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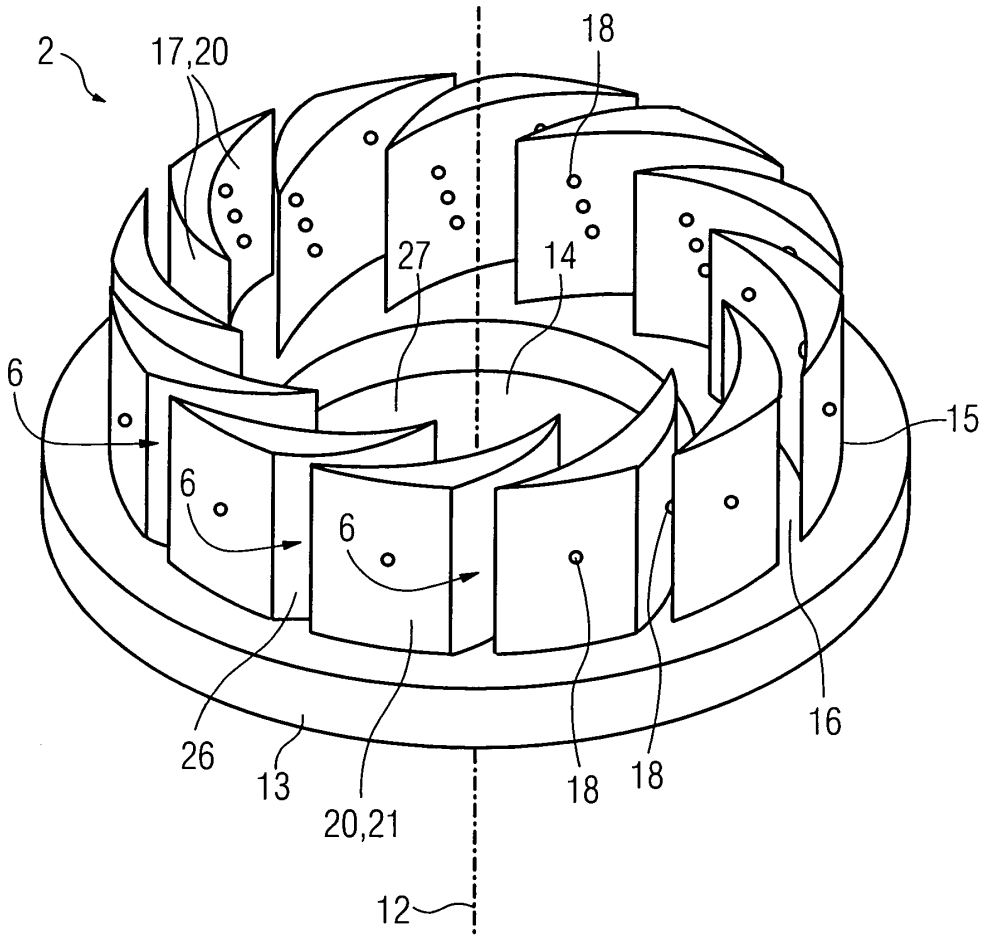
(54) **Swirler vane**

(57) Disclosed is a swirler vane (15) for mixing fuel and air, with a through hole (19) connecting at least two surfaces (20) of the swirler vane (15) for providing a connecting path for a fuel/air mixture (7) to pass from a high pressure side of the swirler vane (15) to a low pressure side.

FIG 8



EP 1 995 521 A1

Description

Field of the Invention

[0001] The invention relates to a swirler vane and a swirler, in particular for a gas turbine engine.

BACKGROUND OF THE INVENTION

[0002] Air pollution is a worldwide concern and many countries have enacted stricter laws further limiting the emission of pollutants from gas turbine engines or offer fiscal or other benefits for environmentally sound installations. Although the prior techniques for reducing the emissions of NO_x from gas turbine engines are steps in the right direction, the need for additional improvements remains.

