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

(11) **EP 2 208 934 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.07.2010 Bulletin 2010/29

(51) Int Cl.:
F23R 3/10 *(2006.01)* ***F23R 3/20*** *(2006.01)*

(21) Application number: **09150583.4**

(22) Date of filing: **15.01.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA RS

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(54) **Burner of a gas turbine for a reactive fuel air mixture**

(57) The burner (1) of a gas turbine for a reactive fuel air mixture comprises a duct (2) housing a plurality of transversally side-by-side elements (3), arranged to condition a compressed air flow (5) entering from an inlet (6) of the duct (2). The side-by-side elements (3) are provided with nozzles for ejecting a fuel to form a mixture to be combusted.

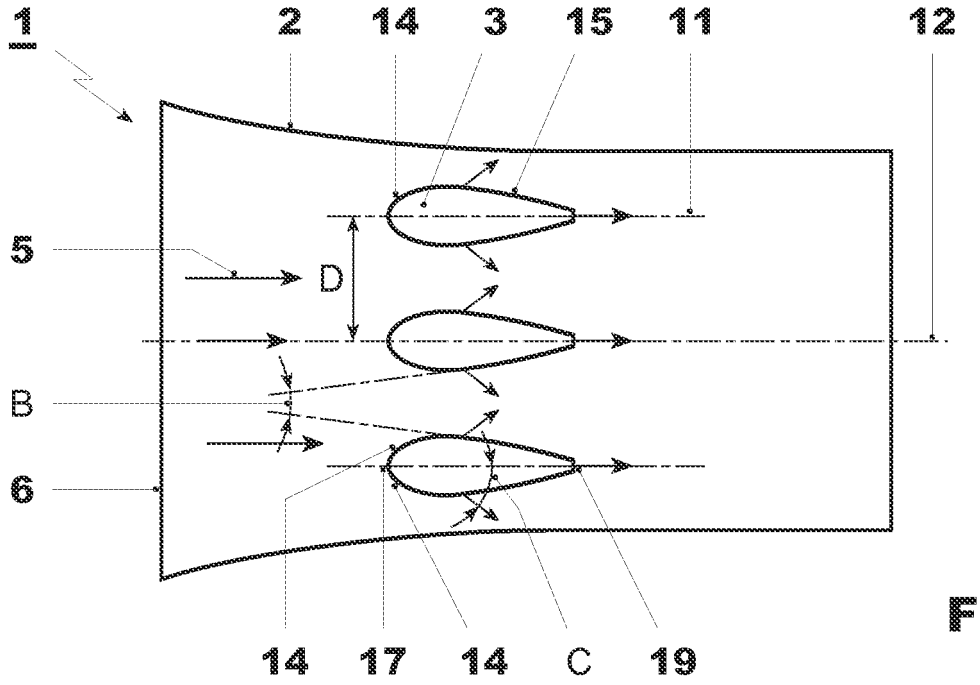

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a burner of a gas turbine for a reactive fuel air mixture.

BACKGROUND ART

[0002] In particular, the present invention relates to a sequential combustion gas turbine, which comprises a compressor for compressing a main air flow, a first burner for mixing a first fuel with the main air flow and generating a first mixture to be combusted, a high pressure turbine where the gases coming from the first burner are expanded, a second burner where a second fuel is injected in the already expanded gases to generate a second mixture to be combusted, and a low pressure turbine where also the gases coming from the second burner are expanded and are discharged.

[0003] Specifically the burner of the present invention is the second burner of the sequential combustion gas turbine.

[0004] As known in the art, as the fuel is usually rich in carbon, the exhausted gases discharged by the turbines are rich in CO_2.

[0005] In order to reduce the percentage of CO_2 in the exhausted gasses discharged by the turbines, the fuel (such as coal or oil) may be submitted to a gasification and subsequent processes, such that the percentage of H_2 within the fuel gas is increased with respect to the amount of carbon; the fuel so obtained (which is then fed to the gas turbines) has a percentage of H_2 which is much greater than for a regular natural gas.

[0006] Such a fuel can be advantageously used to feed a gas turbine because, as it contains a low percentage of carbon (with respect to the percentage of H_2), after combustion the exhausted gases also contain a low percentage of CO_2.

[0007] Nevertheless, fuel air mixtures rich in H_2 (i.e. hydrogen) are very reactive and thus, in order to avoid flashback (i.e. auto ignition of the fuel/air mixture in the mixing zone), they must be kept in the mixing zone only for a short time (short residence time).

