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(54) SEQUENTIAL COMBUSTOR ASSEMBLY FOR A GAS TURBINE ASSEMBLY

(57) A sequential combustor assembly for a gas turbine assembly (1) is provided with a first stage combustor (8); with a second stage combustor (9) arranged downstream the first stage combustor (8) along the gas flow; with a mixer (11) arranged between the first stage combustor (8) and the second stage combustor (9); and with a lance (19) arranged along said main axis (B) and extending through the first stage combustor (8), through

the mixer (11) and at least partially through the second stage combustor (9); the lance (19) comprising at least one first air channel (21); the lance (19) comprising an inlet portion (22) housed in the first stage combustor (8), a middle portion (23) housed in the mixer (11) and an outlet portion (24) housed in the second stage combustor (9); the lance (19) being provided with at least one first air outlet (28; 30, 31, 32) along the middle portion (23).

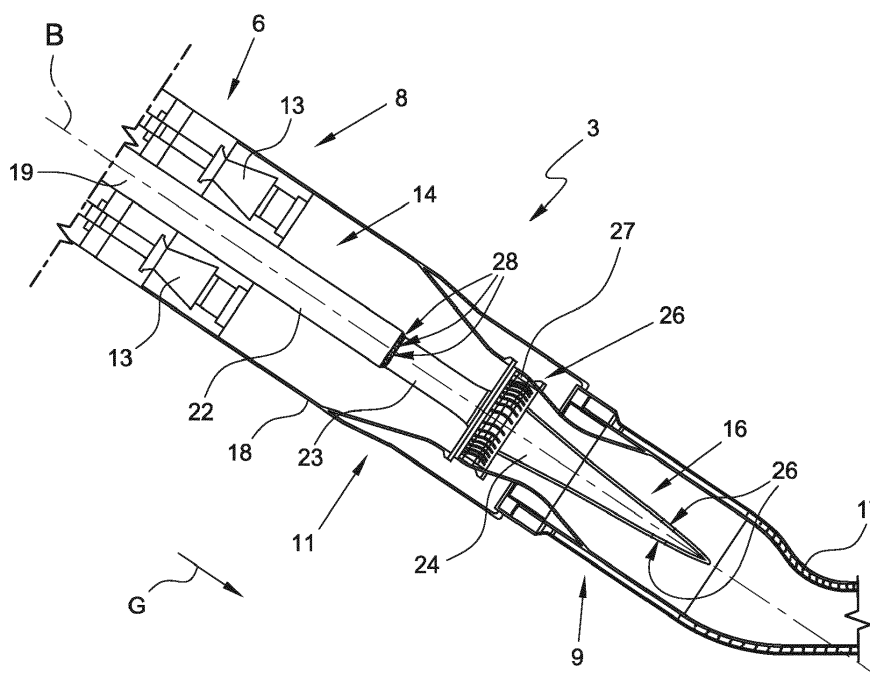


FIG. 2

EP 3 438 530 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a sequential combustor assembly for a gas turbine assembly. In particular, the present invention relates to a sequential combustor assembly for a gas turbine assembly which is part of a plant for the production of electrical power.

BACKGROUND

[0002] As is known, a sequential combustor assembly comprises a first-stage combustor and a second-stage combustor which is arranged downstream the first-stage combustor along the gas flow.

[0003] A mixer is arranged between the first-stage combustor and the second-stage combustor. In use, dilution air is selectively injected in said mixer.

[0004] In sequential combustor assembly of this type, however, combustion instabilities can occur if temperature fluctuations are present at the inlet of the second-stage combustor.

[0005] Said temperature fluctuations are characterized by very low frequencies. Therefore a solution with resonators is impracticable as it would require too large damping volumes.

SUMMARY

[0006] The object of the present invention is therefore to provide a sequential combustor assembly which enables avoiding or at least mitigating the described drawbacks.

[0007] In particular, it is an object of the present invention to provide a sequential combustor assembly wherein the risk of occurring combustion instabilities is noticeably reduced. According to the present invention, there is provided a sequential combustor assembly for a gas turbine assembly; the sequential combustor assembly extending along a main axis and comprising:

- a first stage combustor;
- a second stage combustor arranged downstream the first stage combustor along the gas flow;
- a mixer arranged between the first stage combustor and the second stage combustor; and
- a lance arranged along said main axis and extending through the first stage combustor, through the mixer and at least partially through the second stage combustor; the lance comprising at least one first air channel; the lance comprising an inlet portion housed in the first stage combustor, a middle portion housed in the mixer and an outlet portion housed in the second stage combustor; the lance being provided with at least one first air outlet along the middle portion.