[0003] There are two main measures by which reduction of the temperature of the combustion flame can be achieved. The first is to use a fine distribution of fuel in the air, generating a fuel/air mixture with a low fuel fraction. The thermal mass of the excess air present in the reaction zone of a lean premixed combustor absorbs heat and limits the temperature rise of the products of combustion to a level where thermal NO_x is not excessively formed. The second measure is to provide a thorough mixing of fuel and air prior to combustion. The better the mixing, the fewer regions exist where the fuel concentration is significantly higher than average, the fewer the regions reaching higher temperatures than average, the lower the fraction of thermal NO_x will be.

[0004] Usually the premixing of fuel and air in a gas turbine engine takes place by injecting fuel into an air stream in a swirling zone of a combustor which is located upstream from the combustion zone. The swirling produces a mixing of fuel and air before the mixture enters the combustion zone.

[0005] Figure 2 shows a prior art swirler of a gas turbine engine, comprising a plurality of swirler vanes disposed about a central axis and arranged on a swirler vane support with a central opening. The swirler vanes can be fixed to a burner head (not shown) with their sides showing away from the swirler vane support. Swirler passages are defined and delimited by opposing side faces of swirler vanes, by the surface of the swirler vane support which shows to the burner head and by a surface of the burner head to which the swirler vanes are fixed. Compressor air flows into these passages and starts mixing with fuel which is added through fuel injection openings (not shown). Further downstream, the fuel/air mixture enters the combustion zone with a swirling motion about the central axis of the swirler and is ignited by the heat of the combustion gases.

SUMMARY OF THE INVENTION

[0006] An object of the invention is to provide an improved swirler vane, in particular for a swirler in a gas turbine engine, which is advantageous in providing a homogeneous fuel/air mixture.

[0007] This objective is achieved by a swirler vane according to claim 1. The dependent claims describe advantageous developments and modifications of the invention.

[0008] An inventive swirler vane comprises a through hole connecting at least two surfaces of the swirler vane.

[0009] Advantageously, the respective openings of the through hole are positioned on the respective side faces of the swirler vane. The pressure gradients between swirler passages allow the fuel to pass from the high pressure to the low pressure sides of the swirler vanes and therefore provide a more even fuel distribution and an increased level of premix by cross flow between swirler passages which reduces the fraction of nitrous oxide in the exhaust gases of a gas turbine engine.

[0010] Although, for manufacturing reasons, it is advantageous if the through hole is tube-shaped, the invention may be implemented with other shapes.

[0011] The preferred location of the openings is at a height of between 10% and 90% of a swirler vane height.

[0012] The homogeneity of the fuel/air mixture over the cross sectional area of a swirler passage can be advantageously increased when respective openings are arranged at different swirler vane heights.

[0013] A further improvement is achieved by more than only one through hole per swirler vane.

[0014] The fuel injection system may either be a liquid fuel injection system or a gaseous fuel injection system. The main outlet opening can be provided with turbulence elements, in particular if it is driven with gaseous fuel. Those elements may be present on the circumference of the openings and may e.g. comprise triangular cuts on the circumference. The turbulence enhancing features provide additional mixing and direction of a gaseous fuel/air mixture leaving the through hole.

[0015] Openings arranged on the side faces of swirler vanes do not necessarily need to be arranged at the same radius about the central axis of the swirler vane support. The invention may be implemented with openings having different distances to a central opening of the swirler vane support.

[0016] By such a swirler vane the formation of hot spots, which are the main areas of nitrous oxide formation, is reduced. As a consequence, reduction of the number of hot spots reduces the emission of nitrous oxides from the burner.

[0017] Further features, properties and advantages of the present invention will become clear from the following description of embodiments of the invention in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The invention will now be further described with reference to the accompanying drawings in which:

Figure 1 schematically shows a section through a burner of a combustion chamber assembly,
Figure 2 shows a perspective view of a prior art swirler shown in Figure 1,
Figure 3 shows a side view of an inventive swirler vane,
Figure 4 shows a cut through the swirler vane of Figure 3,
Figure 5 shows a cut through an alternative embodiment of the inventive swirler vane,
Figure 6 shows a cut through the swirler vane of Figure 3,
Figure 7 shows a cut through an alternative embodiment of the inventive swirler vane, and
Figure 8 shows a perspective view of a swirler with inventive swirler vanes.

