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(54) **PILOT BURNER FOR A BURNER ASSEMBLY, BURNER ASSEMBLY INCLUDING SAID PILOT BURNER, AND METHOD FOR OPERATING SAID PILOT BURNER**

(57) A pilot torch for a burner assembly (1) comprises:

• a main duct (20) extending along a longitudinal axis (A) through which a flow of fuel flows in a direction (D); the main duct (20) comprising, at one end thereof, an exhaust wall (28) provided with at least one exhaust nozzle (29);

and

• an auxiliary duct (21) through which a flow of compressed air flows; the auxiliary duct (21) being provided with at least one outlet (42), which faces into the main duct (20) .

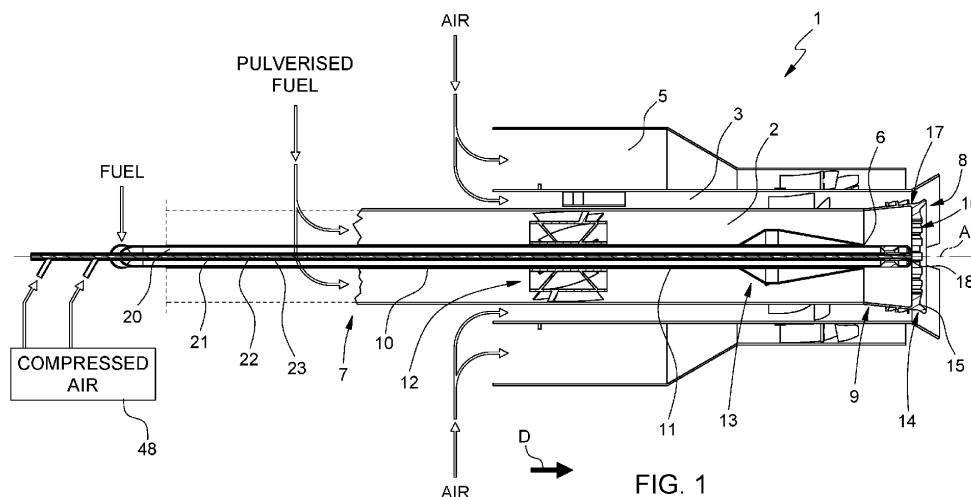


FIG. 1

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority from Italian patent application no. 102022000011549 filed on May 31, 2022, the entire disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to a pilot torch for a burner assembly and to a burner assembly comprising said pilot torch.

[0003] In particular, the present invention relates to a pilot torch for a burner assembly configured to burn preferably pulverised fuel, such as for example pulverised coal and/or pulverised biomass.

BACKGROUND

[0004] Over the last years, in fact, the combustion of pulverised biomass has become a sustainable and efficient complement to renewable sources, such as wind power and solar power.

[0005] Moreover, the conversion of the currently existing coal boilers into biomass boilers can be carried out in a quick manner and with low costs, since it only requires the replacement of the burners and of the grinding mills.

[0006] The pulverised biomass can thus be used as energy source for supplying many of the present energy needs.

[0007] However, it should be considered that the heat value of biomass is lower than that of coal (approximately half). This entails the need to input more biomass, the thermal input being equal.

[0008] Furthermore, a burner capable of burning biomass has to be able to work with a significantly lower air temperature with respect to the burners designed to burn coal. This entails lower velocities, the dimension of the ducts being equal. In order to overcome this problem, the air ducts in the biomass burners have reduced passage sections for preserving the minimum design velocities. In the air ducts having such dimensions, however, it is no longer possible to house the pilot torch and/or the warm-up torch and/or the flame detecting device, as it normally occurs in the coal burners currently available.

[0009] It is thus necessary to have burner assemblies which are capable of burning any pulverised fuel among those available in an efficient manner and which comprise all the necessary components (pilot torch and/or the warm-up torch and/or the flame detecting device) simultaneously respecting the geometrical constraints necessary for making them interchangeable with the coal burners currently available (i.e. for allowing the retrofitting of already existing coal boilers).

[0010] In this view, the need has arisen to manufacture a pilot torch for a burner assembly configured to burn

pulverised fuel which is capable of respecting the geometrical constraints and which is, simultaneously, capable of improving the flame stability and its detectability in all the operating conditions of the burner assembly in which the contribution of the pilot torch is necessary.

SUMMARY

[0011] In accordance with such objects, the present invention relates to a pilot torch for a burner assembly comprising:

- a main duct extending along a longitudinal axis through which a flow of fuel flows in a direction; the main duct comprising, at one end thereof, an exhaust wall provided with at least one exhaust nozzle;
- an auxiliary duct through which a flow of compressed air flows; the auxiliary duct being provided with at least one outlet, which faces into the main duct.

[0012] The pilot torch according to the present invention is thus configured to pre-mix air and fuel before the exhaust into the combustion chamber.

[0013] The fuel enrichment with oxidant allows improving the flame stability, in particular at the low loads.

