(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 992 878 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
19.11.2008 Bulletin 2008/47

(51) Int Cl.:
F23R 3/14 *(2006.01)* ***F23R 3/34*** *(2006.01)*
F23C 7/00 *(2006.01)* ***F23D 11/38*** *(2006.01)*

(21) Application number: **07009960.1**

(22) Date of filing: **18.05.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

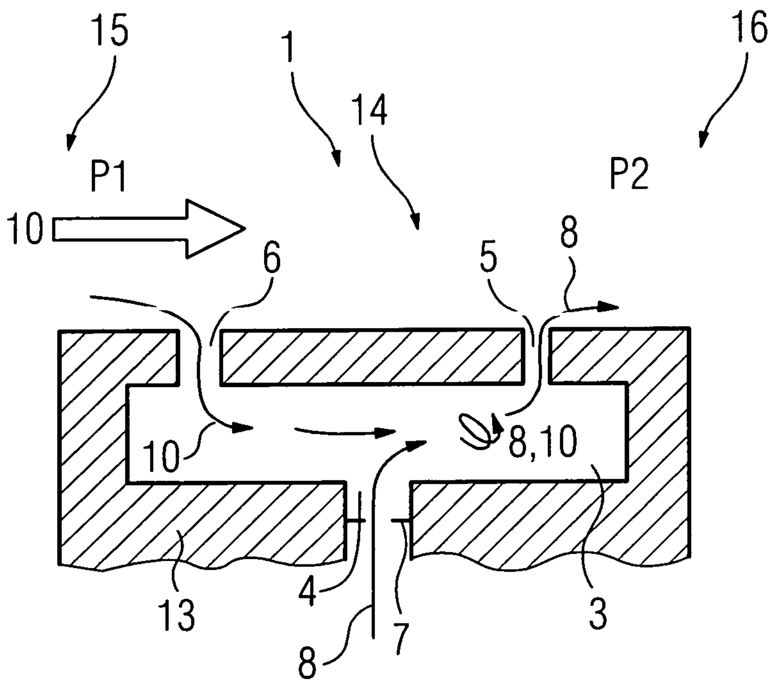
(71) Applicant: **SIEMENS AKTIENGESELLSCHAFT**
80333 München (DE)

(72) Inventors:
- **Headland, Paul**
LN1 1NA Lincoln (GB)
- **Noden, Richard**
TS8 0BB Maltby,
Cleveland (GB)

(54) Fuel distributor

(57) Disclosed is a fuel distributor (1) with a distribution element (18) defining a cavity (3, an inlet opening (4) arranged in the distribution element (18), at least one outlet opening (5) arranged in the distribution element (18); and at least one third opening (6) arranged in the distribution element (18), the cross-section of the at least one third opening (6) being larger than the cross-section of the at least one outlet opening (5).

FIG 4



EP 1 992 878 A1

Description

Field of the Invention

[0001] The invention relates to a fuel distributor, in particular for a burner and a swirler.

BACKGROUND OF THE INVENTION

[0002] The main purpose of the burner is to mix fuel and air together to obtain stable and efficient combustion with good flame stability and the smallest possible amount of NOx emissions. Therefore, the burner design must ensure that the proper amounts of fuel and air are introduced in the right locations within the burner and that these amounts of fuel and air are thoroughly mixed, so that complete combustion takes place with a minimum amount of excess air in order to achieve optimum overall efficiency.

[0003] The two burner principles, which could be combined to use their respective advantages, are the premix combustion burner and the diffusion flame burner.

[0004] In the premix combustion burner, the air, required for combustion, is mixed with the burner fuel before delivery to the combustion zone. The better the mixing of fuel and air the less hot zones with a fuel/air ratio exceeding the stoichiometric requirements exist. Since flame temperature is the dominant factor driving NOx production it follows that the more fuel lean the mixture, the lower the NOx produced.

[0005] In the diffusion flame burner, the fuel is not mixed with the air ahead of the combustion zone, but delivered as pure fuel in the immediate vicinity of the combustion zone. Diffusion flame burners provide good flame stability. The NOx production is relatively high.

