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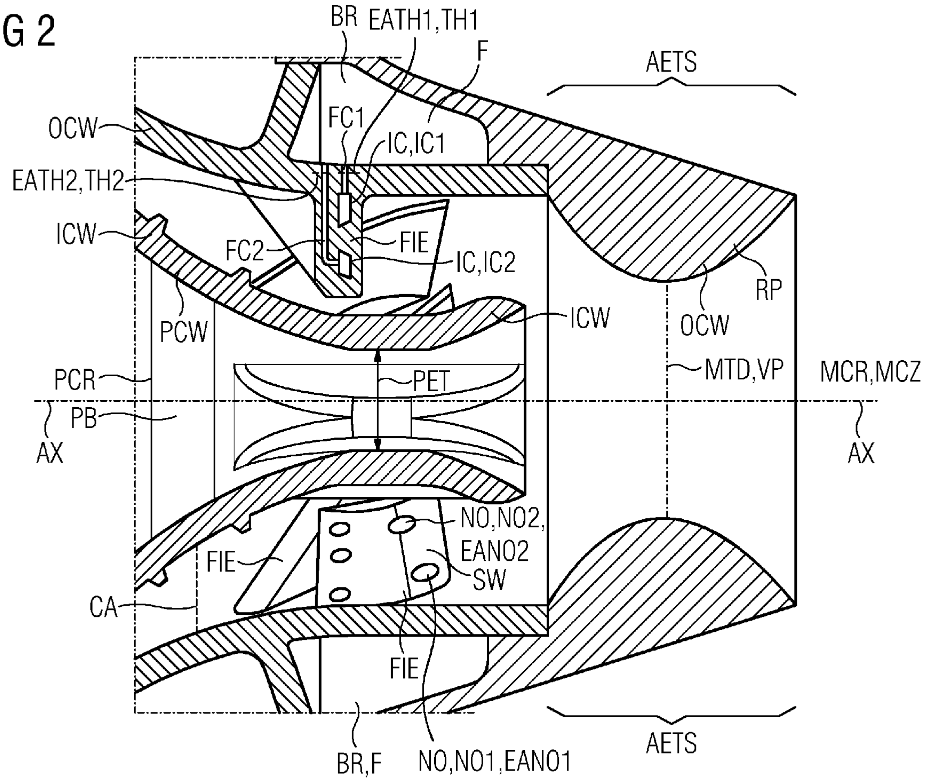
(54) **Gas turbine burner**

(57) The present invention refers to a gas turbine burner (GTB) comprising:
- a main combustion room (MCR) containing a main combustion zone (MCZ) for burning a mixture of air and fuel (AFM),
- at least one gas channel (GC) for supplying a stream of oxygen containing gas (OCG) to the main combustion zone (MCZ) through a gas channel exit (GCE), which gas channel (GC) is confined by channel walls (CW). To enhance especially stability it is proposed to provide said gas channel (GC) with at least one radial protrusion (RP), extending at least along a part of the circumference and continuously reducing the diameter of the axial exit throat segment (AETS) in downstream direction down to a minimum throat diameter (MTD) at a downstream axial position with regard to the axial plane of said radial inner channel wall (ICW) end (APE), wherein downstream said minimum throat diameter (MTD) the radial outer channel wall (OCW) defines an increasing channel diameter.

FIG 2



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Description

Field of the invention

[0001] The present invention refers to a gas turbine burner comprising:

- a main combustion room containing a main combustion zone for burning a mixture of air and fuel,
- at least one gas channel for supplying a stream of oxygen containing gas to the main combustion zone discharging through a gas channel exit, which gas channel is confined by channel walls,
- wherein said gas channel is a channel of annular cross section arranged coaxially to a central axis,
- wherein said channel walls comprise a radially inner channel wall and a radially outer channel wall.