[0014] A further object of the present invention is to manufacture a burner assembly which is reliable and capable of burning any pulverised fuel among those available in an efficient manner and respecting the limits of law in terms of pollutant emission.

[0015] In accordance with such objects, the present invention relates to a burner assembly as claimed in claim 14.

[0016] Finally, a further object of the present invention is to provide a method for operating a pilot torch of a burner assembly which is reliable and which is capable of guaranteeing flame stability and detectability in all the operating conditions of the burner assembly in which the contribution of the pilot torch is necessary.

[0017] In accordance with such objects, the present invention relates to a method for operating a pilot torch of a burner assembly as claimed in claim 15.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Further characteristics and advantages of the present invention will be apparent from the following description of a non-limiting example embodiment thereof, with reference to the figures of the accompanying drawings, wherein:

- Figure 1 is a schematic section view, with parts removed for clarity, of the burner assembly according to the present invention;
- Figure 2 is a perspective view of a first detail of the pilot torch of the burner assembly of Figure 1 in accordance with the present invention;
- Figure 3 is a perspective section view along plane

III-III, with parts removed for clarity of the pilot torch of the burner assembly of Figure 1;

- Figure 4 is a perspective section view along plane IV-IV, with parts in section and parts removed for clarity of the pilot torch of the burner assembly of Figure 1.

DESCRIPTION OF EMBODIMENTS

[0019] In Figure 1, reference numeral 1 indicates a burner assembly according to the present invention.

[0020] In particular, the burner assembly 1 is configured to burn pulverised fuel and is part of a thermal steam generation plant.

[0021] In the non-limiting example described and illustrated herein, the burner assembly 1 is configured to burn pulverised coal and/or pulverised biomass (for example pellet, olive stone of various kind and type, shells of various kind and type, etc). Variations provide for the burner assembly 1 to be configured to burn secondary solid fuel (SSF), etc.

[0022] In principle, in fact, the burner assembly 1 can burn any solid fuel which can be suitably pulverised.

[0023] The burner assembly 1 comprises a primary duct 2, a secondary duct 3, a tertiary duct 5 and a pilot torch 6.

[0024] The primary duct 2 extends along a longitudinal axis A and is provided with an inlet 7 (schematically illustrated in Figure 1) and with an outlet 8, which faces into the combustion chamber of the thermal plant (not illustrated for the sake of simplicity).

[0025] The secondary duct 3 extends around at least a portion of the primary duct 2 and is coaxial to the primary duct 2. In particular, the secondary duct 3 extends around an outlet portion 9 of the primary duct 2, which comprises the outlet 8.

[0026] The tertiary duct 5 extends around the secondary duct 3 and is coaxial to the primary duct 2 and to the secondary duct 3.

[0027] In use, a mixture of air and pulverised fuel flows in the primary duct 2 in a direction D. The mixture of air and pulverised fuel preferably comes from a mill (not illustrated for the sake of simplicity). Air, normally defined in technical jargon as "secondary air", circulates in the secondary duct 3, whereas air, normally defined in technical jargon as "tertiary air", circulates in the tertiary duct 5. In the primary duct 2 a torch holding tube 11 is arranged inside which the pilot torch 6 is arranged. Preferably, the pilot torch 6 is slidable inside the torch holding tube 11.

[0028] The primary duct 2 is preferably cylindrical and centred on the longitudinal axis A.

[0029] In accordance with a variation not illustrated, air flows in the primary duct and the fuel, preferably not solid, is supplied in the secondary duct and/or in the tertiary duct preferably by means of spray nozzles housed in the secondary duct and/or in the tertiary duct.

[0030] In the non-limiting example described and illustrated herein, the torch holding tube 11 is substantially

arranged in the centre of the primary duct 2 and is supported by a structure integral with the primary duct 2 (not illustrated for the sake of simplicity in the accompanying figures).

[0031] In the non-limiting example described and illustrated herein, the burner assembly 1 further comprises a homogenizing device 12 and a segregating device 13 housed in the primary duct 2 and preferably supported by the torch holding tube 11, and a stabilizing device 14 arranged at the outlet 8 of the primary duct 2.

[0032] Preferably, the homogenizing device 12 is housed upstream of the segregating device 13 along the direction D.

[0033] The stabilizing device 14 comprises an annular element 15 centred on the longitudinal axis A, provided with a toothed inner surface 16 and with a finned outer surface 17 which faces into the secondary duct 3.

[0034] The pilot torch 6 is housed in the torch holding tube 11 and preferably extends along the entire length of the primary duct 2.

[0035] Here and in the following, the pilot torch 6 is applied to a burner assembly supplied with pulverised fuel. It is understood, however, that the described pilot torch can be utilized also in a burner assembly supplied with oil/gas or in autonomy.

[0036] The pilot torch 6 comprises a main duct 20, an auxiliary duct 21 (better visible in Figures 3 and 4), a cooling duct 22 (better visible in Figures 3 and 4) and an igniter 23.

