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(54) **Burner assembly, gas turbine power plant comprising said burner assembly, and method for operating said burner assembly**

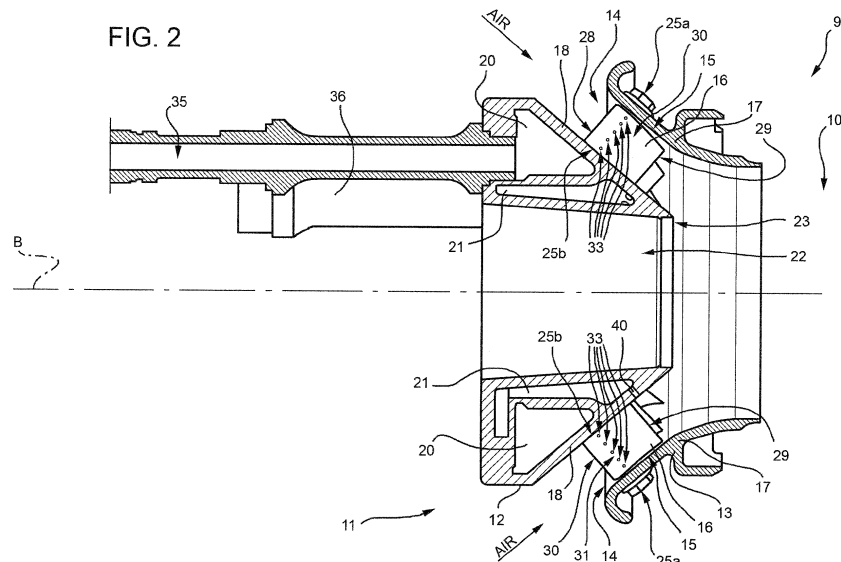
(57) A burner assembly (9) for a gas turbine power plant (1) extends along a longitudinal axis (B) and comprises a premix burner (11) provided with:

- a first supply channel (20) for supplying a first gas mixture;
- a second supply channel (21) for supplying a second gas mixture;
- an air flow channel (14), which is provided with an inner

wall (18) and an outer wall (17);

- a swirler (15) arranged along the air flow channel (14);
- a plurality of first outlets (33) for supplying the first mixture; and
- at least a second outlet (40, 44, 55) for supplying the second mixture; the second outlet (40, 44, 55) being arranged along the inner wall (18) of the air flow channel (14) at the outlet of the swirler (15).

FIG. 2



Description

[0001] The present invention relates to a burner assembly, to a gas turbine power plant comprising said burner assembly, and to a method for operating said burner assembly.

[0002] Over the last few years, the field of gas turbines for generating electric energy has increasingly used mixtures of combustible gases as alternatives to natural gas. In particular, among the gas mixtures as alternatives to natural gas, gas mixtures with a low calorific value are preferred, such as Syngases (synthetic gas) deriving from coal gasification processes.

[0003] Syngases deriving from coal gasification processes are characterized by a high hydrogen and carbon monoxide content.

[0004] Over the last few years, the gasification of solid fuel, such as coal, has taken a fundamental role in decreasing carbon dioxide emissions.

[0005] Indeed, during gasification, the so-called "pre-combustion capture" process is performed, which removes carbon dioxide (CO₂) before combustion for generating hydrogen.

[0006] In particular, the "pre-combustion capture" process includes removing carbon monoxide in the Syngas by converting CO into CO₂ (which process is commonly called "shift CO"). CO₂ may be compressed into a liquid form and transported to a storage site. The Syngas obtained from such a process has a significantly increased hydrogen content (up to 80% volume of hydrogen concentration).

[0007] Burner assemblies of known type, in which the diffusion combustion method is used for burning Syngases, are characterized by high flame temperatures and therefore by high NO_x emissions. In order to decrease the flame temperature, the known art provides for diluting the Syngas with an inert agent (nitrogen, vapour or carbon dioxide). However, this technique involves drastically decreasing the efficiency of the cycle.

[0008] Moreover, burner assemblies are known which use the "lean premix" technology with Syngas, which includes premixing air and fuel before their input into the primary combustion zone.

[0009] However, using such a technology with fuels having a high hydrogen content (which are highly reactive and have high flame speed) is extremely difficult as the risk of flame return phenomena is very high. Flame return is generally determined by igniting the mixture when reaching the primary combustion zone and by then propagating the flame upstream of the primary combustion zone, thus resulting in damages to the burner itself. Indeed, flame return is very dangerous and may cause irreversible damages to the burner assembly.

[0010] For example, document EP2161502 discloses a burner assembly for Syngases comprising a premix burner equipped with an air flow channel and with a swirler arranged along the air flow channel. The swirler is provided with a plurality of nozzles for supplying the nat-

ural gas and with a plurality of nozzles for supplying the Syngas. However, the position of the nozzles for supplying the Syngas is not suitable for the application with a high hydrogen content Syngas. Indeed, the position of the nozzles for supplying the Syngas ensures good premixing and lowering of the flame temperature, and therefore of the NO_x level; however, this design promotes the so-called flame return phenomena with high hydrogen content Syngas.