[0006] Low emission gas turbine engines often use a combustor with two operating modes including a pilot nozzle that forms a diffusion flame and a plurality of main nozzles for discharging a fuel/air mixture to form premixed flames as the main combustion around the diffusion flame. The US 5,901,555 describes a conventional gas turbine with the main burners divided into a plurality of groups in accordance with the load. The flow rate of the pilot fuel is increased when the gas turbine load is low, to achieve stable combustion. When the gas turbine load is high, the ratio of the pilot fuel is decreased, to decrease the amount of NOx. Separately controllable fuel lines, valves, pipe work and a control logic are required to achieve the appropriate fuel flows to the pilot and main nozzles, increasing the cost of the engine.

SUMMARY OF THE INVENTION

[0007] An object of the invention is to provide an improved fuel distributor.

[0008] This object is achieved by the claims. The dependent claims describe advantageous developments and modifications of the invention.

[0009] An inventive fuel distributor uses the pressure gradient across the combustion system to control the proportion of fuel provided to different areas of the combustion system. These areas could provide pilot fuel at low loads, or better mixing of the fuel and air at high loads.

[0010] The system comprises a cavity with an inlet opening and at least two fuel injection openings. The fuel distributor relies on having a larger injection opening arranged in the cavity of the fuel distributor in an upstream section, relative to the flow of compressor air, and a smaller injection opening arranged in the cavity in a downstream section, relative to the flow of compressor air, and serving as feed near combustor pressure.

[0011] In an advantageous embodiment of the invention a restrictor is arranged at the inlet opening to balance between the fuel flows through the at least one smaller outlet opening and the at least one larger third opening, respectively.

[0012] In a further advantageous embodiment, the restrictor is adjustable to adapt the pressure for different fuel types.

[0013] Since at low fuel pressure fuel basically leaves the distributor at the outlet opening that is exposed to the lowest external air pressure, it is advantageous to use this outlet opening as pilot fuel injection opening.

[0014] For the same reason, it is advantageous to use the third opening with a larger cross-sectional area and exposed to higher external air pressure as main fuel injection opening.

[0015] In an advantageous embodiment the principle of the fuel distributor is applied to a diffusion flame burner, where the fuel distributor has a tubular form with the outlet opening at the end of the tube facing the combustion chamber and with third openings arranged upstream the tube, relative to the flow of the fuel. At low fuel flows, the majority of the fuel will enter the combustion chamber through the outlet opening. Compressor air can enter the fuel distributor through the third openings and give some premixing of the fuel and the air. As the fuel flow increases, the pressure in the cavity increases and fuel will spill out through the third openings and will mix with compressor air and enter the combustion chamber.

[0016] In another advantageous embodiment, the principle of the fuel distributor is applied to a swirler. The cavity of the fuel distributor is arranged in the base plate of the swirler. The fuel openings and the third openings are arranged in the mixing ducts, that is, in the passages of the swirler. The openings may be arranged in the base plate of the swirler or in the swirler vanes. If arranged in the swirler vanes, the arrangement could be at different heights to improve the fuel distribution over the swirler vane height. Smaller fuel outlet openings would be closer to the swirler exit hole with lower pressure. Larger third openings would rather be in an upstream part of the swirler passages relative to the flow of compressor air, with higher pressure. The fuel outlet openings would serve as pilot and the third openings as main fuel injection openings.

[0017] In yet another advantageous embodiment, the pressure drop of the air between an outlet opening and a third opening in a mixing duct or a swirler passage is controlled by making the mixing duct or swirler passage convergent or divergent.

[0018] With such a design of the fuel distribution system emissions of NOx are reduced. The inventive fuel distributor provides an increasing level of premix as the fuel flow increases. The inventive fuel distributor even provides some premixing of fuel and air at low flows, thus further reducing NOx emissions. Furthermore, the fuel/air mixing within a premix duct like e.g. a swirler passage can be varied as the fuel flow changes without the use of control valves, thus reducing costs and increasing reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The invention will now be further described with reference to the accompanying drawings in which:

- Figure 1 represents an inventive diffusion flame burner at low fuel flow,
- Figure 2 represents an inventive diffusion flame burner at high fuel flow,
- Figure 3 represents a swirler,
- Figure 4 represents a fuel distributor arranged in a swirler base plate with openings in the swirler base plate at low fuel flow,
- Figure 5 represents a fuel distributor arranged in a swirler base plate with openings in the swirler base plate at high fuel flow,
- Figure 6 represents a fuel distributor arranged in a swirler base plate with openings in the side face of a swirler vane,
- Figure 7 shows a swirler vane corresponding to the fuel distributor of Figure 7,
- Figure 8 shows the percentage of mass flow through the fuel injection openings as a function of the fuel mass flow, and
- Figure 9 represents a fuel distributor arranged in a swirler base plate with openings in the side face of a swirler vane and converging swirler passage.