[0037] The pilot torch 6 further also comprises a flame detector 25 (visible only in Figure 2 and Figure 4) configured to detect the presence of flame, as it will be specifically described in the following.

[0038] With reference to Figures 2, 3 and 4, the main duct 20 extends along the longitudinal axis A and is provided with at least one exhaust nozzle 29.

[0039] In use, the main duct 20 is supplied with a fuel, preferably in the gaseous state, which flows in the main duct 20 in the direction D.

[0040] For example, the main duct 20 is supplied with natural gas or with other types of fuel gas (e.g. NH₃, H₂, etc.).

[0041] Preferably, the main duct 20 is an annular duct and is provided with a plurality of exhaust nozzles 29, which are distributed along an exhaust wall 28.

[0042] With reference to Figure 2, the exhaust nozzles 29 are distributed along a plurality of concentric paths centred on the longitudinal axis A.

[0043] In particular, the exhaust wall 28 is an annular wall provided with an inner annular portion 32 proximal to the axis A and with an outer annular portion 33, distal with respect to the longitudinal axis A.

[0044] Preferably, between the outer annular portion 33 and the inner annular portion 32 a first intermediate annular portion 34 adjacent to the inner annular portion 32 and a second intermediate annular portion 35 adjacent to the outer annular portion 33 are present.

[0045] The inner annular portion 32 has a divergent

inclination along the direction D, whereas the outer annular portion 33 has a convergent inclination along the direction D.

[0046] The first intermediate annular portion 34 is preferably orthogonal to the axial direction, whereas the second intermediate annular portion 35 has a convergent inclination along the direction D.

[0047] Preferably, the inclination of the second intermediate annular portion 35 is different from the inclination of the outer portion 33.

[0048] Preferably, the concentric paths centred on the longitudinal axis A along which the exhaust nozzles 29 are distributed are four and are present on the inner annular portion 32, on the outer annular portion 33, on the first intermediate annular portion 34 and on the second intermediate annular portion 35, respectively.

[0049] Preferably, at least one exhaust nozzle 29 of the plurality of exhaust nozzles 29 is characterised by a geometry capable of giving a swirling component to the outflowing flow for improving the mixture in the boiler.

[0050] In the non-limiting example described and illustrated herein, all the exhaust nozzles 29 have a geometry of this type.

[0051] The exhaust nozzles 29, in particular, extend along an extension axis O, which has a non-zero inclination with respect to the axial direction, the tangential direction and the radial direction (in the accompanying figures only one extension axis O is represented by way of example).

[0052] Upstream of the exhaust wall 28 the main duct 20 is provided with an expansion zone 35, which is preferably made by means of a narrowing 36 of the main duct 20 upstream of the expansion zone 35. In other words, the gas circulating in the main duct 20 passes through the narrowing 36 and then reaches the expansion zone 35.

[0053] The expansion zone 35 is defined between the narrowing 36 and the exhaust wall 28.

[0054] The narrowing 36 is preferably obtained by means of an annular element 37 arranged in contact with an outer wall 38 of the main duct 20.

[0055] In the non-limiting example described and illustrated herein, the annular element 37 is made in one piece with the outer wall 38.

[0056] Preferably, the annular element 37 comprises, in sequence, an inlet portion 39 having a convergent inclination along the direction D, an axial central portion 40 and an outlet portion 41 having a divergent inclination along the direction D.

[0057] In other words, the main duct 20 has, in sequence, a decreasing passage section at the inlet portion 39, a constant passage section at the central portion 40 and an increasing passage section at the outlet portion 41 of the annular element 37.

[0058] Therefore, the fuel supplied at the central portion 40 having a constant passage section will have reduced pressure and increased velocity with respect to the pressure and to the velocity upstream of the narrow-

ing 36.

[0059] With reference to Figures 3 and 4, the auxiliary duct 21 extends along the longitudinal axis A and is provided with at least one outlet 42, which faces into the main duct 20.

[0060] In use, the auxiliary duct 21 is supplied with compressed air coming from a source of compressed air (not illustrated in the accompanying figures).

[0061] Preferably, the pressure of the compressed air is greater than the pressure of the gaseous fuel supplied to the main duct 20.

[0062] Preferably, the main duct 20 extends around the auxiliary duct 21. More preferably, the auxiliary duct 21 and the main duct 20 are separated by a cylindrical wall 45, in which the at least one outlet 42 is made.

[0063] Preferably, the auxiliary duct 21 comprises a plurality of outlets 42 (only two of which are visible in Figure 3), which are defined by channels 46 made in the cylindrical wall 45.

[0064] The channels 46 preferably have a divergent inclination along the direction D.

[0065] In other words, the compressed air supplied to the auxiliary duct 21 passes through the channels 46 and is exhausted into the main duct 20.

[0066] The outlets 42 face upstream of the expansion zone 35 and preferably at the narrowing 36.