Technical background

[0002] Gas turbine engines comprising a gas turbine burner of the incipiently mentioned type are employed in a variety of applications, for example stationary power generation, military automotive application, marine application and as industrial drives to name only some examples. Some major fields of development deal with respectively the decreasing of fuel consumption, lowering emissions - especially NOx (Nitrogen oxides) or reducing noise, improving fuel flexibility, lengthening lifetime of the components of the gas turbine and increasing reliability and availability of the gas turbine and its components. Most of the above objectives are depending on one to another and reveal to be contradictive. For example: the efficiency may be increased by an increase of the operating temperature, which on the other hand has the effect that NOx emissions are increased and the expected lifetime of the hot gas components is reduced.

Summary of the invention

[0003] One objective of the invention is the reduction of emissions without lowering the efficiency. A further objective is the increase of stability without increasing fuel consumption. Still a further objective of the invention is to increase fuel flexibility with regard to the amount of fuel consumed by the burner.

[0004] The above objectives are at least partly fulfilled by a gas turbine burner of the incipiently mentioned type with the further features of the characterizing portion of claim 1. The dependent claims comprise features of preferred embodiments of the invention.

[0005] All geometrical terms referring to a circle or a cylinder (radial axial, circumferential...) are to be referred to the central axis, if not indicated otherwise.

[0006] The main combustion room according to the invention is an enclosure confined by main combustion room walls comprising means for supply of oxygen containing gas and fuel. The oxygen containing gas can be air and can be premixed with the fuel before entering the main combustion room and burning in the main combustion zone contained by the main combustion room. Further the main combustion room comprises an exhaust for ejecting the hot combustion gas preferably in a downstream located turbine for conversion of the kinetic energy contained in the hot combustion gas into the motion of a turbine rotor. The main combustion room can comprise a recirculation zone, by which at least a part of the combustion gas generated in the main combustion zone is recirculated with a fresh mixture of fuel and oxygen containing gas to generate further hot combustion gas to be processed in the downstream turbine.

[0007] The gas channel according to the invention needs not to be the only fuel and oxygen containing gas supply to the main combustion zone but preferably is only one of several possible fuel and gas supplies.

[0008] With regard to the flow direction of the gas through said gas channel refers to the intended gas flow direction of the gas flowing through the channel during normal operation.

[0009] The radial outer channel wall extends further downstream than the inner channel wall by an axial exit throat segment extending downstream an axial plane of an annular edge of a radial inner channel wall, wherein said axial exit throat segment can be one piece with the radial outer channel wall, but needs not to be.

[0010] Said axial exit throat segment joins the upstream annular gas channel into a circular gas channel without central constriction by said radial inner channel wall because said radial inner channel wall ends upstream of said axial exit throat segment by definition of said axial exit throat segment.

[0011] The radial protrusion is made in continuous curves to avoid any serious disturbance of the flow, wherein the preferred shape is designed in the manner of a venturi nozzle.

[0012] According to a beneficial embodiment of the invention the gas channel is provided with swirler wings to imprint a certain velocity distribution on the gas flow through the gas channel improving the mixing of fuel and said oxygen containing gas further. Further beneficial the imprinted velocity distribution might positively affect the mixing in the main combustion zone. A further feature of the invention is that the fuel injection elements are provided as swirler wings itself to improve the mixing in the gas channel and in the main combustion zone downstream.

[0013] A preferred feature of said fuel injection element is that at least two nozzles respectively two sets of nozzles are supplied with fuel to be injected into the fuel gas channel preferably from two different and separate cavities. Preferably each one of said cavities supplies fuel - preferably a gaseous fuel - to a specific set of nozzles. By dividing the fuel distribution in such a way, fuel is distributed more homogeneously compared to the conventional mode of fuel injection. The pressure in the cavities can be adjusted individually to obtain the best possible fuel distribution downstream the fuel injection elements. Depending on said pressure, the specific geometry and location of the nozzles and the geometric specifications of the channel as well as the aerodynamic parameters of the flow of said oxygen containing gas may be the input for a computational fluid dynamic analysis leading a person with ordinary skill in the art to an optimized specific geometric design based on the idea of the invention.