[0011] Moreover, in burner assemblies of this type, there is often the need to dilute high hydrogen content Syngases with a high flow of inert gases (usually nitrogen or vapour) to keep the NO_x emissions under legal limits. In addition to being an operating cost, the consumption of such diluents is an important complication in terms of plant engineering.

[0012] On the other hand, document US 20070275337 discloses a burner assembly for Syngases comprising a premix burner equipped with an air flow channel, a swirler arranged along the air flow channel, a plurality of nozzles for supplying the natural gas, and a plurality of nozzles for supplying the Syngas.

[0013] The nozzles for supplying the natural gas are obtained in the swirler, while the nozzles for supplying the Syngas are obtained on the outer wall of the air flow channel substantially at the outlet of the air flow channel. This design is advantageous because it significantly decreases the risk of flame return for high hydrogen content Syngases, however it does not ensure adequate premixing of the Syngas with air. The contact between air and Syngas substantially occurs close to the primary combustion zone and thus very high flame temperatures are reached, which result in high NO_x emissions.

[0014] In this type of burner assemblies, there is also often the need to dilute the high hydrogen content Syngases with a high flow of inert gases (usually nitrogen or vapour) to keep the NO_x emissions under legal limits.

[0015] It is thus the object of the present invention to provide a burner assembly for a gas turbine power plant which is free from the known art drawbacks described herein; in particular, it is an object of the present invention to ensure the integrity and reliability of the burner assembly while ensuring emissions of pollutants below the legal limits, while minimizing the amount of diluents to be supplied to the burner assembly.

[0016] In accordance with these objects, the present invention relates to a burner assembly for a gas turbine power plant according to claim 1.

[0017] It is a further object of the present invention to provide a reliable power plant, in which the emissions of pollutants are below the legal limits, while minimizing the supply of diluents.

[0018] In accordance with these objects, the present invention relates to a gas turbine power plant according to claim 15.

[0019] It is a further object of the invention to provide a method for operating a burner assembly for a gas turbine power plant which makes the burner assembly re-

liable and minimizes the use of diluents.

[0020] In accordance with these objects, the present invention relates to a method for operating a burner assembly for a gas turbine power plant according to claim 16.

[0021] Further features and advantages of the present invention will become more apparent from the following description of a non-limiting embodiment thereof, with reference to the figures in the accompanying drawings, in which:

- figure 1 is a diagrammatic view, with parts removed for clarity, of a power plant according to the invention;
- figure 2 is a sectional view, with parts removed for clarity, of a burner assembly according to the invention;
- figure 3 is a perspective view, with cut-out parts and parts removed for clarity, of a detail of the burner assembly in figure 2, in accordance with a first embodiment;
- figure 4 is a perspective view, with cut-out parts and parts removed for clarity, of the detail of the burner assembly in figure 2, in accordance with a second embodiment;
- figure 5 is a perspective view, with cut-out parts and parts removed for clarity, of the detail of the burner assembly in figure 2, in accordance with a third embodiment.

[0022] In figure 1, numeral 1 indicates a power plant comprising a gas turbine 2 extending along an axis A, a compressor 3, a combustion chamber 4, an assembly 6 for supplying fuel to combustion chamber 4, and a generator 7, which transforms the mechanical power supplied by the gas turbine 2 into output electric power.

[0023] The combustion chamber 4 is of annular type and comprises a plurality of seats 8, each of which is adapted to be engaged by a burner assembly 9 (better shown in figures 2-5).

[0024] Seats 8 are arranged along a circular path close to a peripheral edge of the combustion chamber 4. In the non-limiting example described and shown herein, there are twenty-four seats 8 and burner assemblies 9.

[0025] With reference to figure 2, each burner assembly 9 extends along an axis B and is designed to define a primary combustion zone 10.

[0026] Each burner assembly 9 is supplied with air, a first gas mixture and a second gas mixture.

[0027] Air, first mixture and second mixture are supplied to the burner assembly 9 along a supply direction D1 directed towards the interior of the combustion chamber 4.

[0028] The first gas mixture preferably has a first calorific value and the second gas mixture has a second calorific value lower than the first calorific value.

[0029] In particular, the first mixture is preferably natural gas.

[0030] The second gas mixture has a calorific value

between about 18 MJ/kg and 20 MJ/kg, and a hydrogen concentration greater than about 80% volume. The hydrogen concentration of the second gas mixture is preferably of about 83% volume.

[0031] The second gas mixture is a Syngas, for example, obtained from the coal gasification processes.

[0032] Each burner assembly 9 comprises a premix burner 11 and a pilot burner (not shown in the accompanying drawings for simplicity). The pilot burner substantially extends along axis B, while the premix burner 11 is coaxial to the pilot burner and surrounds the pilot burner.

[0033] In particular, premix burner 11 comprises a main body 12, substantially truncated-conical in shape, an outer annular element 13, which extends about the main body 12 for defining an air flow channel 14, and a swirler 15 arranged along the air flow channel 14 and provided with a plurality of blades 16.

[0034] The air flow channel 14 is annular in shape, coaxially extends to axis B and has a radial height which decreases in the supply direction D1 so as to generate an annular channel with a substantially truncated-conical shape.

