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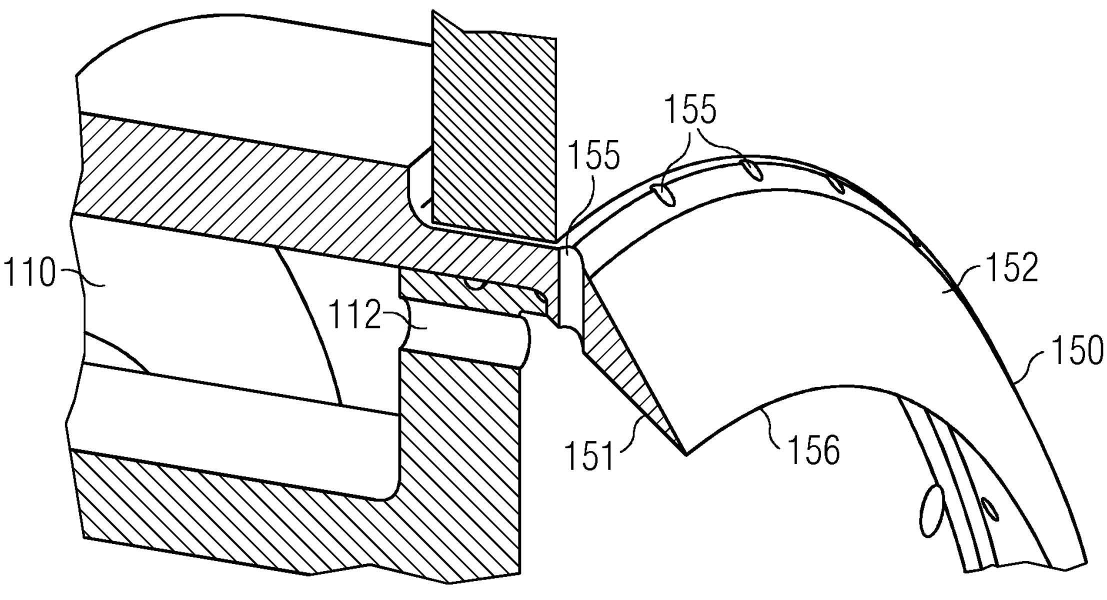
(54) COMBUSTOR FOR A GAS TURBINE

(57) The present invention relates to a combustor (100) for a gas turbine comprising:
a pre-combustion chamber (101),
a swirler (103),
a pilot burner (110) upstream the pre-combustion chamber (101) which comprises a pilot burner surface (111) separating the pilot burner (110) from the pre-combustion chamber (101), the pilot burner (110) further comprising at least a pilot fuel injector (112),
wherein the combustor (100) includes a lip (150) extending from the pilot burner surface (111) in the pre-combustion chamber (101), the lip including an internal surface (151) oriented towards the pilot fuel injector (112), the internal surface (151) being inclined of an inclination angle (θ) comprised between 0 degrees and 90 degrees with respect to the centre axis (35) of the pre-combustion chamber (101), and the lip (150) comprises at least a feed passage (155) for connecting the internal surface (151) with the flow (F) of oxidant gas coming from the swirler (103).

FIG 5



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Description

Field of invention

[0001] The present invention relates to a combustor for a gas turbine.

Art Background

[0002] In such a technical field, a combustor generally comprises a main combustion chamber and a pre-combustion chamber, upstream of the main combustion chamber. The pre-combustion chamber comprises a swirler section having a swirler through which a main fuel stream is provided. In the swirler the main fuel is mixed to a non-combustible gas flow comprising an oxidant, for example air. The main fuel stream and the non-combustible gas flow are injected via the swirler into the pre-combustion chamber of the combustor in a generally tangential direction with respect to the centre axis of the combustor.

[0003] A pilot fuel is further injected in the pre-combustion chamber for controlling the combustor flame in which the main fuel in burned. The pilot fuel is typically injected by a pilot burner, generally according a direction parallel to the centre axis of the combustor.

[0004] The pilot fuel is injected from the pilot burner into the pre-combustion chamber through a plurality of pilot fuel injectors arranged on the pilot burner surface, i.e. the surface separating the pilot burner from the pre-combustion chamber. The main fuel and the pilot fuel is a gaseous fuel. Liquid fuel injection may also be provided in similar positions on the swirler and on the pilot burner.

[0005] The combustion of the pilot fuel is achieved through an oxidant, for example air, first being mixed together with the fuel in the pilot burner.