[0020] In the drawings like references identify like or equivalent parts.

DETAILED DESCRIPTION OF THE INVENTION

[0021] Figure 1 shows the scheme of the inventive fuel distributor 1 applied in a diffusion flame burner 2. The fuel distributor 1 comprises a distribution element 18 defining a cavity 3 with an inlet opening 4, an outlet opening 5, opposing the inlet opening 4, and two third openings 6. The third openings 6 are larger than the outlet opening 5. A restrictor 7 is arranged upstream the inlet opening 4 relative to the fuel flow 8, and sized to give the correct pressure to balance the fuel flows 8 between the outlet opening 5 and the third openings 6. Pressure P1 at the third openings 6 is greater than pressure P2 at the outlet opening 5. At low fuel flows 8, the majority of the fuel 8 will enter the combustion chamber 9 through the outlet opening 5. If the fuel flow 8 is low enough, air 10 may enter the cavity 3 through third openings 6 and give some premixing of the fuel 8 and air 10. As the fuel flow 8 increases, the pressure in the cavity 3 increases. When the pressure in the cavity 3 is higher than P1, fuel 8 will spill out of the third openings 6, as shown in Figure 2, and mix with air 10. The fuel/air premix will then enter the combustion chamber 9.

[0022] Referring to Figure 3 a swirler 11 for a gas turbine engine is shown. The swirler 11 comprises swirler vanes 12 arranged on a swirler vane support 13. The swirler vanes 12 can be fixed to a burner head (not shown) with their sides showing away from the swirler vane support 13. Between neighbouring swirler vanes 12 swirler passages 14 are formed. The swirler passages 14 extend between a swirler passage inlet opening 15 and a swirler passage outlet opening 16. The swirler passages 14 are delimited by opposing side faces 16 of swirler vanes 12, by the surface of the swirler vane support 13 which shows to the burner head (not shown) and by a surface of the burner head to which the swirler vanes 12 are fixed. Outlet openings 5 and third openings 6 are arranged in the swirler passages 14 in the swirler vane support 13.

[0023] Referring to Figures 4 and 5 a cross-sectional view of an inventive fuel distributor 1 arranged in a swirler vane support 13 is shown. The outlet opening 5 and the third opening 6 open out into a swirler passage 14. Compressor air 10 is entering the swirler passage 14 from the left by the swirler passage inlet opening 15, where the pressure P1 exceeds the pressure P2 at the swirler passage outlet opening 16. Figure 4 shows the fuel distributor at low loads. Fuel 8 enters the cavity 3 of the fuel distributor 1 by the inlet opening 4 through the restrictor 7. A predominant proportion of the fuel 8 enters the swirler passage 14 through the outlet opening 5. Only a small amount of fuel 8 enters the swirler passage 14 through the third opening 6. This is beneficial for providing pilot fuel to the outlet opening 5. At very low load a part of the compressor air 10 entering the swirler passage 14 flows into the cavity 3 through the third opening 6, leading to some premixing in the cavity 3.

[0024] At high loads the proportion of fuel 8 entering the swirler passage 14 through the third opening 6 is increased, as shown in Figure 5. The fuel pressure in the cavity 3 overcomes the pressure at the swirler passage inlet opening 15 and fuel 8 spills out into the swirler passage 14 mainly through the third opening 6 with the larger cross-sectional area.

[0025] Figures 6 and 7 show an alternative arrangement where the distribution of the fuel flow 8 across the height of the swirler passage 14 could be varied. The cavity 3 of the fuel distributor 1 is again arranged in the swirler vane support 13. The outlet opening 5 and the third opening 6 are arranged at different heights of the swirler vane 12 in the swirler passage 14. Again, the outlet opening 5 has a smaller cross-sectional area and is arranged close to the swirler passage outlet opening 16, where the pressure is low and the third opening 6 has a larger cross-sectional area and is arranged close to the swirler passage inlet opening 15, where the pressure is higher than at the swirler passage outlet opening 16.

