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(54) Burner of a gas turbine and method for mixing a fuel with a gaseous flow

(57) The burner (1) of a gas turbine has a duct (2) that comprises at least a vortex generator (3) and downstream of it a plurality of nozzles (5) for injecting a fuel within the duct (2). The nozzles (5) are arranged along the wall of the duct (2) and are arranged for injecting fuel toward the inner of the duct (2). The present invention also relates to a method for mixing a fuel with a gaseous flow in such a burner.

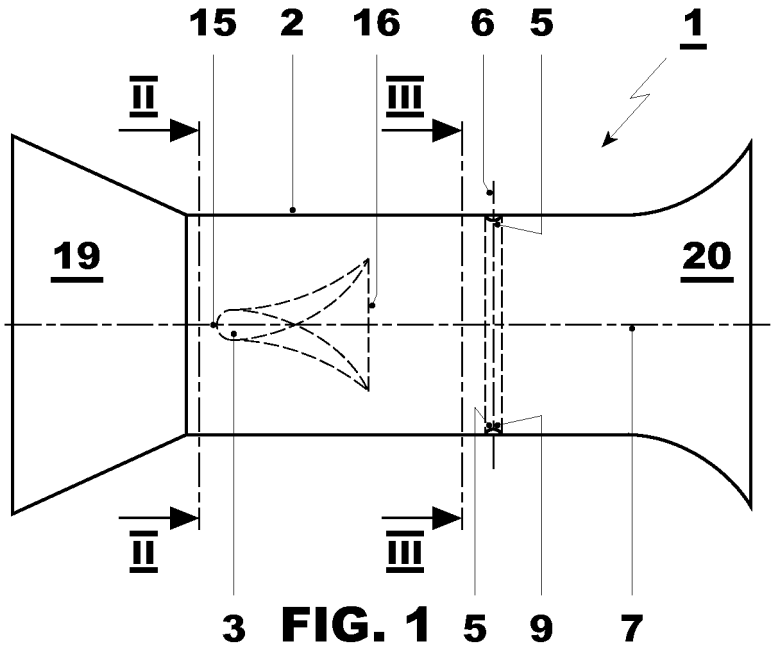

FIG. 1

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Description

Technical Field

[0001] The present invention relates to a burner of a gas turbine and a method for mixing the fuel with a gaseous flow.

[0002] In particular the present invention refers to a burner wherein the fuel is injected in a hot gases flow and spontaneously auto ignites after a delay time from injection.

Background art

[0003] Burners wherein auto ignition of fuel occurs are typically the second burners of sequential combustion gas turbines.

[0004] In these gas turbines a compressor compresses a main air flow and feeds it to a first burner where a fuel is injected to generate a mixture. Afterwards the mixture is combusted and then expanded in a high pressure turbine. The hot gases flow coming from the high pressure turbine (that are still rich in oxygen) pass through a second burner where further fuel is injected to form a mixture. This mixture is combusted and then expanded in a low pressure turbine.

[0005] The second burner of the sequential combustion gas turbine has a duct (often square, quadrangular or trapezoidal in shape) enclosing four static vortex generators made of tetraedrical elements connected to the walls of the duct.

[0006] Downstream of the vortex generators the burner has a lance made of a straight tubular element placed perpendicularly to the direction of the hot gases flow and provided with a terminal portion that is parallel to the direction of the hot gases flow. The terminal portion has usually four nozzles that inject the fuel.

[0007] During operation the hot gases flow passes trough the vortex generators increasing its vorticity; afterwards the fuel is injected such that it mixes with the hot gases flow.

[0008] Nevertheless, this traditional burner is only able to achieve a mixing quality that is not optimal; this negatively influences the NOx emissions.

[0009] In addition traditional burners cause pressure drops in the hot gases flow passing through them that are usually very high and should be reduced to improve the engine efficiency.

[0010] Moreover, as the velocity in the vortices core is very low, traditional burners have a low flashback margin.

[0011] US2008/0148736 discloses a burner that has a duct containing a rotating hub. The rotating hub has airfoils that are provided, in a zone close to their leading edges, with nozzles for injecting the fuel.

[0012] This burner let the pressure drop be reduced and the mixing quality be improved; nevertheless a further improvement of these features is desired.

[0013] In fact the hub generates a wake that causes pressure drop, bad mixing (with high NOx emissions) and high flashback risks.

