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(54) **FUEL DISTRIBUTOR**

BRENNSTOFFVERTEILER

DISTRIBUTEUR DE COMBUSTIBLE

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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.

[0007] The EP 0936406 discloses another gas turbine burner provided with a swirler. The swirler comprises a swirler vane support, a plurality of swirler vanes arranged on the swirler vane support, a plurality of swirler passages formed by the swirler vanes and the swirler vane support, a plurality of fuel distributors, each of them comprising a distribution element, inlet openings, a plurality of outlet openings and a plurality of third outlet openings, wherein the third openings are arranged in an upstream section of the respective swirler passage and the outlet openings are arranged in a downstream section of the respective swirler passage, and wherein the cross section of the third openings is larger than the cross-section of the openings.

SUMMARY OF THE INVENTION

[0008] An object of the invention is to provide an improved fuel distributor.

[0009] This object is achieved by the claims. The dependent claims describe advantageous developments and modifications of the invention.

[0010] 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.

[0011] 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.

[0012] 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.

[0013] In a further advantageous embodiment, the restrictor is adjustable to adapt the pressure for different fuel types.

[0014] 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.

[0015] 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.

[0016] 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.

[0017] 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.

[0018] 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.

[0019] 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

[0020] 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.

[0021] In the drawings like references identify like or equivalent parts.

DETAILED DESCRIPTION OF THE INVENTION

[0022] 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.

[0023] 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.

[0024] 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 pas-

sage 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.

[0025] 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.

[0026] 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.

[0027] 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.

[0028] 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 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), each of the fuel distributors (1), comprising

- a distribution element (18) defining a cavity (3),
- whereby the cavity (3) has an inlet opening (4), at least one outlet opening (5) and at least one third opening (6),
- whereby the at least one third opening (6) is arranged in the cavity (3) of the fuel distributor (1) in an upstream section of a respective swirler passage (14), and the at least one outlet opening (5) is arranged in the cavity (3) in a downstream section of the respective swirler passage (14), and
- whereby the cross-section of the at least one third opening (6) is larger than the cross-section of the at least one outlet opening (5),

wherein the cavities (3) of the plurality of fuel distributors (1) are arranged in the swirler vane support (13).

2. A swirler (11) as claimed in claim 1, wherein a restrictor (7) is arranged upstream the inlet opening (4) of a respective fuel distributor (1), 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. A swirler (11) as claimed in claim 2, wherein the restrictor (7) of a respective fuel distributor (1) is adjustable.

4. A swirler (11) as claimed any of the preceding claims, wherein the at least one outlet opening (5) of a respective fuel distributor (1) is a pilot fuel injection opening.

5. A swirler (11) as claimed in any of the preceding claims, wherein the at least one third opening (6) of a respective fuel distributor (1) is a main fuel injection opening.

6. A swirler (11) as claimed in any of the preceding claims, wherein the outlet openings (5) and the third openings (6) of the plurality of fuel distributors (1) are arranged in the swirler passages (14).

7. A swirler (11) as claimed in any of the preceding claims, wherein the outlet openings (5) of the plurality of fuel distributors (1) are arranged at a downstream end of the swirler passages (14) relative to the flow of compressor air (10).

8. A swirler (11) as claimed in any of the preceding claims, wherein the third openings (6) of the plurality

of fuel distributors (1) are arranged at an upstream end of the swirler passages (14) relative to the flow of compressor air (10).

9. A swirler (11) as claimed in any of the preceding claims, wherein the outlet openings (5) and the third openings (6) of the plurality of fuel distributors (1) are arranged in the swirler vanes support (13).

10. A swirler (11) as claimed in any of the preceding claims, wherein the outlet openings (5) and the third openings (6) of the plurality of fuel distributors (1) are arranged in the swirler vanes (12).

11. A swirler (11) as claimed in claim 10, wherein the outlet openings (5) and the third openings (6) of the plurality of fuel distributors (1) are arranged at different heights of the swirler vanes (12).

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

13. A swirler (11) as claimed in any of claims 1 to 11, wherein a cross-sectional area of the swirler passages (14) decreases in a downstream direction relative to the flow of compressor air (10).