[0019] In the drawings like references identify like or equivalent parts.

DETAILED DESCRIPTION OF THE INVENTION

[0020] Figure 1 illustrates a longitudinal section through a combustor. The combustor comprises relative to a flow direction: a burner with swirler 2 and a burnerhead 1 attached to the swirler 2, a transition piece referred to as combustion pre-chamber 3 and a main combustion chamber 4. The main chamber 4 has a diameter being larger than the diameter of the pre-chamber 3. The combustion chamber 4 is connected to the pre-chamber 3 via a dome portion 10 comprising a dome plate 11. In general, the transition piece 3 may be implemented as a one part continuation of the burner head 1 towards the main chamber 4, as a one part continuation of the main chamber 4 towards the burner head 1, or as a separate part between the burner head 1 and the main chamber 4. The burner head 1 and the main chamber 4 assembly show rotational symmetry about a longitudinally central axis 12.

[0021] A fuel conduit 5 is provided for leading fuel to the burner which is to be mixed with in-streaming air in the swirler 2. The fuel/air mixture 7 is then guided towards the primary combustion zone 9 where it is burnt to form hot, pressurised exhaust gases streaming in a direction 8 indicated by arrows to a turbine of the gas turbine engine (not shown).

[0022] A perspective view of a prior art swirler 2 is shown in Figure 2. The swirler comprises a ring-shaped swirler vane support 13 with a central opening 14. Six swirler vanes 15 with pie slice shape are disposed about the central axis 12 and arranged on the swirler vane support 13. The swirler vanes 15 can be fixed to the burner head (see Figure 1) with their sides showing away from the swirler vane support 13. Swirler passages 16 are defined and delimited by opposing side faces 17 of swirler vanes 15, by the surface of the swirler vane support 13 which shows to the burner head and by a surface of the burner head to which the swirler vanes 15 are fixed. Compressor air 6 flows into these swirler passages 16 and starts mixing with fuel which is added through fuel injection openings (not shown).

[0023] Figure 3 schematically shows a side view of an isolated inventive swirler vane 15 arranged on a swirler vane support 13. The surface 20 of the swirler vane 15 shown is a side face 17 with openings 18 of through holes 19. On the left is the edge of the outer surface 21 of the swirler vane 15. Compressor air 6 inflow is from this side and compressor air 6 flows along the surface 20 of the swirler vane 15 as indicated by the arrow.

[0024] The opening 18 on the right of Figure 3 comprises additional turbulence elements 22 for causing a turbulence of a fuel/air mixture guided through the through hole 19. These elements 22 comprise triangular cuts 23 on the circumference of the opening 18.

[0025] Figure 4 shows a cut through the swirler vane 15 of Figure 3, with swirler passages 16 delimited by the swirler vane support 13 and by side faces 17 of the swirler vane 15. Here, the through hole 19, connecting two surfaces 20 of the swirler vane 15, can be seen more clearly. The through hole 19 can be straight and horizontal, as shown here, or inclined, as shown in Figure 5, or curved (not shown) when using, for example, different production methods. The preferred location of the openings 18 is at a height of between 10% and 90% of the swirler vane height.

[0026] Figures 6 and 7 show alternative embodiments of the inventive swirler vane 15 with through holes 19 not being tangential to a circle about the central axis 12 of the swirler 2, but with openings 18 of a through hole 19, the openings arranged at different radii 24, 25 about the central axis 12.