[0008] Nevertheless, if the fuel remains in the mixing zone of the burner only for a short time, the fuel/air mixing quality is poor and this causes high NO_x emissions.

SUMMARY OF THE INVENTION

[0009] The technical aim of the present invention is therefore to provide a burner of a gas turbine for a reactive fuel air mixture by which the said problems of the known art are eliminated.

[0010] Within the scope of this technical aim, an object of the invention is to provide a burner that may use high reactivity fuel air mixtures with no flashback risks and, at the same time, which allows a good fuel/gas mixing quality in order to have low NO_x emissions.

[0011] The technical aim, together with these and further objects, are attained according to the present invention by providing a burner of a gas turbine for reactive fuel air mixtures in accordance with the accompanying claims.

[0012] Advantageously, the burner of the invention also has a duct that is shorter than the duct of the traditional burners. This allows a more efficient turbine to be manufactured, because the zone to be cooled is smaller.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Further characteristics and advantages of the invention will be more apparent from the description of a preferred but non-exclusive embodiment of the burner according to the invention, illustrated by way of non-limiting example in the accompanying drawings, in which:

Figure 1 is a schematic top view of a burner according to the present invention;

Figure 2 is a schematic view of the burner of the invention from the outlet of the duct;

Figure 2A is a schematic view of the burner of the invention from the outlet of the duct in a different embodiment, with nozzles staggered with respect to each other;

Figure 3 is a schematic cross section of a side-by-side fuel injector element different from the one shown in figures 1 and 2, in this figure the internal pipes for feeding fuel gases, fuel oil and air to the nozzles are not shown in detail because they are of conventional type;

Figures 4 and 5 are respectively a side view and a rear view of the side-by-side fuel injector element shown in figure 3;

Figure 6 is a schematic longitudinal cross section of the fuel injector side-by-side element of figure 3, also in this figure the internal pipes for feeding fuel gases, fuel oil and air to the nozzles are not shown in detail because they are of conventional type;

Figure 7 is a schematic perspective view of the side-by-side element of figure 3, also in this figure the internal pipes for feeding fuel gases, fuel oil and air to the nozzles are not shown in detail because they are of conventional type; and

Figure 8 is a view from the outlet of the duct of a burner provided with the side-by-side fuel injector elements shown in figures 3-7.

DETAILED DESCRIPTION OF THE INVENTION

[0014] With reference to the figures, these show a burner of a gas turbine for a reactive fuel air mixture overall indicated by the reference 1.

[0015] In particular, the burner 1 is the second burner of a sequential combustion gas turbine.

[0016] The burner 1 comprises a duct 2 having a sub-

stantially rectangular cross section or an annular sector cross section.

[0017] The duct 2 houses a plurality of transversally side-by-side fuel injector elements 3 arranged to condition a compressed air flow 5 entering from an inlet 6 of the duct 2; this let the remaining swirl after the high pressure turbine be removed and create turbulence to enhance fuel- hot gas mixing.

[0018] The side-by-side elements 3 are also provided with nozzles 7, 8 for ejecting at least a fuel to form a mixture to be combusted.

[0019] Preferably the nozzles are able to inject a liquid fuel such as oil (through and inner opening), a gaseous fuel (through an intermediate annular opening coaxial with the inner opening) and air (through an outer annular opening coaxial with the inner and the intermediate openings); for sake of simplicity the enclosed figures do not show the internal pipes of the side-by-side elements for feeding the nozzles.

[0020] The side-by-side elements 3 extend between two opposite lateral walls of the duct 2 and are provided with conduits for feeding the nozzles with liquid/gaseous fuel and air; these conduits are connected at one of the ends of the side-by-side elements 3 to pipes (not shown) for feeding the liquid/gaseous fuel and air to be injected through the nozzles 7, 8.

[0021] Preferably the duct 2 has an annular sector cross section and the side-by-side elements extend radially.

[0022] Each side-by-side element 3 has an elongated cross section extending along an axis 11 parallel to a longitudinal axis 12 of the burner 1; in different embodiments the axes 11 and 12 are not parallel.

[0023] As shown in the figures, the side-by-side elements are shaped as symmetrical wings.

[0024] For example these wings have a fluetelike cross section which is aerodynamically optimised.