Patentansprüche

1. Verwirbeler (11), welcher Folgendes umfasst:

einen Verwirbelungsschaufelträger (13);
eine Vielzahl von Verwirbelungsschaufeln (12), die an dem Verwirbelungsschaufelträger (13) angeordnet sind;
eine Vielzahl von Verwirbelungsdurchlässen (14), die von den Verwirbelungsschaufeln (12) und dem
Verwirbelungsschaufelträger (13) gebildet werden; und
eine Vielzahl von Brennstoffverteilern (1), wobei jeder der Brennstoffverteiler (1) Folgendes umfasst:

- ein Verteilungselement (18), das einen Hohlraum (3) definiert,
- wobei der Hohlraum (3) eine Einlassöffnung (4), mindestens eine Auslassöffnung (5) und mindestens eine dritte Öffnung (6) aufweist,
- wobei die mindestens eine dritte Öffnung (6) in dem Hohlraum (3) des Brennstoffverteilers (1) in einem stromaufwärtigen Abschnitt eines jeweiligen Verwirbelungsdurchlasses (14) angeordnet ist und die mindestens eine Auslassöffnung (5) in dem Hohlraum (3) in einem stromabwärtigen Abschnitt des jeweiligen Verwirbelungsdurchlasses (14) angeordnet ist und
- wobei der Querschnitt der mindestens einen dritten Öffnung (6) größer als der Querschnitt der mindestens einen Auslassöffnung (5) ist,

wobei die Hohlräume (3) der Vielzahl von Brennstoffverteilern (1) in dem Verwirbelungsschaufelträger (13) angeordnet sind.

2. Verwirbeler (11) nach Anspruch 1, wobei ein Begrenzer (7) stromaufwärts der Einlassöffnung (4) eines jeweiligen Brennstoffverteilers (1) in Bezug auf den Brennstoffstrom (8) angeordnet ist, wobei der Begrenzer (7) so bemessen und gestaltet ist, dass er einen Ausgleich zwischen den Brennstoffströmen (8) durch die mindestens eine Auslassöffnung (5) bzw. die mindestens eine dritte Öffnung (6) herstellt.

3. Verwirbeler (11) nach Anspruch 2, wobei der Begrenzer (7) eines jeweiligen Brennstoffverteilers (1) einstellbar ist.

4. Verwirbeler (11) nach einem der vorhergehenden Ansprüche, wobei mindestens eine Auslassöffnung (5) eines jeweiligen Brennstoffverteilers (1) eine Pilotbrennstoff-Einspritzöffnung ist.

5. Verwirbeler (11) nach einem der vorhergehenden Ansprüche, wobei mindestens eine dritte Öffnung (6) eines jeweiligen Brennstoffverteilers (1) eine Hauptbrennstoff-Einspritzöffnung ist.

6. Verwirbeler (11) nach einem der vorhergehenden Ansprüche, wobei die Auslassöffnungen (5) und die dritten Öffnungen (6) der Vielzahl von Brennstoffverteilern (1) in den Verwirbelungsdurchlässen (14) angeordnet sind.

7. Verwirbeler (11) nach einem der vorhergehenden Ansprüche, wobei die Auslassöffnungen (5) der Vielzahl von Brennstoffverteilern (1) an einem in Bezug auf den Strom von Verdichterluft (10) stromabwärtigen Ende der Verwirbelungsdurchlässe (14) angeordnet sind.

8. Verwirbeler (11) nach einem der vorhergehenden Ansprüche, wobei die dritten Öffnungen (6) der Vielzahl von Brennstoffverteilern (1) an einem in Bezug auf den Strom von Verdichterluft (10) stromaufwärtigen Ende der Verwirbelungsdurchlässe (14) angeordnet sind.

9. Verwirbeler (11) nach einem der vorhergehenden Ansprüche, wobei die Auslassöffnungen (5) und die

dritten Öffnungen (6) der Vielzahl von Brennstoffverteilern (1) in dem Verwirbelungsschaufelträger (13) angeordnet sind.

10. Verwirbeler (11) nach einem der vorhergehenden Ansprüche, wobei die Auslassöffnungen (5) und die dritten Öffnungen (6) der Vielzahl von Brennstoffverteilern (1) in den Verwirbelungsschaufeln (12) angeordnet sind.