[0006] In known solution, the injected pilot fuel generates a diffusion flame inside the pre-combustion chamber, close to pilot burner surface. This has the main drawback of increasing the local temperature at the pilot burner surface, with the consequence of reducing the life cycle of the pilot burner.

[0007] It is therefore desirable to provide a new design of the combustor above described, in particular at the interface between the pilot burner and the pre-combustion chamber, for limiting temperatures at the pilot burner surface, at the same time without compromising the overall efficiency of the combustor. Inside the combustor, avoiding areas with high temperature has also the positive effect in reducing overall nitrogen oxides (NOx) emissions.

Summary of the Invention

[0008] It may be an objective of the present invention to provide a combustor solving the above described inconveniences experimented in known combustors.

[0009] It may be a further objective of the present invention to provide a combustor with a proper fuel distribution in the mixture of the gas inside the pre-combustion chamber, in order to avoid areas with non-desirable high temperature.

[0010] It may be another objective of the present invention to provide a combustion chamber with an improved life-cycle of components subject to high temperature, in particular the pilot burner.

[0011] This object is solved by a combustor for a gas turbine according to the independent claim. The dependent claims describe advantageous developments and modifications of the invention.

[0012] According to an aspect of the present invention, a combustor for a gas turbine is presented. The combustor comprises:

a pre-combustion chamber,

a swirler which is connected to the pre-combustion chamber for providing pre-combustion chamber with a flow of oxidant gas. The swirler is arranged around the pre-combustion chamber in a circumferential direction with respect to an axis of the pre-combustion chamber,

a pilot burner upstream the pre-combustion chamber which comprises a pilot burner surface separating the pilot burner from the pre-combustion chamber. The pilot burner further comprises at least a pilot fuel injector which is arranged to the pilot burner surface for injecting pilot fuel into the pre-combustion chamber.

The combustor includes a lip extending from the pilot burner surface in the pre-combustion chamber, the lip including an internal surface oriented towards the pilot fuel injector for intercepting at least part of the pilot fuel from the pilot fuel injector, the internal surface being inclined of an inclination angle with respect to the centre axis of the pre-combustion chamber, the inclination angle being comprised between 0 degrees and 90 degrees. The lip comprises one or more feed passage for connecting the internal surface with the flow of oxidant gas coming from the swirler.

[0013] The combustor may be an annular-type or a can-type combustor. The combustion chamber may have a cylindrical or oval shape. The combustion chamber may comprise a main combustion chamber and a pre-combustion chamber with a swirler section. The centre axis of the pre-combustion chamber may be a symmetry line of the pre-combustion chamber. At the swirler section, the swirler is mounted to the pre-combustion chamber and surrounds the pre-combustion chamber centre axis.

[0014] Advantageously, the inclined orientation of the lip guides the flow away from the pilot burner surface and towards a main combustion zone of the pre-combustion chamber. The injection of oxidant gas through the feed passages enhance mixing of the oxidant gas with the pilot fuel from the pilot fuel injector. As a result, temperature at the pilot burner surface is reduced, up to more acceptable values, which make life of the pilot burner longer.

According to possible embodiments, an inclination angle is comprised between 30° and 60° has proved to be particularly advantageous.

[0015] According to possible embodiments of the present invention, the lip further comprises an external surface oriented towards the swirler for intercepting at least part of the flow of oxidant gas coming from the swirler, the feed passages being provided between the internal surface and the external surface. The feed passages may be provided in plurality, regularly distributed around the centre axis.

The external surface may be provided with a plurality of turbulators for inducing turbulence in at least part of the flow of oxidant gas coming from the swirler. The turbulators may comprise a plurality of protrusions extending orthogonally from the external surface and/or a plurality of channels having a depth extending from the external surface towards the internal surface. The protrusions may comprise a circular rim concentric with the centre axis of the pre-combustion chamber.

Advantageously, the turbulators enhance the turbulence from the swirler oxidant gas to mix with the pilot fuel emerging from the lip towards the inside of the pre-combustion chamber. This produces premixed pilot for lowering temperatures and hence NOx emissions.

[0016] According to possible embodiments of the present invention, the internal surface and the external surface have a common trailing edge, at the end of the lip, where both the pilot fuel and the oxidant gas separate from the lip. The trailing edge may have a circular profile around the centre axis of the pre-combustion chamber. The trailing edge may have a waved profile.