[0014] The first inner cavity may advantageously be connected to a buffer room by a first fuel channel and the second inner cavity may advantageously be connected to said buffer room by a second fuel channel, wherein the first fuel channel is provided with a first throttle and the second fuel channel is provided with a second throttle to imprint a certain pressure drop on the flow through said first and second fuel channel respectively. Said respective throttles provided in said fuel channels leading fuel to the inner cavities maybe of fixed cross sectional area size and chosen according to a specific operation point intended for the gas turbine burner. To obtain a higher degree of flexibility these throttles maybe adjustable. One preferred embodiment is a manually adjustable throttle. To adjust the throttle during operation to specific conditions dynamically the throttles maybe provided as automatic valves controlled by a specific control unit.

[0015] Preferably the cross section area of the opening of the throttle is chosen or adjusted such that an exit area of the respective throttle is at least three times bigger than the sum of the exit areas of said nozzles in which the respective connected inner cavity joins into. Accordingly said control unit can be made to fulfill this design rule, too. The exit area of the throttle is hereby defined as the smallest cross sectional area with regard to the flow direction through the throttle. Referring to the sum of the exit areas of the nozzles, this parameter can be determined as the sum of the respective smallest cross sections with regard to the flow through the set of nozzles assigned to a specific inner cavity. Said proportion of the exit areas leads to a sufficient pressure drop during the ejection of the fuel into the gas channel, which leads to better predictable fuel pressures in the inner cavities respectively.

[0016] Another preferred embodiment may be provided with a reduction of the cross sectional area of the gas channel in downstream direction upstream of the fuel injection element. This way the gas is accelerated before the fuel is injected into the gas flow, leading to a better mixing.

[0017] A still further preferred embodiment may provide the gas channel or gas channels as channels of annular cross section surrounding a pilot burner coaxially, which pilot burner may comprise a pilot combustion room, which is discharging a pilot combustion gas generated in the pilot combustion room through a constricted pilot exit throat into said main combustion room, wherein the pilot exit throat is coaxially surrounded by the annular shaped gas channel exit. The hot combustion gas from the pilot combustion room mixing with the fuel and oxygen containing gas from the surrounding gas channel exit stabilizes the combustion in the main combustion room.

[0018] The gas channel may advantageously be connected to an oxygen containing gas collector by a perforated channel wall, which perforation is made such that jets of oxygen containing gas hit the surrounded pilot burner for the purpose of heat exchange. This way the oxygen containing gas is preheated on the one hand and the pilot burner is cooled on the other hand, which increases the lifetime expectancy of the pilot burner exhibited to high temperatures from the pilot combustion zone.

Brief description of the drawings

[0019] The above mentioned attributes and other features and advantages of this invention and the manner of attaining them will become more apparent and the invention itself will be better understood by reference to the following description of the currently best mode of carrying out the invention taken in conjunction with the accompanying drawings, wherein

Figure 1 shows a schematic cross sectional depiction of a gas turbine burner according to the invention and

Figure 2 shows a schematic depiction of a detail of the gas turbine burner according to figure 1, showing a venturi type exit of the gas channel and some fuel injection elements in the gas channel enlarged.

Description of the preferred embodiments

[0020] Figure 1 shows a gas turbine burner GTB comprising a main combustion room MCR containing a main combustion zone MCZ enclosed by main combustion room walls MCRW. The main combustion room MCR is supplied with a mixture of fuel F and air AE through a main supply MS. At a downstream end DE of the main combustion room MCR an exhaust EX is provided, through which exhaust combustion gas ECG is discharged. At an upstream end UE of the main combustion zone MCZ - respectively said main combustion room MCR - a forward stagnation point SP located on a central axis AX indicates the location, where recirculated combustion gas CG is axially decelerated to an axial velocity of 0.