[0014] Moreover, as the fuel is injected close to the leading edges of the airfoils, there is the risk that it auto ignites before leaving the burner and entering the combustion chamber; this would severely impair the structure of the burner.

Summary of the Invention

[0015] The technical aim of the present invention is therefore to provide a burner and a method by which the said problems of the known art are eliminated.

[0016] Within the scope of this technical aim, an object of the invention is to provide a burner and a method with which mixing quality is improved and the NOx emissions are reduced.

[0017] Another object of the invention is to provide a burner and a method by which the pressure drop is reduced.

[0018] A further object of the present invention is to provide a burner and a method which let the risk of auto ignition of the fuel within the burner (flashback) be greatly reduced.

[0019] The technical aim, together with these and further objects, are attained according to the invention by providing a burner and a method in accordance with the accompanying claims.

Brief Description of the drawings

[0020] Further characteristics and advantages of the invention will be more apparent from the description of a preferred but non-exclusive embodiment of the burner and the method according to the invention, illustrated by way of nonlimiting example in the accompanying drawings, in which:

Figure 1 is a schematic view of a burner of the invention;
Figure 2 is a cross section along line II-II of figure 1;
Figure 3 is an enlarged cross section along line III-III of figure 1;
Figure 4 is a top view of the duct with an aperture for inserting the lance therein;
Figure 5 is a schematic perspective view of an airfoil being a vortex generator of figure 1;
Figures 6-8 are respectively two cross sections along lines VI-VI and VII-VII and a side view in direction of arrow VIII of the airfoil of figure 5;
Figure 9 is a front view in direction of arrow IX of the airfoil of figure 5; and
Figure 10 is a different embodiment of the vortex generator comprising two airfoils.

Detailed Description of the Invention

[0021] With reference to the figures, these show a

burner of a gas turbine overall indicated by the reference number 1.

[0022] The burner 1 is the second burner of a sequential gas turbine and has a duct 2 that has a circular cross section and comprises a vortex generator 3 and, downstream of it, a plurality of nozzles 5 for injecting a fuel within the duct 2.

[0023] The nozzles 5 are of hybrid type and in this respect they are arranged to inject oil (from a central aperture), gas (from an intermediate annular aperture encircling the central aperture) and shielding air (from an outer annular aperture encircling the central and the intermediate annular aperture).

[0024] The nozzles 5 are arranged along the wall of the duct 2 and, in addition, are arranged for injecting fuel toward the inner of the duct 2.

[0025] As shown in figure 1-3, the nozzles 5 have their axes 6 toward a longitudinal axis 7 the duct 2.

[0026] Preferably, the nozzles 5 are located on a lance 9 that is annular (i.e. toroidal) in shape and is housed in the duct 2 with a portion lying on the wall of the same duct 2, and with its central aperture facing the vortex generator 3 such that the hot gases flow may pass through it.

[0027] In a first embodiment, the duct 2 is provided with a longitudinal aperture 11 such that the lance 9 can be introduced within the duct 2 via this longitudinal aperture 11 and subsequently (once it is inside the duct 2) rotated to be transversal housed within the duct 2 (i.e. to be placed in its operating conditions as shown in figure 3).

[0028] In a different embodiment (not shown in the figures) the duct is provided with a transversal aperture for letting the lance 9 be inserted within the duct 2.

[0029] The vortex generator 3 comprises an airfoil 13 rotating about the longitudinal axis 7 of the duct 2.

[0030] The airfoil 13 has a leading edge 15 (with 0 angle of attack) and a trailing edge 16 that are tilted with each other.

[0031] In particular the leading edge 15 of the airfoil 13 lay radially within the duct 2 and the trailing edge 16 of the airfoil 13 is straight but not radial within the duct 2.

[0032] Figure 6 shows a central cross section of the airfoil 13; this central cross section is symmetrical with respect to the rotation axis of the airfoil that overlaps the longitudinal axis 7 of the duct 2; moreover also the cord 18 of the airfoil (i.e. the line between the leading edge 15 and the trailing edge 16) overlaps the longitudinal axis 7 of the duct 2.

[0033] The other sections are not symmetric but, as the leading edge 15 and the trailing edge 16 are both straight but tilted with each other, they have the cord 18 that is tilted with respect to the rotation axis of the airfoil (this axis overlaps the axis 7).