[0035] The air flow channel 14 receives air from compressor 3 and is provided with an outer wall 17, defined by the outer annular element 13, and with an inner wall 18 defined by the main body 12.

[0036] Moreover, main body 12 comprises an annular supply channel 20 for supplying the first mixture, an annular supply channel 21 for supplying the second mixture, and a central hole 22, provided with an outer edge 23 and designed to accommodate the pilot burner.

[0037] Each blade 16 of swirler 15 is provided with one end 25a coupled to the outer wall 17 of the air flow channel 14, and one end 25b coupled to the inner wall 18 of the air flow channel 14.

[0038] In particular, the blades 16 are evenly distributed along an annular path centred on axis B. Each blade 16 is oriented so as to conveniently deflect the air flow passing therethrough, and has a leading edge 28, a trailing edge 29, a suction side 30 and a pressure side 31 (better shown in figures 3-5).

[0039] Each blade 16 is provided with a plurality of outlets 33 arranged on suction side 30 and on pressure side 31 of each blade 16 close to the leading edge 28 of blade 16. The outlets 33 are in communication with an inner channel of the blade (not shown in the accompanying figures), which is connected with the first supply channel 20 of the first mixture.

[0040] In particular, the outlets 33 are arranged in groups of outlets which are aligned and inclined with respect to axis B.

[0041] The supply channel 20 for supplying the first mixture extends about axis B and is supplied by a supply tube 35. As mentioned above, the supply channel 20 is in communication with the inner channel of each blade 16 in order to supply the outlets 33 with the first mixture.

[0042] The second mixture supply channel 21 extends about axis B, is supplied by a supply tube 36 and is in

communication with the air flow channel 13 by means of a plurality of outlets 40.

[0043] With reference to figure 3, the outlets 40 are obtained in the inner wall 18 of the flow channel 13 and are evenly arranged along a circular path at the outlet of swirler 15.

[0044] In particular, the outlets 40 are arranged downstream of swirler 15 close to the trailing edge 29 of the blades 16.

[0045] The outlets 40 are circumferentially spaced apart so that two outlets 40 are arranged between two consecutive blades 16 of swirler 15.

[0046] In detail, the outlets 40 have a circular section, the diameter of which depends on the size of the burner assembly 9.

[0047] The position of outlets 40 ensures a proper, effective mixing of air and first and second mixtures, thus minimizing the NO_x emissions.

[0048] With this design, the integration of the second mixture with composite diluents may be minimized (for example, an integration of diluents of about 30% vol. of the second mixture is sufficient) so as to lower the NO_x levels.

[0049] Moreover, the position of the outlets 40 prevents dangerous flame returns from occurring, which are typical in Syngases deriving from coal gasification.

[0050] Figure 4 shows a second embodiment of the outlets 44 for supplying the second mixture.

[0051] For simplicity, figure 4 keeps the same reference numerals used in figures 1-3, to indicate similar parts.

[0052] The outlets 44 are obtained in the inner wall 18 inside the flow channel 13 and are evenly arranged along a circular path at the outlet of swirler 15.

[0053] In particular, the outlets 44 are arranged downstream of swirler 15 close to the trailing edge 29 of blades 16.

[0054] The outlets 44 are circumferentially spaced apart so that a single outlet 44 is arranged between two consecutive blades 16 of swirler 15.

[0055] Each outlet 44 comprises a plurality of nozzles 45, which are preferably evenly distributed on a circle.

[0056] Each nozzle 45 preferably has a circular section, the diameter of which depends on the size of the burner assembly 9.

[0057] Certain nozzles 45 are preferably arranged upstream of the trailing edge 29 of blades 16, while other nozzles 45 are arranged downstream of the trailing edge 29 of blades 16.

[0058] The particular shape of outlets 44 and the particular distribution of nozzles 45 gives the second mixture a swirling component, which promotes mixing the second mixture with air, and possibly with the first mixture.

[0059] The position of outlets 44 ensures a proper, effective mixing of air, first mixture and second gas mixture by minimizing the NO_x emissions.

[0060] With this design, the integration of the second mixture with composite diluents may be minimized (for

example, an integration of diluents of about 25% vol. of the second mixture is sufficient) so as to lower the NO_x levels.

[0061] Figure 5 shows a third embodiment of the outlets 55 for supplying the second mixture.

[0062] For simplicity, figure 5 keeps the same reference numbers used in figures 1-3, to indicate similar parts.

[0063] Outlets 55 are obtained in the inner wall 18 of the flow channel 13 and are evenly arranged along a circular path at the outlet of swirler 15.

[0064] In particular, outlets 55 are arranged downstream of swirler 15 close to the trailing edge 29 of blades 16.

[0065] Outlets 55 are circumferentially spaced apart so that a single outlet 55 is arranged between two consecutive blades 16 of swirler 15.

[0066] Each outlet 55 comprises a flow deflector element 56, which is preferably accommodated inside the respective outlet 55.

[0067] In particular, each outlet 55 has a circular section, the diameter of which depends on the size of the burner assembly 9.

[0068] Each flow deflector element 56 is shaped so as to give the second mixture a swirling component, which promotes mixing the second mixture with air, and possibly with the first mixture.