[0021] A pilot burner PB is part of the gas turbine burner GTB and generates a mixture of fuel F and free radicals supplied as a hot gas meeting the recirculated combustion gas CG at the forward stagnation point SP. Said pilot burner PB comprises a pilot combustion room PCR containing a pilot combustion zone PCZ, generating a pilot combustion gas PCG containing heat and free radicals HERA, which are discharged through a constricted pilot exit throat PET into the main combustion room MCR. A flame front FF starts approximately at the forward stagnation point SP, where the recirculated combustion gas CG meets the heat and free radicals HERA generated by said pilot burner PB.

[0022] The pilot burner PB is surrounded coaxially by a gas channel GC of annular cross section, discharging an air fuel mixture AFM into the main combustion room MCR through an annular gas channel exit GCE arranged coaxially around the pilot exit throat PET.

[0023] In the main combustion room MCR said flame front FF progresses from the forward stagnation point SP along the gas channel exit GCE and along the main supply exits MSE, which are also arranged coaxially to the pilot exit throat PET. The main supply MS comprises several (here depicted are two) annular shaped exits MSE divided from each other by partition plates PP (here depicted is one). The flame front FF establishes from the forward stagnation point SP extending along the gas channel exit GCE and the exit of the main supply MSE due to the increased oxygen concentration in these areas discharging into the main combustion zone MCZ.

[0024] The gas channel GC surrounding the pilot burner PB is supplied with an oxygen containing gas OCG collected in an oxygen containing gas collector OCGC, which is preferably air AE through a perforation PF of channel walls CW confining said gas channel GC. Said perforation PF of the channel wall CW is designed such that the oxygen containing gas OCG hits the surrounded pilot burner for the purpose of heat exchange. This way the oxygen containing gas OCG is preheated and the pilot burner wall is cooled accordingly. Downstream said perforation PF the oxygen containing gas OCG enters a part of the gas channel GC, which is reduced with regard to the cross section areas CA leading to an acceleration of the oxygen containing gas OCG. Fuel injection elements FIE are provided as swirler wings SW injecting fuel into the accelerated flow of oxygen containing gas OCG and giving this flow a swirl before discharging into the main combustion zone MCZ.

[0025] As shown in figure 2 the fuel injection elements FIE comprise inner cavities IC, respectively a first inner cavity IC1 and a second inner cavity IC2 for each fuel injection element FIE respectively swirler wing SW. The inner cavities IC are respectively supplied with fuel F from a buffer room BR through a first fuel channel FC1 respectively a second fuel channel FC2. The inner cavities IC join into nozzles NO with nozzle opening NO1 respectively N02. Through the nozzle openings NO1, NO2 fuel F is discharged into the gas channel to mix with the oxygen containing gas OCG which is simultaneously provided with a swirl from the swirler wings SW. The first fuel channel FC1 is provided with a first throttle TH1, through which a pressure drop from the buffer room BR to the first inner cavity IC1 is imprinted on the fuel flow. A second throttle TH2 is provided in the second fuel channel FC2 for an according purpose. An exit area EATH1 of the first throttle is at least three times bigger than the sum of the exit area EANO1 of said first nozzle NO1 respectively set of said first nozzles NO1. The according relation is established between an exit area EATH2 of the second throttle TH2 with regard the sum of the exit areas EAN02 of said second nozzle NO2 respectively set of said second nozzles N02.

[0026] The throttles TH1, TH2 can be provided as adjustable throttles TH1, TH2 or throttles TH1, TH2 of fixed size. Further the throttles TH1, TH2 can be manually adjustable or automatically adjustable.