11. Verwirbeler (11) nach Anspruch 10, wobei die Auslassöffnungen (5) und die dritten Öffnungen (6) der Vielzahl von Brennstoffverteilern (1) auf unterschiedlichen Höhen der Verwirbelungsschaufeln (12) angeordnet sind.

12. Verwirbeler (11) nach einem der vorhergehenden Ansprüche, wobei sich eine Querschnittsfläche der Verwirbelungsdurchlässe (14) in einer in Bezug auf den Strom von Verdichterluft (10) stromabwärtigen Richtung vergrößert.

13. Verwirbeler (11) nach einem der Ansprüche 1 bis 11, wobei sich eine Querschnittsfläche der Verwirbelungsdurchlässe (14) in einer in Bezug auf den Strom von Verdichterluft (10) stromabwärtigen Richtung verkleinert.

Revendications

1. Coupelle rotative (11), comprenant :

un support d'aubes de coupelle rotative (13) ;
une pluralité d'aubes de coupelle rotative (12) agencées sur le support d'aubes de coupelle rotative (13) ;
une pluralité de passages de coupelle rotative (14) formés par les aubes de coupelle rotative (12) et le support d'aubes de coupelle rotative (13) ; et
une pluralité de distributeurs de carburant (1), chacun des distributeurs de carburant (1) comprenant

- un élément de distribution (18) définissant une cavité (3),
- ce par quoi la cavité (3) a une ouverture d'entrée (4), au moins une ouverture de sortie (5) et au moins une troisième ouverture (6),
- ce par quoi l'au moins une troisième ouverture (6) est agencée dans la cavité (3) du distributeur de carburant (1) dans une section amont d'un passage de coupelle rotative (14) respectif, et l'au moins une ouverture de sortie (5) est agencée dans la cavité (3) dans une section aval du passage de coupelle rotative (14) respectif, et
- ce par quoi la coupe transversale de l'au moins une troisième ouverture (6) est plus grande que la coupe transversale de l'au moins une ouverture de sortie (5),

dans laquelle les cavités (3) de la pluralité de distributeurs de carburant (1) sont agencées dans le support d'aubes de coupelle rotative (13).

2. Coupelle rotative (11) selon la revendication 1, dans laquelle un restricteur (7) est agencé en amont de l'ouverture d'entrée (4) d'un distributeur de carburant (1) respectif, par rapport à l'écoulement de carburant (8), le restricteur (7) étant dimensionné et configuré pour créer un équilibre entre les écoulements de carburant (8) à travers l'au moins une ouverture de sortie (5) et l'au moins une troisième ouverture (6), respectivement.

3. Coupelle rotative (11) selon la revendication 2, dans laquelle le restricteur (7) d'un distributeur de carburant (1) respectif est ajustable.

4. Coupelle rotative (11) selon l'une quelconque des revendications précédentes, dans laquelle l'au moins une ouverture de sortie (5) d'un distributeur de carburant (1) respectif est une ouverture d'injection pilote de carburant.

5. Coupelle rotative (11) selon l'une quelconque des revendications précédentes, dans laquelle l'au moins une troisième ouverture (6) d'un distributeur de carburant (1) respectif est une ouverture d'injection principale de carburant.

6. Coupelle rotative (11) selon l'une quelconque des revendications précédentes, dans laquelle les ouvertures de sortie (5) et les troisièmes ouvertures (6) de la pluralité de distributeurs de carburant (1) sont agencées dans les passages de coupelle rotative (14).

7. Coupelle rotative (11) selon l'une quelconque des revendications précédentes, dans laquelle les ouvertures de sortie (5) de la pluralité de distributeurs de carburant (1) sont agencées au niveau d'une extrémité aval des passages de coupelle rotative (14) par rapport à l'écoulement d'air de compresseur (10).

8. Coupelle rotative (11) selon l'une quelconque des revendications précédentes, dans laquelle les troisièmes ouvertures (6) de la pluralité de distributeurs de carburant (1) sont agencées au niveau d'une extrémité amont des passages de coupelle rotative (14) par rapport à l'écoulement d'air de compresseur

(10).

9. Coupelle rotative (11) selon l'une quelconque des revendications précédentes, dans laquelle les ouvertures de sortie (5) et les troisièmes ouvertures (6) de la pluralité de distributeurs de carburant (1) sont agencées dans le support d'aubes de coupelle rotative (13).