[0008] In this way, air injected into the mixer by the lance contributes to create a uniform temperature distribution in the mixer. Damping of the temperature fluctuations in the mixer can be optimized by suitably regulate the axial position of the first air inlet. In this way, the temperature fluctuations of the flow entering the second-stage combustor are reduced to the minimum and the instabilities of the combustion in the sequential combustor assembly are reduced too.

[0009] This solution is cost effective and does not require additional parts to be added to the sequential combustor assembly. With a simple and cost effective redesign of the lance, great improvements in terms of efficiency can be reached.

[0010] According to a preferred embodiment of the present invention the lance is provided with a plurality of first air outlets circumferentially aligned and evenly distributed along the circumference. In this way a better uniform temperature distribution can be reached in the mixer.

[0011] According to a preferred embodiment of the present invention the plurality of first air outlets have the same outlet section. In this way the amount of the air flowing into the mixer can be controlled.

[0012] According to a preferred embodiment of the present invention the at least one first air outlet is provided with an insert. In this way it is possible to regulate the outlet section and/or to create turbulence and/or to deviate the flow in a desired direction and/or to modify the radial position of the injection of the air flow inside the mixer.

[0013] According to a preferred embodiment of the present invention the lance is provided with at least one second air outlet axially spaced from the first air outlet along the middle portion. In this way damping of the temperature fluctuations in another area of the mixer can be obtained, if necessary. According to a preferred embodiment of the present invention the lance is provided with a plurality of second air outlets axially spaced from the first air outlet along the middle portion. In this way a better uniform temperature distribution can be reached in the mixer.

[0014] According to a preferred embodiment of the present invention the plurality of second air outlets are circumferentially aligned.

[0015] According to a preferred embodiment of the present invention the first air outlet and the second air outlet are in fluidic communication with the first air channel. In this way the pressure of air injected through the first air outlet and the second air outlet is the same.

[0016] According to a preferred embodiment of the present invention the lance comprises at least one second air channel distinct from the first air channel; the first air outlet being in fluidic communication with the first air channel while the second air outlet being in fluidic communication with the second air channel. In this way the pressure of air exiting through the first air outlet and the second air outlet can be regulated differently in order to

obtain an optimized damping effect.

[0017] According to a preferred embodiment of the present invention the sequential combustor assembly comprises a liner; a part of the liner defines the mixer; the liner being provided with at least one first air injection along the mixer.

[0018] In this way air is injected also along peripheral zone of the mixer, thus providing damping of temperature fluctuations in different locations of the mixer and with different time delays, if needed.

[0019] Thanks to the presence of the at least one first air injection the air jet penetration required for the at least one first air outlets of the lance to create a uniform temperature distribution is lower since air is injected from both the liner wall and the central lance. Consequently the required pressure drop in the at least one air outlet is lower. According to a preferred embodiment of the present invention the liner is provided with at least one second air injection axially spaced from the first air injection along the mixer. In this way a regulation and an optimization of the damping can be obtained.

[0020] According to a preferred embodiment of the present invention the at least one first air injection is in fluidic communication with a respective liner air plenum; wherein the pressure of the air in the liner plenum is greater than the pressure of the air in the first air channel of the lance.

[0021] It is furthermore an object of the present invention to provide a turbine assembly having an improved efficiency. According to the present invention, there is provided a gas turbine assembly as claimed in claim 15.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The present invention will now be described with reference to the accompanying drawings, which illustrate some non-limitative embodiment, in which:

- Figure 1 is a simplified block diagram of a gas turbine assembly;
- Figure 2 is a longitudinal section through a sequential combustor assembly in accordance to an embodiment of the present invention;
- Figure 3 is a longitudinal section through a sequential combustor assembly in accordance to a further embodiment of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0023] In figure 1 reference numeral 1 indicates a gas turbine assembly. The gas turbine assembly 1 comprises a compressor section 2, a sequential combustor assembly 3 and a turbine section 5. The compressor section 2 and the turbine section 3 extend along a main axis A.

[0024] In use, an airflow compressed in the compressor section 2 is mixed with fuel and is burned in the sequential combustor assembly 3. The burned mixture is

then expanded to the turbine section 5 and converted in mechanical power.