[0017] Advantageously, the above described designs of the end portion of the lip improve turbulence and flow aerodynamics. Pressure loss may be also reduced.

[0018] According to other embodiments of the present invention, the internal surface has an aerofoil shape. Advantageously, this improves turbulence and flow aerodynamics and reduces pressure loss.

[0019] According to further embodiments of the present invention, the lip is provided as an edge of a shroud of the pilot burner extending inside the pre-combustion chamber. Advantageously, this allows to manufacture a pilot burner directly including a lip optimised for the present invention.

Brief Description of the Drawings

[0020] The aspects defined above and further aspects of the present invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to the examples of embodiment. The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Fig. 1 shows a longitudinal sectional view of a gas turbine engine including a combustor according to the present invention,

Fig. 2 shows a partial and schematic longitudinal section of a combustor for a gas turbine according to an exemplary embodiment of the present invention, showing a pilot burner, a pre-combustion chamber and a swirler section;

Fig. 3 shows a sectional view of a swirler according to exemplary embodiments of the present invention, according to the section line III-III of Fig. 2;

Fig. 4 shows a magnified view of the detail IV of Fig. 2;

Fig. 5 shows an assonometric partial view of the combustor for a gas turbine, according to an exemplary embodiment of the present invention, partially showing a pilot burner;

Fig. 6 shows a partial sectional view of the combustor of Fig. 5;

Fig. 7 shows a partial sectional view, corresponding to the sectional view of Fig. 6, of another embodiment of a combustor for a gas turbine according to the present invention;

Figs. 8 to 10 show three assonometric partial views, corresponding to the assonometric view of Fig. 5, of other respective embodiments of a combustor for a gas turbine according to the present invention.

Detailed Description

[0021] The illustrations in the drawings are schematic. It is noted that in different figures, similar or identical elements are provided with the same reference signs.

[0022] **Fig. 1** shows an example of a gas turbine engine 10 in a sectional view. The gas turbine engine 10 comprises, in flow series, an inlet 12, a compressor section 14, a burner section 16 and a turbine section 18 which are generally arranged in flow series and generally about and in the direction of a longitudinal or rotational axis 20. The gas turbine engine 10 further comprises a shaft 22 which is rotatable about the rotational axis 20 and which extends longitudinally through the gas turbine engine 10. The shaft 22 drivingly connects the turbine section 18 to the compressor section 14.

In operation of the gas turbine engine 10, air 24, which is taken in through the air inlet 12 is compressed by the compressor section 14 and delivered to the combustion section or burner section 16.

[0023] The burner section 16 comprises a burner plenum 26, one or more combustion chambers 28, each having a respective upstream pre-combustion chamber 101. The burner section 16 further comprises at least one pilot burner 30 and a swirler section 31 fixed to each pre-combustion chamber 101. The pre-combustion chambers 101, the combustion chambers 28, the pilot burners 30 and the swirler section 31 are located inside the burner plenum 26. The compressed air passing through the compressor 14 enters a diffuser 32 and is discharged from the diffuser 32 into the burner plenum 26 from where a portion of the air enters the pilot burner 30 and is mixed with a gaseous or liquid pilot fuel. The air/fuel mixture is then burned and the combustion gas 34 or working gas from the combustion is channelled through the combustion chamber 28 to the turbine section 18 via a transition duct 17.

A main flow of air/fuel mixture is further inserted in the pre-combustion chamber 101 through the swirler section 31, as better detailed in a following section of the present text. The main fuel burns when mixing with the hot gasses in the pre-combustion chamber 101 and in the main combustor chamber 28.

[0024] This exemplary gas turbine engine 10 has a cannular combustor section arrangement, which is constituted by an annular array of combustor cans 19 each having a pilot burner 30 and a combustion chamber 28, the transition duct 17 having a generally circular inlet that interfaces with the combustor chamber 28 and an outlet in the form of an annular segment. An annular array of transition duct outlets form an annulus for channelling the combustion gases to the turbine 18.

[0025] The turbine section 18 comprises a number of blade carrying discs 36 attached to the shaft 22. In the present example, two discs 36 each carry an annular array of turbine blades 38. However, the number of blade carrying discs could be different, i.e. only one disc or more than two discs. In addition, guiding vanes 40, which are fixed to a stator 42 of the gas turbine engine 10, are disposed between the stages of annular arrays of turbine blades 38. Between the exit of the combustion chamber 28 and the leading turbine blades 38 inlet guiding vanes 44 are provided and turn the flow of working gas onto the turbine blades 38.