[0067] In the non-limiting example described and illustrated herein, the outlets 42 face into the central portion 40 having a constant passage section.

[0068] More preferably, the outlets 42 face into the central portion 40 in a zone proximal to the inlet portion 39.

[0069] In the non-limiting example described and illustrated herein, the outlets 42 are six arranged circumferentially equidistant.

[0070] The igniter 23 extends along the longitudinal axis A and the cooling duct 22 extends along the longitudinal axis A around the igniter 23 for cooling the igniter 23 during use.

[0071] The cooling duct 22 is thus an annular duct.

[0072] Preferably, the cooling duct 22 is supplied with compressed air.

[0073] The source of compressed air 48 which supplies the cooling duct 22 is preferably the same which supplies the auxiliary duct 21, as is schematically illustrated in Figure 1.

[0074] The auxiliary duct 21 extends around the cooling duct 22.

[0075] More preferably, the auxiliary duct 21 and the cooling duct 22 are separated by a cylindrical wall 50.

[0076] With reference to Figure 4, the pilot torch 6 preferably also comprises a flame detector 25, which is housed in the main duct 20 and is provided with an end 52 which faces into the combustion chamber.

[0077] Specifically, the flame detector 25 is defined by an optical probe housed in a housing tube 53.

[0078] In order to allow the housing of the flame detector 25, the annular element 37 which defines the narrowing 36 is provided with a recess 55 shaped so as to

allow the passage of the flame detector 25.

[0079] In use, the pilot torch 6 is used in the ignition steps of the burner assembly 1 and in the warm-up steps of the boiler.

[0080] The ignition of the burner assembly and the warm-up of the boiler are two distinct operations.

[0081] The warm-up of the boiler, in particular, is carried out when the boiler is cold and the burner assemblies are turned off.

[0082] The ignition steps provide for the pilot torch 6 to generate a pilot flame. If the pilot flame detector detects the presence of flame it is thus possible to supply the pulverised fuel to the primary duct 2 for generating the main flame of the burner assembly 1.

[0083] The pilot torch 6 according to the present invention is capable of generating a pilot flame which is stable and well detectable also at the low fuel flow rates.

[0084] Thanks to the structure of the described pilot torch, the pilot flame generated by the pilot torch is a flame partially obtained pre-mixing air and fuel.

[0085] The fuel enrichment with oxidant allows improving the flame stability, in particular at the low loads. This allows a reliable flame detection by the flame detector 25 at all loads.

[0086] Besides, the reliability of the flame detection is also increased by the position of the flame detector 25, which is housed in the main duct 20 and faces into the combustion chamber. The air-fuel ratios of the mixture outflowing from the pilot torch 6 are optimal and guarantee a correct ignition of the flame when the igniter 23 is active, but also a correct maintenance of the flame conditions when the igniter 23 is turned off and the heating step of the flame is carried out.

[0087] In particular, it has been observed that with the partial pre-mixing, the stoichiometric zone draws close to the igniter 23. A localized zone of air/gas stoichiometrically mixed is obtained close to the igniter 23. This allows a quick and thus safe ignition.

[0088] It has been further observed that, also thanks to the design of the exhaust nozzles 29, the flame root is very close to the exhaust wall 28. Moreover, the air/fuel pre-mixing occurs without the need for hardware dedicated to the adjustment of the flow rates thanks to the particular structure of the auxiliary duct 21 and of the main duct 20.

[0089] The compressed air supplied to the auxiliary duct 21 is injected into the main duct 20 without the need to adjust the flow rate.

[0090] The pressure difference between the fuel and the compressed air and the further pressure variation given by the presence of the narrowing 36 allow guaranteeing a correct contribution of compressed air in the main duct 20 upstream of the expansion zone 35 in all the operating conditions of the pilot torch 6.

[0091] Advantageously, the structure also allows a correct balance of the flow rates upon the varying of the pressure of the fuel supplied to the main duct 20.

[0092] If the pressure of the fuel supplied to the main

duct 20 increases, in fact, the flow rate of compressed air injected into the main duct is reduced.

[0093] It has been observed, in fact, that for high loads (i.e. high pressure of the fuel supplied to the main duct 20) the outflow velocity of the fuel from the exhaust nozzles 29 tends to sonic conditions. In sonic conditions or close to sonic conditions, it has occurred that the flame is stable and therefore there is no real need for compressed air.

[0094] In the expansion zone 35, the mixing of compressed air and fuel occurs. The mixture outflowing through the exhaust nozzles 29 is therefore a suitably pre-mixed mixture.

[0095] Furthermore, the arrangement of the nozzles 29 along the divergent inner annular portion 32 favours the ignition when the igniter 23 is active, whereas the arrangement of the nozzles 29 along the convergent outer annular portion 33 favours a good mixing with the air. The huge quantity of fuel air invests the outer part of the pilot torch 6.

[0096] The presence of several crowns of exhaust nozzles 29 oriented differently favours a correct mixing. The better the mixing, the better the stability of the flame and its detectability.

