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(54) **INJECTION HEAD FOR A GAS TURBINE COMBUSTOR**

(57) An injection unit for a gas turbine combustor includes an injection head (15) extending about a central axis (A) and an injection manifold (14) coupled to the injection head (15). The injection head (15) includes: a fuel plenum assembly (22) extending about the central axis (A) and including a primary fuel plenum (24); a plurality of injector fingers (19, 20) extending radially outward from the fuel plenum assembly (22) and each provided with at least a respective fuel nozzle (30); a fuel inlet (27, 28), fluidly coupled to the fuel plenum assembly (22); and a cooling air housing, at least partly enclosing the fuel plenum assembly (22) and defining a cooling air plenum (21). Each fuel nozzle (30) has a respective primary fuel line (31) fluidly coupled to the primary fuel plenum (24; 224) and a respective shielding air line (33) fluidly coupled to the cooling air plenum (21).

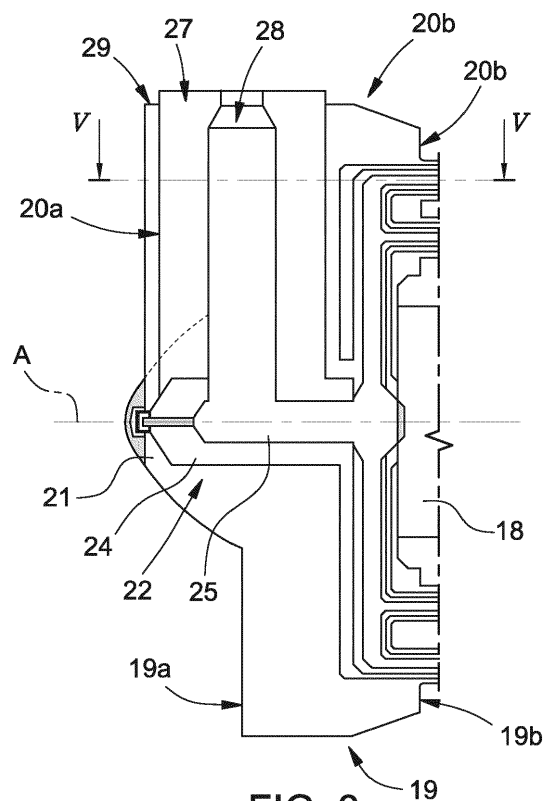


FIG. 3

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority from Russian patent application no. 2018146134 filed on December 25, 2018.

TECHNICAL FIELD

[0002] The present invention relates to an injection head for a gas turbine combustor.

BACKGROUND

[0003] As known, modern gas turbines may operate on a number of different fuels, such as various kinds of liquid and gaseous fuels, such as natural gas and diesel fuel. In general, the choice of operational fuel depends on the price, availability and operational parameters.

[0004] Several kinds of combustors have been designed to produce hot gas by burning gaseous or liquid fuel which is delivered in a compressed air through one or more fuel nozzles. One kind of combustor which proved to be effective comprises fuel nozzles arranged radially about a central axis and a fuel delivery system comprising nested fuel feed lines (at least one for each kind of fuel, but possibly two or more) with respective distributor rings and delivery pipes. The delivery pipes extend radially inward from the distributor rings and have respective outer ends connected thereto. The fuel nozzles may be provided at inner ends or on sidewalls of respective delivery pipes. Fuel, either gas or liquid, is supplied from the fuel feed lines to the distributor rings, that act as annular plena to equalize pressure and create uniform injection conditions at all the fuel nozzles.

[0005] Connection of the outer ends of the delivery pipes to the distributor rings is quite complicate and expensive, however. In fact, delivery pipes need to be individually connected and compensators are required at the outer end of each delivery pipe to damp vibrations and to accommodate stress caused by thermal expansion. Compensators may be e.g. in the form of bellows applied between the distributor rings and the delivery pipes. In any case, numerous additional components are necessary for the connections and corresponding welding seams must be accounted for, which may be critical under a mechanical standpoint and makes assembling process more complicate. Moreover, space required for the distributor rings, which extend around the burner, does not allow to provide compact structures and size may be an issue.

SUMMARY OF THE INVENTION

[0006] It is an aim of the present invention to provide an injection head for a gas turbine combustor, which allows to overcome or at least to attenuate the limitations

described.

[0007] According to the present invention, there is provided an injection head for a gas turbine combustor, the injection head comprising:

a fuel plenum assembly extending about the central axis and including a primary fuel plenum;
a plurality of injector fingers extending radially outward from the fuel plenum assembly and each provided with at least a respective fuel nozzle;
a fuel inlet, fluidly coupled to the fuel plenum assembly;
a cooling air housing, at least partly enclosing the fuel plenum assembly and defining a cooling air plenum;
wherein at least part of the fuel nozzles have respective primary fuel lines fluidly coupled to the primary fuel plenum and respective shielding air lines fluidly coupled to the cooling air plenum.

[0008] The distribution of fuel to the fingers from the centre to the periphery requires a single connection point to feed the fuel plenum assembly. Accordingly, a single compensator system is to be provided to attenuate adverse effects of mechanical vibrations and thermal expansion. The overall structure is thus simplified, to the benefit of manufacturing process and cost.

[0009] According to an aspect of the invention, the fuel plenum assembly includes a secondary fuel plenum extending about the central axis and at least partly enclosed within the primary fuel plenum, and wherein part of the fuel nozzles have respective secondary fuel lines at least partly enclosed within the respective primary fuel lines and fluidly coupled to the secondary fuel plenum.

[0010] The concentric structure of the first and second is compact and functional to the central feed system.

[0011] According to an aspect of the invention, the fuel inlet comprises a primary inlet line, fluidly coupled to the primary fuel plenum, and a secondary inlet line, fluidly coupled to the secondary fuel plenum and at least in part enclosed within the primary inlet line.