The combustion gas from the combustion chamber 28 enters the turbine section 18 and drives the turbine blades 38 which in turn rotate the shaft 22. The guiding vanes 40, 44 serve to optimise the angle of the combustion or working gas on the turbine blades 38.

The turbine section 18 drives the compressor section 14. The compressor section 14 comprises an axial series of vane stages 46 and rotor blade stages 48. The rotor blade stages 48 comprise a rotor disc supporting an annular array of blades. The compressor section 14 also comprises a casing 50 that surrounds the rotor stages and supports the vane stages 48. The guide vane stages include an annular array of radially extending vanes that are mounted to the casing 50. The vanes are provided to present gas flow at an optimal angle for the blades at a given engine operational point. Some of the guide vane stages have variable vanes, where the angle of the vanes, about their own longitudinal axis, can be adjusted for angle according to air flow characteristics that can occur at different engine operations conditions.

The casing 50 defines a radially outer surface 52 of the passage 56 of the compressor 14. A radially inner surface 54 of the passage 56 is at least partly defined by a rotor drum 53 of the rotor which is partly defined by the annular array of blades 48.

[0026] The present invention is described with reference to the above exemplary turbine engine having a single shaft or spool connecting a single, multi-stage compressor and a single, one or more stage turbine. However, it should be appreciated that the present invention is equally applicable to two or three shaft engines and which can be used for industrial, aero or marine applications.

[0027] The terms upstream and downstream refer to the flow direction of the airflow and/or working gas flow through the engine unless otherwise stated. When not differently specified, the terms axial, radial and circumferential are made with reference to an axis 35 of the combustor.

[0028] **Fig. 2** shows a combustor 100 for a gas turbine. The combustor 100 has a centre axis 35 and comprises:

- an upstream portion with a pre-combustion chamber 101 and a swirler 103, and
- a downstream portion with a combustion chamber 28.

The pre-combustion chamber 101, the swirler 103 and the combustion chamber 28 are all axially symmetric around the centre axis 35. With respect to the centre axis 35, the pre-combustion chamber 101 has a smaller diameter than the combustion chamber 28. The pre-combustion chamber 101 and the combustion chamber 28 are adjacent to one another along the centre axis 35 and in fluid communication with one another. Downstream of the pre-combustion chamber 101 the combustion chamber 28 extends up to the transition duct 17. The combustion chamber 28 is conventional and therefore not described in further detail.

[0029] The swirler 103 is mounted on a peripheral wall 115 of the pre-combustion chamber 101, in such a way that the swirler 103 surrounds the pre-combustion chamber 101 in a circumferential direction with respect to the centre axis 35. The swirler 103 comprises a bottom surface 104 which is orthogonal to the centre axis 35 and which forms a part of a slot 201 (see Fig. 3) through which, typically, an oxidant/fuel mixture flow F is injectable into the pre-combustion chamber 101.

The swirler 103 further comprises a cylindrical peripheral surface 119 having axis coincident with the combustor centre axis 35,

[0030] With reference to **Fig. 3,** the swirler 103 comprises a plurality of slots 201 (twelve slots in the embodiment of figure 3). Each slot 201 is formed by circumferentially spaced apart vanes 203 and the bottom surface 104. Oxidant/fuel mixture which flows through the slots

201 is directed approximately tangentially with respect to the centre axis 35. This orientation of the slots 201 induces a swirl movement, i.e. a movement according to a tangentially orientated direction around the centre axis 35, of the gasses inside the pre-combustion chamber 101.

[0031] Each slot 201 comprises a base fuel injector 107 which is arranged to the bottom surface 104 such that an air/fuel mixture is injectable into the slot 201 according to a main fuel injection direction which is orthogonal or inclined with respect to the bottom surface 104.

[0032] Additionally, further side fuel injectors 202 may be provided for some of the slots 201 or for all of the slots 201 on the cylindrical peripheral surface 119 of the swirler 103.

[0033] In the embodiment of the attached figures two side fuel injectors 202 are provided for each of the slots 201.

The side fuel injectors 202 inject further fuel. The further fuel may be mixed inside the slots 201 with the fuel which is injected by the base fuel injector 107 and with the oxidant. Side fuel injectors 202 are in the form of holes, injecting further gaseous fuel.

According to other embodiments of the present invention, atomizers or nozzles for liquid fuel injection are provided in the same slots 201, close to the trailing edges of the swirler vanes 203.