[0069] In the non-limiting example disclosed and shown herein, the flow deflector element 56 comprises a cylindrical body 58 provided, on its side surface, with a plurality of legs 59, which extend along substantially tangential directions with respect to the cylindrical body 58.

[0070] The position of outlets 55 ensures a proper, effective mixing of air, first mixture and second mixture by minimizing the NO_x emissions. With this design, the integration of the second mixture with composite diluents may be minimized (for example, an integration of diluents of about 20% vol. of the second mixture is sufficient) so as to lower the NO_x levels.

[0071] The burner assembly 9 according to the present invention advantageously allows combustible gas mixtures with high hydrogen content and at an average calorific value to be burned, thus minimizing the supply of diluents while keeping the pollutant emission levels below the legal limits.

[0072] The strategic position of outlets 40, 44 and 55 in the premix burner 11 determines a drastic decrease of the flame temperature due to the suitable premixing between Syngas and air before reaching the primary combustion zone. Accordingly, the generation of nitrogen oxides is naturally limited.

[0073] Instead from a merely economic point of view, the application of this technology allows the cost and plant engineering complexity to be avoided, which are associated with the consumption of diluents required to lower the NO_x emissions.

[0074] Moreover, the position of outlets 40, 44 and 55

in the premix burner 11 suppresses the risk of flame return phenomena.

[0075] Finally, it is apparent that modifications and variants may be made to the burner assembly, to the plant and to the method described herein, without departing from the scope of the appended claims.

Claims

1. Burner assembly (9) for a gas turbine power plant (1), the burner assembly (9) extending along a longitudinal axis (B) and comprising a premix burner (11) provided with:
 - a first supply channel (20) for supplying a first gas mixture;
 - a second supply channel (21) for supplying a second gas mixture (21);
 - an air flow channel (14), which is provided with an internal wall (18) and an outer wall (17);
 - a swirler (15) arranged along the air flow channel (14);
 - a plurality of first outlet (33) for supplying the first gas mixture; and
 - at least a second outlet (40, 44, 55) for supplying the second gas mixture; the second outlet (40, 44, 55) being arranged along the inner wall (18) of the air flow channel (14) at the exit of the swirler (15).
2. Burner assembly according to claim 1, wherein the premix burner (11) comprises a main body (12), which defines the inner wall (18) of the air flow channel (14), the first supply channel (20) and the second supply channel (21), and is provided with a central hole (22) having an outer edge (23); the second outlet (40, 44, 55) being arranged along the inner wall (18) of the air flow channel (14) between the outlet of the swirler (15) and the outer edge (23) of the central hole (22) of the main body (12).
3. Burner assembly according to claim 1 or 2, wherein the swirler (15) comprises a plurality of blades (16) having a first end (25a) coupled to the outer wall (17) and a second end (25b) coupled to the inner wall (18), each blade (16) being provided with a leading edge (28) and a trailing edge (29).
4. Burner assembly according to claim 3, wherein the blades (16) are uniformly distributed along the air flow channel (14).
5. Burner assembly according to claim 3 or 4, wherein the second outlet (40, 44, 55) is arranged along the inner wall (18) of the air flow channel (14) near the trailing edge (29) of at least one blades (16) of the swirler (15).
6. Burner assembly according to any of claims 3 to 5, wherein the premix burner (11) comprises a plurality of second outlets (40, 44, 55) arranged along a circular path along the inner wall (18) of the air flow channel (14).
7. Burner assembly according to claim 6, wherein the plurality of second outlets (40, 44, 55) is arranged uniformly along the circular path.
8. Burner assembly according to claim 6 or 7, wherein the second outlets (40) are circumferentially spaced so that two second outlets (40) are arranged between two consecutive blades (16) of the swirler (15).
9. Burner assembly according to claim 6 or 7, wherein the second outlets (44, 55) are circumferentially spaced so that one second outlet (44, 55) is arranged between two consecutive blades (16) of the swirler (15).
10. Burner assembly according to any of the preceding claims, wherein the second outlet (40, 44, 55) has a substantially circular section.
11. Burner assembly according to any of claims 1 to 10, wherein each second outlet (44) comprises a plurality of nozzles (45).
12. Burner assembly according to claim 11, wherein the nozzles (45) of each second outlet (44) are uniformly distributed on a circle.
13. Burner assembly according to anyone of claims 1 to 10, wherein each second outlet (55) comprises a flow deflector element (56).
14. Burner assembly according to claim 13, wherein the flow deflector element (56) is arranged inside the respective second outlet (55).
15. Gas turbine power plant comprising a combustion chamber (4) provided with at least one burner assembly (9) according to anyone of previous claims.
16. Method for operating a burner assembly (9) for a gas turbine power plant (1), the burner assembly (9) extending along a longitudinal axis (B) and comprising a premix burner (11) provided with:
 - a first supply channel (20) for supplying a first gas mixture;
 - a second supply channel (21) for supplying a second gas mixture (21);
 - an air flow channel (14), which is provided with an internal wall (18) and an outer wall (17);
 - a swirler (15) arranged along the air flow channel (14);

the method comprising the step of supplying at least one between the first gas mixture and second gas mixture; the step of supplying at least one between the first gas mixture and second gas mixture comprising the steps of:

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- supplying the first gas mixture through a plurality of first outlets (33);
- supplying the second gas mixture through at least a second outlet (40, 44, 55) arranged along the inner wall (18) of the air flow channel (14) at the exit of the swirler (15).

