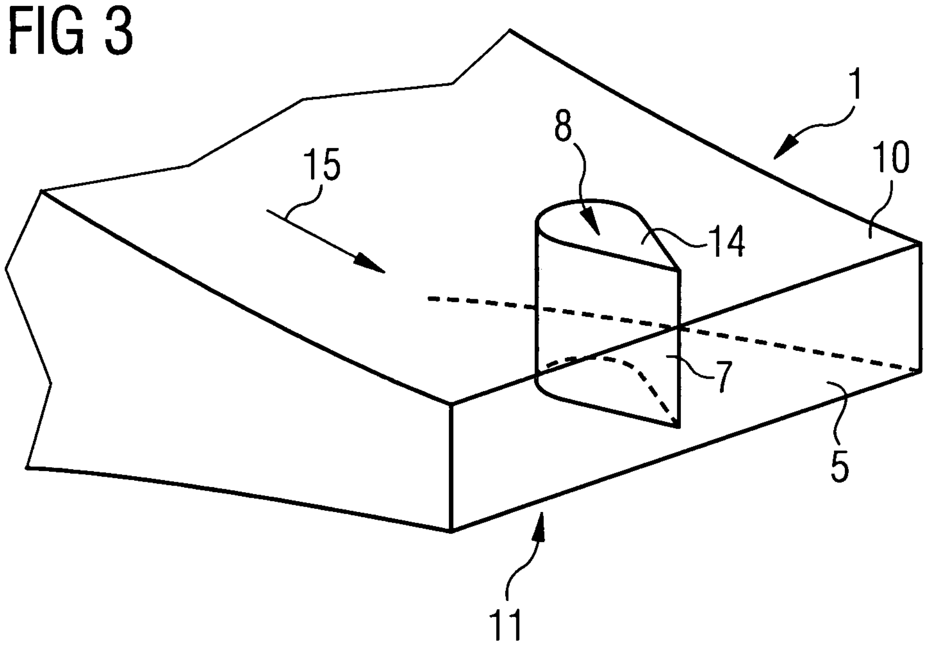
(54) **Transition duct**

(57) A transition duct (1) is provided, which comprises an inlet, an outlet (5) and an inner cavity. The inlet is connectable to a combustor comprising a swirler which produces a swirl with a vortex core (6). A low pressure region generating element (7) is located in the inner cavity of the transition duct (1) at a position of the outlet (5) of the transition duct (1) where the vortex core from the combustor extends to. Moreover, a gas turbine, which comprises such a transition duct (1), is disclosed.

FIG 3



EP 2 028 344 A1

Description

Transition duct

[0001] The present invention relates to a transition duct of a gas turbine.

[0002] Typically, a gas turbine comprises a compressor, at least one combustor and a turbine which are connected sequentially in flow series. In the combustor a mixture of fuel and air delivered from the compressor is combusted and the hot combustion gas is led to the turbine to drive the turbine. In some gas turbines, especially in gas turbines which comprise can-like combustors, the combustor is connected to the turbine via a transition duct.

[0003] The combustor comprises a burner, wherein fuel and air are mixed, for example by means of a swirler assembly. The swirled fuel-air mixture sometimes causes vortices in the hot combustion gas which extend through the transition duct. The occurrence of a vortex core is depending on the aerodynamics com the swirler. The higher the so called swirl number is the more likely a strong vortex core is being generated.

[0004] At the outlet of the transition duct such a vortex attaches to the first stage nozzle guide vane. Usually, this vortex core attaches to the vane corresponding to the centre of the transition duct. If there are more than one burner in a can-like combustor, one may even end up with several vortex cores in different positions.

[0005] The attachment of the high temperature vortex core to the nozzle guide vanes can lead to excessively high temperatures that are localised at the point of attachment. This is an unwanted result because the high temperature can lead to a degradation of the nozzle guide vanes, which may shorten the operation time before a refurbishment is needed and causes considerable effort to protect the nozzle guide vane from the hot temperatures in the core of the vortex. Generally, a refurbishment is expensive and disruptive to the operation of the machine.