[0034] In particular, the cross sections in each longitudinal section of the airfoil (i.e. the cross section similar to that of figures 6-7) has the angle between the rotational axis of the airfoil (overlapping the axis 7) and the cord 18 that increases with the distance from the rotation axis.

[0035] Advantageously, the duct 2 has an inlet portion 19 that is convergent; the inlet portion is preferably made of a trapezoidal cross section at its larger end (this is due to the fact that the flow comes from the high pressure turbine) and a circular cross section at its smaller end.

[0036] The outlet portion 20 has a diffuser.

[0037] The operation of the burner of the invention is apparent from that described and illustrated and is substantially the following.

[0038] The hot gases flow coming from the high pressure turbine enters the duct 2 through the convergent inlet portion 19; in this zone of the duct the hot gases flow is straightened and stabilised.

[0039] Thus the hot gases flow passes around the rotating airfoil that makes it increase its vorticity by generating a vortex that rotates about the longitudinal axis 7 of the duct 2 (see arrows F).

[0040] Advantageously there are no wakes in the duct 2 where the hot gases flow may have a very low velocity.

[0041] Afterwards the hot gases flow (rotating about the axis 7) passes through the lance 9, and the nozzles 5 inject the gaseous or liquid fuel (i.e. the gas or the oil eventually with the shielding air) according to the operating stage.

[0042] Advantageously the fuel (both liquid and gaseous fuel) is injected from a plurality of nozzles (in the embodiment shown the nozzles 5 are eight in number, but in different embodiments the nozzles can also be much more than eight, for example sixteen or even more); the great number of nozzles and the fact that they are placed along all the perimeter of the duct and also the fact that the fuel is injected toward the inner of the duct lets the fuel be distributed in the whole cross section of the duct 2.

[0043] In addition, the rotating velocity of the hot gases flow and the velocity of the fuel injected toward the centre of the duct 2 are such that while the hot gases flow rotate of an angle A between two next nozzles 5, the fuel goes from the nozzle 5 to the axis 7 of the duct 2; this further increases fuel distribution over the whole cross section of the duct 2.

[0044] Moreover, thanks to the structure with rotating airfoil as a vortex generator and annular lance, when passing through the duct 2 the hot gases flow generates no wakes or zones where the velocity is low, but it generates a single vortex rotating about the axis 7 of the duct.

[0045] Advantageously, the zone of the hot gases flow having the lowest velocity (i.e. the zone along the axis 7 of the duct) is the last to be reached by the fuel; this improves flashback margin.

[0046] Afterwards, the hot gases flow flows within the duct 2 up to the exit 2 and the entrance of the combustion chamber where the fuel is combusted; in the zone between the lance and the combustion chamber (mixing zone) the hot gases flow further mixes with the fuel to achieve an optimal mixing quality.

[0047] The present invention also relates to method for mixing a fuel with a gaseous flow passing through the duct of the burner of the gas turbine.

[0048] The method comprises generating at least a vortex within the gaseous flow and radially injecting a fuel toward the inner of the duct.

[0049] Advantageously the vortices are generated making the gaseous flow rotate around the axis 7 of the duct 2 and, during rotation, while the gas flow sweep an angle A between two next nozzles 5, the fuel sweeps the distance B between the nozzle 5 from which it was injected and the axis 7 of the duct 2.

[0050] Modifications and variants in addition to those already stated are possible, for example figure 10 shows a different vortex generator that could be used in the burner 1 of the invention.

[0051] In particular the vortex generator of figure 10 is made of two airfoils 13 each having the features of the airfoil already described.

[0052] These airfoils 13 have the leading edges at right angle with each other and the trailing edges tilted in the same direction with respect to the leading edges.

[0053] The burner provided with this vortex generator having two airfoils has the same operation already described for the burner with vortex generator with one single airfoil.

[0054] 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

[0055]

1 burner
2 duct
3 vortex generator
5 nozzles
6 axes of the nozzles
7 longitudinal axis of the duct
9 lance
11 longitudinal aperture of the duct
13 airfoil
15 leading edge of the airfoil
16 trailing edge of the airfoil
18 cord of the airfoil
19 inlet portion of the duct
20 outlet portion of the duct
A angle between two adjacent nozzles
B distance between a nozzle and the axis of the duct
F vortex

Claims

1. Burner (1) of a gas turbine having a duct (2) that comprises at least a vortex generator (3) and downstream of it a plurality of nozzles (5) for injecting a fuel within the duct (2), **characterised in that** said nozzles (5) are arranged along the wall of the duct (2) and are arranged for injecting fuel toward the inner of the duct (2).