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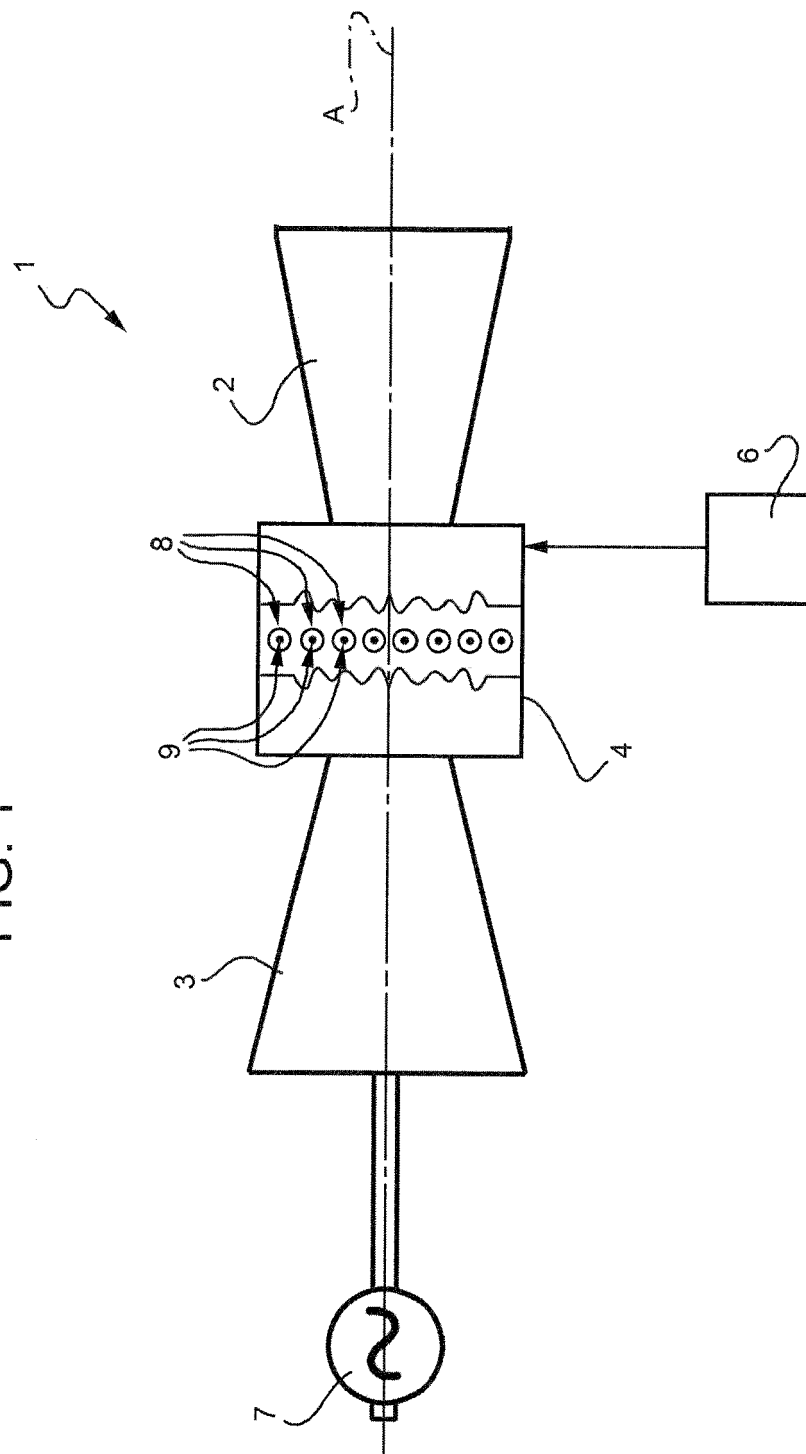
17. Method according to claim 16, wherein the step of supplying the second gas mixture comprises the step of imparting a swirling motion to the second gas mixture in the proximity of the second outlet (40, 44, 55). 15
18. Method to claim 16 or 17, wherein the second gas mixture has a calorific value of between about 18 MJ/kg and 20 MJ/kg. 20
19. Method according to any one of claims 16 to 18, wherein the first gas mixture has a calorific value of 50 MJ/kg 25
20. Method according to any one of claims 16 to 19, wherein the first gas mixture has a first hydrogen volume concentration and the second gas mixture has a second hydrogen volume concentration greater than the first hydrogen volume concentration. 30
21. Method according to any one of claims 16 to 20, wherein the second gas mixture has a second hydrogen volume concentration greater than about 80%. 35
22. Method according to any one of claims 16 to 21, wherein the second gas mixture has a second hydrogen volume concentration greater than about 83%. 40