[0006] It is therefore an objective of the present invention to provide a transition duct which reduces the mentioned difficulties regarding the high temperature vortex core. It is a further objective of the present invention to provide an improved gas turbine.

[0007] These objectives are solved by a transition duct, as claimed in claim 1, and a gas turbine, as claimed in claim 10. The depending claims define further developments of the invention.

[0008] The inventive transition duct comprises an inlet, an outlet and in inner cavity. The inlet is connectable to a combustor with a swirler which produces a swirl with a vortex core. The inventive transition duct is characterised in that a low pressure region generating element is located in the inner cavity of the transition duct at a position of the outlet of the transition duct where the vortex core from the combustor would extend to.

[0009] By placing a low pressure region generating element in the transition duct, as described, one causes a low pressure region to be generated at the outlet of the transition duct which in turn forces the vortex core to attach to this element. This effectively prevents an attachment of the vortex core to the nozzle guide vanes. On the other hand, since the only function of the low pressure region generating element is to catch the vortex core, this element can be optimised to sustain the high temperature. Moreover, the low pressure region generating element is easily accessible after removing the transition duct.

[0010] In particular, the low pressure region generating element may extend from an upper wall or from a bottom wall of the transition duct, preferably at the outlet of the transition duct. In particular, the low pressure region generating element may extend from the upper wall to the bottom wall. This allows a stable mounting of the low pressure region generating element inside of the transition duct especially if the low pressure region generating element is fixed to the upper wall as well as to the bottom wall of the transition duct. Furthermore, the used low pressure region generating element can be located in the transition duct such that the centreline of the low pressure region generating element is perpendicular to the centreline of the transition duct.

[0011] Preferably, the used low pressure region generating element may be a vane. Moreover, the low pressure region generating element may comprise a hollow space. The hollow space may be used to introduce cooling air or any other cooling fluid. To provide a more effective cooling, the low pressure region generating element can comprise cooling holes. These cooling holes may be used for providing a cooling fluid film over the low pressure region generating element. The used cooling fluid can be, for instance, compressed air. Especially, cooling air may be supplied to the low pressure region generating element by access through the upper wall and/or the bottom wall of the transition duct.

[0012] Furthermore, the transition duct may comprise an inner wall, a perforated outer wall and a cooling channel formed between the outer wall and the inner wall. The cooling channel then leads to the hollow space of the low pressure region generating element. This implementation of the inventive of the inventive transition duct is particularly suitable for turbines with high turbine entry temperatures since it allows for protecting the transition duct and the low pressure region generating element from the high temperature of the combustion gas flowing through the transition duct and in a possibly occurring high temperature vortex core, respectively.

[0013] Besides cooling, the low pressure region generating element can be provided with a thermal barrier coating (TBC) to handle the high temperatures of the vortex core.

[0014] The inventive gas turbine comprises an inventive transition duct, as previously described. The mentioned advantages of the inventive transition duct also apply to the inventive gas turbine.

[0015] Further features, properties and advantages of the present invention will become clear from the following description of embodiments in conjunction with the accompanying drawings.

Fig. 1 schematically shows a part of a combustion chamber of the gas turbine.

Fig. 2 schematically shows a part of a transition duct in a perspective view.

Fig. 3 shows a part of a first embodiment of the inventive transition duct in a perspective view.

Fig. 4 schematically shows a vane located in the transition duct in a perspective view.

Fig. 5 shows a second embodiment of the inventive transition duct in a sectional view.

[0016] An embodiment of the present invention will now be described with reference to Figures 1 to 4. Figure 1 schematically shows a part of a gas turbine which comprises a transition duct 1, a combustor 12 and a turbine which is indicated in the figure by the first stage nozzle guide vane 13. The transition duct 1 is located between the combustor 12 and the first stage nozzle guide vane 13. The centreline of this arrangement is designated by reference numeral 2. In the combustor 12 a mixture of fuel and air is combusted to generate a hot combustion gas and the generated hot combustion gas is used to drive the turbine the first stage nozzle guide vane 13 is a part of.