10. Coupelle rotative (11) selon l'une quelconque des revendications précédentes, dans laquelle les ouvertures de sortie (5) et les troisièmes ouvertures (6) de la pluralité de distributeurs de carburant (1) sont agencées dans les aubes de coupelle rotative (12).

11. Coupelle rotative (11) selon la revendication 10, dans laquelle les ouvertures de sortie (5) et les troisièmes ouvertures (6) de la pluralité de distributeurs de carburant (1) sont agencées à différentes hauteurs des aubes de coupelle rotative (12).

12. Coupelle rotative (11) selon l'une quelconque des revendications précédentes, dans laquelle une superficie de coupe transversale des passages de coupelle rotative (14) augmente dans une direction vers l'aval par rapport à l'écoulement d'air de compresseur (10).

13. Coupelle rotative (11) selon l'une quelconque des revendications 1 à 11, dans laquelle une superficie de coupe transversale des passages de coupelle rotative (14) diminue dans une direction vers l'aval par rapport à l'écoulement d'air de compresseur (10).

FIG 1

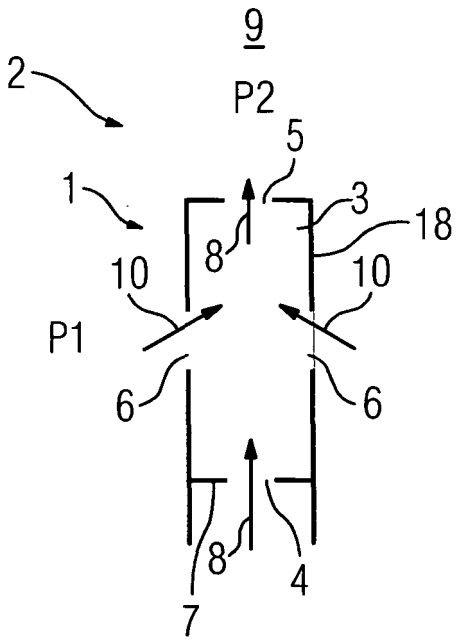


FIG 2

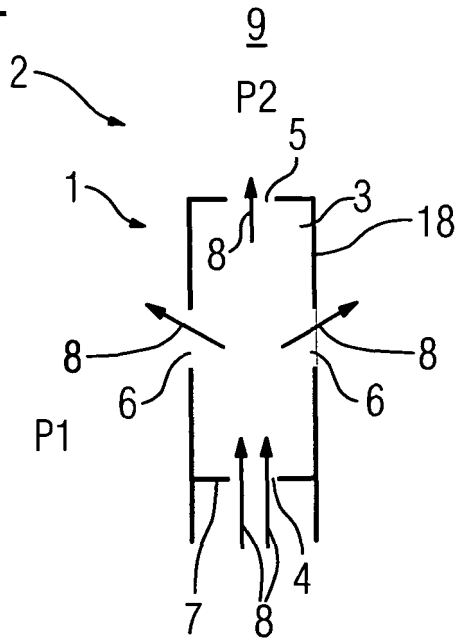


FIG 3

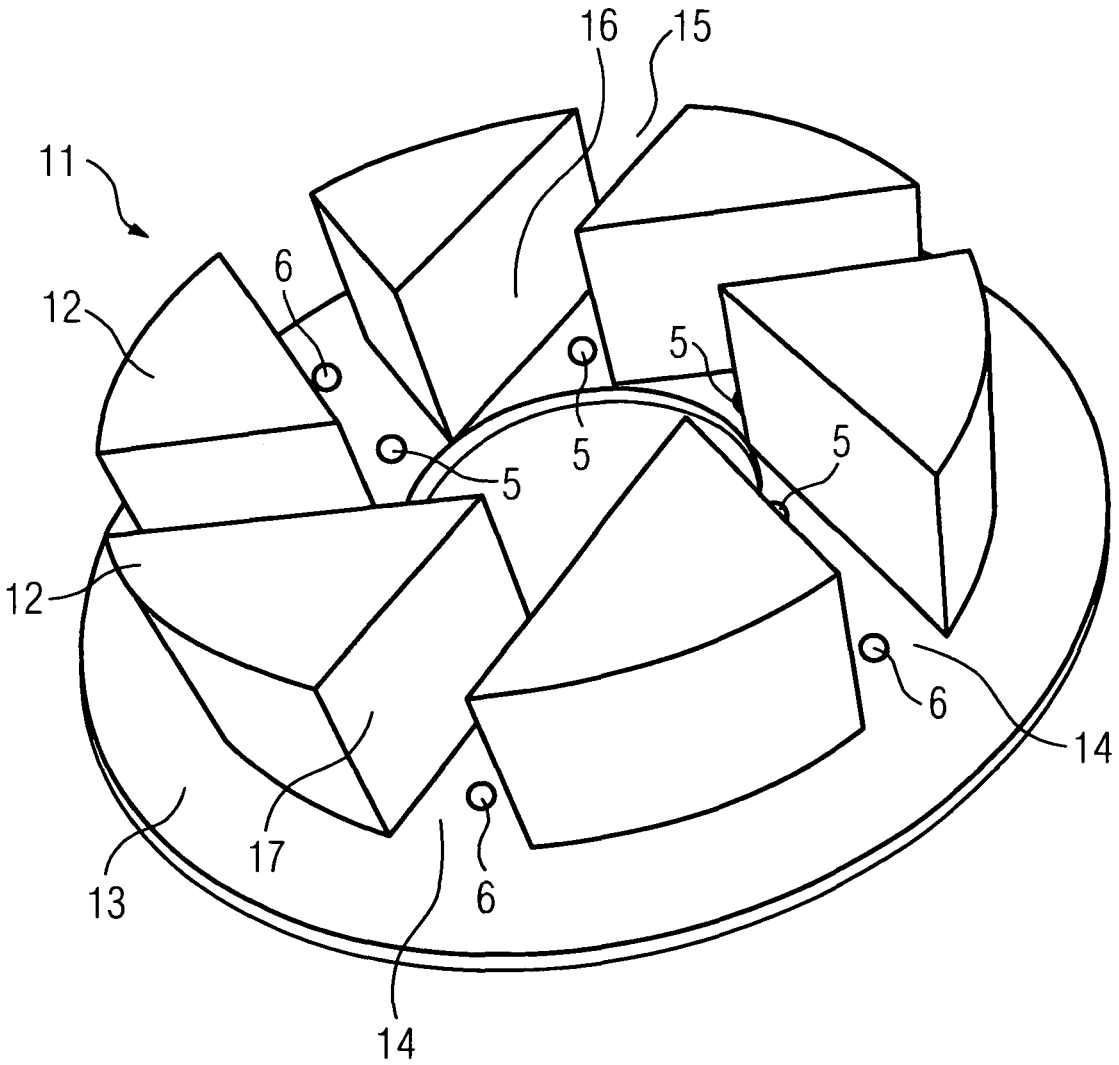


FIG 4

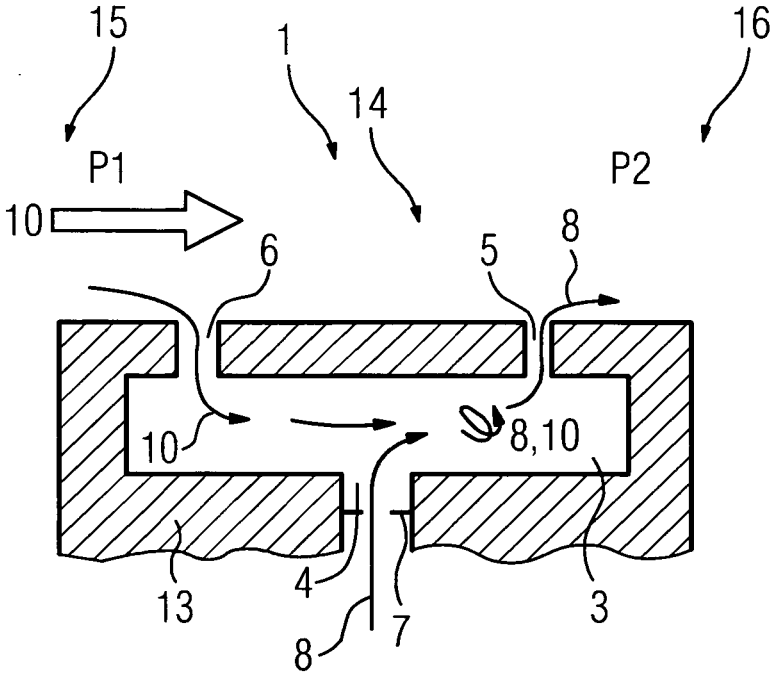

15
1
16
14
P1
P2
10
6
5
8
10
8,10
13
4
7
3
8

FIG 5

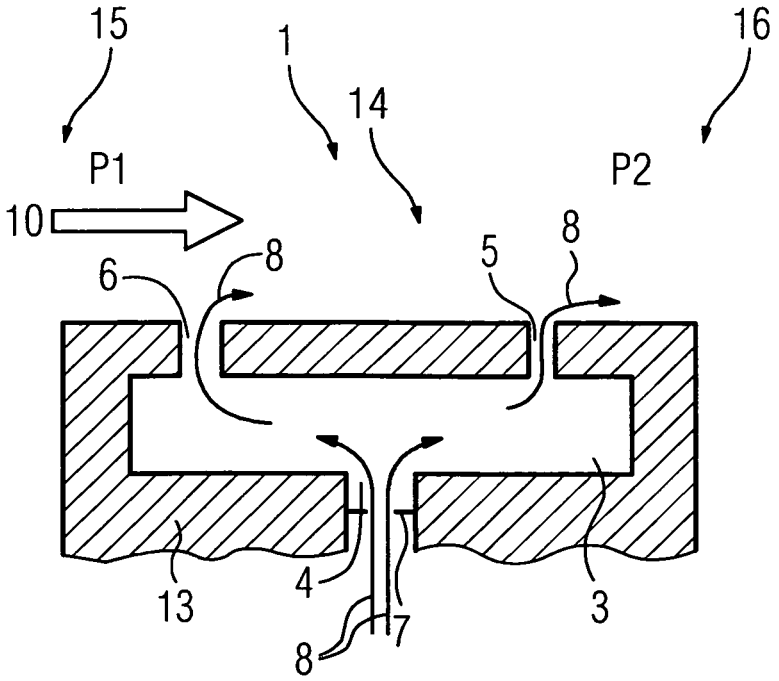

15
1
16
14