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FIG. 1



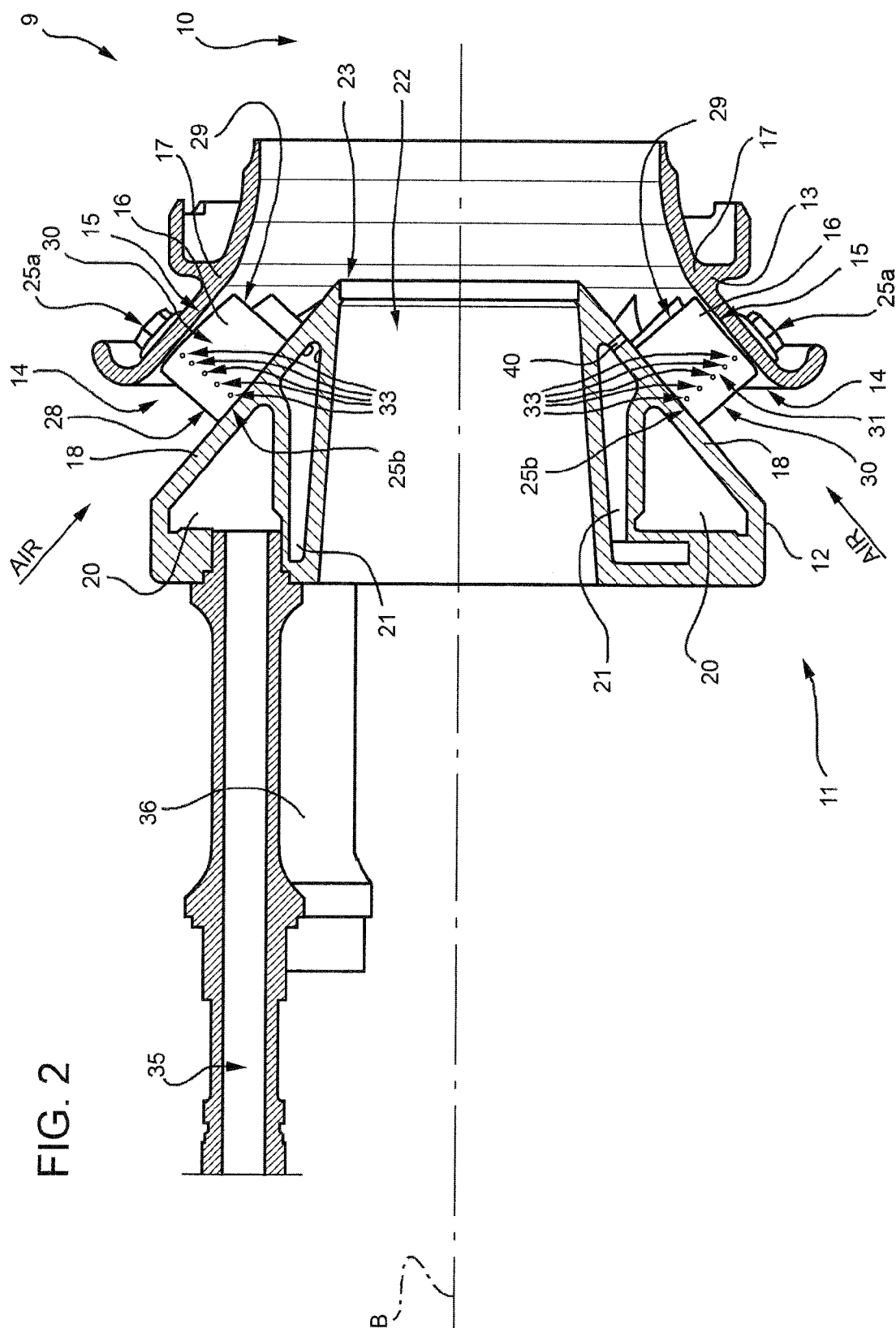
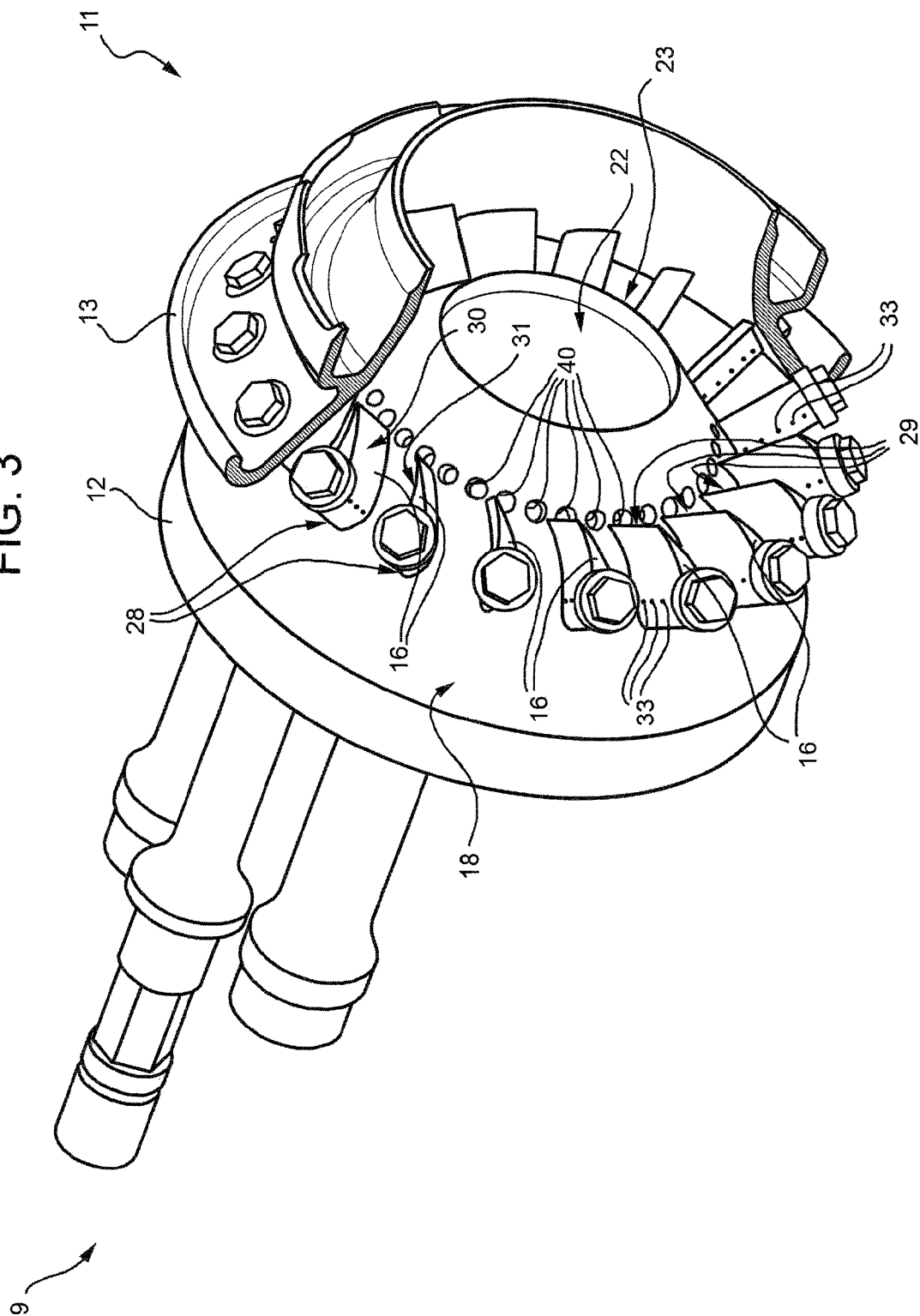