[0027] Referring to Figure 8 a perspective view of a swirler 2 with inventive swirler vanes 15 is shown. Twelve swirler vanes 15 are disposed about a central axis 12 and arranged on a swirler vane support 13. The top face of the swirler vanes 15 according to the orientation of the swirler vanes 15 as shown in Figure 8 would be connected to the burner head. Figure 8 shows an embodiment of the inventive swirler vanes 15 with openings 18 arranged on the side faces 17 as well as on curved outer surfaces 21 of the swirler vanes 15.

[0028] In operation, compressor air 6 is introduced through a plenum (not shown) and flows through the swirler passages 16 with a pressure gradient from the accelerating flow towards the central opening 14 of the swirler vane support 13. The curvature of the swirler vanes 15 in Figure 8 from an inlet 26 of the swirler passage 16 to an outlet 27 of the swirler passage 16 which gradually is turning the flow, whereas in Figure 2, there is a straight but staggered swirler passage 16, giving rise to a more sudden deflection of fuel and air. In the swirler passage 16, the pressure gradient generates a rotating flow, with a cork screw like appearance, as the flow moves from the outside towards the central opening 14 of the swirler 2. If, for example due to manufacturing constraints, the fuel injection distribution amongst the swirler

passages 16 is disproportionate, a pressure gradient in the through holes 19 between swirler passages 16 allows the fuel to pass from the high pressure side to the low pressure side of a swirler vane 15 to more evenly distribute the fuel. Some fraction of the compressor air enters the swirler passages 16 via through holes 19 with openings 18 arranged on curved outer surfaces 21 of the swirler vanes 15 and with openings 20 arranged on side faces 17 of the swirler vanes 15, thus creating additional turbulence in the swirler passages 16 which in turn further improves the mixing of fuel and air.

[0029] The fuel/air mixture 7 then leaves the swirler passages 16 and streams through a central opening 14 of the swirler vane support 13 into the pre-chamber 3 (see Figure 1). From the pre-chamber 3 the fuel/air mixture 7 streams into the combustion zone 9 of the main chamber 4 where it is burned.

[0030] Although the swirler 2 of the present embodiment has twelve swirler vanes 15, the invention may be implemented with a swirler 2 having a different number of swirler vanes 15, which may either be higher or lower than in the described embodiment. The side faces 17 of the swirler vanes 15 may be curved, as shown in Figure 8, or straight, as shown in Figure 2.

Claims

1. A swirler vane (15) for mixing fuel and air, comprising a through hole (19) connecting at least two surfaces (20) of the swirler vane (15) for providing a connecting path for a fuel/air mixture (7) to pass from a high pressure side of the swirler vane (15) to a low pressure side.

2. The swirler vane (15) as claimed in claim 1, wherein the at least one through hole (19) is tube-shaped.

3. The swirler vane (15) as claimed in claim 1 or claim 2, wherein the through hole (19) is arranged at a height of between 10% and 90% of a swirler vane height.

4. The swirler vane (15) as claimed in claims 1 to 3, wherein the through hole (19) has a horizontal orientation relative to a swirler vane support (13).

5. The swirler vane (15) as claimed in claims 1 to 3, wherein the through hole (19) has an inclined orientation relative to a swirler vane support (13).

6. The swirler vane (15) as claimed in claims 1 to 5, wherein the swirler vane (15) is shaped as a pie slice.

7. The swirler vane (15) as claimed in claims 1 to 6, wherein the through hole (19) is sized and configured to guide liquid fuel and air.

8. The swirler vane (15) as claimed in claims 1 to 6, wherein the through hole (19) is sized and configured to guide gaseous fuel and air.

9. The swirler vane (15) as claimed in claims 1 to 8, wherein at least one opening (18) of the through hole comprises a turbulence element (22) for causing a turbulence of a fuel/air mixture (7) guided through the through hole (19).

10. The swirler vane (15) as claimed in claim 9, wherein the turbulence element (22) comprises triangular cuts (23) on the circumference of the opening (18).

11. A swirler (2), comprising a plurality of swirler vanes (15) as claimed in any of the preceding claims.

12. The swirler (2) as claimed in claim 11, wherein the openings (18) of through hole (19) are arranged at different radii (24,25) about a central axis (12) of the swirler (2).