[0026] Referring to Figure 8 the percentage of fuel mass flow through the outlet opening 5 and the third opening 6 as a function of the total fuel mass flow is shown. At low load, i.e. at low mass flow, fuel mainly flows through the outlet opening 5. The higher the fuel mass flow the higher the percentage of fuel flowing through the third opening 6.

[0027] Figure 9 shows a further embodiment of the inventive fuel distributor 1. The general layout is similar to the embodiment described in Figure 6. The pressure drop of the air 10 in the swirler passage 14 between the outlet opening 5 and the third opening 6 is varied by making the swirler passage 14 convergent (as shown in Figure 9) or divergent (not shown).

Claims

1. A fuel distributor (1), comprising:

a distribution element (18) defining a cavity (3);
an inlet opening (4) arranged in the distribution element (18);
at least one outlet opening (5) arranged in the distribution element (18); and
at least one third opening (6) arranged in the distribution element (18), the cross-section of the at least one third opening (6) being larger than the cross-section of the at least one outlet opening (5).

2. The fuel distributor (1) as claimed in claim 1, wherein a restrictor (7) is arranged upstream the inlet opening (4), relative to the fuel flow (8), the restrictor (7) being sized and configured to balance between the fuel flows (8) through the at least one outlet opening (5) and the at least one third opening (6), respectively.

3. The fuel distributor (1) as claimed in claim 2, wherein the restrictor (7) is adjustable.

4. The fuel distributor (1) as claimed any of the preceding claims, wherein the at least one outlet opening (5) is a pilot fuel injection opening.

5. The fuel distributor (1) as claimed in any of the preceding claims, wherein the at least one third opening (6) is a main fuel injection opening.

6. A diffusion flame burner (2), comprising a fuel distributor (1) as claimed in any of the preceding claims.

7. A swirler (11), comprising:

a swirler vane support (13);
a plurality of swirler vanes (12) arranged on the swirler vane support (13);
a plurality of swirler passages (14) formed by the swirler vanes (12) and the swirler vane support (13); and
a plurality of fuel distributors (1) as claimed in any of claims 1 to 5, wherein the cavities (3) are arranged in the swirler vane support (13).

8. A swirler (11) as claimed in claim 7, wherein the outlet openings (5) and the third openings (6) are arranged in the swirler passages (14).

9. A swirler (11) as claimed in claim 7 or claim 8, wherein the outlet openings (4) are arranged at a downstream end of the swirler passages (14) relative to the flow of compressor air (10).

10. A swirler (11) as claimed in any of the claims 7 to 9, wherein the third openings (6) are arranged at an upstream end of the swirler passages (14) relative to the flow of compressor air (10).

11. A swirler (11) as claimed in any of the claims 7 to 10, wherein the outlet openings (5) and the third openings (6) are arranged in the swirler vanes support (13).

12. A swirler (11) as claimed in any of the claims 7 to 10, wherein the outlet openings (5) and the third openings (6) are arranged in the swirler vanes (12).

13. A swirler (11) as claimed in claim 12, wherein the outlet openings (5) and the third openings (6) are arranged at different heights of the swirler vanes (12).

14. A swirler (11) as claimed in any of claims 7 to 13, wherein a cross-sectional area of the swirler passages (14) increases in a downstream direction relative to the flow of compressor air (10).

15. A swirler (11) as claimed in any of claims 7 to 13, wherein a cross-sectional area of the swirler passages (14) decreases in a downstream direction relative to the flow of compressor air (10).