[0025] In addition, the side-by-side elements 3 have a symmetrical cross section with respect to the axis 11 parallel to the longitudinal axis 12 of the burner 1; advantageously the maximum width of the side-by-side elements is 25 millimetres.

[0026] The lateral walls of each side-by-side element 3 (i.e. the two walls opposite with respect to the longitudinal axis 11 of the side-by-side elements 3) have a curved front part 14 and a rear part 15 which may be either plane or curved according to the needs. The embodiment with plane rear part 15 is preferred because, in normal working conditions, it ensures a better flow of the fuel air mixture.

[0027] The plane rear parts 15 of two adjacent (i.e. next) side-by-side elements 3 form an angle B less than 13° and preferably comprised between 5-10°. This value of the angle B prevents the flow separation from the walls of the side-by-side elements 3.

[0028] The front parts 14 of each side-by-side element 3 define a leading edge 17.

[0029] In a preferred embodiment of the invention, the distance D between the leading edges 17 of two adjacent (i.e. next) side-by-side elements 3 is less than 150 millimetres and preferably it is comprised between 30-100 millimetres; this value of the distance D allows a good conditioning of the flow coming from the high pressure turbine and also guarantees low pressure drops.

[0030] In addition the burner walls are also optimised to adjust the flow field according to the needs (i.e. best possible mixing, no flow separation).

[0031] In the embodiment of figures 1 and 2 the nozzles 7 of the side-by-side elements 3 are located at a rear edge 19 between the plane rear parts 15; in particular the nozzles 7 are located along all of the edge 19, in order to inject fuel spreading in a large area.

[0032] These nozzles 7 are arranged to inject the fuel along the longitudinal axis 11 of each element 3.

[0033] In addition, the side-by-side elements 3 of the embodiment of figures 1 and 2 also have nozzles 8 which are located at the lateral walls (for instance at the front part 14 or the rear part 15 of the lateral walls or between these portions).

[0034] Also the nozzles 8 are located along all of the lateral walls (parallel to the edge 19), in order to allow fuel spreading in a large area.

[0035] Specifically, the nozzles 8 are symmetrically located at the lateral walls with respect to the longitudinal axis 11; in a different embodiment the nozzles 8 are not symmetrically located with respect to the longitudinal axis 11 but have an asymmetrical disposition.

[0036] The nozzles 8 are arranged to inject fuel along an axis which is inclined of an angle C with respect to the longitudinal axis 11 of the side-by-side elements 3; the angle C is less than 90° and preferably less than 45°.

[0037] The embodiment of figure 2A is similar to that of figure 2 and, in addition, it is provided with nozzles 8 which are located at the lateral walls which are staggered with each other, in order to achieve a better mixing.

[0038] Figures 3-8 show a further embodiment of the burner of the invention.

[0039] This burner has the same features already described for the embodiment of figures 1 and 2 and, in this respect, similar elements are indicated by the same references.

[0040] In addition, the side-by-side elements 3 of this embodiment of the invention have one or more vortex generators for increasing the vorticity of the air flow in the zones of the nozzles and improve mixing.

[0041] In particular, the vortex generators comprise fins 25 for increasing the vorticity of the air flow (in particular figures 3-8 show side-by-side elements 3 provided with three fins 25 on each lateral wall); these fins 25 preferably have a curved shape.

[0042] As shown in the figures, each rear nozzle 7 of the side-by-side elements 3 cooperates with two fins 25 which are placed on opposite walls of the side-by-side element 3.

[0043] Specifically, each two fins 25 which cooperate with a rear nozzle 7 extend along directions converging

towards the same rear nozzle 7.

[0044] Moreover, the converging fins 25 do not intersect with each other, but they have their terminal portions 27 that are placed on opposite sides of the corresponding rear nozzle 7.

[0045] The side-by-side elements 3 shown in figures 3-8 are not provided with nozzles at their lateral walls, nevertheless in further different embodiments such nozzles at the lateral walls may be present.

[0046] In a different embodiment of the invention (not shown in the figures) the side-by-side elements are arranged in two or more adjacent rows (i.e. two or more next rows) and may be provided or not with the fins 25.

[0047] In other words the burner according to this embodiment has the duct which houses a first row of side-by-side elements; this first row of side-by-side elements may for example have the same features already described with reference to the embodiment of figures 1-2 or 3-8 and thus it may comprise three side-by-side elements.

[0048] Downstream of this first row of side-by-side elements, this burner has a second row of side by side elements which may have the same features already described with reference to the embodiment of figures 1-2 or 3-8.