13. A burner, comprising a swirler (2) as claimed in claim 11 or claim 12.

FIG 1

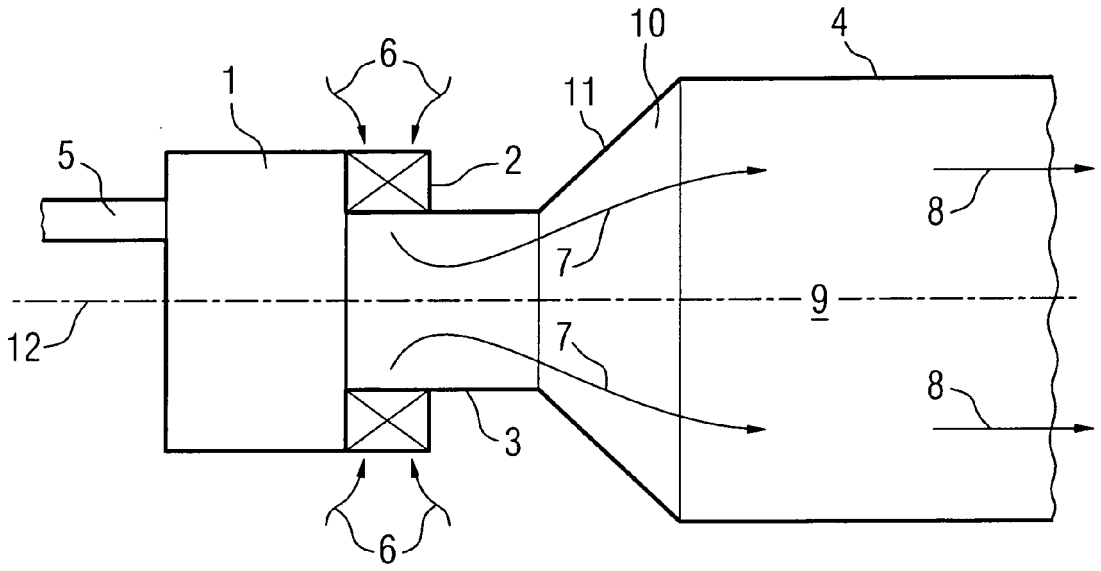


FIG 2
(PRIOR ART)