[0012] According to an aspect of the invention, the injection unit comprises an air inlet line at least in part enclosing the primary inlet line and the secondary inlet line and fluidly coupled to the cooling air plenum.

[0013] Nesting of primary and secondary fuel lines and possibly of the air inlet contributes to small size of the fuel plenum assembly, which is also beneficial to aerodynamics.

[0014] According to an aspect of the invention, the primary inlet line and the secondary inlet line extend radially between the fuel plenum assembly and the injection manifold.

[0015] Compact design is favoured by radial arrangement of the fuel inlet lines.

[0016] According to an aspect of the invention, the primary inlet line and the secondary inlet line are aligned to a respective one of the injector fingers upstream in an

axial direction.

[0017] According to an aspect of the invention, the injector fingers are in the form of streamlined bodies with respective leading edges and trailing edges extending radially outward from the fuel plenum assembly and comprise at least an inlet injector finger configured to be coupled to an injection manifold, wherein the primary inlet line and the secondary inlet line are at least partially enclosed within the inlet injector finger.

[0018] Due to radial arrangement, the fuel inlet lines may be enclosed in one of the injector fingers, which therefore has also a fuel supply function for the whole injection head. Aerodynamic efficiency is improved by inclusion in the streamlined finger.

[0019] According to an aspect of the invention, the injection head comprises a plurality of primary inlet lines, fluidly coupled to the primary fuel plenum, and of secondary inlet lines, fluidly coupled to the secondary fuel plenum at least in part enclosed within the respective primary inlet line, wherein the injector fingers comprise a plurality of inlet injector fingers, and wherein the primary inlet lines and the secondary inlet lines are at least partially enclosed within respective inlet injector fingers.

[0020] Flexible design is provided to meet design preferences, e.g. to further increase uniform conditions in the fuel plenum assembly, without significantly increasing complexity of the structure.

[0021] According to an aspect of the invention, the primary inlet line and the secondary inlet line feed axially into the fuel plenum assembly.

[0022] According to an aspect of the invention, in each fuel nozzle the respective shielding air line encloses the respective primary fuel line and the respective secondary fuel line.

[0023] Effective shielding air is thus provided to prevent hot air ingestion.

[0024] According to an aspect of the invention, the secondary fuel line tapers at a delivery end, whereby an annular space is provided between the primary fuel line and the respective secondary fuel line at the delivery end.

[0025] According to an aspect of the invention, the primary fuel line has through openings at the delivery end, thereby fluidly coupling the shielding air line and the annular space between the primary fuel line and the respective secondary fuel line at the delivery end.

[0026] An additional flow of shielding air is thus provided immediately around the inner secondary fuel line, for further protection.

[0027] According to an aspect of the invention, the injection head comprise spacers extending radially between the primary fuel line and the respective shielding air line at the delivery end and configured to allow the primary fuel line to axially slide with respect to the shielding air line.

[0028] The nozzle are thus designed to accommodate different thermal expansion of the primary and secondary fuel lines.

[0029] According to an aspect of the invention, the in-

jection unit comprises a compensator between the injection manifold and the injection head, the compensator being configured to allow relative movements of the injection head and of the injection manifold in an axial direction and/or in a radial direction.

[0030] According to an aspect of the invention, a gas turbine combustor comprises a least an injection unit as defined above and an injection manifold coupled to the injection head.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] The present invention will now be described with reference to the accompanying drawings, which show some non-limitative embodiment thereof, in which:

- figure 1 is a longitudinal cross section of a gas turbine assembly;
- figure 2 is a simplified longitudinal cross section of a can combustor of the gas turbine assembly of figure 1, including an injection unit in accordance to an embodiment of the present invention;
- figure 3 is a longitudinal cross section of an injection head of the injection unit of figure 2;
- figure 4 is a rear view of the injection head of figure 3;
- figure 5a is an enlarged cross section of a detail of the cross section of the injection head of figure 4, cut along plane V-V of figure 4;
- figure 5b is an enlarged cross section of a detail of an injection head in accordance with a different embodiment of the present invention;
- figure 6 is a rear view of a nozzle of the injection head of figure 3;
- figure 7 is a perspective view, partially cut along a longitudinal axial plane, of the nozzle of figure 6;
- figure 8 is a side view of the nozzle of figure 6, cut along plane VIII-VIII of figure 6;
- figure 9a and 9b are perspective of respective components of the nozzle of figure 6;
- figure 10 is a rear view of an injection head of an injection nit in accordance to a different embodiment of the present invention; and
- figure 11 is a side view, cut along a longitudinal axial plane, of an injection head of an injection nit in accordance to another embodiment of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0032] Figure 1 shows a simplified view of a gas turbine assembly, designated as whole with numeral 1. The gas turbine assembly 1 comprises a compressor section 2, a combustor assembly 3 and a turbine section 5. The compressor section 2 and the turbine section 5 extend along a main axis M. The combustor assembly 3 may be a single-stage combustor assembly or a sequential combustor assembly. In one embodiment, the combustor as-

sembly 3 comprises a plurality of sequential can combustors 7, circumferentially arranged about the main axis M.

[0033] The compressor section 3 of the gas turbine assembly 1 provides a compressed airflow, which is added with fuel and burned in the can combustors 7. The airflow delivered by the compressor section 2 is supplied to the combustor assembly 3 and to the turbine section 5 for the purpose of cooling.

[0034] In the combustor assembly 3, the can combustors 7 are coupled to the turbine section 5 through respective transition ducts 8.