[0049] In addition the first row and the second row may have either the same number of side-by-side elements, which are aligned with one another or not, or a different number of side-by-side elements, which are aligned with one another or not.

[0050] Upstream of the side-by-side elements 3, the burner 1 may also be provided with a conditioning device for the compressed air flow.

[0051] Moreover, the nozzles 7 and/or the nozzles 8 may be provided with sleeves to enhance penetration and to avoid flame attachment in the wake flow.

[0052] The operation of the burner of the invention is apparent from that described and illustrated and is substantially the following.

[0053] The flow 5 of compressed air (also comprising exhausted gasses) coming from the high pressure turbine enters the duct 2 and passes through the side-by-side elements 3.

[0054] The side-by-side elements 3 define between each other a path which drives the compressed air flow 5 and let it be conditioned; in other words they generate uniform conditions of the flow inside the duct 2 independently of the upstream conditions caused by the high pressure turbine.

[0055] In addition, the side-by-side elements also generate vorticity (in particular at their rear edge 19); this vorticity let the fuel very efficiently mix with the compressed air flow.

[0056] As the side-by-side elements 3 only generate a small pressure drop in the compressed air flow (when compared to the traditional burners that have conditioning devices, vortex generators and lance), the compressed air flow passing through the burner 1 may have a very high velocity (higher than the velocity in traditional burners), such that the fuel injected in the main compressed air flow only remains in the mixing zone of the burner (i.e. in the zone of the burner downstream of the side-by-side elements) enough time to let the fuel be mixed to the air, but not to a too long time to avoid flashback.

[0057] Tests showed that an increase of the main compressed air flow velocity by 40 to 100% could be achieved compared to the velocity of traditional burners (with conditioning element, vortex generators and lance) at the same pressure drop over the burner.

[0058] In addition, as the fuel is injected by a plurality of nozzles spread in the whole volume of the burner (for instance the embodiment of figures 1-2 has 45 nozzles and the embodiment of figures 3-8 has 9 nozzles whereas traditional lances have only four nozzles), the fuel is injected in small amount directly in zones of the burner where air for mixing is available. This lets mixing of fuel with air improve even if the residence time of the fuel in the mixing zone of the burner is short and leads to a better distribution of fuel right in the injection plane.

[0059] In addition, the fins 25 (in the embodiment of figures 3-8) direct the flow towards the nozzles and thus they further improve mixing of the fuel with the air.

[0060] In practice the materials used and the dimensions can be chosen at will according to requirements and to the state of the art.

REFERENCE NUMBERS

[0061]

1 burner
2 duct
3 side-by-side fuel injector elements
5 compressed air flow
6 inlet
7, 8 nozzles
11 axis of the side-by-side elements
12 axis of the burner
14 curved front part of the side-by-side element wall
15 rear part of the side-by-side element wall
17 leading edge
19 rear edge
25 vortex generators/fins
D distance between leading edges of two adjacent side-by-side elements
B angle between plane rear parts of two adjacent side-by-side elements
C angle between the axis of the nozzles 8 and the longitudinal axes 11 of the side-by-side elements

Claims

1. Burner (1) of a gas turbine for a reactive fuel air mixture, **characterised by** comprising a duct (2) hous-

ing a plurality of transversally side-by-side elements (3), arranged to condition a compressed air flow (5) entering from an inlet (6) of the duct (2), said side-by-side elements (3) also being provided with nozzles (7, 8) for injecting at least a fuel to form a mixture to be combusted.

2. Burner (1) as claimed in claim 1, **characterised in that** each side-by-side element (3) has an elongated cross section extending along an axis (11) parallel or not parallel to a longitudinal axis (12) of the burner (1).

3. Burner (1) as claimed in claim 2, **characterised in that** each side-by-side element (3) has a symmetrical cross section along an axis (11) parallel to the longitudinal axis (12) of the burner (1).

4. Burner (1) as claimed in claim 3, **characterised in that** the lateral walls of each side-by-side element (3) have at least a curved front part (14) and a plane rear part (15), wherein the plane rear parts (15) of two adjacent side-by-side elements (3) form an angle less than 13° and preferably comprised between 5-10°.

5. Burner (1) as claimed in claim 4, **characterised in that** the front parts (14) of each side-by-side element (3) define a leading edge (17), wherein the distance (D) between the trailing edges (17) of two adjacent side-by-side elements (3) is less than 150 millimetres and preferably comprised between 30-100 millimetres.