[0097] Finally, it is evident that modifications and variations can be made to the pilot torch and to the burner assembly described herein without departing from the scope of the appended claims.

Claims

1. Pilot torch for a burner assembly (1) comprising:

- a main duct (20) extending along a longitudinal axis (A) through which a flow of fuel flows in a direction (D); the main duct (20) comprising, at one end thereof, an exhaust wall (28) provided with at least one exhaust nozzle (29);
- an auxiliary duct (21) through which a flow of compressed air flows; the auxiliary duct (21) being provided with at least one outlet (42), which faces into the main duct (20).

2. Torch according to claim 1, wherein the auxiliary duct (21) is coaxial to the main duct (20).

3. Torch according to claim 1 or 2, wherein the main duct (20) is an annular duct extending around the auxiliary duct (21).

4. Torch according to any of the preceding claims, wherein the main duct (20) is provided with an expansion zone (35) upstream of the at least one exhaust nozzle (29); the at least one outlet (42) of the auxiliary duct (21) being arranged to face into the main duct (20) upstream of the expansion zone (35).

5. Torch according to claim 4, wherein the main duct (20) is provided with a narrowing (36) upstream of the expansion zone (35) and configured to result in a narrowing of the passage section of the main duct (20); the at least one outlet (42) of the auxiliary duct (21) being arranged to face the narrowing (36). 5
6. Torch according to claim 5, wherein the narrowing (36) is defined by an annular element (37) arranged in contact with an outer wall (38) of the main duct (20); wherein the annular element (37) preferably comprises, in sequence, an inlet portion (39) having a convergent inclination along the direction (D), an axial central portion (40) and an outlet portion (41) having a divergent inclination along the direction (D); the at least one outlet (42) of the auxiliary duct (21) being arranged to face the central portion (40) of the narrowing (36). 10 15
7. Torch according to any of the preceding claims, wherein the at least one outlet (42) is defined by a channel (46) having a divergent inclination along the direction (D). 20
8. Torch according to claim 7, wherein the auxiliary duct (21) and the main duct (20) are separated by a cylindrical wall (45), in which the at least one channel (46) is made. 25
9. Torch according to any of the preceding claims, wherein the auxiliary duct (21) comprises a plurality of outlets (42). 30
10. Torch according to any of the preceding claims, wherein the compressed air flowing through the auxiliary duct (21) has a pressure greater than the pressure of the fuel flowing through the main duct (20). 35
11. Torch according to any of the preceding claims, comprising an igniter (23) extending along a direction parallel to the longitudinal axis (A) and a cooling duct (22), which extends around the igniter (23) and is supplied with compressed air; wherein the auxiliary duct (21) is preferably arranged around the cooling duct (22). 40 45
12. Torch according to any of the preceding claims, comprising a flame detector (25) housed in the main duct (21) and provided with an end (52), which passes through the exhaust wall (28). 50
13. Torch according to any of the preceding claims, wherein the main duct (20) is provided with a plurality of exhaust nozzles (29), which are distributed along the exhaust wall (28); wherein at least one exhaust nozzle (29) of the plurality of exhaust nozzles (29) extends along an extension axis (O), which preferably has non-zero inclination with respect to an axial direction, a circumferential direction and a radial direction. 55
14. Burner assembly for a thermal steam generation plant comprising:
 - a primary duct (2) extending along a longitudinal axis (A),
 - in which air or a mixture of air and pulverised fuel flows in a direction (D);
 - at least one secondary duct (3) through which air flows in the direction (D);
 - a pilot torch (6) housed in the primary duct (2) and of the type claimed in any of the preceding claims.
15. Method for operating a pilot torch (6) for a burner assembly (1); the pilot torch (6) comprising a main duct (20), comprising, at one end thereof, an exhaust wall (28) provided with at least one exhaust nozzle (29), and an auxiliary duct (21) provided with at least one outlet (42), which faces into the main duct (20); the method comprising the steps of supplying fuel to the main duct (20) and supplying compressed air to the auxiliary duct (21).