[0027] Figures 1 and 2 show that the channel GC is a channel of annular cross section arranged coaxially to said central axis AX, wherein said channel walls CW comprise a radially inner channel wall ICW and a radially outer channel wall OCW. With regard to the flow direction of the gas through said gas channel GC the radial outer channel wall OCW extends further downstream than the inner channel wall ICW by an axial exit throat segment AETS extending downstream an axial plane of an annular edge of a radial inner channel wall ICW end APE. Said axial exit throat segment AETS joins the upstream annular gas channel into a circular gas channel without central constriction by said radial inner channel wall ICW. Said radial outer channel wall OCW of the axial exit throat segment AETS comprises one radial protrusion RP, extending along the circumference and continuously reducing the diameter of the axial exit throat segment AETS in downstream direction down to a minimum throat diameter MTD at a downstream axial position with regard to the axial plane of said radial inner channel wall ICW end APE. Downstream said minimum throat diameter MTD the radial outer channel wall OCW defines an increasing channel diameter. Said radial protrusion RP extents along the total circumference reducing the axial exit throat segment AETS diameter in the manner of a venturi type nozzle VP.

Claims

1. Gas turbine burner (GTB) comprising:

- a main combustion room (MCR) containing a main combustion zone (MCZ) for burning a mixture of air and fuel (AFM),
- at least one gas channel (GC) for supplying a stream of oxygen containing gas (OCG) to the main combustion zone (MCZ) discharging through a gas channel exit (GCE), which gas channel (GC) is confined by channel walls (CW),
- wherein said gas channel (GC) is a channel of annular cross section arranged coaxially to a central axis (AX),
- wherein said channel walls (CW) comprise a radially inner

channel wall (ICW) and a radially outer channel wall (OCW) **characterized in that**

- with regard to the flow direction of the gas through said gas channel (GC) the radial outer channel wall (OCW) extends further down-

stream than the inner channel wall (ICW) by an axial exit throat segment (AETS) extending downstream an axial plane of an annular edge of a radial inner channel wall (ICW) end (APE),
- wherein the axial exit throat segment (AETS) joins the upstream annular gas channel into a circular gas channel without central constriction by said radial inner channel wall (ICW),
- wherein the radial outer channel wall (OCW) of the axial exit throat segment (AETS) comprises at least one radial protrusion (RP), extending at least along a part of the circumference and continuously reducing the diameter of the axial exit throat segment (AETS) in downstream direction down to a minimum throat diameter (MTD) at a downstream axial position with regard to the axial plane of said radial inner channel wall (ICW) end (APE),
- wherein downstream said minimum throat diameter (MTD) the radial outer channel wall (OCW) defines an increasing channel diameter.

2. Gas turbine burner (GTB) according to claim 1, wherein said at least one radial protrusion (RP), extents along the total circumference reducing the axial exit throat segment (AETS) diameter like a venturi nozzle (VP).

3. Gas turbine burner (GTB) according to claim 1, wherein

- at least one fuel injection element (FIE) protruding from at least one of said channel walls (CW), comprising an inner cavity (IC) being supplied with fuel (F), which inner cavity (IC) joins into at least one nozzle opening (NO1, N02) of at least one nozzle (NO) of said at least one fuel injection element (FIE) to inject fuel (F) into the gas channel (GC).

4. Gas turbine burner (GTB) according to claim 3, wherein

- said gas channel (GC) is provided with at least one swirler wing (SW) protruding from the channel wall (CW) to imprint a certain velocity distribution on the gas flow through said gas channel (GC) and

wherein said at least one fuel injection element (FIE) itself is made as said at least one swirler wing (SW).

5. Gas turbine burner (GTB) according to claim 3, wherein said fuel injection element (FIE) comprises at least two separate inner cavities (IC), a first inner cavity (IC1) joining into at least a first nozzle opening (NO1) or a set of first nozzle openings (NO1) and a second inner cavity (IC2) joining into at least a second nozzle opening (NO2) or a set of second nozzle openings (N02).

6. Gas turbine burner (GTB) according to claim 5, wherein said first inner cavity (IC1) is connected to a buffer room (BR) by a first fuel channel (FC1), said second inner cavity (IC2) is connected to said buffer room (BR) by a second fuel channel (FC2), wherein said first fuel channel (FC1) is provided with a first throttle (TH1) and said second fuel channel (FC2) is provided with a second throttle (TH2) to imprint a certain pressure drop on the flow through said first fuel channel (FC1) and said second fuel channel (FC2) respectively.