6. Burner (1) as claimed in claim 1, **characterised in that** the nozzles (7) of each side-by-side element (3) are located at a rear edge (19) and are arranged to inject the fuel along a longitudinal axis (11) of each side-by-side element (3).

7. Burner (1) as claimed in claim 1 or 6, **characterised in that** the nozzles (8) of each side-by-side element (3) are located at the lateral walls and are arranged to inject fuel along an axis which is inclined with respect to a longitudinal axis (11) of the side-by-side element (3).

8. Burner (3) as claimed in claim 7, **characterised in that** the axis of each nozzle (8) at the lateral walls of the side-by-side elements (3) is inclined with respect to the longitudinal axis (11) of the side-by-side element (3) less than 90° and preferably less than 45°.

9. Burner (1) as claimed in claim 1, **characterised in that** said side-by-side elements (3) have at least a vortex generator for increasing the vorticity in the air flow (5).

10. Burner (1) as claimed in claim 9, **characterised in that** said at least a vortex generator comprises at least a fin (25).

11. Burner (1) as claimed in claim 6 and 10, **characterised in that** each nozzle (7) at a rear edge (19) of said side-by-side elements (3) cooperates with at least two fins (25) placed on opposite walls of the side-by-side element (3).

12. Burner (1) as claimed in claim 11, **characterised in that** said at least two fins (25) cooperating with a nozzle (7) at a rear edge (19) of said side-by-side elements (3) extend along directions converging towards the same nozzle (7).

13. Burner (1) as claimed in claim 12, **characterised in that** said converging fins (25) have their terminal portions placed on opposite sides of the corresponding nozzle (7).

14. Burner (1) as claimed in claim 1, **characterised in that** said side-by-side elements (3) are arranged in two or more adjacent rows.

15. Burner (1) as claimed in claim 1, **characterised by** comprising a conditioning device for the compressed air flow upstream of said side-by-side elements (3).