FIG 1

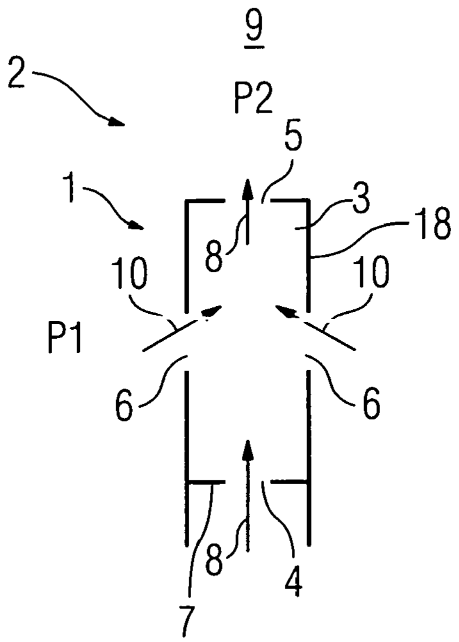


FIG 2

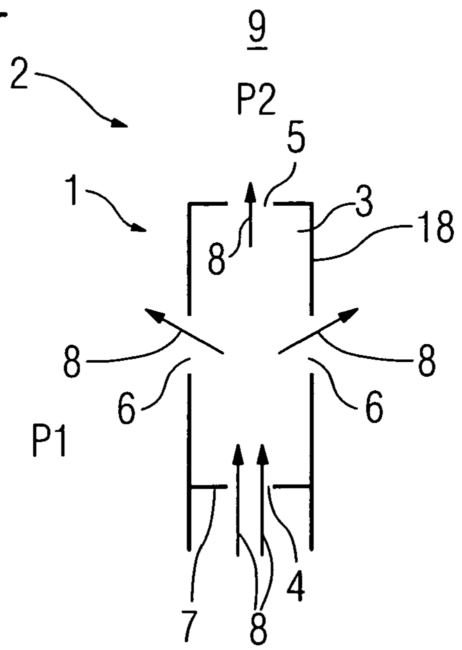


FIG 3

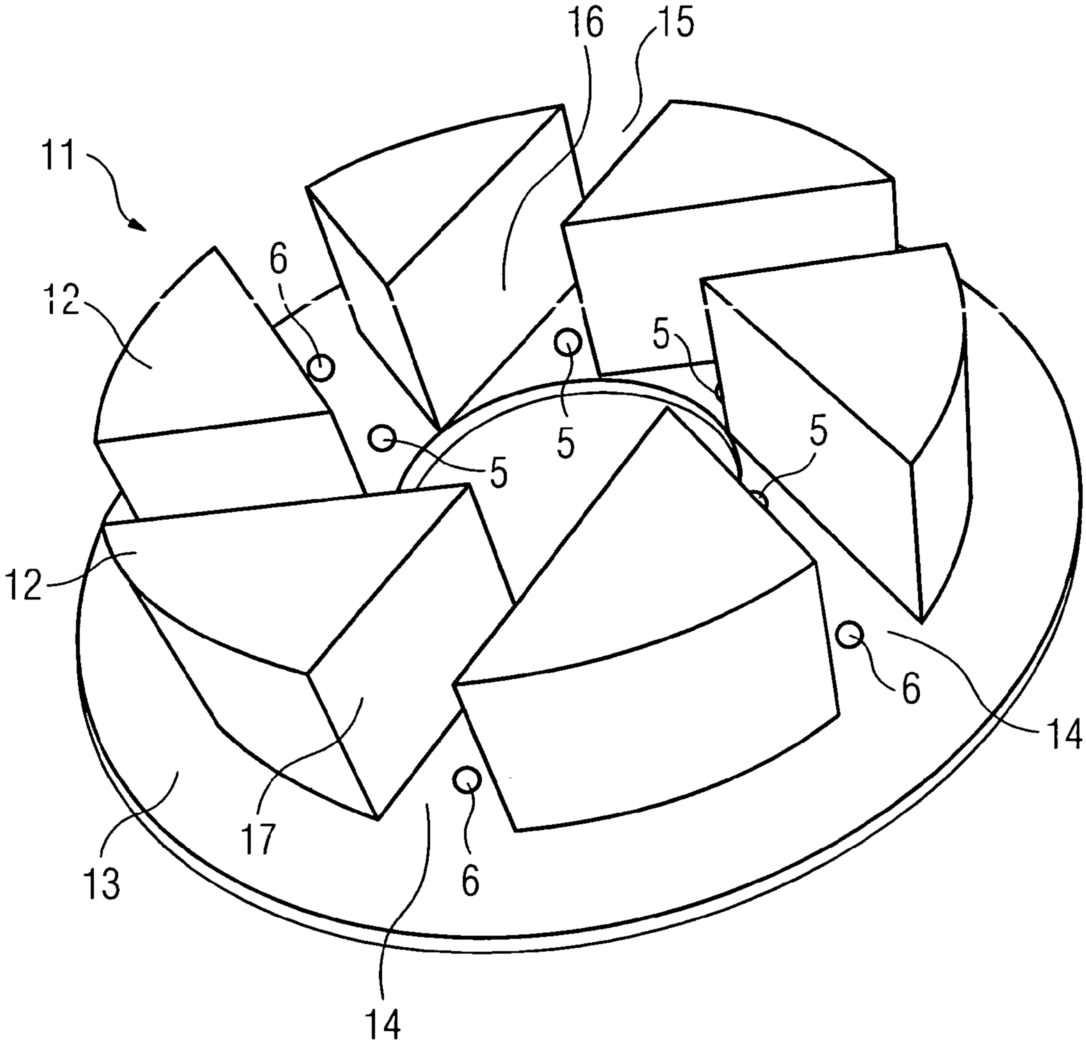


FIG 4

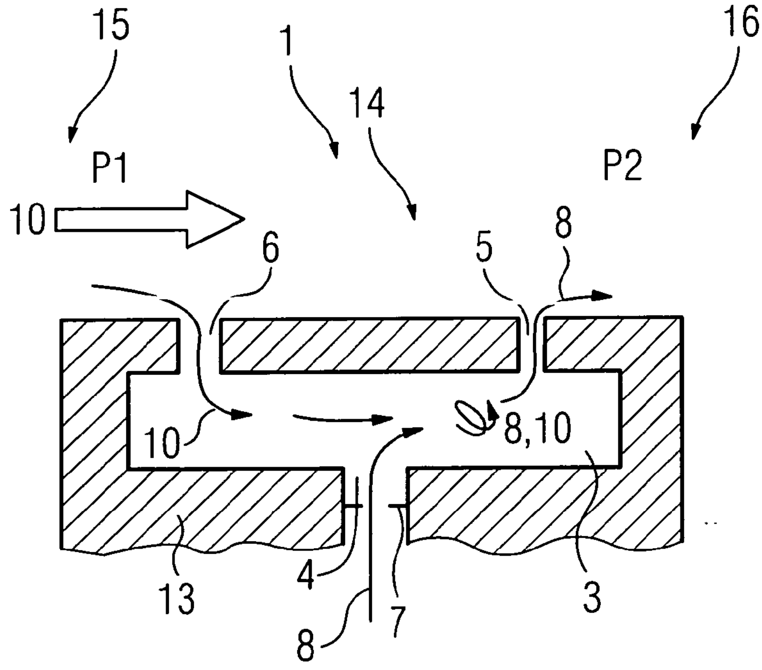

15
1
14
16
P1
P2
10
6
5
8
10
8,10
13
4
8
7
3

FIG 5

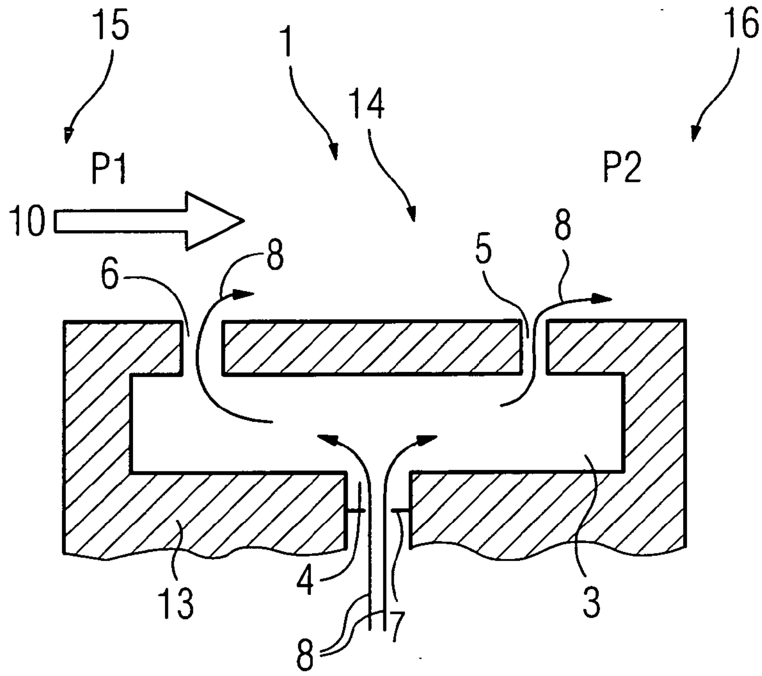

15
1
14
16
P1
P2
10
6
8
5
8
13
4
8
7
3

FIG 6

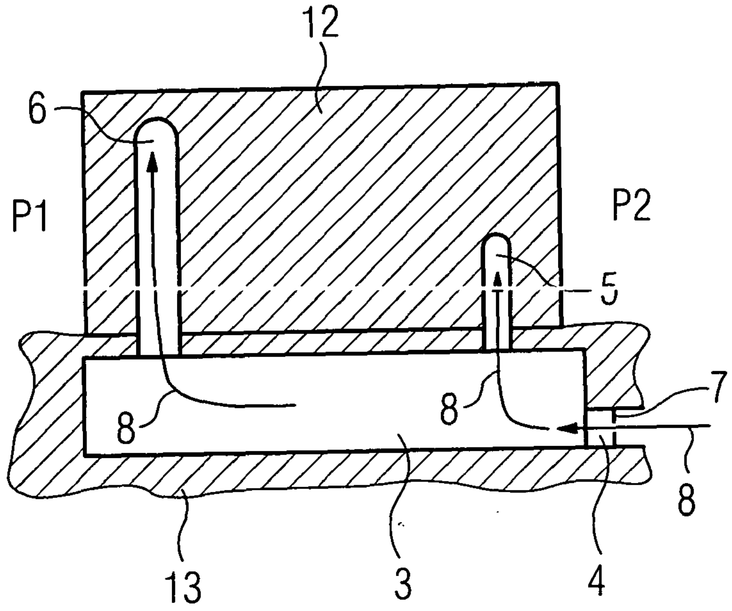


FIG 7

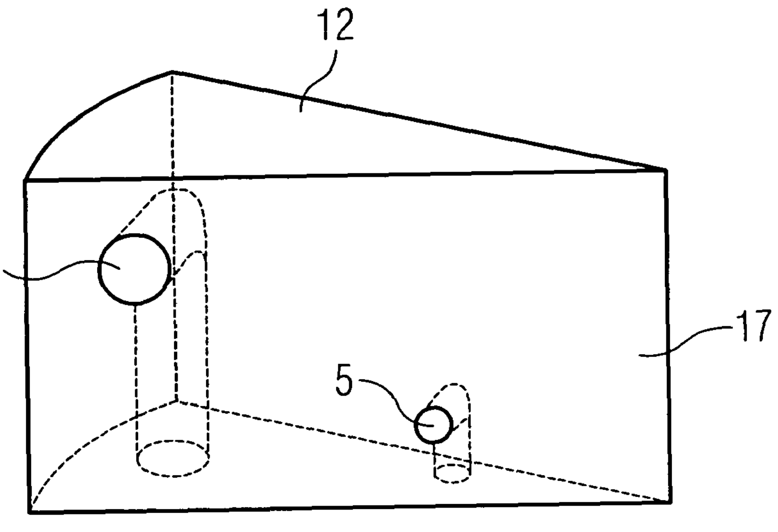


FIG 8

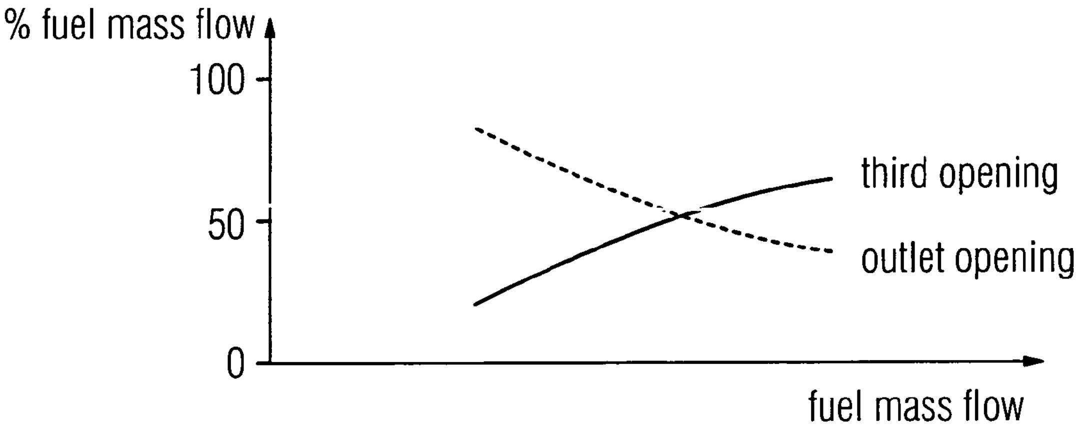
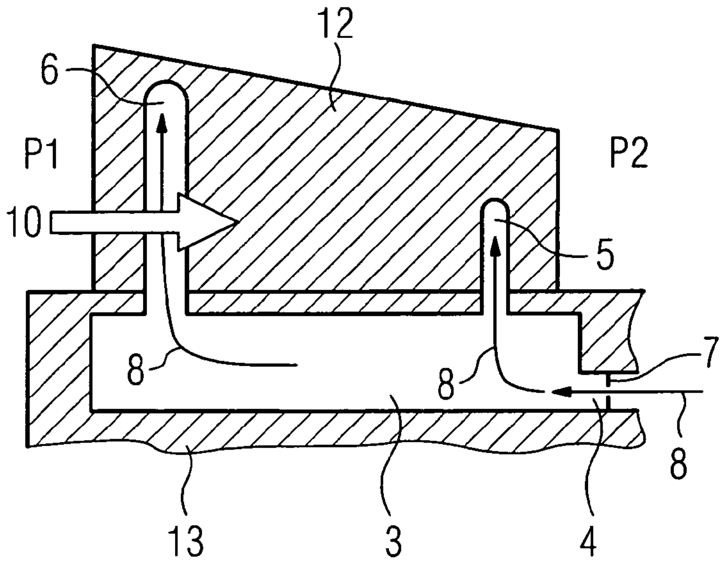

% fuel mass flow
100
50
0
third opening
outlet opening
fuel mass flow

FIG 9


12
6