7. Gas turbine burner (GTB) according to claim 6, wherein an exit area (EATH1) of said first throttle (TH1) is at least three times bigger than the sum of exit areas of the first nozzle opening (EANO1) or the sum of exit areas of a set of said first nozzle openings (EANO1) and/or
an exit area (EATH2) of said second throttle (TH2) is at least three times bigger than the exit area of said second nozzle opening (EAN02) or the sum of exit areas of a set of second nozzle openings (N02).

8. Gas turbine burner (GTB) according to any of the preceding claims 3 to 7,
wherein a cross section area (CA) of said gas channel (GC) is reduced in downstream direction upstream of said fuel injection element (FIE).

9. Gas turbine burner (GTB) according to at least one of the preceding claims 3 to 8,
wherein said gas channel (GC) is a channel of annular cross section surrounding coaxially a pilot burner (PB) comprising a pilot combustion room (PCR), which is discharging a pilot combustion gas (PCG) generated in said pilot combustion room (PCR) through a constricted pilot exit throat (PET) into said main combustion room (MCR), wherein said pilot exit throat (PET) is coaxially surrounded by said annular shaped gas channel exit (GCE).

10. Gas turbine burner (GTB) according to claim 9, wherein said gas channel (GC) is connected to an oxygen containing gas collector (OCGC) by a perforated channel wall (CW), which perforation (PF) is made such that jets of oxygen containing gas (OCG) hit said surrounded pilot burner (PB) for the purpose of heat exchange.