[0017] The combustor 12 is connected to the turbine, in particular to the first stage nozzle guide vane 13, via a transition duct 1. The transition duct 1 has an inlet 4 and an outlet 5. It is connected to the combustor at the inlet side 4 and to the first stage nozzle guide vane 13 at the outlet side 5. The direction of the hot combustion gas flow from the combustor 12 via the transition duct 1 to the turbine is designated by an arrow 15. While flowing through the transition duct 1 the cross-section of the hot combustion gas flow is decreased. This is realised by a comparably large cross-section of the transition duct inlet compared to a small cross-section of the transition duct outlet 5. This causes an increase in the combustion gas flow velocity.

[0018] The combustor 12 comprises a swirler which swirls the mixture of air and fuel. The swirled mixture of fuel and air combusts and a swirl with a hot vortex core 6 is produced. This hot vortex core 6 may extend through the transition duct 1. Figure 2 schematically shows a part of the transition duct 1 in a perspective view. One can see in Figure 2 the centreline 2 and the outlet 5 of the transition duct 1. Due to the swirl in the fuel-air-mixture a vortex core 6 typically extends through the transition duct to the centre of the transition duct outlet 5. This hot vortex core 6 usually attaches to the first stage nozzle guide vane 5 which is an unwanted result because the hot vortex core 6 locally heats up the vanes.

[0019] The outlet 5 of an inventive transition duct 1 is shown in Figure 3 in a perspective view. The direction of the hot gas flow through the transition duct 1 is indicated by an arrow 15. At the position where the hot vortex core 6 typically occurs, usually at the centre of the outlet 5 as in the present embodiment, a vane 7 is mounted. The vane 7 is a low pressure region generating element which causes a low pressure region to form at the side faces of the vane 7. This low pressure region attracts the vortex core and forces it to attach to this vane 7.

[0020] The transition duct 1, as it is shown in Figure 3, comprises an upper wall 10 and a bottom wall 11. The vane 7 is mounted at the centre of the outlet 5 of the transition duct 1 and is, in the present embodiment, fixed to the upper wall 10 and also to the bottom wall 11. If the vane 7 is at both its ends fixed (perpendicular) to the transition duct 1 it should have sufficient strength not to experience a condition of collapse due to the heating of the centre part of the vane 7. Whether this happens depends on the strength of the vane 7 itself relative to the structural strength of the walls in the transition duct 1. An alternative way of avoiding a collapse which also avoids forming the vane 7 with high strength is to only make one end of the vane 7 fixed to the transition duct 1, by welding or using an attachment element such as a spring or a washer, and allow the other end to slide "radially" relative to the transition duct wall. To avoid leakage the sliding end can be provided with some kind of seal, for example a piston seal. In a further alternative of avoiding a collapse the vane 7 may be inclined in the circumferential direction of the transition duct 1. In this case both ends of the vane could be fixed to the transition duct 1 with the vane having lower strength, as compared to being fixed at both ends without inclination. The expansion by the heat could then be taken up as a bending of the vane 7.

[0021] Moreover, the vane 7 comprises a hollow space 8 with an opening 14 which may be connected through the upper wall 10 to a cooling fluid supply, for example via a burner plenum to the compressor of the gas turbine, to provide cooling of the vane 7. In the same manner, the vane 7 may comprise an opening which may be connected through the bottom wall 11 to the cooling fluid supply.

[0022] In Figure 4 the vane 7 is shown in a perspective view. The figure shows the vane 7 with its internal hollow space 8 and the opening 14. The centreline 3 of the vane 7 may be perpendicular to the centreline 2 of the transition duct 1 when the vane 7 is mounted in the transition duct 1.

[0023] Generally, the vane 7 is aerodynamically shaped. In the present embodiment the vane 7 comprises a leading edge 16 and a trailing edge 17 and aerodynamically formed walls 18, 19 extending from the leading edge 16 to the trailing edge 17. The direction of the hot gas flow is indicated by an arrow 15, as shown in Figure 4. The hot gas flow arrives at the vane at the leading edge 16, flows around the walls 18, 19 of the vane 7 to the trailing edge 17, thereby forming the low pressure region.