2. Burner (1) as claimed in claim 1, **characterised in that** said nozzles (5) have their axes toward the longitudinal axis (7) of the duct (2).

3. Burner (1) as claimed in claim 1, **characterised in that** said nozzles (5) are located on a lance (9) that is annular in shape.

4. Burner (1) as claimed in claim 3, **characterised in that** said duct (2) is provided with a longitudinal aperture (11) such that the lance (9) can be introduced within the duct (2) via said longitudinal aperture (11) and subsequently rotated to be transversal housed within the duct (2).

5. Burner (1) as claimed in claim 1, **characterised in that** said vortex generator (3) comprises at least an airfoil (13) rotating about a longitudinal axis (7) of the duct (2).

6. Burner (1) as claimed in claim 5, **characterised in that** said airfoil (13) has a leading edge (15) and a trailing edge (16) that are tilted with each other.

7. Burner (1) as claimed in claim 6, **characterised in that** said leading edge (15) of said airfoil extends radially within said duct (2) and said trailing edge (16) of the airfoil is straight.

8. Burner (1) as claimed in claim 6, **characterised in that** said airfoil (13) has a symmetrical central cross section.

9. Burner (1) as claimed in claim 1, **characterised in that** said duct (2) has a circular cross section.

10. Burner (1) as claimed in claim 1, **characterised by** comprising an inlet convergent portion (19).

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

12. Method for mixing a fuel with a gaseous flow passing through the duct (2) of a burner (1) of a gas turbine, **characterised by** generating at least a vortex within the gaseous flow and radially injecting a fuel toward the inner of the duct.

13. A method as claimed in claim 12, **characterised in that** the vortices are generated making the gaseous flow rotate around the axis (7) of the duct (2).

14. A method as claimed in claim 13, **characterised in that**, while during rotation the gas flow sweep an angle (A) between two next nozzles (5), the fuel

sweeps the distance (B) between the nozzle (5) from which it was injected and the axis (7) of the duct (2).