P1
P2
10
5
7
8
8
8
13
3
4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 00 9960

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 0 870 989 A2 (EUROP GAS TURBINES LTD [GB]) 14 October 1998 (1998-10-14) * column 1, line 11 - line 37 * * column 2, line 44 - column 3, line 23 * * column 4, line 46 - column 5, line 1 * * figures 1-3,5(a),5(b) * -----	1,4-8, 12,15	INV. F23R3/14 F23R3/34 F23C7/00 F23D11/38
X	EP 0 936 406 A2 (GEN ELECTRIC [US]) 18 August 1999 (1999-08-18) * column 6, line 28 - column 7, line 26 * * figures 2,3 * -----	1,6-8, 10,12	
X	EP 1 394 471 A (SIEMENS AG [DE]) 3 March 2004 (2004-03-03) * column 2, line 53 - column 3, line 45 * * figures 3,4 * -----	1,6-8, 12,13	
X	EP 1 507 119 A (SIEMENS AG [DE]) 16 February 2005 (2005-02-16) * column 6, line 55 - column 7, line 35 * * column 8, line 31 - column 9, line 1 * * figures 3-5,8,9 * -----	1,6-8, 12,13	TECHNICAL FIELDS SEARCHED (IPC) F23R F23C F23D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 October 2007	Gavriliu, Costin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 00 9960

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-10-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0870989 A2	14-10-1998	DE 69825804 D1	30-09-2004
		DE 69825804 T2	01-09-2005
		GB 2324147 A	14-10-1998
		US 6216466 B1	17-04-2001
EP 0936406 A2	18-08-1999	DE 69916911 D1	09-06-2004
		DE 69916911 T2	21-04-2005
		JP 11337068 A	10-12-1999
		TW 425467 B	11-03-2001
		US 2001052229 A1	20-12-2001
EP 1394471 A	03-03-2004	CN 1678871 A	05-10-2005
		WO 2004025183 A2	25-03-2004
		JP 2006507466 T	02-03-2006
		US 2006035188 A1	16-02-2006
EP 1507119 A	16-02-2005	CN 1860333 A	08-11-2006
		WO 2005019733 A1	03-03-2005
		JP 2007501926 T	01-02-2007
		US 2007031771 A1	08-02-2007

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5901555 A **[0006]**