[0034] Upstream to the swirler 103 and to the pre-combustion chamber 101, the combustor 100 further comprises a pilot burner 110, which comprises a burner face 111. In particular, the burner face 111 is aligned or substantially parallel to the bottom surface 104. The pilot burner 110 further comprises a cylindrical shroud 170, extending around the centre axis 35, for peripherally delimiting the pilot burner 110.

The pilot burner 110 comprises a plurality of pilot fuel injectors 112 which are arranged to the burner face 111 for injecting pilot fuel into the pre-combustion chamber 101. In the embodiments of the attached figures, twelve side pilot fuel injectors 112 regularly distributed 30 degrees apart circumferentially around the centre axis 35 are provided.

The pilot fuel injectors 112 are oriented substantially parallel to the centre axis 35.

[0035] The pilot fuel forms a separation layer and a flame front 105. The circulation induced by the radial swirler 103 forms a central circular zone around the centre axis 35, inside of which the pilot fuel (i.e. the oxidant/fuel mixture) is burned. This central zone is called the reaction zone RZ. Around the central reaction zone RZ, the oxidant/fuel mixture is injected by the swirler 103.

[0036] With reference to **Figs. 4** to **10,** the combustor 100 further includes a lip 150 extending from the pilot burner surface 111 in the pre-combustion chamber 101. In a circumferential direction, the lip 150 further extends around the centre axis 35.

The lip 150 extends from a portion of the pilot burner surface 111 whose distance from the centre axis 35 of the pre-combustion chamber 101 is greater than the distance between the pilot fuel injectors 112 and the centre axis 35. With respect to the more internal portion of the pre-combustion chamber 101, identified as the portion around the centre axis 35, the lip 150 includes an internal surface 151 and an external surface 152.

The internal surface 151 is inclined towards the centre axis 35 and oriented towards the pilot fuel injectors 112 for intercepting at least part of the pilot fuel from the pilot fuel injectors 112. With respect to the centre axis 35, the internal surface 151 is inclined of an inclination angle α comprised between 0 degrees and 90 degrees. More particularly, in the embodiments of **Figs. 4** to **10,** the inclination angle α is comprised between 30 degrees and 60 degrees. The external surface 152 is oriented towards the swirler 103 for intercepting at least part of the flow F coming from the swirler 103.

[0037] The lip 150 is integral with the pilot burner 110, being provided as an edge of the shroud 170, extending inside the pre-combustion 101.

According to other embodiments of the present invention (not shown) the lip 150 is provided on pilot burner surface 111 or on the swirler 103.

[0038] The lip 150 further comprises a plurality of feed passages 155 provided between the internal surface 151 and the external surface 152, for connecting the internal surface 151 with the flow F coming from the swirler 103. The feed passages 155 are regularly distributed around the centre axis 35.

[0039] With specific reference to **Figs. 8** and **10,** the external surface 152 comprises a plurality of turbulators 160, 161, 162 for inducing turbulence in the flow F coming from the swirler 103.

In the embodiment of **Fig. 8,** the turbulators comprise a plurality of protrusions 160, 162 extending orthogonally from the external surface 152. Some of the protrusions 160, 162 are constituted by a plurality of first protrusions 160, placed around the centre axis 35, at a same distance from the centre axis 35. The first protrusions 160 have respective bases on the external surface 152, the bases having, for example, circular or rectangular shape. The protrusions 160 are regularly distributed around the centre axis 35, at a fixed angular distance. A further protrusion 162 is provided as a circular rim 162, concentric with the centre axis 35 of the pre-combustion chamber 101. With respect to the flow F coming from the swirler 103, the circular rim 162 is provided on the external surface 152, downstream of the first protrusions 160. According to other possible embodiments (not shown), the circular rim 162 is provided on the external surface 152, upstream of the first protrusions 160.

In the embodiment of **Fig. 10,** the turbulators comprise a plurality of channels 161 regularly distributed around the central axis Y. Each channel 161 extends from the external surface 152 up the internal surface 151, in such a way that the channels 161 divide the lip 150 into a plurality of segments 158, each segment 158 being comprised between two consecutive channels 161. According to other possible embodiments (not shown), the channels 161 are not completely extended from the external surface 152 up the internal surface 151, but are provided on the external surface 152 along a direction inclined of an inclination angle α with respect to the centre axis 35 and with a depth extending from the external surface 152 towards the internal surface 151.