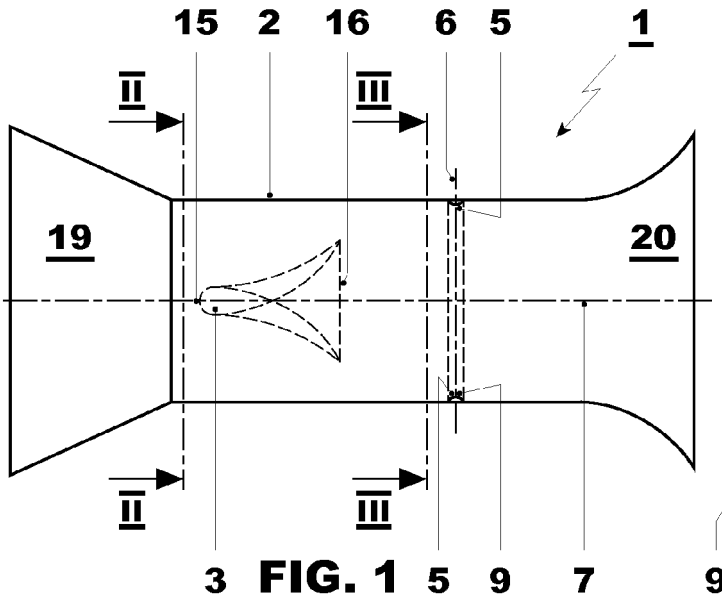

FIG. 1

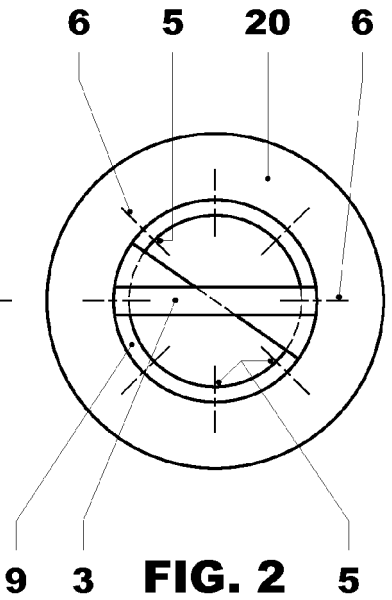

FIG. 2

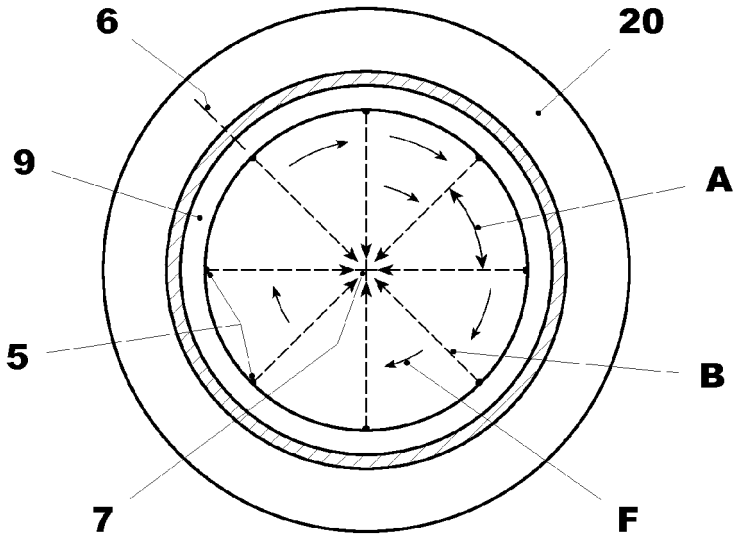

FIG. 3

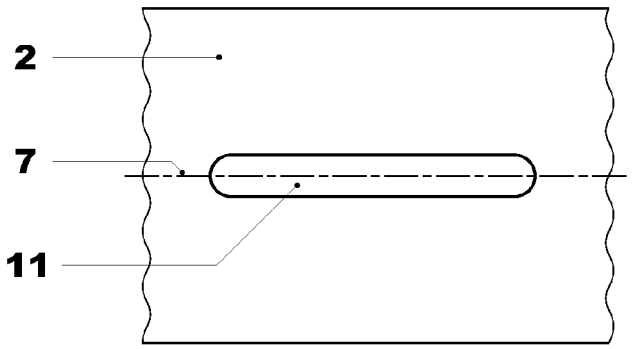

FIG. 4

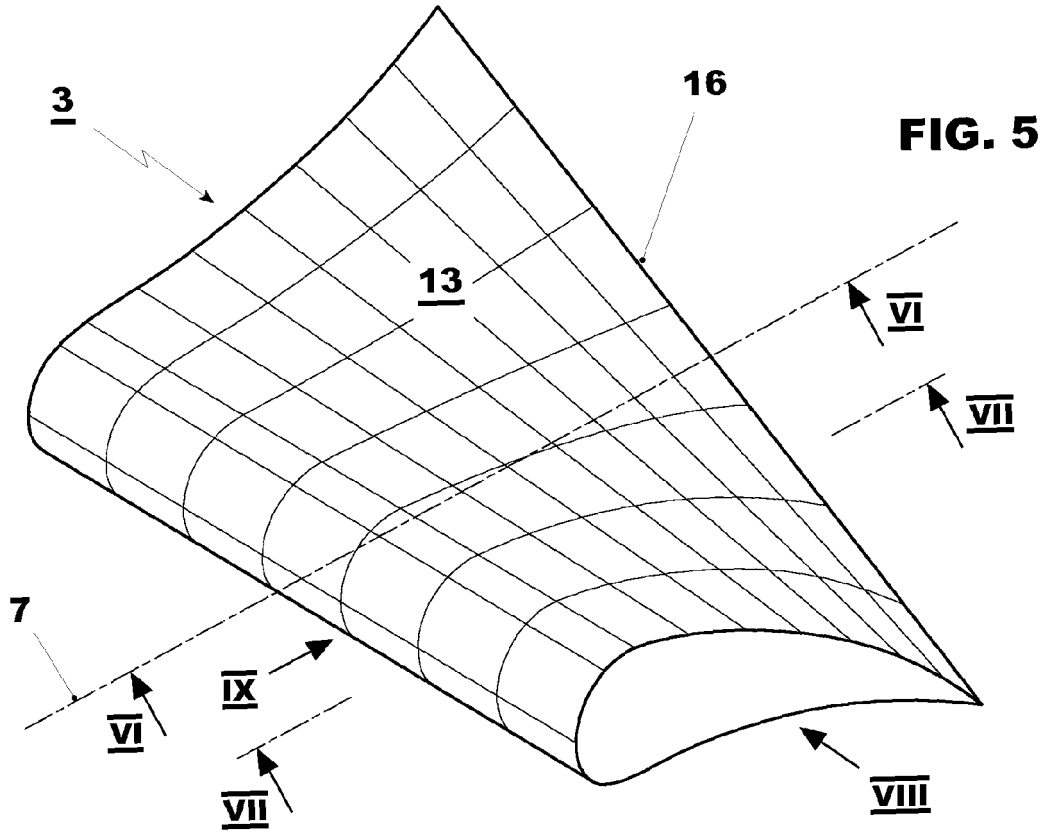

FIG. 5

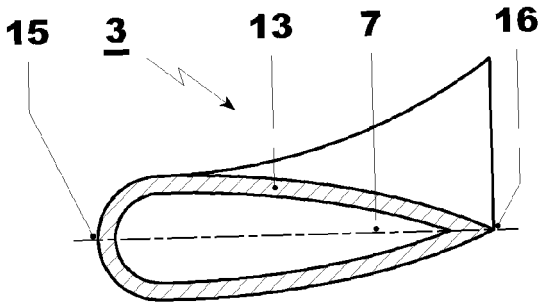

FIG. 6

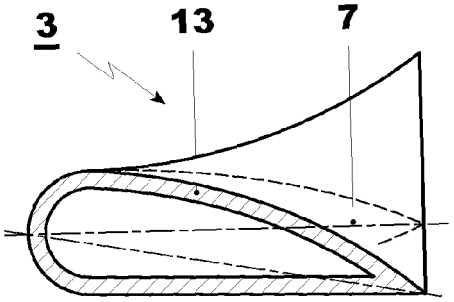

FIG. 7

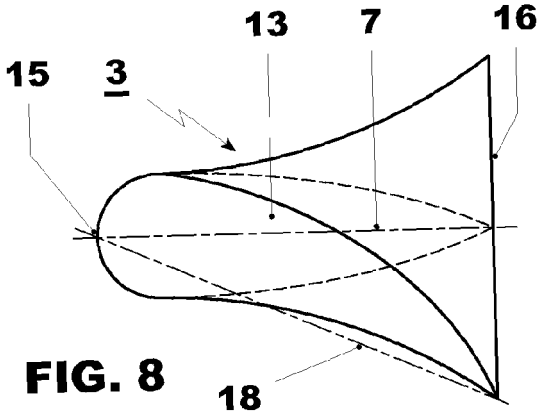

FIG. 8

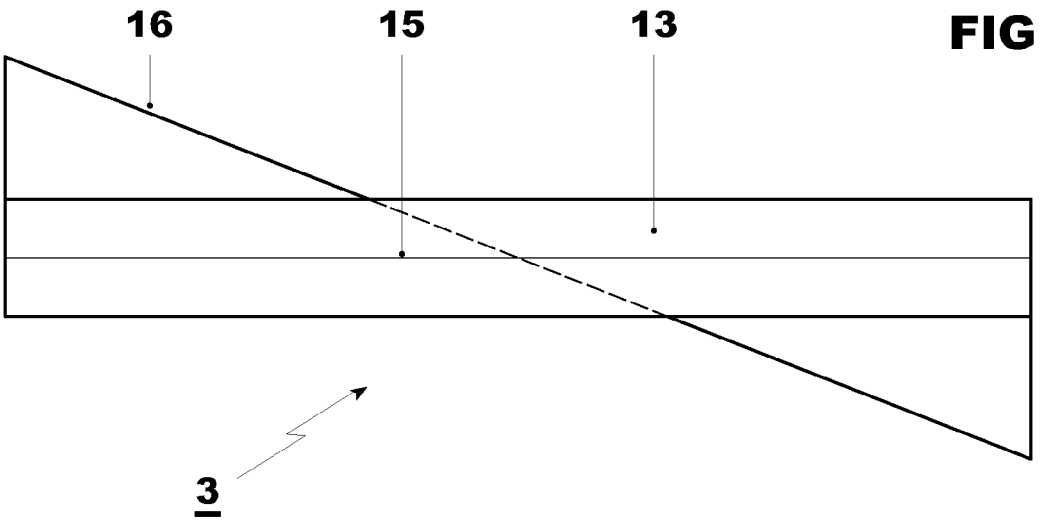

FIG. 9

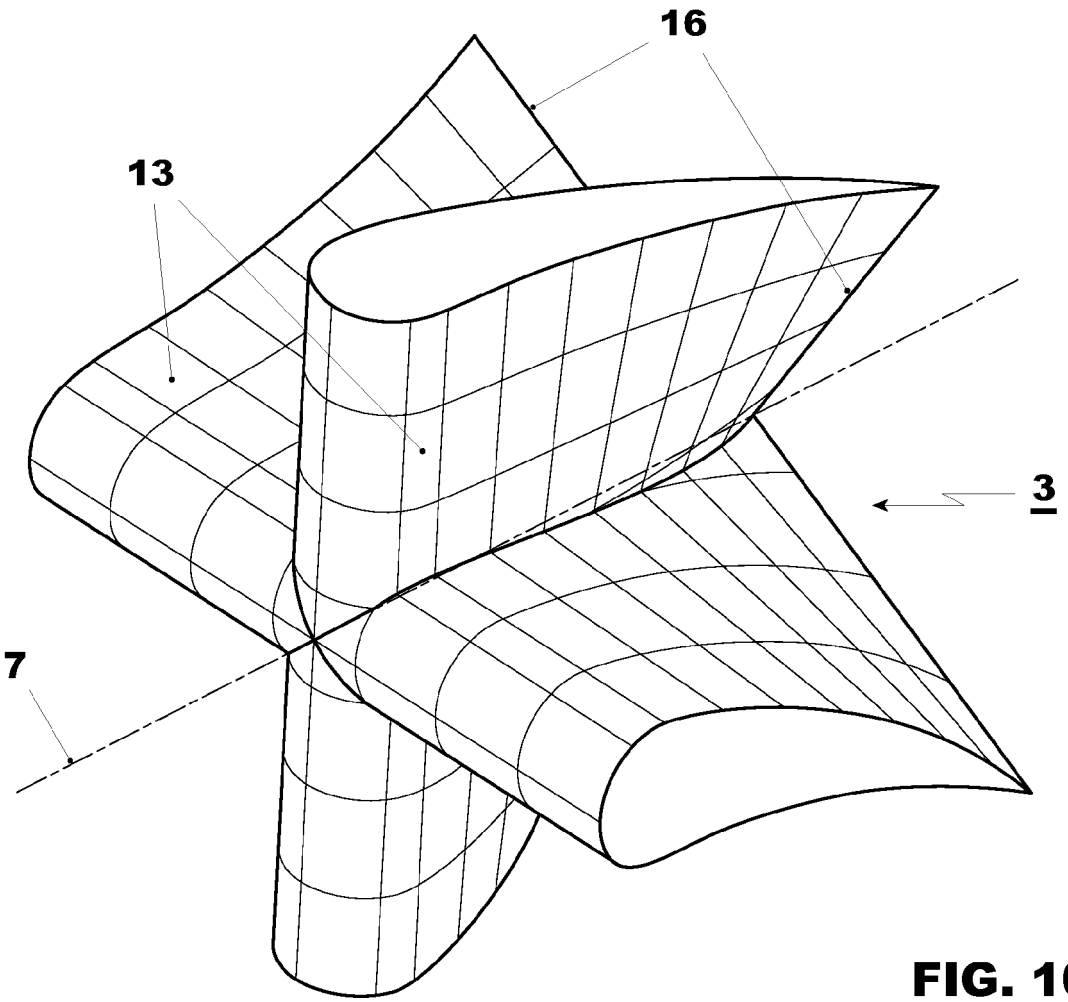

FIG. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 1189

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 September 2009	Coli, Enrico

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 1189

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

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Application Number
EP 09 15 1189

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 09 15 1189

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-4, 9, 11

   Duct-burner provided with a vortex generator wherein the duct (2) is provided with a longitudinal aperture (11) such that a fuel lance (9) can be introduced within the duct (2).

   ---

2. claims: 1, 5-8, 10, 12-14

   Duct-burner provided with a vortex generator wherein said vortex generator (3) comprises at least an airfoil (13) rotating about a longitudinal axis (7) of the duct (2).

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 15 1189

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08-09-2009

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

REFERENCES CITED IN THE DESCRIPTION

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