[0035] A portions of one of the can combustors 7 is illustrated in Figure 2. The can combustor 7 extends along a central axis A and comprises an outer shell 10, a liner 11 defining a flow path 12 for compressed air or hot gas and an injection unit 13 configured to deliver a controlled amount of fuel into air or hot gas in the flow path. The can combustor 7 may be run on different kinds of fuel, depending on conditions. For example, the can combustor 7 may use a gas fuel as a primary fuel and a liquid fuel as a secondary fuel.

[0036] The injection unit 13 in turn comprises an injection manifold 14, coupled to fuel feed lines (here not shown) for receiving the primary fuel and the secondary fuel, and an injection head 15. The injection manifold 14 is coupled to the injection head 15 through a compensator 17, which is configured to allow relative movements of the injection manifold 14 and of the injection head 15 in an axial direction and/or in a radial direction. The compensator 17 allows to damp vibrations and accommodate thermal expansion and may be in the form of bellows and/or an axial slider.

[0037] The injection head 15, shown in figures 2 and 3, is arranged about the central axis A of the can combustor 7 and comprises a centre body 18 with a plurality of injector fingers 19, 20 that extend radially outward from the centre body 18 to the periphery of the flow path 12. In one embodiment, the injector fingers 19, 20 are arranged across the whole diameter of the flow path 12. In one embodiment, the injection head 15 may be a monolithic body obtained by additive manufacturing techniques, such as Selective Laser Melting (SLM). The great advantage of the additive techniques reside in that they are extremely flexible and allow to produce complex objects incorporating a wide variety of features. The injection head can thus be built as a single body. This simplifies assembling of the injection unit, without limiting in any way functionality. In another embodiment, however, the injection head 15 may be formed by assembled parts connected e.g. by a central fixing assembly extending along the central axis A.

[0038] A cooling housing 21 and a fuel plenum assembly 22 are provided in the centre body 18 and both extend about the central axis A.

[0039] The cooling housing 21 is provided on an upstream side by an outer casing of the injection head 15 and defines an air plenum that at least partly encloses

the fuel plenum assembly 22.

[0040] The fuel plenum assembly 22 comprises a primary fuel plenum 24 and a secondary fuel plenum 25, both of substantially annular shape about the central axis A. The secondary fuel plenum 25, which in one embodiment may be also cylindrical, is at least partly enclosed within the primary fuel plenum 24.

[0041] The injector fingers 19, 20 are in the form of streamlined bodies with respective leading edges 19a, 20a and trailing edges 19b, 20b extending radially outward from the plenum assembly 22. In the embodiment of figures 2 and 3, the injector fingers 19, 20 have straight trailing edges 19b, 20b. In other embodiments, however, the trailing edges 19b, 20b of the injector fingers 19, 20 may be curved, e.g. lobed, in accordance with design preferences.

[0042] One of the injector fingers, here designated by numeral 20 (see also figure 5a), has a special design and provides also a function of inlet for primary and secondary fuel and for shielding air. Specifically, the inlet injector finger 20 comprises a primary inlet line 27, fluidly coupled to the primary fuel plenum 24, and a secondary inlet line 28, fluidly coupled to the secondary fuel plenum 25 and at least in part enclosed within the primary inlet line 27. Moreover, the inlet injector finger 20 comprises an air inlet 29, which at least in part encloses the primary inlet line 27 and the secondary inlet line 28 and is fluidly coupled to the cooling air housing 21. In the embodiment described, therefore, the primary inlet line 27 and the secondary inlet line 28 extend radially between the fuel plenum and the injection manifold. In this manner, the primary inlet line 27 and the secondary inlet line 28 are also aligned to the injector finger 20 upstream in an axial direction, to the benefit of uniform airflow. This is not mandatory, however, and inlet lines may not be aligned to any injector finger.

[0043] At respective trailing edges 19b, 20b, the injector fingers 19, 20 are provided with respective one or more fuel nozzles 30 (two for each injector finger 19, 20, in the example described). Each fuel nozzle 30 (one of which is shown in detail in figures 6 to 9a, 9b) has a respective primary fuel line fluidly 31 coupled to the primary fuel plenum 24, a respective secondary fuel line 32 fluidly coupled to the secondary fuel plenum 25 and a respective shielding air line 33 fluidly coupled to the cooling air housing 21. Fuel nozzle 30 are oriented substantially parallel to the central axis A and discharge fuel in a downstream direction. In one embodiment, the fuel nozzle or nozzles of the inlet injector finger 20 may be directly coupled to the primary inlet line 27 and/or secondary inlet line 28, as shown in figure 5b. Moreover, in other embodiments not illustrated, some of the fuel nozzles 30 may be provided with the primary fuel line 31 only.

[0044] The primary fuel line 31, the secondary fuel line 32 and the shielding air line 33 are arranged coaxially, with the shielding air line 33 enclosing the primary fuel line 31 and the primary fuel line 31 in turn enclosing the secondary fuel line 32. Moreover, the primary fuel line

fluidly 31, the secondary fuel line 32 and the shielding air line 33 extend substantially radially outward from the fuel plenum assembly 22 outside the nozzle 30 and substantially parallel to the central axis A inside the nozzle 30. Arrangement of the primary fuel line 31, the secondary fuel line 32 and the shielding air line 33 does not need to be coaxial and mutual offset may be present to compensate for thermal expansion in accordance with design preferences.

[0045] The secondary fuel line 32 tapers at a delivery end 30a of the nozzle 30, so that an annular space 35 is provided between the primary fuel line 31 and the respective secondary fuel line 32. At the delivery end 30a, the primary fuel line 31 has through openings 37 that fluidly couple the shielding air line 33 and the annular space 35. The annular space 35 is open toward the outside, so that shielding air flowing through the openings 37 is discharged downstream. Accordingly, a first shielding airflow F1 is delivered around the primary fuel line 31 and a second shielding airflow F2 is delivered between the primary fuel line 31 and the secondary fuel line 32 (figure 8).