[0024] The vane 7 in Figure 4 further comprises cooling holes 9. The cooling holes 9 extend through the vane's walls 18, 19 and are connected to the hollow space 8 inside of the vane 7. Compressed air can be delivered to the internal hollow space 8 which then exits the internal hollow space 8 through the cooling holes 9 to provide effusion cooling or film cooling for the surface of the vane 7.

[0025] Although only one vane 7 has been described in the embodiment, more than one vane 7 may be positioned inside of the transition duct 1 at positions where hot vortex cores 6 may extend to. The used vane 7 or vanes can be provided with sufficient protection to handle the high temperatures of the vortex core through cooling, as described in conjunction with Figure 4, or through sufficient coating of the vane's surface, for example with a suitable thermal barrier coating (TBC). A suitable thermal barrier coating would, for example, be zirconium oxide the structure of which is at least partly stabilised by yttrium oxide. Further, a bond coat may be located between the surface of the vane's 7 base material and the thermal barrier coating. A suitable bond coat would be a so-called MCrAlX coating, where M stand for iron (Fe), cobalt (Co) or nickel (Ni) and X for yttrium (Y) and/or silicon (Si) and/or at least one rare earth element and/or hafnium (Hf).

[0026] An alternative to taking the air directly from a plenum as described with respect to the embodiment shown in Figures 3 and 4 can be employed if the transition duct is impingement cooled and the burner has a sufficiently high pressure drop. A respective cooling system but for a combustor than for a transition duct is described in EP 0 732 564 B1. An embodiment of the inventive transition duct in which the mentioned alternative is realised is shown in Fig. 5 in a sectional view. The transition duct 101 comprises an inner wall 103 and a perforated outer wall 105 which is in flow connection with the burner plenum. Between the inner wall 103 and the outer wall 105 a cooling channel 107 is formed which leads to the hollow space 8 of the vane 7. In the mentioned alternative, the air is guided through the cooling channel 107 into the hollow space 8 of the vane 7 after impinging on the inner wall 103 of the transition duct 101. After cooling the vane 7 the cooling air is introduced into the transition duct 101 through the cooling holes 9 in the vane's wall.

[0027] The cooling scheme described with respect to the embodiment shown in Fig. 5 will be particularly useful if the transition duct is to be used with high turbine inlet temperatures. The issue with the vortex core becomes more accentuated as the turbine inlet temperature is increased. In turn an increased turbine inlet temperature requires a more effective cooling of the transition duct such as using an impingement scheme, with or without a vortex core. With the embodiment shown in Fig. 5 one can increase the turbine entry temperature and, at the same time, effectively protect the transition duct from the increased temperature while protecting the nozzle guide vane from a possibly forming high temperature vortex core.

[0028] In summary, the present invention allows for a specific handling of the high temperature vortex core. In the case that a low pressure region generating element, for instance a vane comprising a hollow space, is used, then the invention makes a tailored cooling of the low pressure region generating element or the vane possible. The cooling can depend on the characteristics of the particular vortex core. Furthermore, the used low pressure region generating element or vane is renewable together with the transition duct assembly. Advantageously, the low pressure region generating element or vane can be positioned inside of the transition duct such that the vortex core can optimally be disrupted.

Claims

1. A transition duct (1, 101) comprising an inlet, an outlet (5) and an inner cavity, the inlet being connectable to a combustor with a swirler which produces a swirl with a vortex core (6),
   characterised in that
   a low pressure region generating element (7) is located in the inner cavity of the transition duct (1) at a position of the outlet (5) of the transition duct (1) where the vortex core from the combustor extends to.

2. The transition duct (1, 101) as claimed in claim 1,
   characterised in that
   the low pressure region generating element (7) extends from an upper wall (10) or a bottom wall (11) of the transition duct (1).

3. The transition duct (1, 101) as claimed in claim 2,
   characterised in that
   the low pressure region generating element extends from the upper wall (10) to the bottom wall (11).