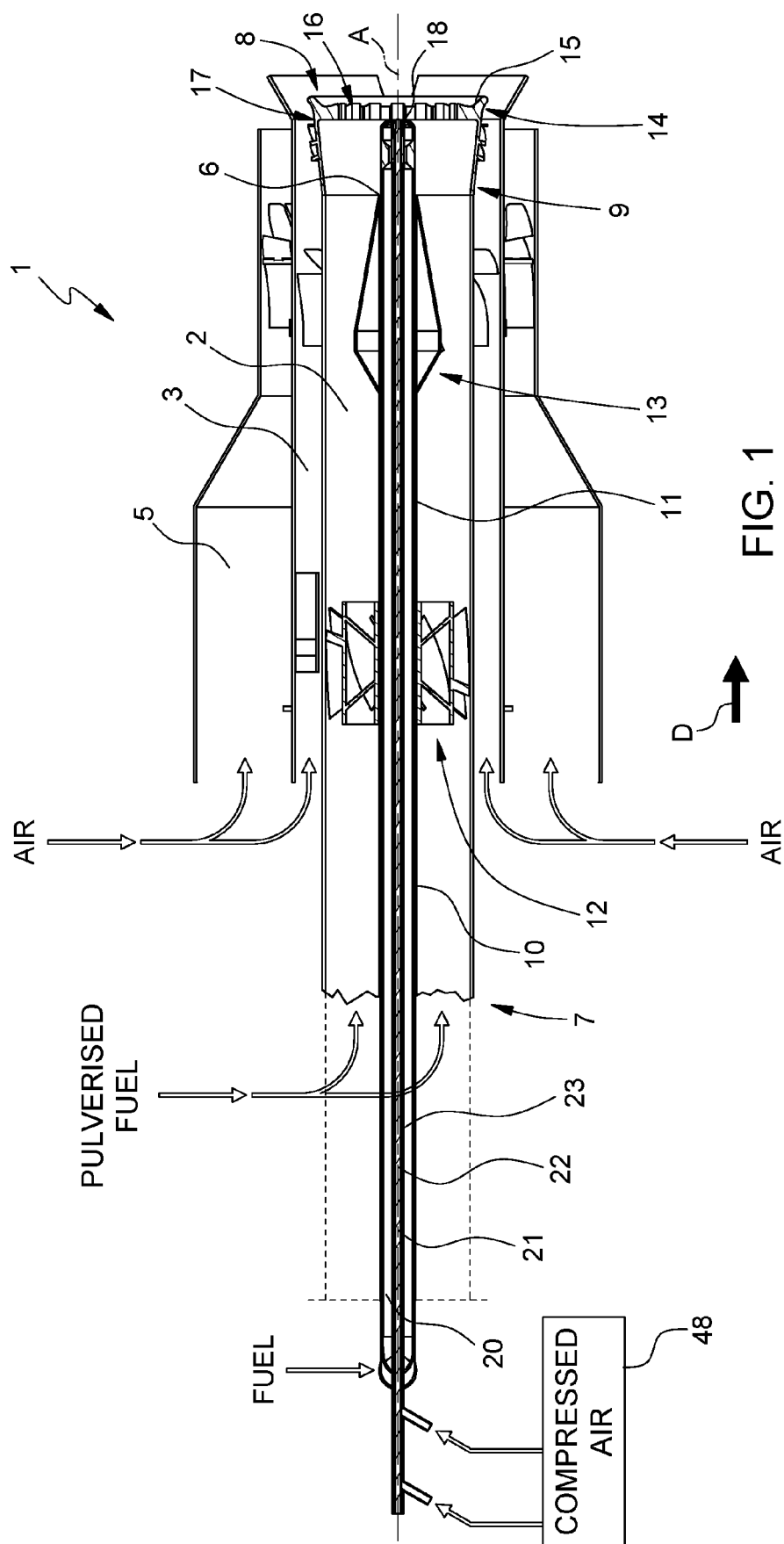


FIG. 1

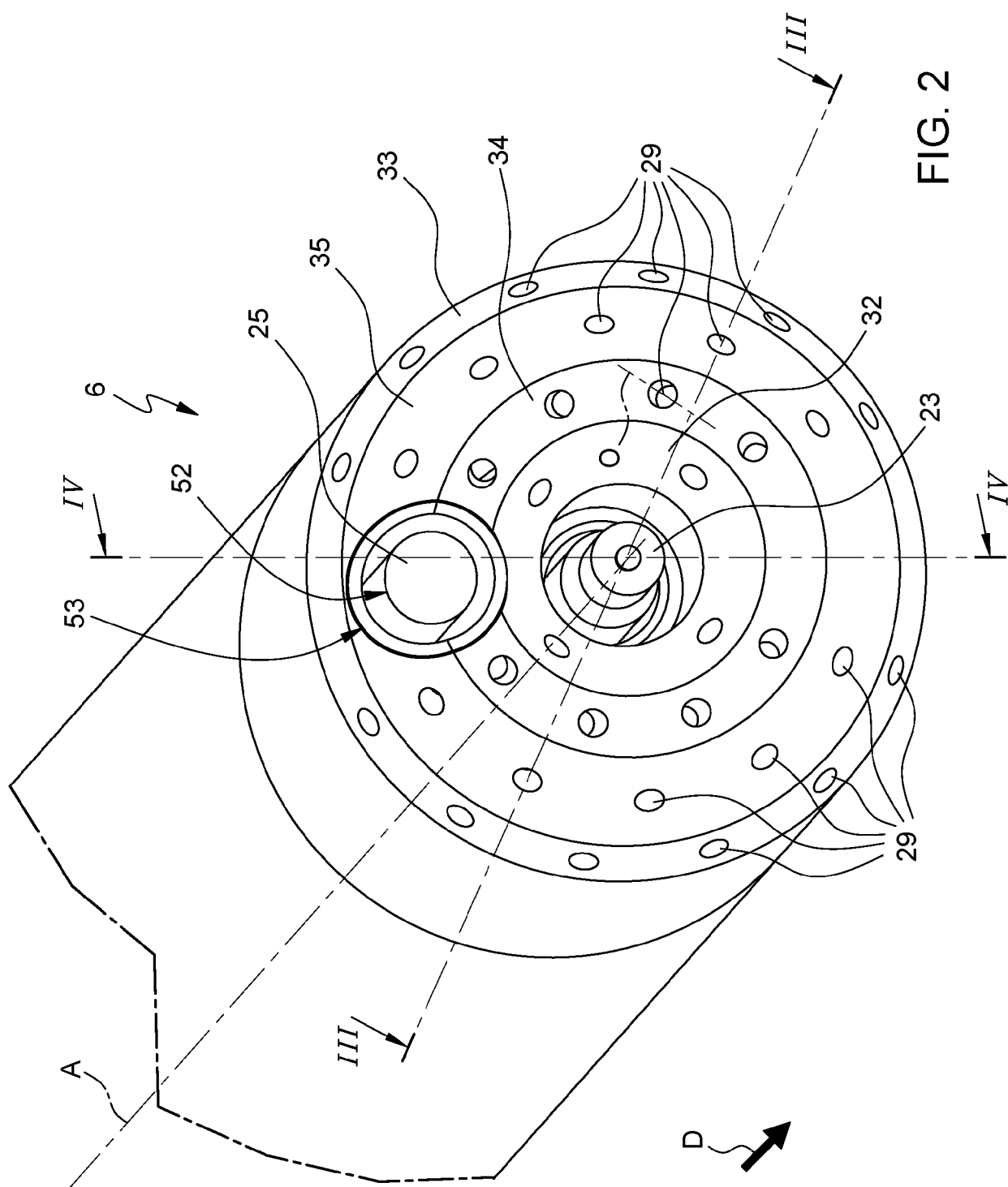


FIG. 2