[0025] With reference to figure 2, the sequential combustor assembly 3 comprises at least one can 6 which extends along a main axis B and comprises a first-stage combustor 8 and a second-stage combustor 9 sequentially arranged along the gas flow direction G. In other words, the second stage combustor 9 is arranged downstream the first stage combustor 8 along the gas flow.

[0026] The combustor assembly 3 further comprises a mixer 11 arranged between the first stage combustor 8 and the second stage combustor 9.

[0027] More specifically, the first-stage combustor 8 comprises at least one burner 13 and a first combustion chamber 14.

[0028] The second-stage combustor 9 comprises a second combustion chamber 16.

[0029] The combustor assembly 3 further comprises a transition element 17 arranged downstream the can 6 for coupling the second combustion chamber 16 to the turbine section 5 (not shown).

[0030] The first combustion chamber 14, the second combustion chamber 16 and the mixer 11 are in fluidic communication and are defined by a liner 18 which extends axially.

[0031] Preferably the liner 18 is substantially cylindrical along the first combustion chamber 14, is conical along the mixer 11 and again substantially cylindrical along the second combustion chamber 16. Preferably, in the mixer 11 the liner 18 converges along the gas flow direction G.

[0032] The combustor assembly 3 further comprises a lance 19, which extends axially through the first combustion chamber 14 of the first-stage combustor 8, through the mixer 11 and discharges in the second combustion chamber 16.

[0033] Preferably, the lance 19 is arranged along the axis B, i.e. substantially centrally with respect to the liner 18.

[0034] The lance 19 is configured to feed air and at least one fuel.

[0035] With reference to figure 3, the lance 19 comprises at least one fuel channel 20 and at least one air channel 21.

[0036] Air flowing in the air channel 21 comes from a respective lance plenum (not illustrated) wherein air has a determined pressure.

[0037] According to a variant not illustrated, the lance comprises a further fuel channel.

[0038] According to a further variant not illustrated, the lance comprises a plurality of air channels, in each of which flows air coming from different plena having preferably different air pressure.

[0039] In the non-limiting example here disclosed and illustrated the fuel channel 20 is centrally arranged, while the air channel 21 extends about the fuel channel 20.

[0040] With reference to figure 2, the lance 19 comprises an inlet portion 22 housed in the first combustion chamber 14, a middle portion 23 and an outlet portion 24

housed in the second combustion chamber 16.

[0041] The lance 19 is provided with at least one fuel discharge 26 in the outlet portion 24 in order to provide fuel to the second combustion chamber 16. In the non-limiting example illustrated in figure 2 the lance 19 comprises a swirler 27 and one first fuel discharge 26 located at the swirler 27 and at least one second fuel discharge 26 located near the tip of the lance 19.

[0042] The lance 19 is further provided with at least one air outlet 28 along the middle portion 23 housed in the mixer 11.

[0043] In the non-limiting example illustrated in figure 2 the lance 19 is provided with a plurality of air outlets 28 circumferentially aligned.

[0044] Preferably, the plurality of air outlets 28 are evenly distributed along the circumference.

[0045] According to a variant not illustrated, the plurality of air outlets are unevenly distributed in order to create zones of air injections substantially separated.

[0046] Preferably, the plurality of air outlets 28 have the same outlet section.

[0047] According to a variant not illustrated, the plurality of air outlets can have different outlet sections in order to regulate the air flow rate entering in the mixer 11.

[0048] According to a further variant not illustrated the at least one air outlet 28 is provided with an insert.

[0049] The insert can be configured to regulate the outlet section and/or to create turbulence and/or to deviate the flow in a desired direction and/or to modify the position of the injection of the air flow inside the mixer.

[0050] According to a variant not illustrated the air outlet 28 can be a slot realized on the middle portion 23 of the lance 19. Preferably the slot is an annular slot.

[0051] According to a variant illustrated in figure 3, along the middle portion 23 the lance 19 is provided with at least one first air outlet 30, at least one second air outlet 31 and, preferably, at least a third air outlet 32.

[0052] The first air outlet 30, the second air outlet 31 and the third air outlet 32 are axially spaced along the middle portion 23.

[0053] The presence of three axially-spaced air outlets 30, 31, 32 allows to damp temperature fluctuations in a broader frequency range compared to the case with less than three air outlets.