[0046] Radial spacers 38 are provided between the primary fuel line 31 and the shielding air line 33 at the delivery end 30a of the nozzle 30. The spacers 38 are integral with one of the primary fuel line 31 and the shielding air line 33 and axial sliding relative movement therebetween.

[0047] According to the embodiment illustrated in figure 10, an injection unit has substantially the structure already described except in that an injection head 115 comprises a plurality of inlet injection fingers 120 equally spaced in a circumferential direction about the central axis A. In the example of figure 10, three injection fingers 120 at 120° with respect to one another are provided. The inlet injection fingers 120 include respective nested shielding air lines, primary inlet lines and secondary inlet lines as already described (here not shown for the sake of simplicity). In embodiments not illustrated herein, the inlet injection fingers 120 may not be equally spaced in the circumferential direction.

[0048] According to the embodiment shown in figure 11, an injection head 215 of an injection unit 213 has substantially the structure of the injection head 15 of figure 3, except in that primary fuel, secondary fuel and cooling air are supplied axially. In this case, the primary inlet line 227 and the secondary inlet line 228 feed axially directly into the fuel plenum assembly an injection manifold 214 is connected to the injection head 215 at the central axis and feeds directly into the primary fuel plenum 224 and the secondary fuel plenum 225. Air inlet is axially arranged as well and encloses in part primary inlet line 227 and the secondary inlet line 228.

[0049] Inlet injector fingers with special design are not required in this case.

[0050] Finally, it is evident that the described injection head may be subject to modifications and variations, without departing from the scope of the present invention,

as defined in the appended claims.

Claims

1. An injection head for a gas turbine combustor, the injection head (15; 115; 215) comprising:
 - a fuel plenum assembly (22) extending about the central axis (A) and including a primary fuel plenum (24; 224);
 - a plurality of injector fingers (19, 20; 120) extending radially outward from the fuel plenum assembly (22) and each provided with at least a respective fuel nozzle (30);
 - a fuel inlet (27, 28), fluidly coupled to the fuel plenum assembly (22);
 - a cooling air housing, at least partly enclosing the fuel plenum assembly (22) and defining a cooling air plenum (21);
 - wherein at least part of the fuel nozzles (30) have respective primary fuel lines (31) fluidly coupled to the primary fuel plenum (24; 224) and respective shielding air lines (33) fluidly coupled to the cooling air plenum (21).
2. The injection head according to claim 1, wherein the fuel plenum assembly (22) includes a secondary fuel plenum (25; 225) extending about the central axis (A) and at least partly enclosed within the primary fuel plenum (24; 224), and wherein part of the fuel nozzles (30) have respective secondary fuel lines (32) at least partly enclosed within the respective primary fuel lines (31) and fluidly coupled to the secondary fuel plenum (25; 225).
3. The injection head according to claim 2, wherein the fuel inlet (27, 28) comprises a primary inlet line (27), fluidly coupled to the primary fuel plenum (24; 224), and a secondary inlet line (28), fluidly coupled to the secondary fuel plenum (25; 225) and at least in part enclosed within the primary inlet line (27).
4. The injection head according to claim 3, comprising an air inlet (29) at least in part enclosing the primary inlet line (27) and the secondary inlet line (28) and fluidly coupled to the cooling air plenum (21).
5. The injection head according to claim 3 or 4, wherein the primary inlet line (27) and the secondary inlet line (28) extend radially between the fuel plenum assembly (22) and the injection manifold (14; 214).
6. The injection head according to claim 5, wherein the primary inlet line (27) and the secondary inlet line (28) are aligned to a respective one of the injector fingers (19, 20; 120) upstream in an axial direction.

7. The injection head according to claim 6, wherein the injector fingers (19, 20; 120) are in the form of streamlined bodies with respective leading edges (19a, 20a) and trailing edges (19b, 29b) extending radially outward from the fuel plenum assembly (22) and comprise at least an inlet injector finger (20) configured to be coupled to an injection manifold (14; 214), wherein the primary inlet line (27) and the secondary inlet line (28) are at least partially enclosed within the inlet injector finger (20). 10
8. The injection head according to claim 7, comprising a plurality of primary inlet lines (27), fluidly coupled to the primary fuel plenum (24; 224), and of secondary inlet lines (28), fluidly coupled to the secondary fuel plenum (25; 225) at least in part enclosed within the respective primary inlet line (27), wherein the injector fingers (19, 20; 120) comprise a plurality of inlet injector fingers (19, 20; 120), and wherein the primary inlet lines (27) and the secondary inlet lines (28) are at least partially enclosed within respective inlet injector fingers (19, 20; 120) . 15 20
9. The injection head according to claim 3 or 4, wherein the primary inlet line (27) and the secondary inlet line (28) feed axially into the fuel plenum assembly (22). 25
10. The injection head according to any one of the preceding claims, wherein in each fuel nozzle (30) the respective shielding air line (33) encloses the respective primary fuel line (31) and secondary fuel line (32). 30
11. The injection head according to claim 13, wherein the secondary fuel line (32) tapers at a delivery end (30a), whereby an annular space (35) is provided between the primary fuel line (31) and the respective secondary fuel line (32) at the delivery end (30a). 35
12. The injection head according to claim 11, wherein the primary fuel line (31) has through openings (37) at the delivery end (30a), thereby fluidly coupling the shielding air line (33) and the annular space (35) between the primary fuel line (31) and the respective secondary fuel line (32) at the delivery end (30a). 40 45
13. The injection head according to claim 11 or 12, comprising spacers (38) extending radially between the primary fuel line (31) and the respective shielding air line (33) at the delivery end (30a) and configured to allow the primary fuel line (31) to axially slide with respect to the shielding air line (33). 50
14. The injection head according to any one of the foregoing claims, comprising a compensator (17) between the injection manifold (14; 214) and the injection head (15; 115; 215), the compensator (17) being configured to allow relative movements of the injection head (15; 115; 215) and of the injection manifold (14; 214) in an axial direction and/or in a radial direction. 55
15. A gas turbine combustor, comprising at least an injection head (15; 115; 215) according to any one of the preceding claims and an injection manifold (14; 214) coupled to the injection head (15; 115; 215).