FIG 1

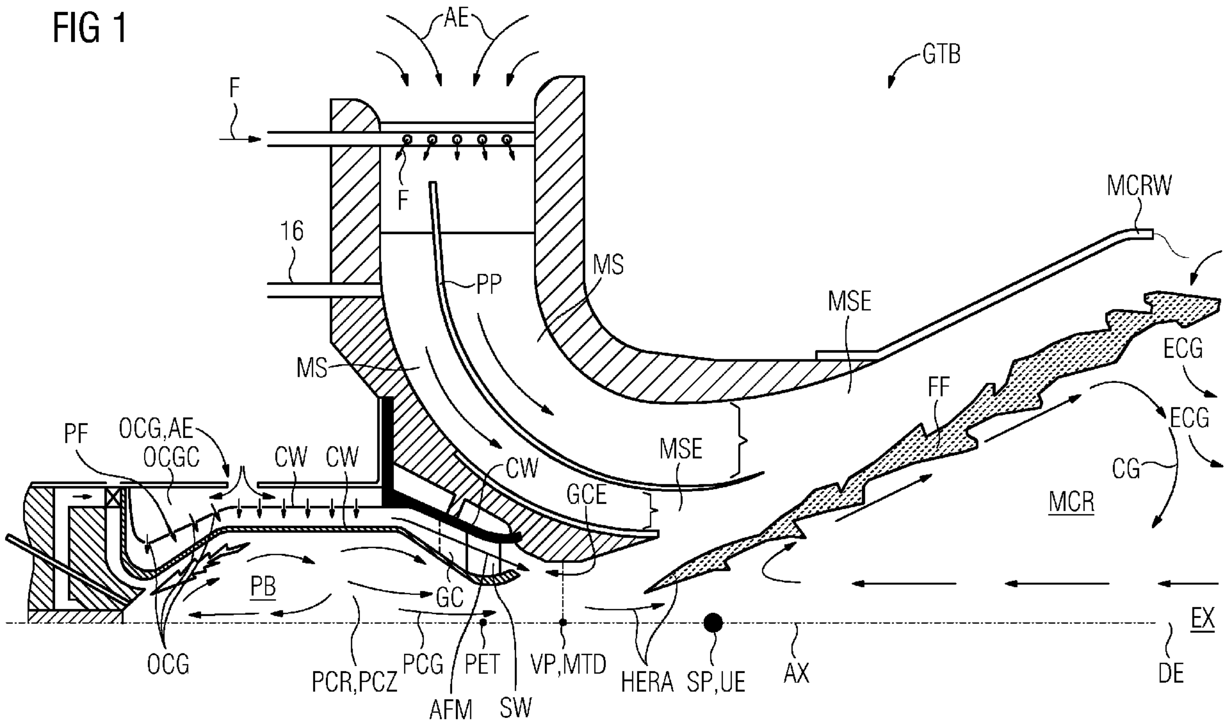
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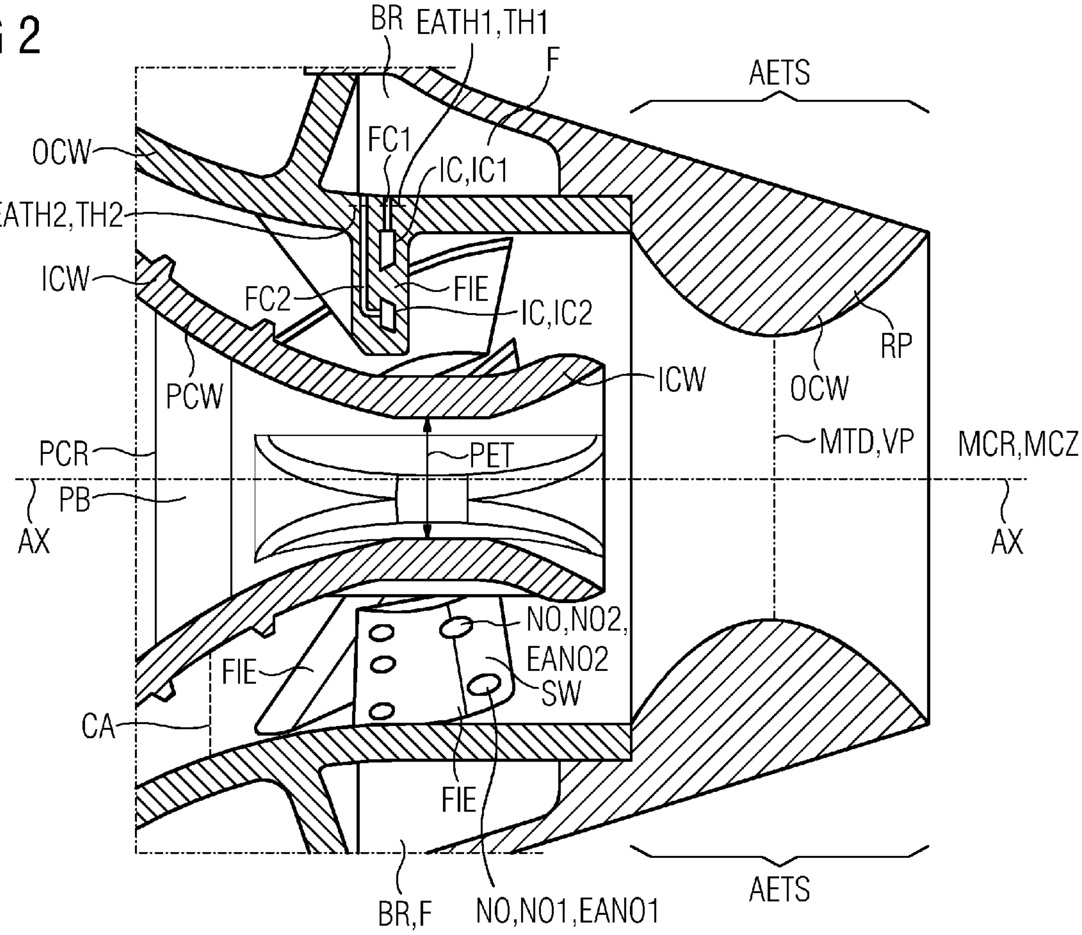
FIG 2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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	21 October 2011	Harder, Sebastian

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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