[0054] In the non-limiting embodiment here disclosed and illustrated, air exiting through the first air outlet 30, the second air outlet 31 and the third air outlet 32 comes from the same air channel 21.

[0055] According to a variant not illustrated air exiting through the first air outlet, the second air outlet and the third air outlet comes from respective separate air channels supplied with air coming from different plena having different air pressures.

[0056] In the non-limiting embodiment here disclosed and illustrated the lance 19 is provided with a plurality of first air outlets 30, a plurality of second air outlets 31 and, preferably, a plurality of third air outlets 32.

[0057] Preferably, the plurality of first air outlets 30 are

circumferentially aligned, the plurality of second air outlets 31 are circumferentially aligned and the plurality of third air outlets 32 are circumferentially aligned.

[0058] Preferably, the plurality of first air outlets 30, the plurality of second air outlets 31 and the plurality of third air outlets 32 are evenly distributed along the respective circumferences.

[0059] Preferably the liner 18 is provided with at least one air injection 35 along the mixer 11.

[0060] More preferably, the liner 18 is provided with a first air injection 35a, a second air injection 35b and a third air injection 35c. The first air injection 35a, the second air injection 35b and the third air injection 35c are axially spaced along the mixer 11.

[0061] In this way air enters in the mixer 11 from the central lance 19 through the air outlets 30 31 32 and from the peripheral liner 18 through the air injections 35a 35b 35c.

[0062] In the non-limiting embodiment here disclosed and illustrated, the liner 18 is provided with a plurality of first air injections 35a, a plurality of second air injections 35b and a plurality of third air injections 35c.

[0063] Preferably air exiting through the air injection 35 or through the air injections 35a, 35b, 35c comes from a respective liner plenum (not illustrated) wherein air has a determined pressure.

[0064] Preferably in the liner plenum air has a pressure different from the pressure of the air in the lance plenum.

[0065] According to a variant not illustrated, the liner plenum and the lance plenum can have the same pressure. For example the liner plenum and the lance plenum can coincide. Thanks to the presence of the air injections 35a, 35b, 35c, the air jet penetration required for air outlets 28, 30, 31, 32 in the lance 16 to create a uniform temperature distribution is lower since air is injected from both the liner wall (through air injections 35a, 35b, 35c) and the central lance 16 (through air outlets 28, 30, 31, 32). Consequently the required pressure drop in air outlets 28, 30, 31, 32 is also lower. Axial positions of air injections 35a, 35b, 35c and of air outlets 30, 31, 32 can be defined in the designing phase in order to conveniently damp the temperature fluctuations at the inlet of the second-stage combustor 9.

[0066] Air coming from the lance 19, in fact, contributes to create a more uniform temperature distribution in the mixer 11 with a lower overall pressure drop through the air outlets 30, 31, 32, since a lower jet penetration is required to generate a uniform temperature profile at the exit of the mixer 11. In this way, the temperature fluctuations of the flow entering the second-stage combustor 9 are reduced to the minimum and the instabilities of the combustion in the sequential combustor assembly 3 are reduced too.

[0067] Advantageously, air injections 35a, 35b, 35c can be designed in order to direct air towards distal zones of the mixer 11 near the wall of the liner 18 while the air outlets 30, 31, 32 can be designed in order to direct air towards proximal zones of the mixer 11 near the lance

16. In other words, air outlets 30, 31, 32 direct air mainly towards zone of the mixer which are radially proximal with respect to axis B, while air injections 35a, 35b, 35c direct air mainly towards zone of the mixer which are radially distal with respect to axis B.

[0068] Moreover, the axial position of air injections 35a, 35b, 35c and of air outlets 30, 31, 32 can be selected in order to have a uniform distribution of the air injected from the lance 16 and from the liner 18 or in order to focus the air injection towards one or more zones of the mixer 11 wherein temperature fluctuations are particularly relevant. In this way, the design and the axial position of air injections 35a, 35b, 35c and of air outlets 30, 31, 32 can be optimized in order to damp different unstable modes affecting the mixer 11.

[0069] Finally, it is clear that modifications and variants can be made to the sequential combustor assembly 3 and to the gas turbine assembly 1 described herein without departing from the scope of the present invention, as defined in the appended claims.