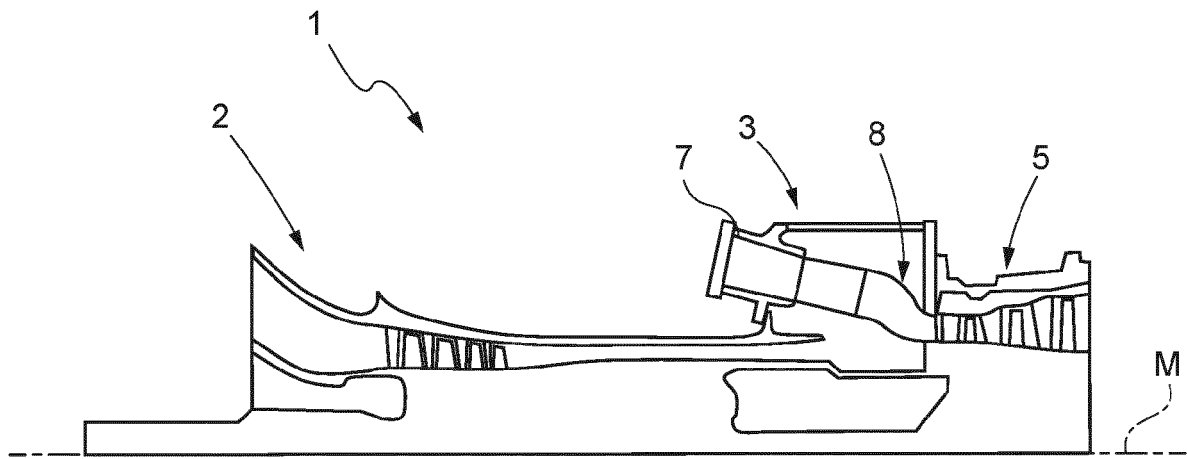


FIG. 1

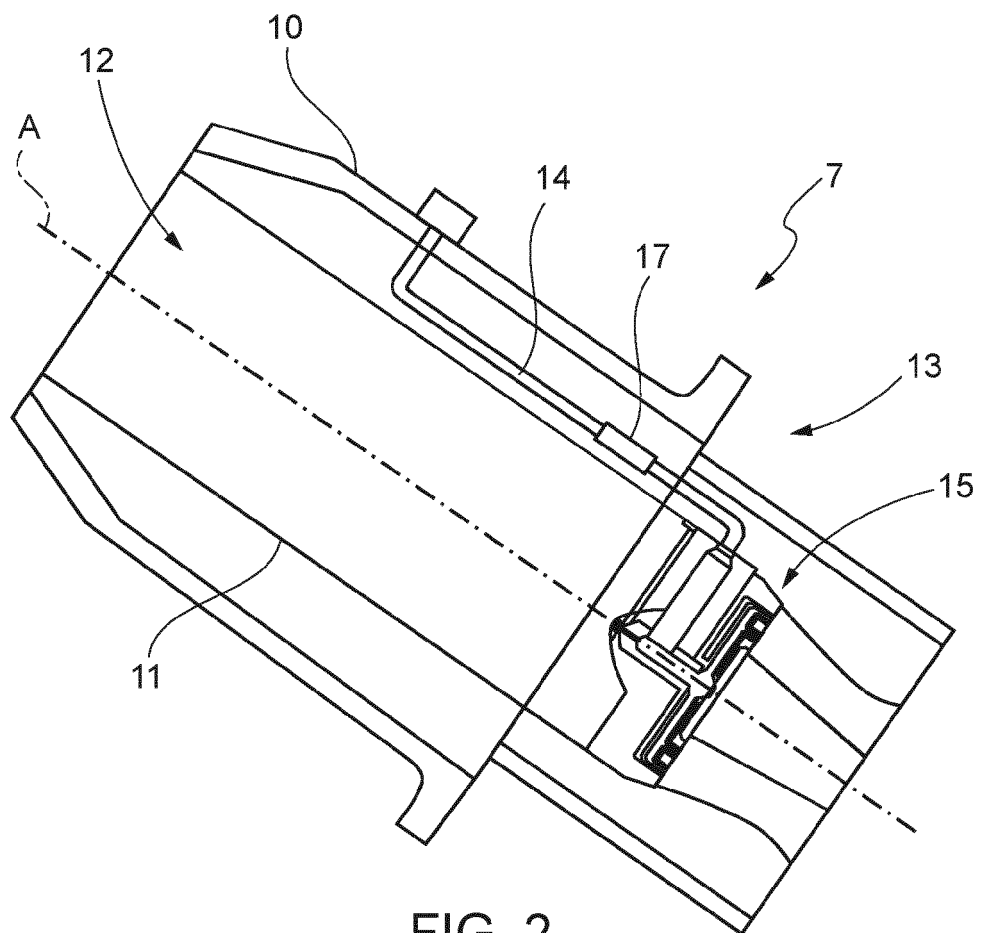