[0040] In other embodiments of the present invention (not shown) other combination of the turbulators 160, 161, 162 described above may be possible. In particular, any other array of the turbulators 160, 161, 162 may be arranged, each array being characterized by the type(s), number and distribution of the turbulators 160, 161, 162.

[0041] The internal surface 151 and the external surface 152 have a common trailing edge 156, at the end of the lip 150, where both the pilot fuel and the flow F separate from the lip 150.

[0042] With specific reference to **Figs. 5, 6,** and **8,** the trailing edge 156 has a sharp circular profile around the centre axis 35. With specific reference to **Fig. 9,** the trailing edge 156 has a rounded profile in a section view (equivalent, for example to the view of **Fig. 6)** and a waved profile in a circumferential view, around the centre axis 35.

[0043] With reference to **Figs. 7** and **10,** the trailing edge 156 is clipped, i.e. the lip 150 has, in a sectional plane including the centre axis 35, a trapezoidal shape, including a face 159, connecting the external surface 152 and the internal surface 151, at the end of the lip 150.

[0044] With further reference to **Fig. 6,** the lip 150 may be provided, in embodiments of the present invention, with an internal surface 151b having an aerofoil shape (dashed line of **Fig. 6).**

[0045] It should be noted that the term "comprising" does not exclude other elements or steps and "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

Claims

1. Combustor (100) for a gas turbine, the combustor (100) comprising:

a pre-combustion chamber (101),
a swirler (103) which is connected to the pre-combustion chamber (101) for providing pre-combustion chamber (101) with a flow (F) of fuel and oxidant gas, the swirler (103) being arranged around the pre-combustion chamber (101) in a circumferential direction with respect to a centre axis (35) of the pre-combustion chamber (101),
a pilot burner (110) upstream the pre-combustion chamber (101) which comprises a pilot burner surface (111) separating the pilot burner (110) from the pre-combustion chamber (101), the pilot burner (110) further comprising at least a pilot fuel injector (112) which is arranged to the pilot burner surface (111) for injecting pilot fuel into the pre-combustion chamber (101),
wherein the combustor (100) includes a lip (150) extending from the pilot burner surface (111) in the pre-combustion chamber (101), the lip including an internal surface (151) oriented towards the pilot fuel injector (112) for intercepting at least part of the pilot fuel from the pilot fuel injector (112), the internal surface (151) being inclined of an inclination angle (α) with respect to the centre axis (35) of the pre-combustion chamber (101), the inclination angle (α) being comprised between 0 degrees and 90 degrees, and
wherein the lip (150) comprises at least a feed passage (155) for connecting the internal surface (151) with the flow (F) of oxidant gas coming from the swirler (103).

2. Combustor (100) according to claim 1,
wherein the lip (150) further comprises an external surface (152) oriented towards the swirler (103) for intercepting at least part of the flow (F) coming from the swirler (103), the feed passage (155) being provided between the internal surface (151) and the external surface (152).

3. Combustor (100) according to claim 2,
wherein the external surface (152) comprises a plurality of turbulators (160, 161, 162) for inducing turbulence in at least part of the flow (F) of oxidant gas coming from the swirler (103).

4. Combustor (100) according to claim 3,
wherein the turbulators (160, 161, 162) comprise a plurality of protrusions (160, 162) extending orthogonally from the external surface (152).

5. Combustor (100) according to claim 3 or 4,
wherein the protrusions (160, 162) comprise a circular rim (162), the circular rim (162) being concentric with the centre axis (35) of the pre-combustion chamber (101).

6. Combustor (100) according to any of the claims 3 to 5,
wherein the turbulators (160, 161, 162) comprise a plurality of channels (161) having a depth extending from the external surface (152) towards the internal surface (151).

7. Combustor (100) according to any of the claims 2 to 6,
wherein internal surface (151) and the external sur-

face (152) have a common trailing edge (156).

8. Combustor (100) according to claim 7, wherein the trailing edge (156) has a circular profile around the centre axis (35) of the pre-combustion chamber (101).

9. Combustor (100) according to claim 7, wherein the trailing edge (156) has a waved profile.

10. Combustor (100) according to any of the preceding claims, wherein the internal surface (151) has an aerofoil shape.

11. Combustor (100) according to any of the preceding claims, wherein the value of the inclination angle (α) is comprised between 30° and 60°.