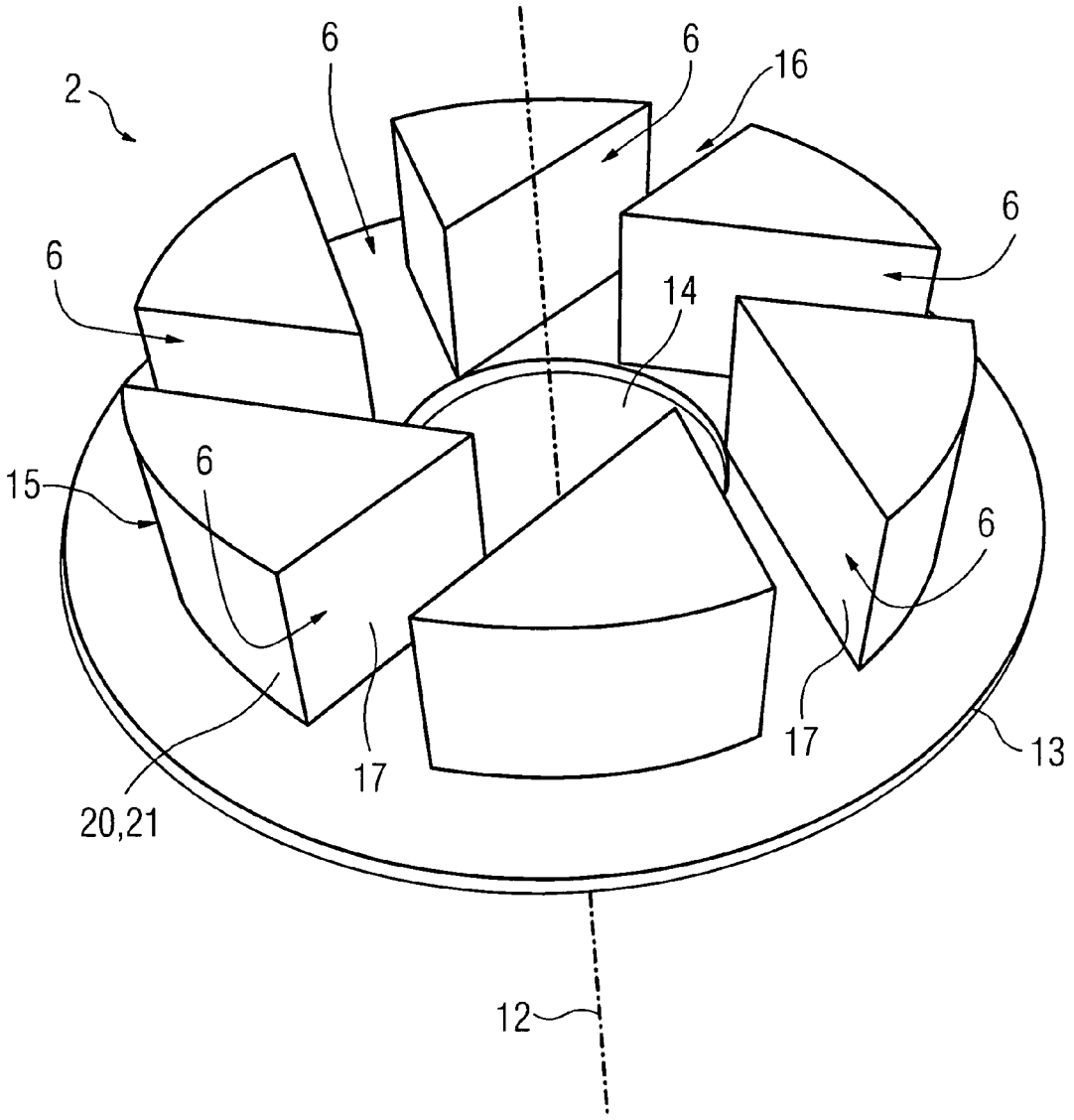


FIG 3

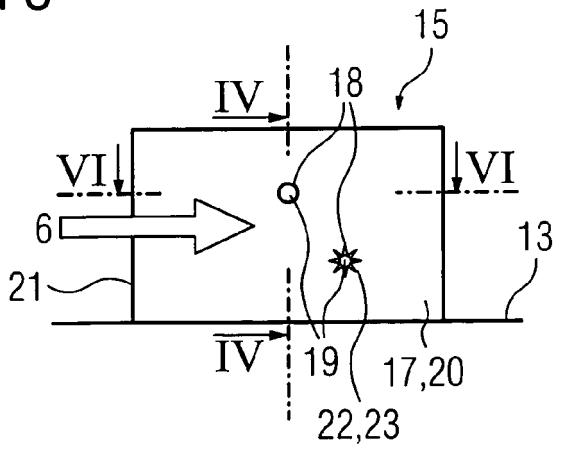


FIG 4

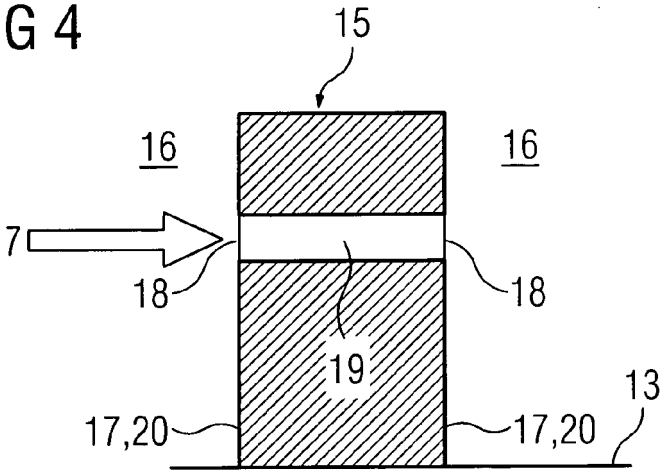


FIG 5

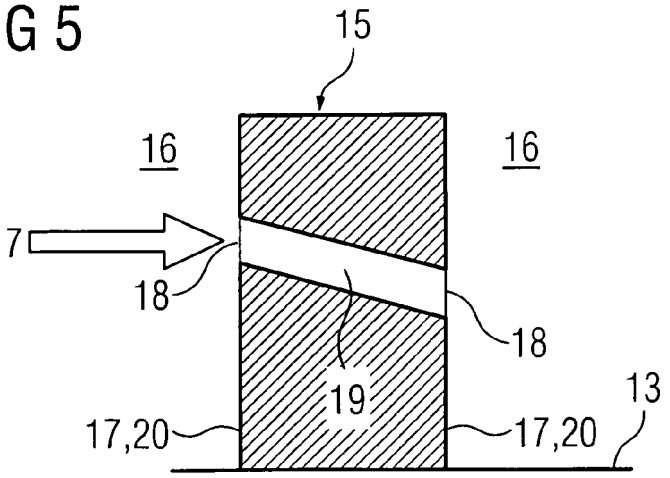


FIG 6

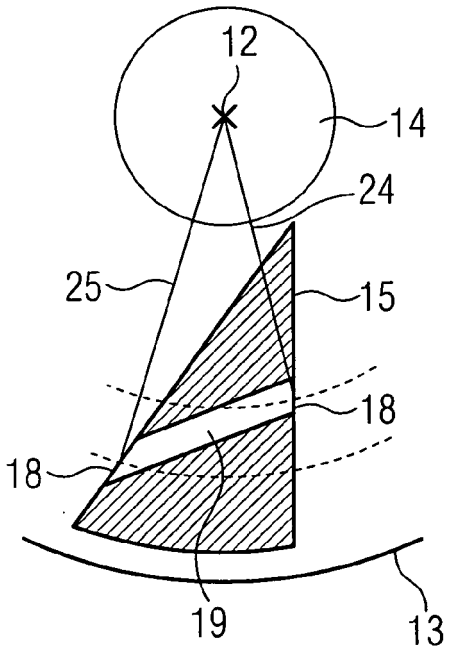


FIG 7

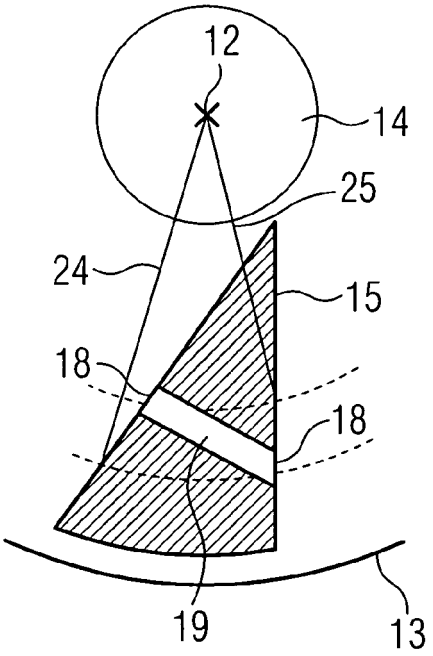
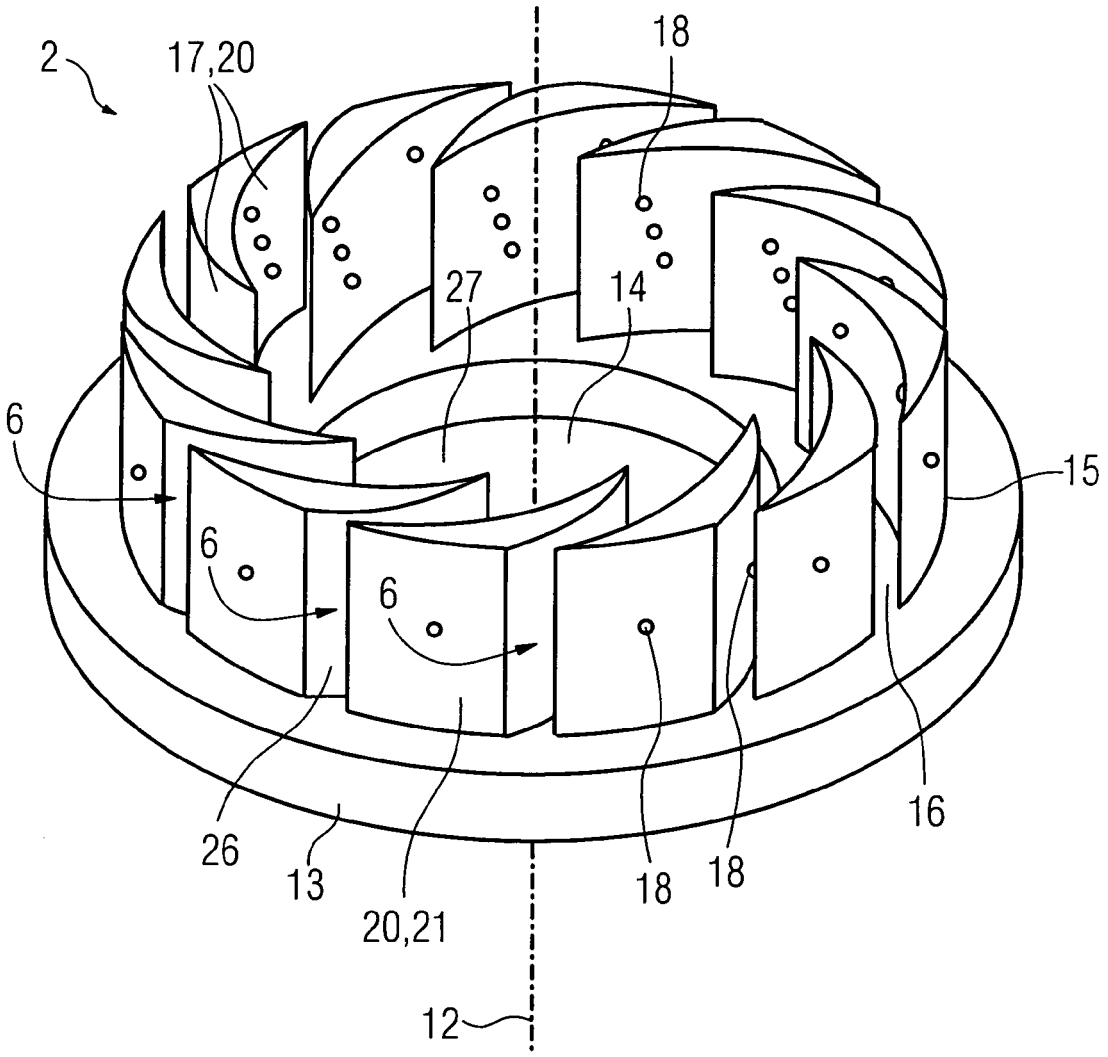


FIG 8



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EUROPEAN SEARCH REPORT

Application Number
EP 07 01 0376

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 0 828 115 A (SNECMA [FR] SNECMA MOTEURS [FR]) 11 March 1998 (1998-03-11) * column 2, line 56 - column 3, line 48 * * figures 4-6 * -----	1,2,4,6, 11,13	INV. F23R3/14 F23R3/28 F23C7/00 F23D11/38
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TECHNICAL FIELDS SEARCHED (IPC)

F23R
F23C
F23D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	24 October 2007	Gavriliu, Costin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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