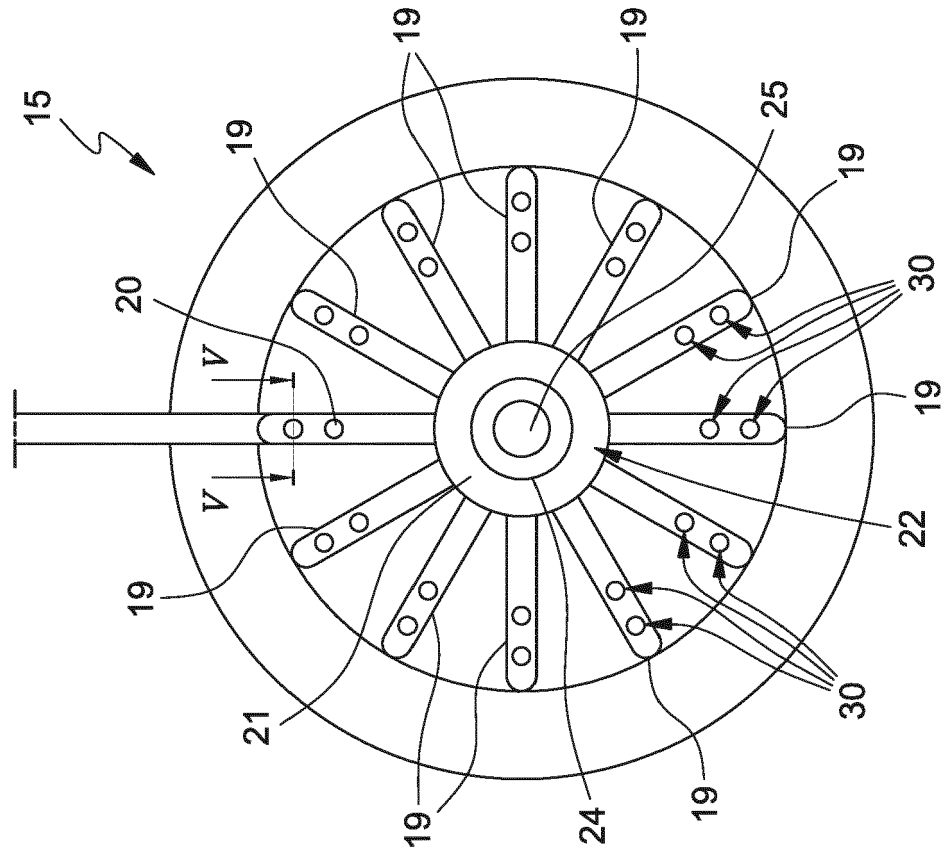
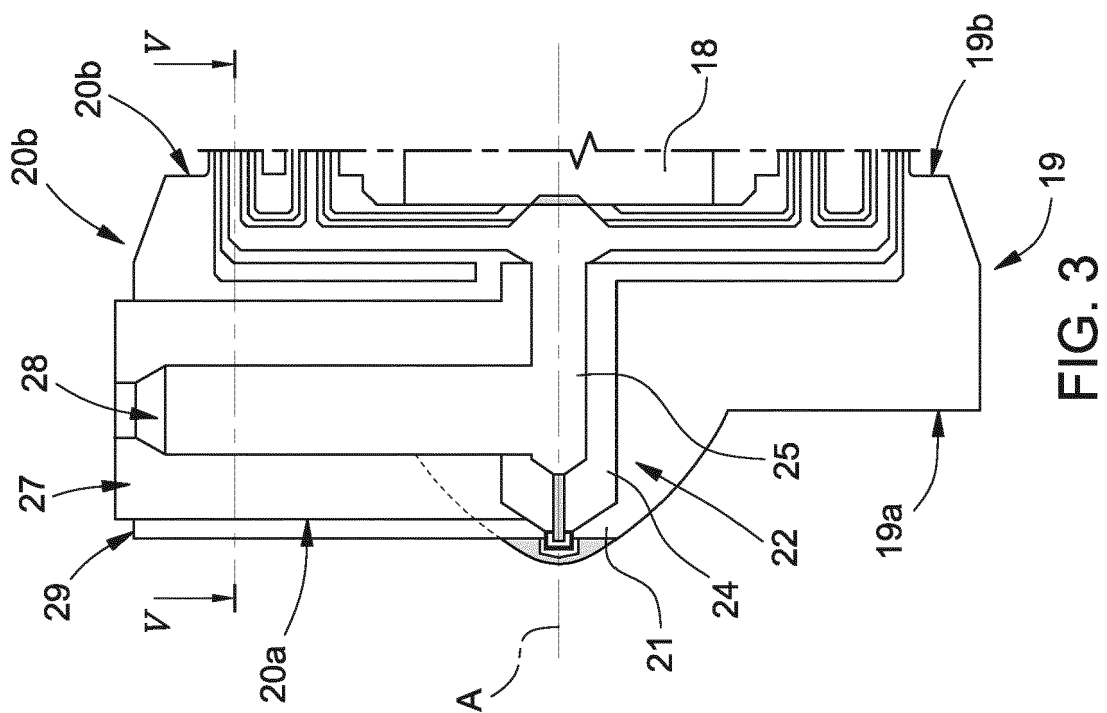