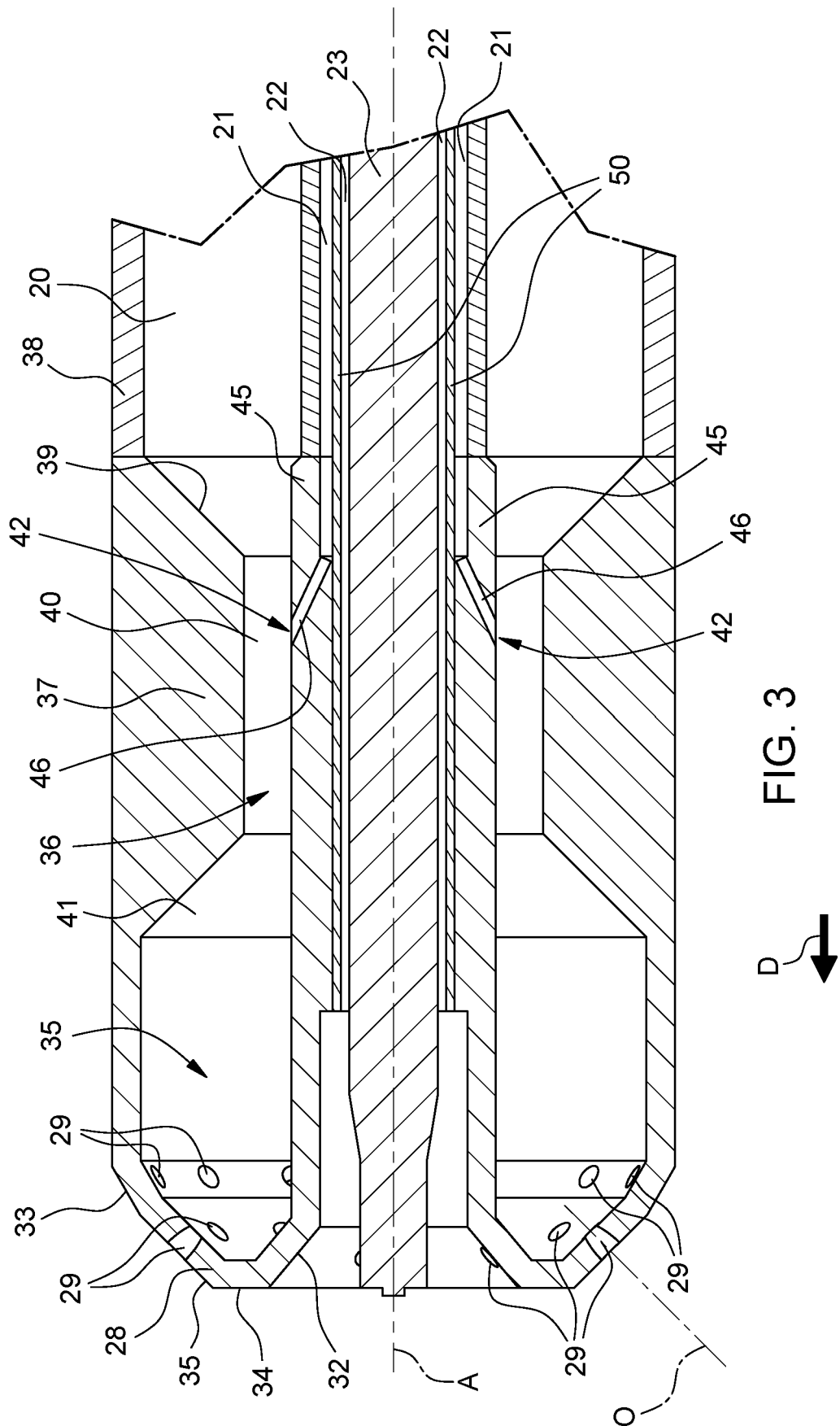


FIG. 3

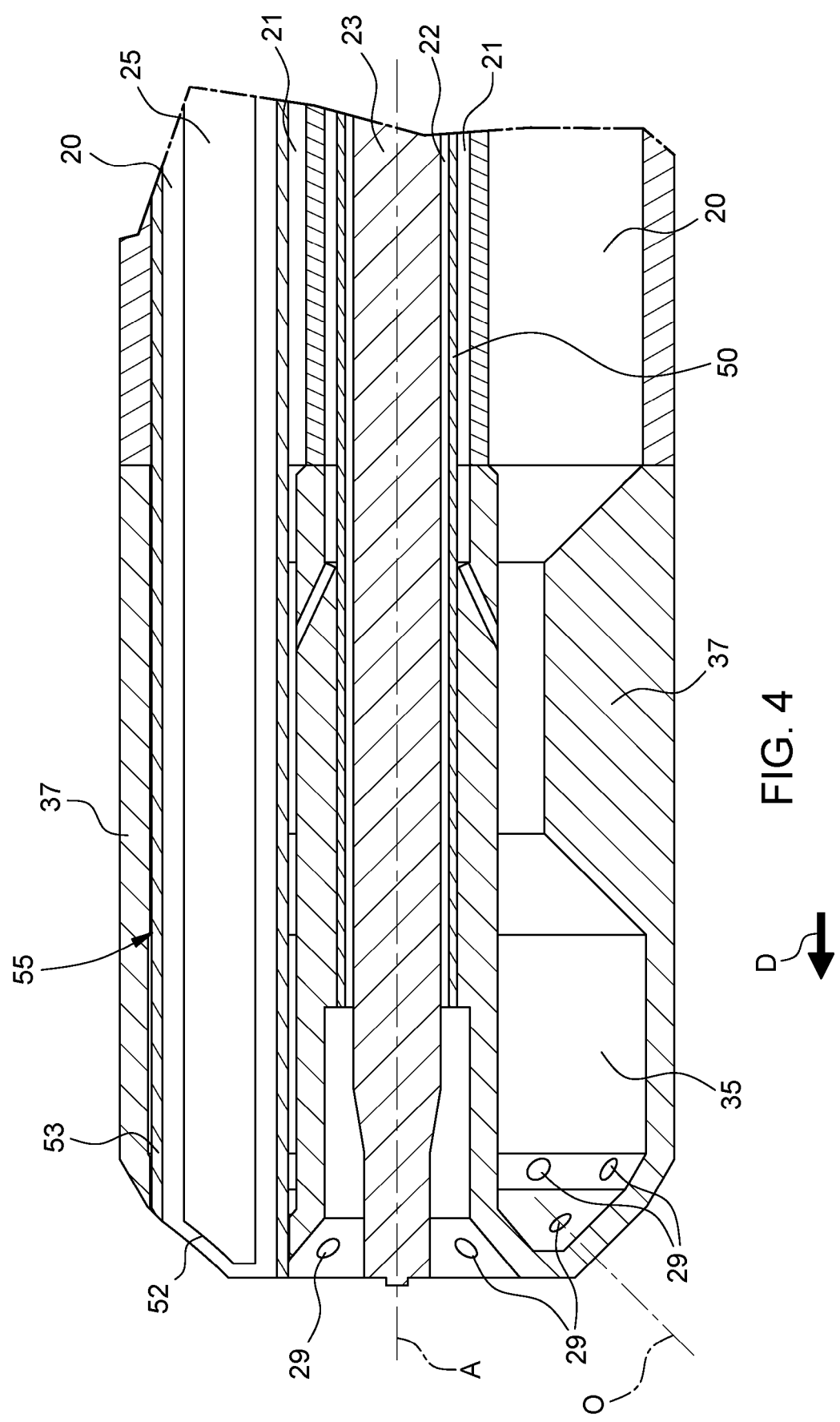


FIG. 4



EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims			
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