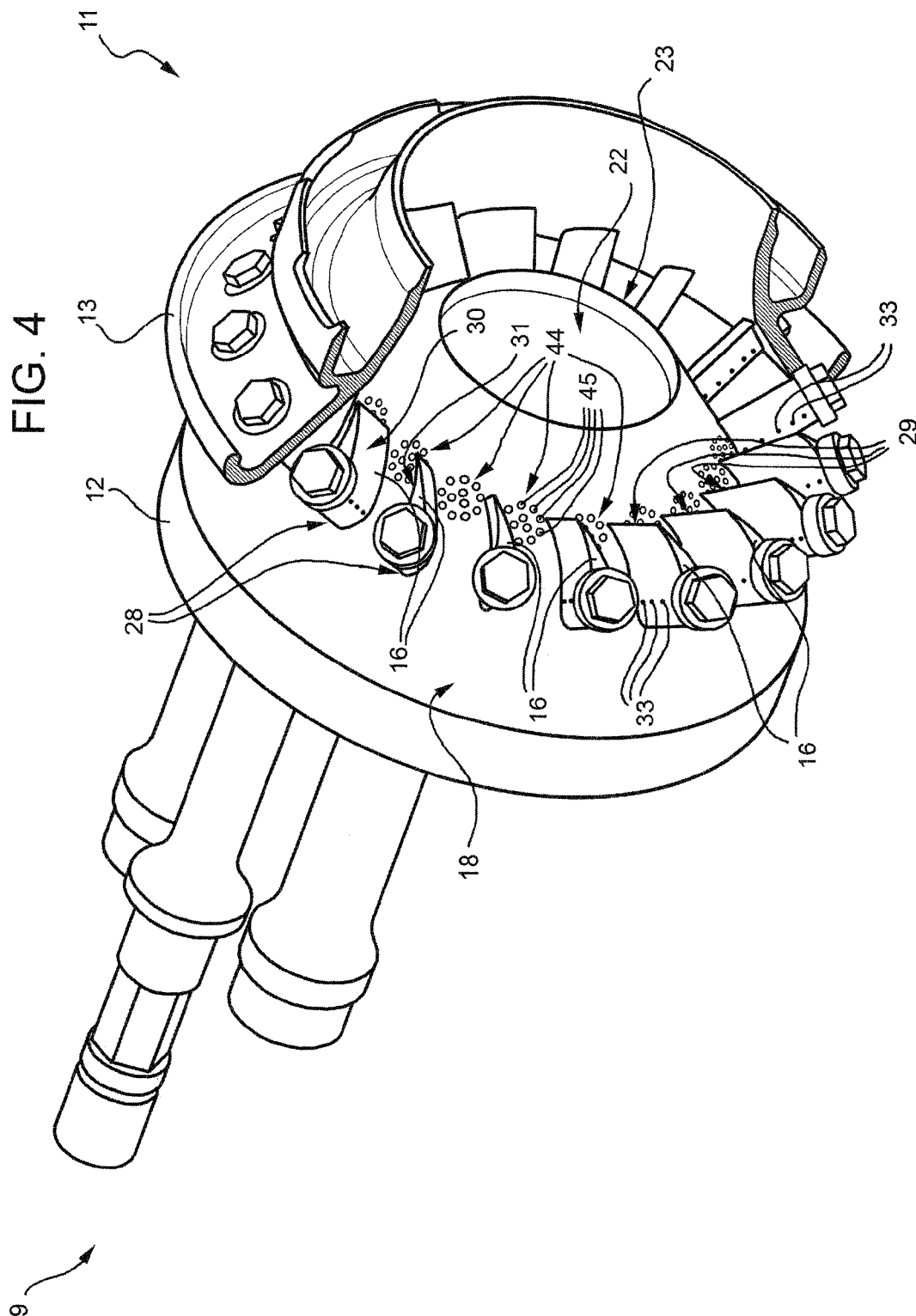
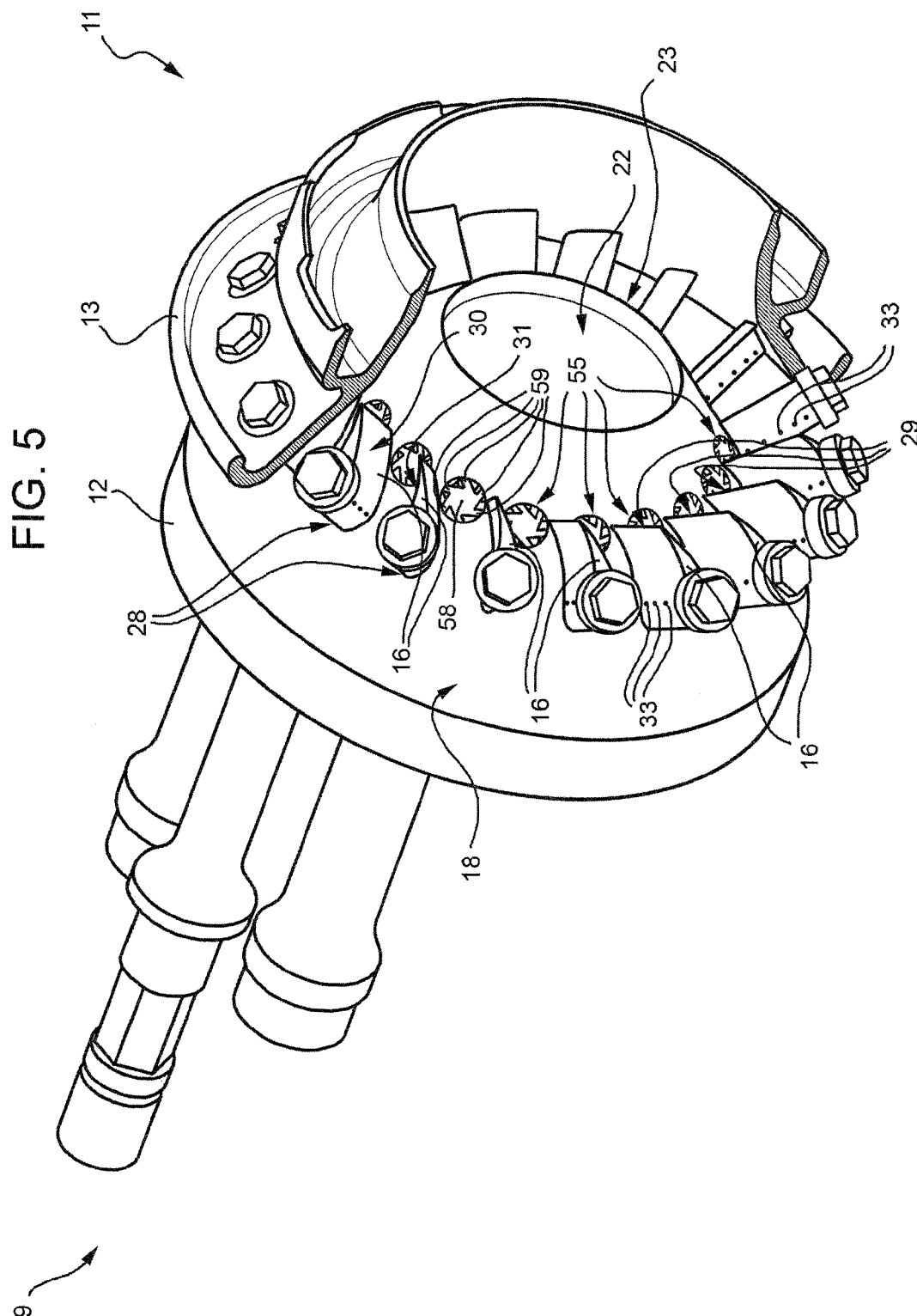


FIG. 2

FIG. 3









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Application Number
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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