12. Combustor (100) according to any of the preceding claims, wherein the lip (150) extends from a portion of the pilot burner surface (111) whose distance from the centre axis (35) of the pre-combustion chamber (101) is greater than the distance between the pilot fuel injector (112) and the centre axis (35).

13. Combustor (100) according to any of the preceding claims, wherein the lip (150) is provided as an edge of a shroud (170) of the pilot burner (110) extending inside the pre-combustion chamber (101).

14. Combustor (100) according to any of the preceding claims, wherein the lip (150) comprises a plurality of feed passages (155) for connecting the internal surface (151) with the flow (F) of oxidant gas coming from the swirler (103), the feed passages (155) being regularly distributed around the centre axis (35).

FIG 1

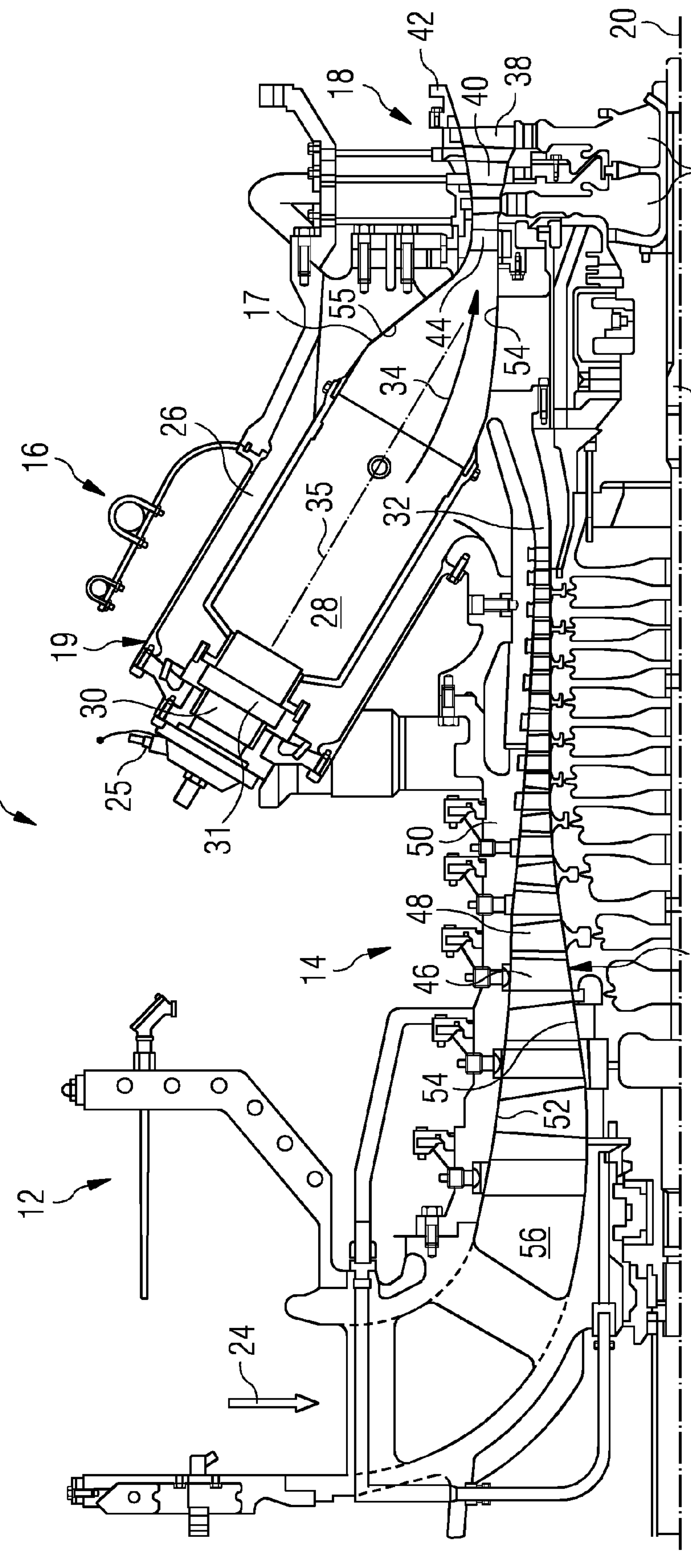
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FIG 2