FIG. 2



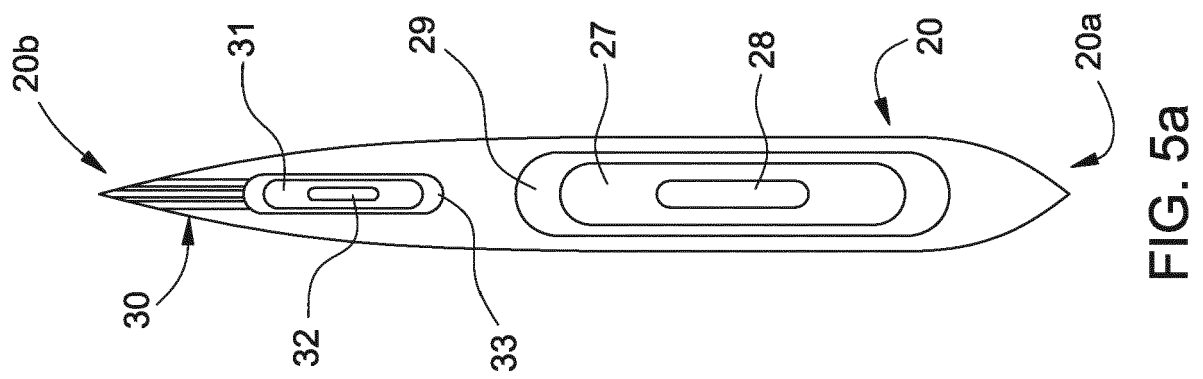


FIG. 5a

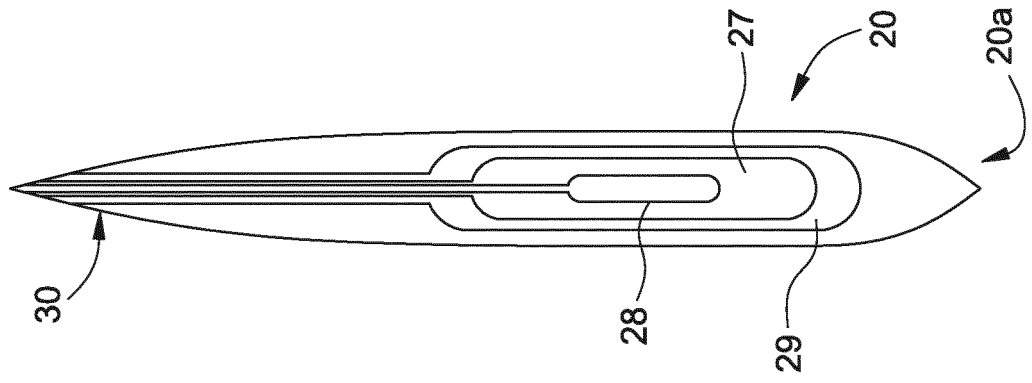


FIG. 5b

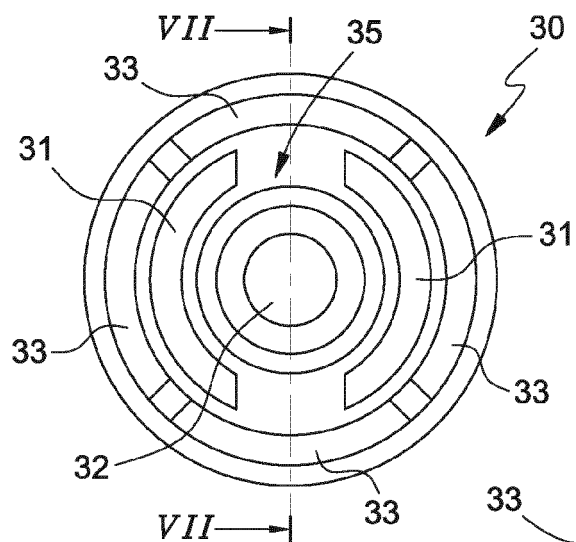


FIG. 6

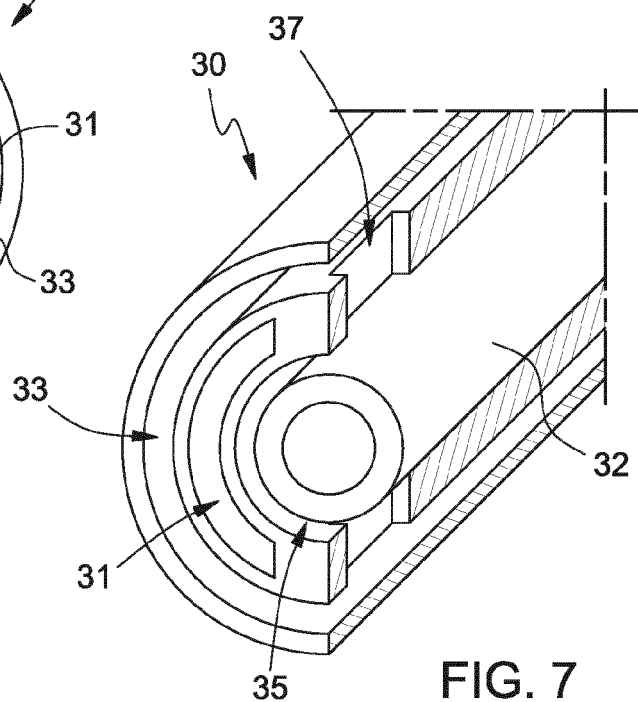


FIG. 7

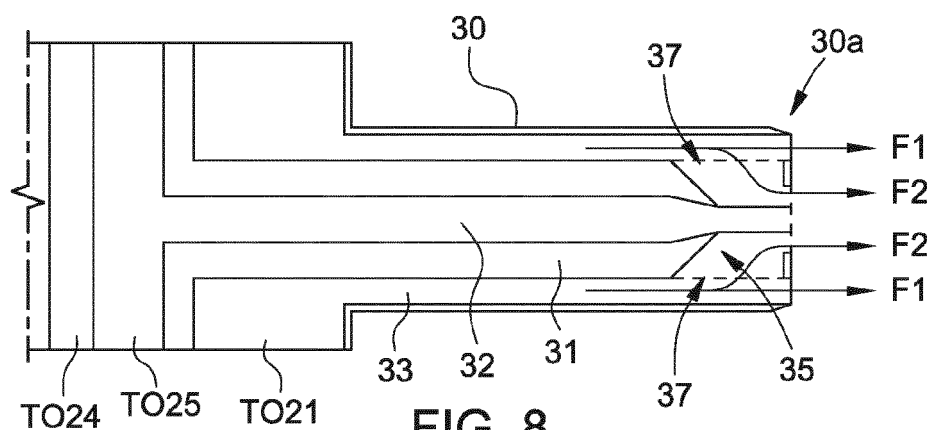


FIG. 8

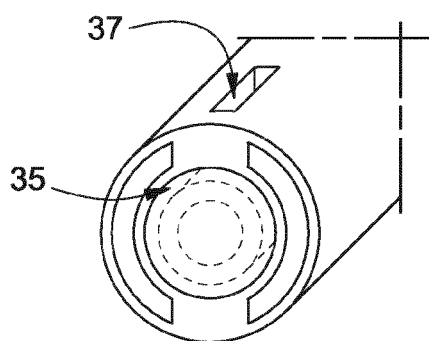


FIG. 9a

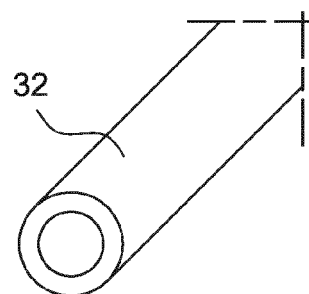


FIG. 9b

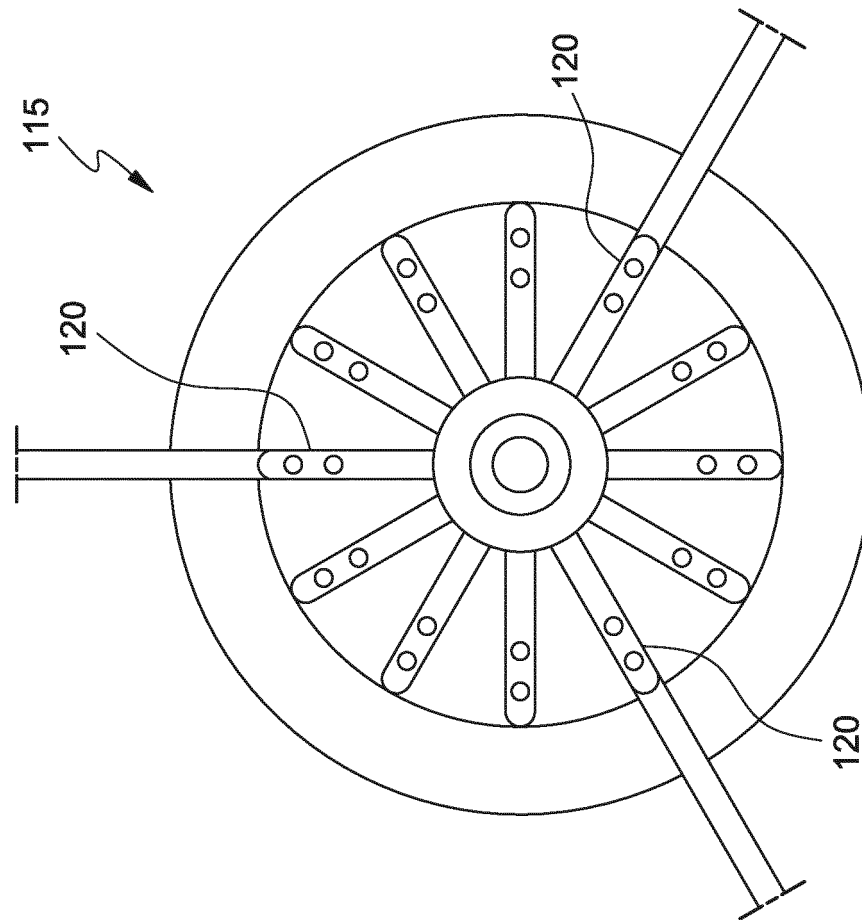


FIG. 10

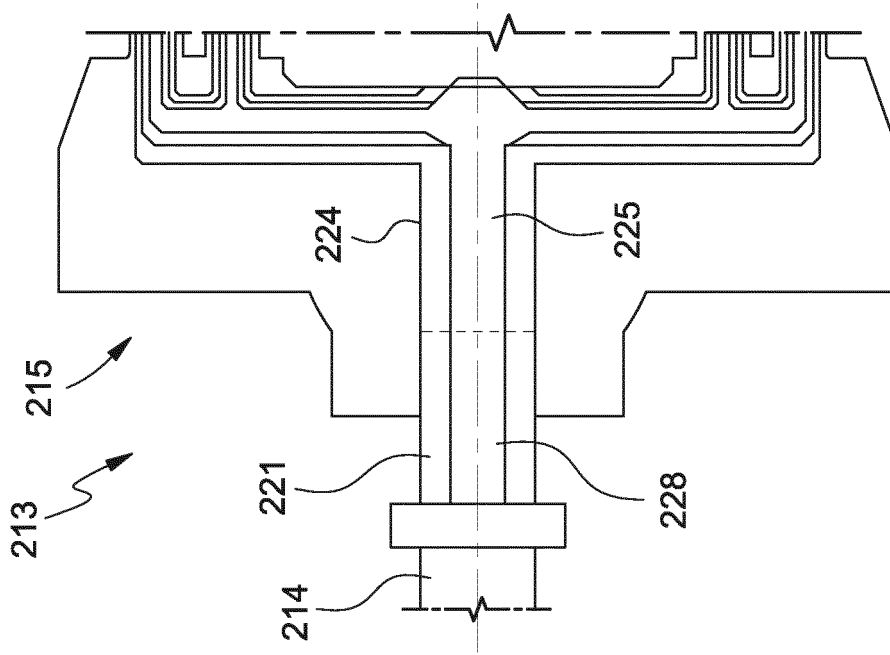


FIG. 11



EUROPEAN SEARCH REPORT

Application Number
EP 19 21 9662

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	* paragraphs [0022], [0046] - paragraph [0055]; figures *	2-7, 9-12,14	
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 20 March 2020	Examiner Mootz, Frank
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			

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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