16. Burner (1) as claimed in claim 1, **characterised by** being the second burner of a sequential combustion machine.

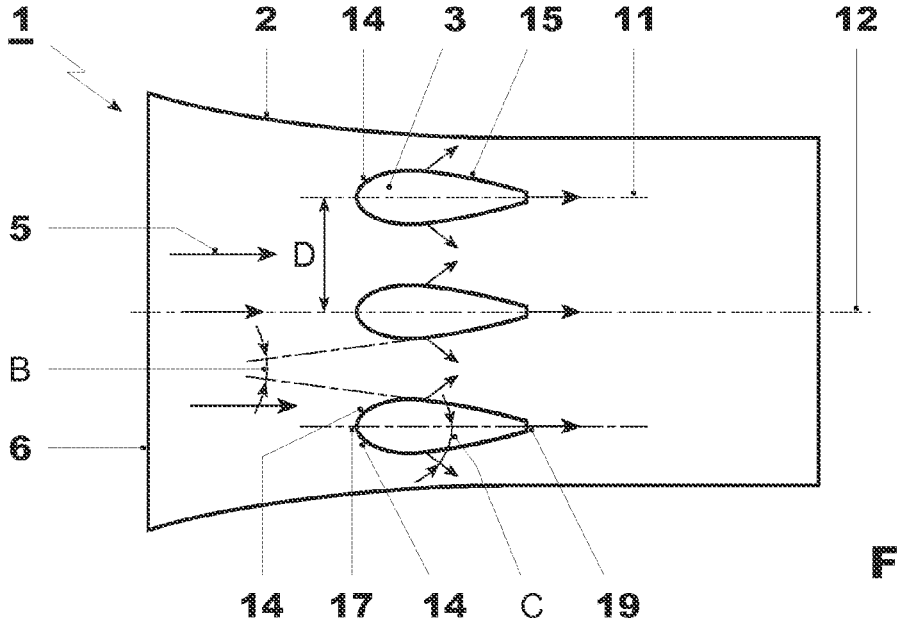

FIG. 1

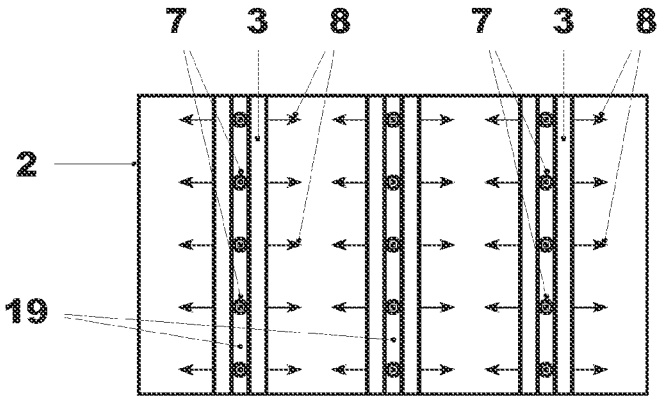

FIG. 2

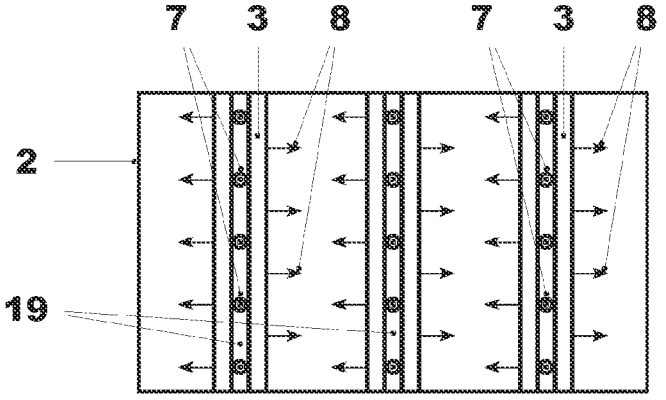

FIG. 2A

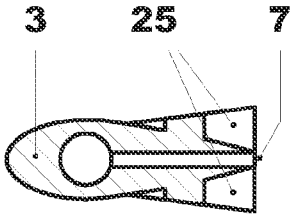

FIG. 3

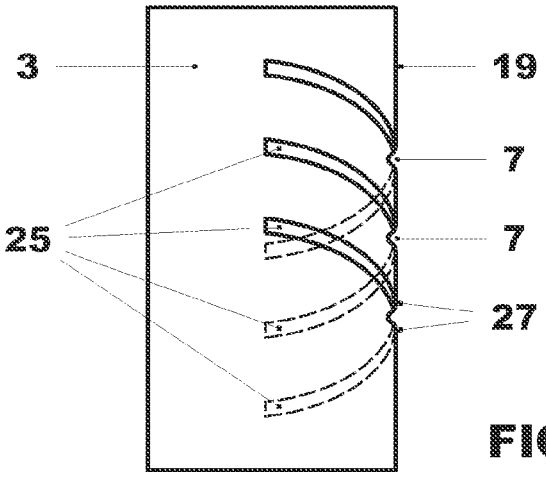

FIG. 4

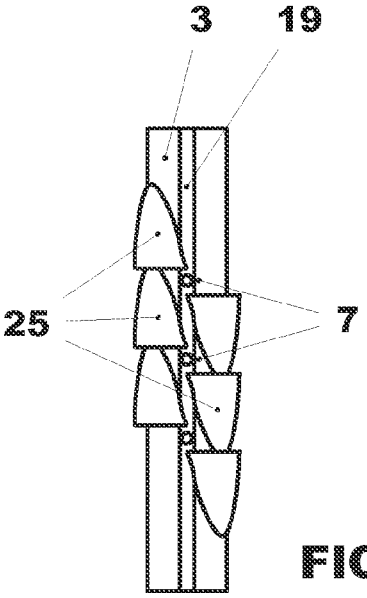

FIG. 5

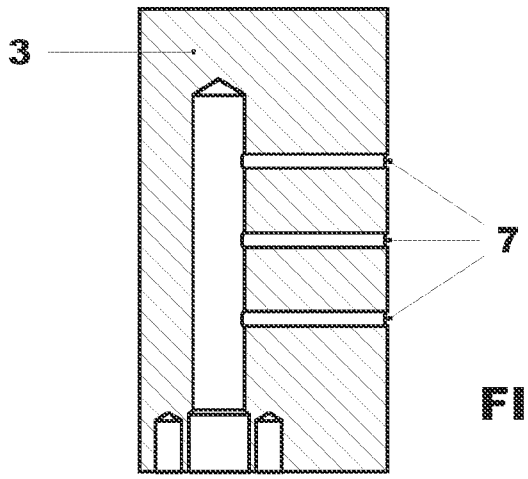

FIG. 6

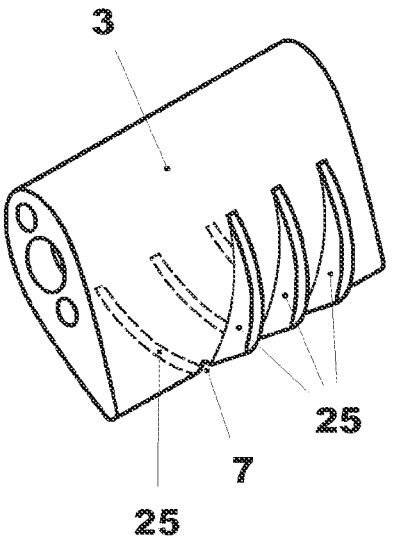

FIG. 7

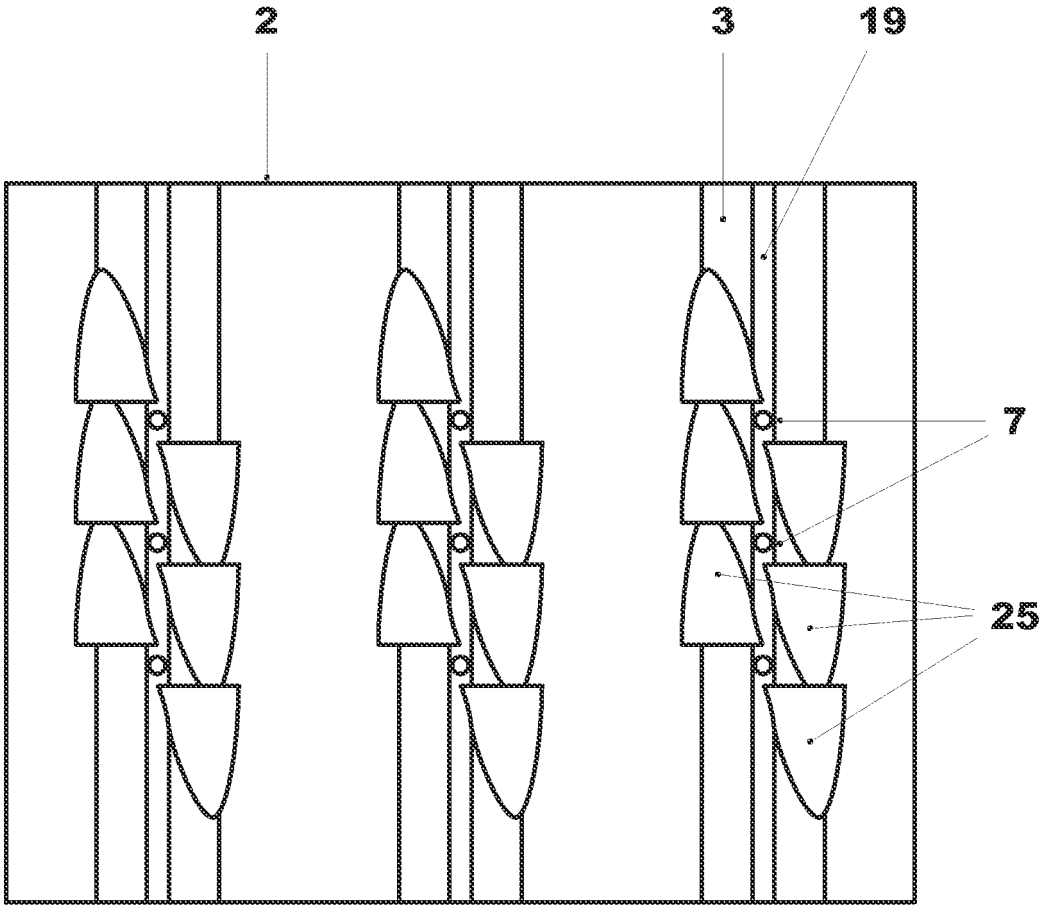

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 0583

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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
Munich	11 August 2009	Vogl, Paul

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 0583

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X	US 5 619 855 A (BURRUS DAVID L [US]) 15 April 1997 (1997-04-15) * column 1, lines 10-15 * * column 2, line 56 - column 4, line 13 * * column 5, line 61 - column 6, line 9 * * claims 1,3,7,18,24; figures 1-3,7 * -----	1-2, 7-10,15	
			TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

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Munich	11 August 2009	Vogl, Paul

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A : technological background
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D : document cited in the application
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82