4. The transition duct (1, 101) as claimed in any of claims 1 to 3,
   characterised in that
   the low pressure region generating element (7) is situated in the transition duct (1) such that the centreline (3) of the low pressure region generating element (7) is perpendicular to the centreline (2) of the transition duct (1).

5. The transition duct (1, 101) as claimed in any of the claims 1 to 4,
   characterised in that
   the low pressure region generating element (7) is a vane.

6. The transition duct (1, 101) as claimed in any of the claims 1 to 5,

characterised in that
the low pressure region generating element (7) comprises a hollow space (8).

7. The transition duct (1, 101) as claimed in claim 6,
characterised in that
the low pressure region generating element (7) comprises a wall through which cooling holes (9) extend from the hollow space.

8. The transition duct (101) as claimed in claim 6 or claim 7,
characterised in that
it comprises an inner wall (103), a perforated outer wall (105) and a cooling channel (107) formed between the outer wall (105) and the inner wall (103) which leads to the hollow space of the low pressure region generating element (7).

9. The transition duct (1) as claimed in any of the claims 1 to 8
characterised in that
its surface is coated with a thermal barrier coating.

10. A gas turbine, comprising at least one transition duct (1) as claimed in any of the claims 1 to 9.

FIG 1

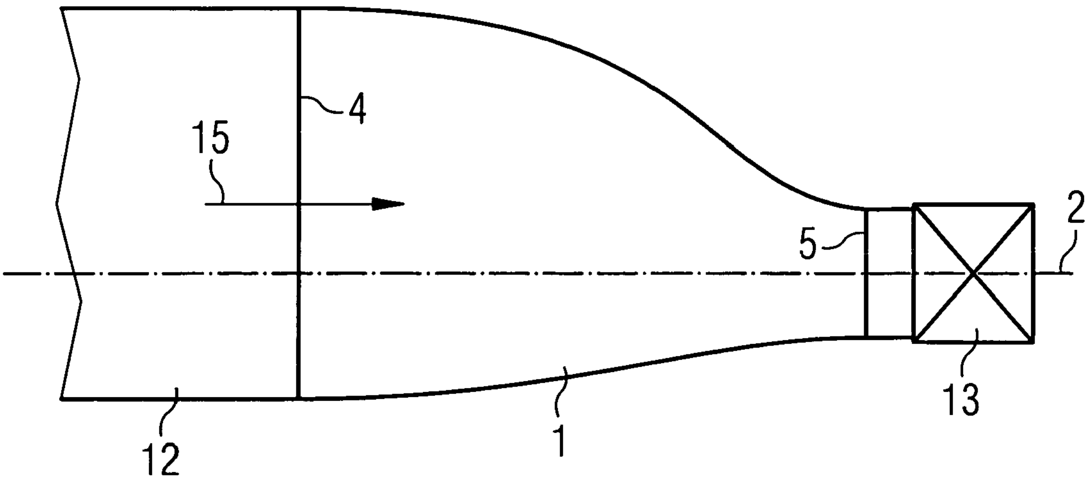


FIG 2

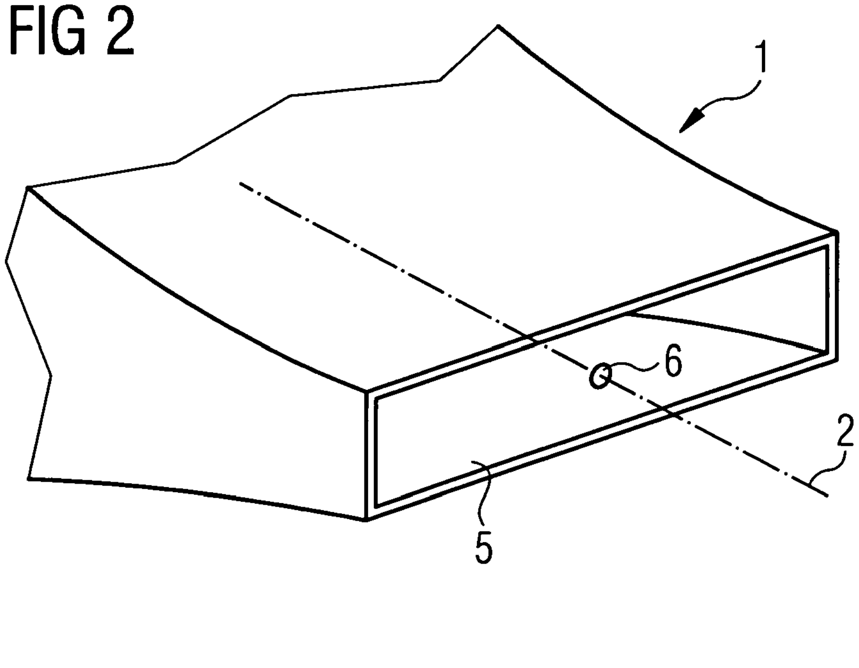


FIG 3

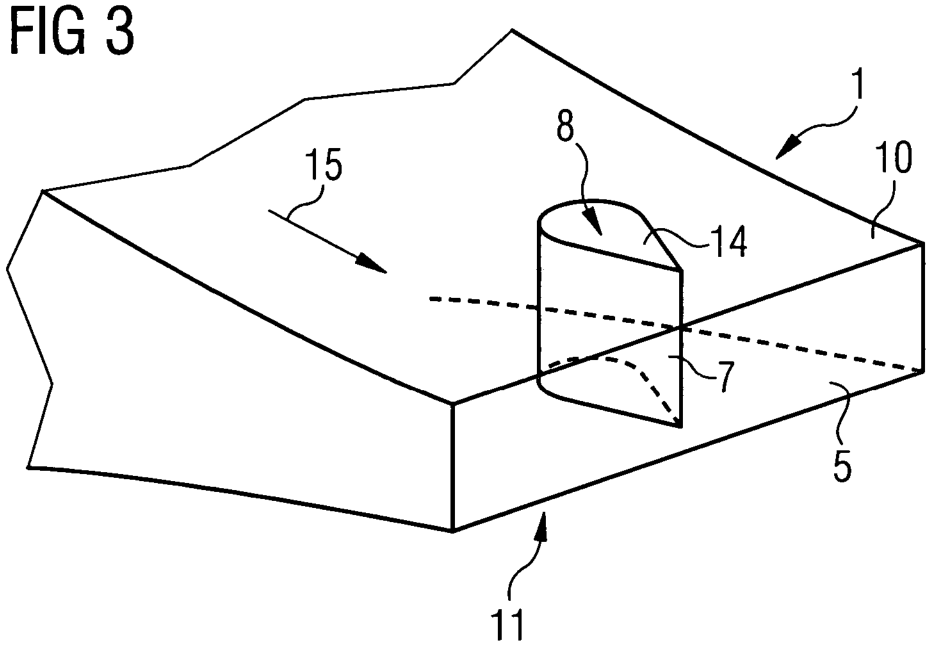


FIG 4

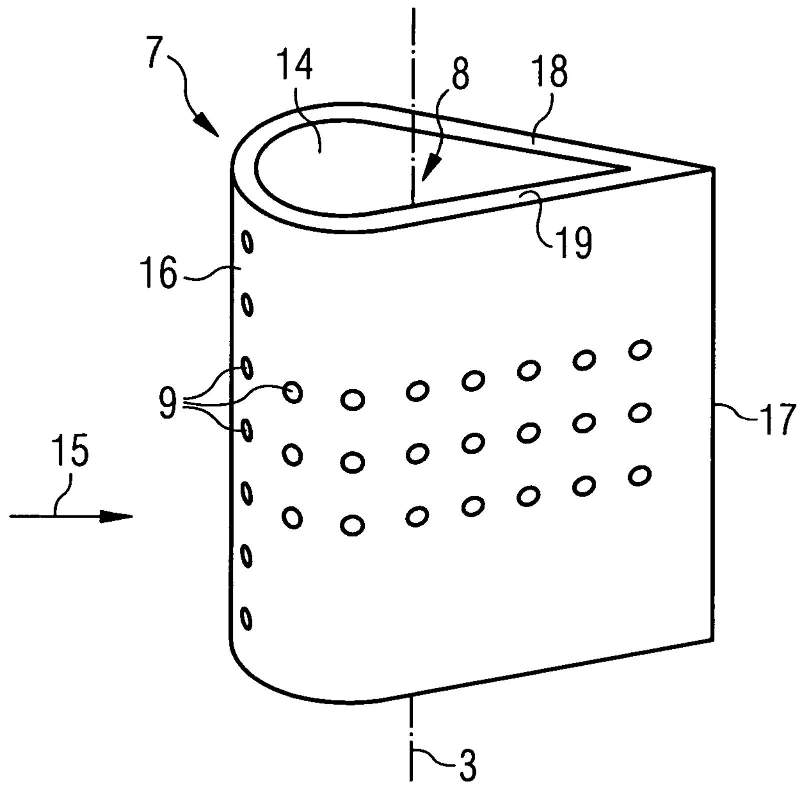
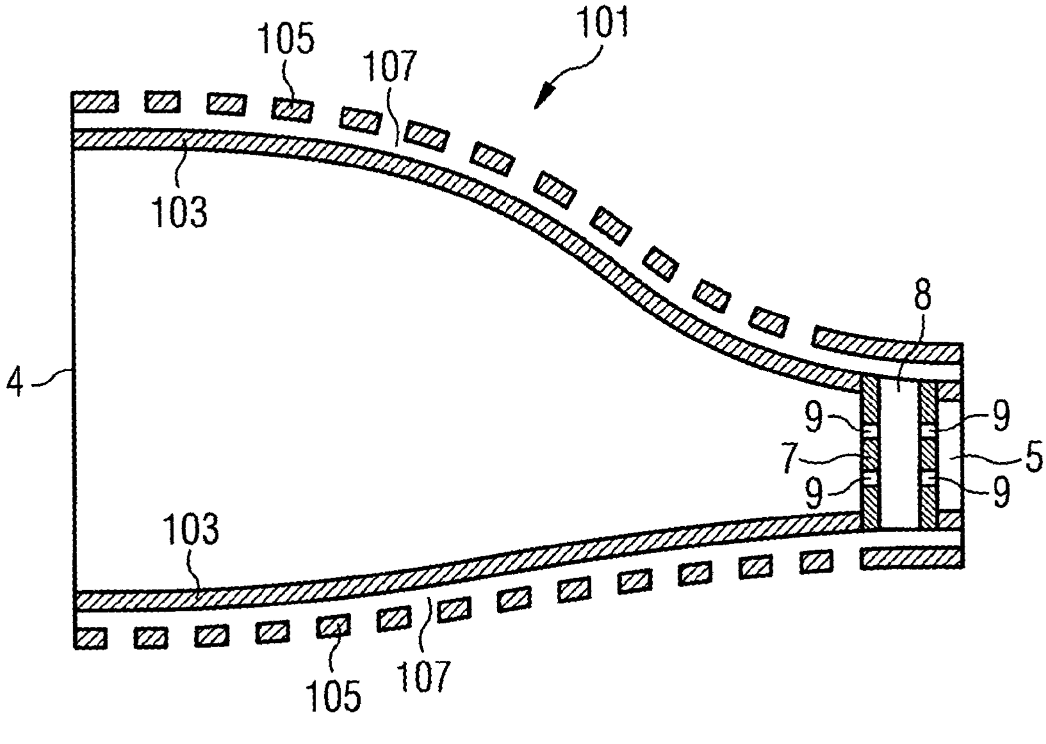


FIG 5



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EUROPEAN SEARCH REPORT

Application Number
EP 07 01 6387

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	US 2005/084657 A1 (OHARA MINORU [JP]) 21 April 2005 (2005-04-21) * page 1, paragraphs 5,6 * * figure 4 *	9	
A	US 4 719 748 A (DAVIS JR LEWIS B [US] ET AL) 19 January 1988 (1988-01-19) * column 8, lines 58-67 * * figure 3a *	1-10	TECHNICAL FIELDS SEARCHED (IPC) F01D F23R
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	26 March 2008	Souris, Christophe

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
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document

6
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 01 6387

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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