P1
P2
10
8
6
5
8
13
4
7
3
8

FIG 6

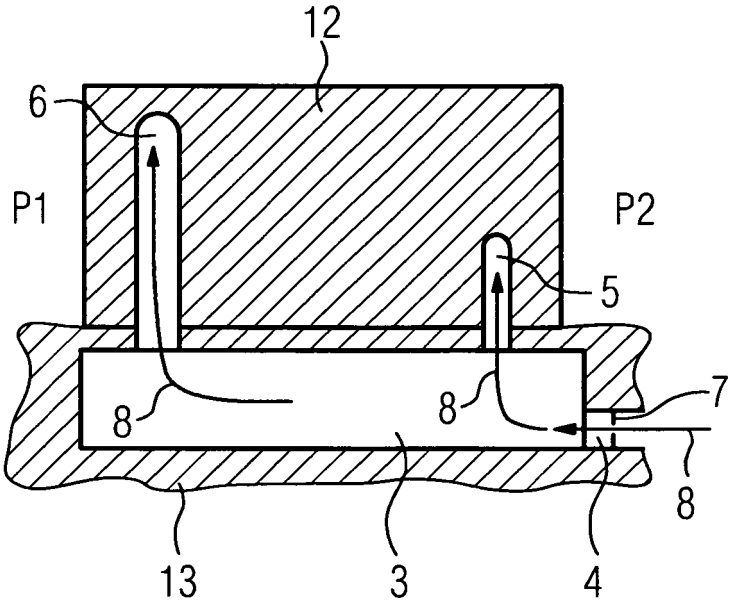


FIG 7

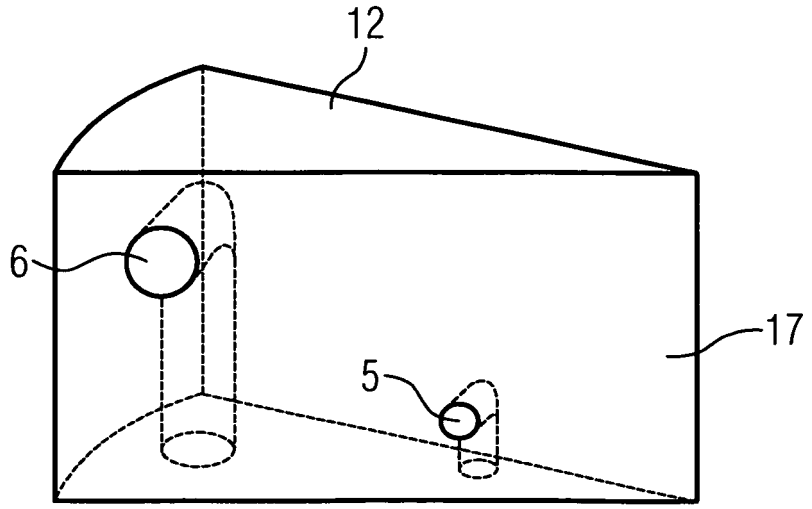


FIG 8

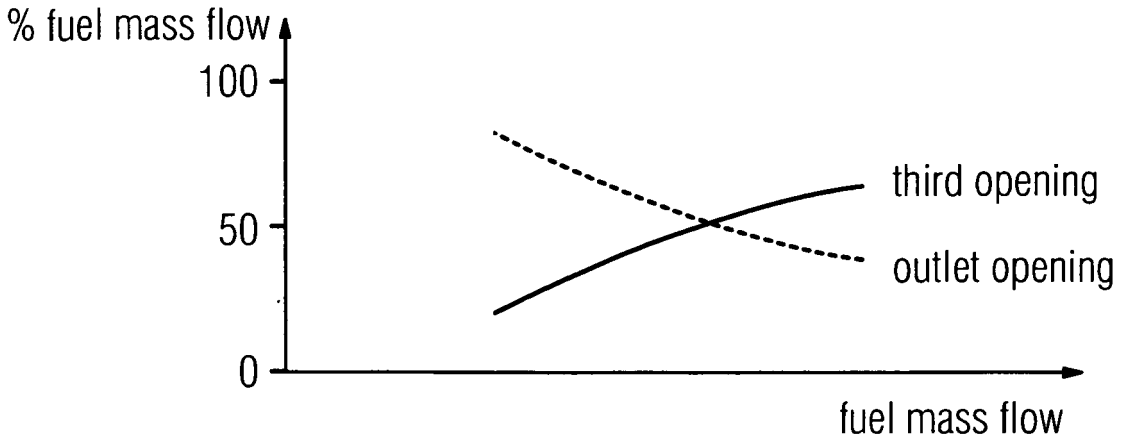
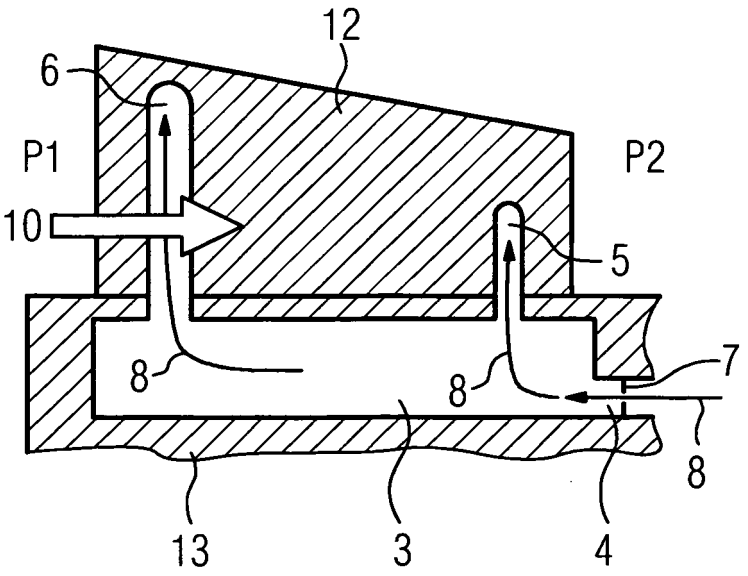

% fuel mass flow
100
50
0
third opening
outlet opening
fuel mass flow

FIG 9


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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5901555 A **[0006]**
- EP 0936406 A **[0007]**