Claims

1. Sequential combustor assembly for a gas turbine assembly (1); the sequential combustor assembly (3) extending along a main axis (B) and comprising:
 - a first stage combustor (8);
 - a second stage combustor (9) arranged downstream the first stage combustor (8) along the gas flow;
 - a mixer (11) arranged between the first stage combustor (8) and the second stage combustor (9); and
 - a lance (19) arranged along said main axis (B) and extending through the first stage combustor (8), through the mixer (11) and at least partially through the second stage combustor (9); the lance (19) comprising at least one first air channel (21); the lance (19) comprising an inlet portion (22) housed in the first stage combustor (8), a middle portion (23) housed in the mixer (11) and an outlet portion (24) housed in the second stage combustor (9); the lance (19) being provided with at least one first air outlet (28; 30, 31, 32) along the middle portion (23).
2. Sequential combustor assembly according to claim 1, wherein the lance (19) is provided with a plurality of first air outlets (28; 30, 31, 32) circumferentially aligned.
3. Sequential combustor assembly according to claim 2, wherein the plurality of first air outlets (28; 30, 31, 32) are evenly distributed along the circumference.
4. Sequential combustor assembly according to claim 2 or 3, wherein the plurality of first air outlets (28; 30, 31, 32) have the same outlet section.
5. Sequential combustor assembly according to any one of the foregoing claims, wherein the at least one first air outlet (28; 30, 31, 32) is provided with an insert.
6. Sequential combustor assembly according to any one of the foregoing claims, wherein the lance (19) is provided with at least one second air outlet (31, 32, 30) axially spaced from the first air outlet (30, 31, 32) along the middle portion (23).
7. Sequential combustor assembly according to claim 6, wherein the lance (19) is provided with a plurality of second air outlets (31, 32, 30) axially spaced from the first air outlet (30, 31, 32) along the middle portion (23).
8. Sequential combustor assembly according to claim 7, wherein the plurality of second air outlets (31, 32, 30) are circumferentially aligned
9. Sequential combustor assembly according to any one of claims from 6 to 8, wherein the first air outlet (30, 31, 32) and the second air outlet (31, 32, 30) are in fluidic communication with the first air channel (21).
10. Sequential combustor assembly according anyone of claims from 6 to 8, wherein the lance (19) comprises at least one second air channel distinct from the first air channel (21); the first air outlet (30, 31, 32) being in fluidic communication with the first air channel (21) while the second air outlet (31, 32, 30) being in fluidic communication with the second air channel.
11. Sequential combustor assembly according to any one of the foregoing claims, comprising a liner (18); a part of the liner (18) defining the mixer (11); the liner (18) being provided with at least one first air injection (35; 35a, 35b, 35c) along the mixer (11).
12. Sequential combustor assembly according to claim 11, wherein the liner (18) is provided with at least one second air injection (35b, 35c, 35d) axially spaced from the first air injection (35a, 35b, 35c) along the mixer (11).
13. Sequential combustor assembly according to claim 11 or 12, wherein the at least one first air injection (35; 35a, 35b, 35c) is in fluidic communication with a respective liner air plenum.
14. Sequential combustor assembly according to claim 13, wherein the pressure of the air in the liner plenum

is greater than the pressure of the air in the first air channel (21) of the lance (19).

15. Gas turbine assembly comprising a compressor section (2), a turbine section (5); and a sequential combustor assembly (3) as claimed in anyone of the foregoing claims.

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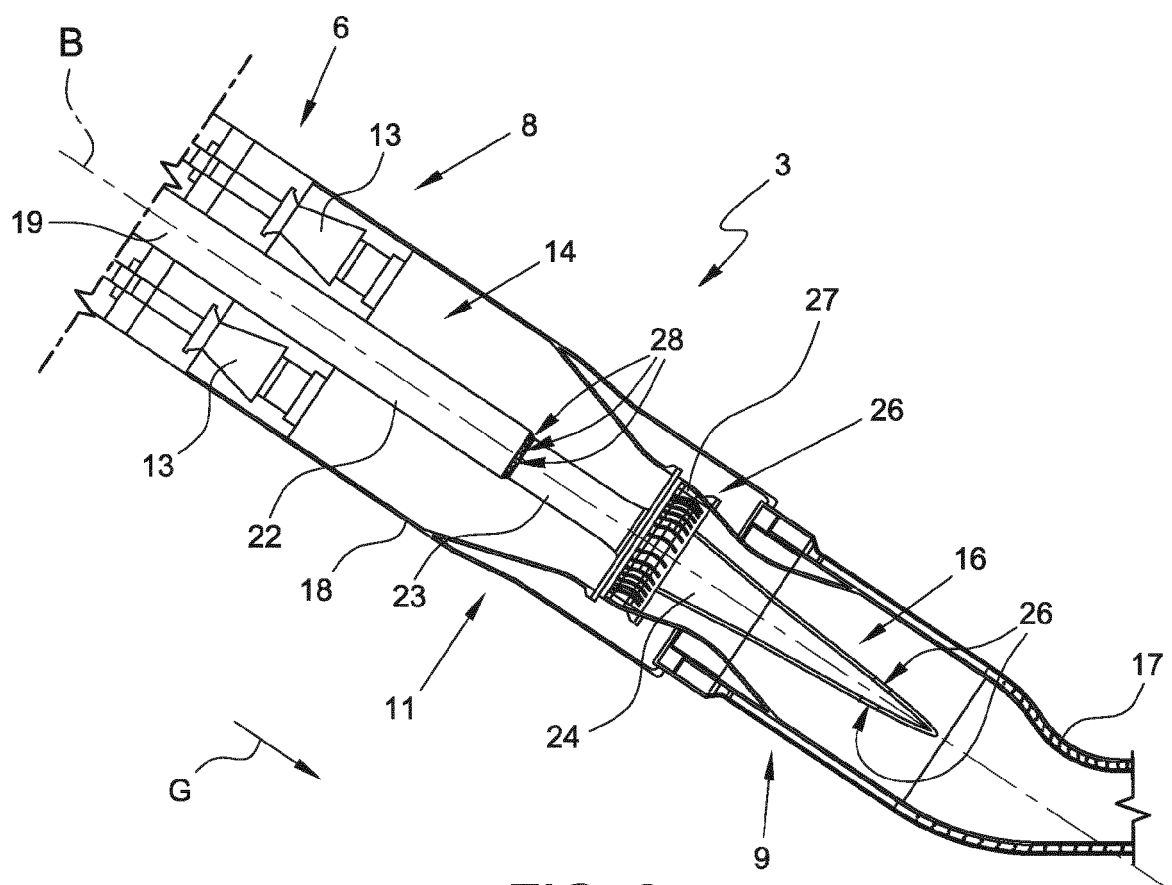
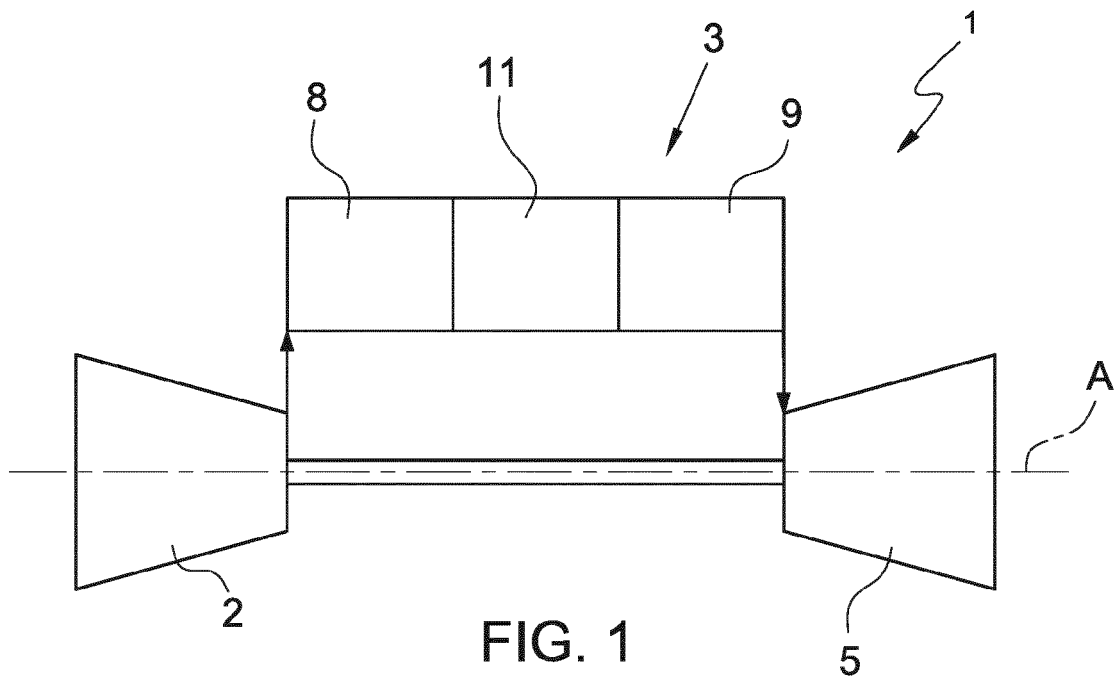
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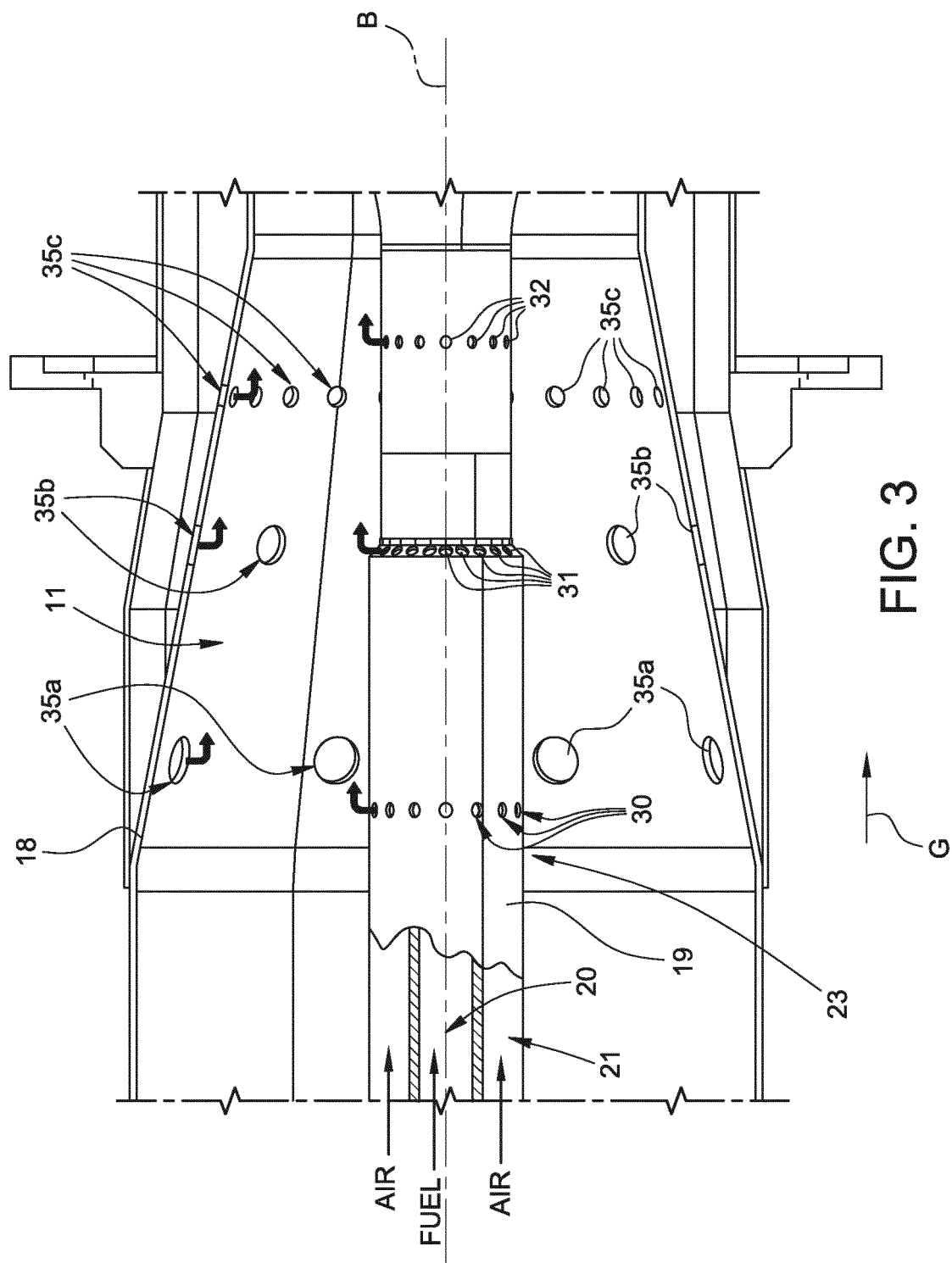
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CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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