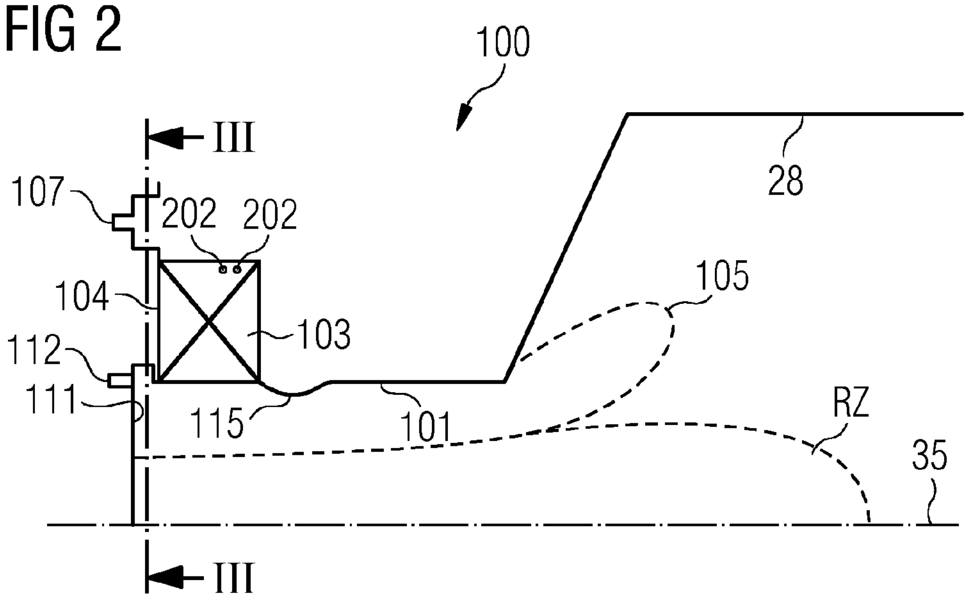


FIG 3

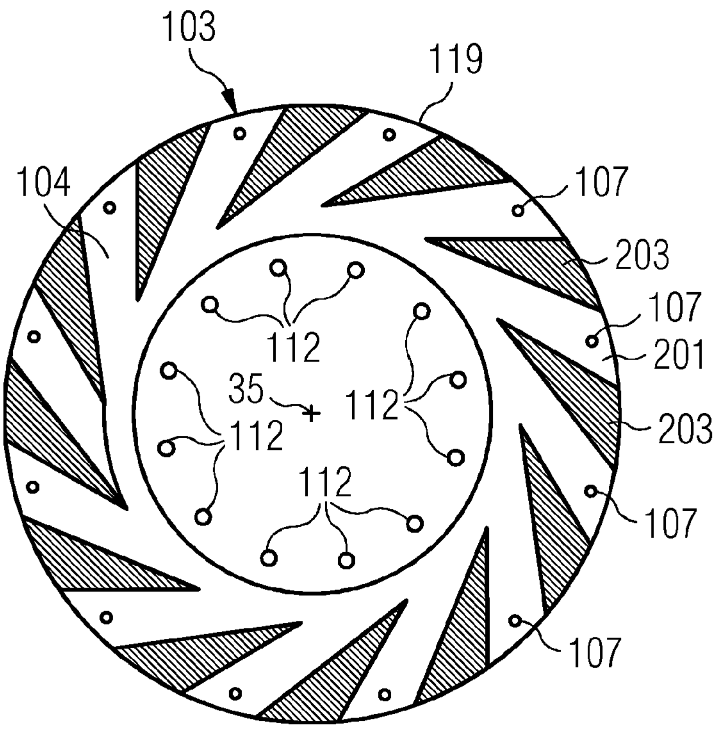


FIG 4

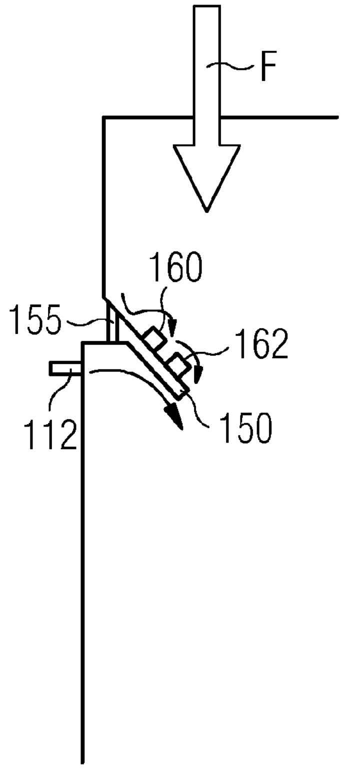


FIG 5

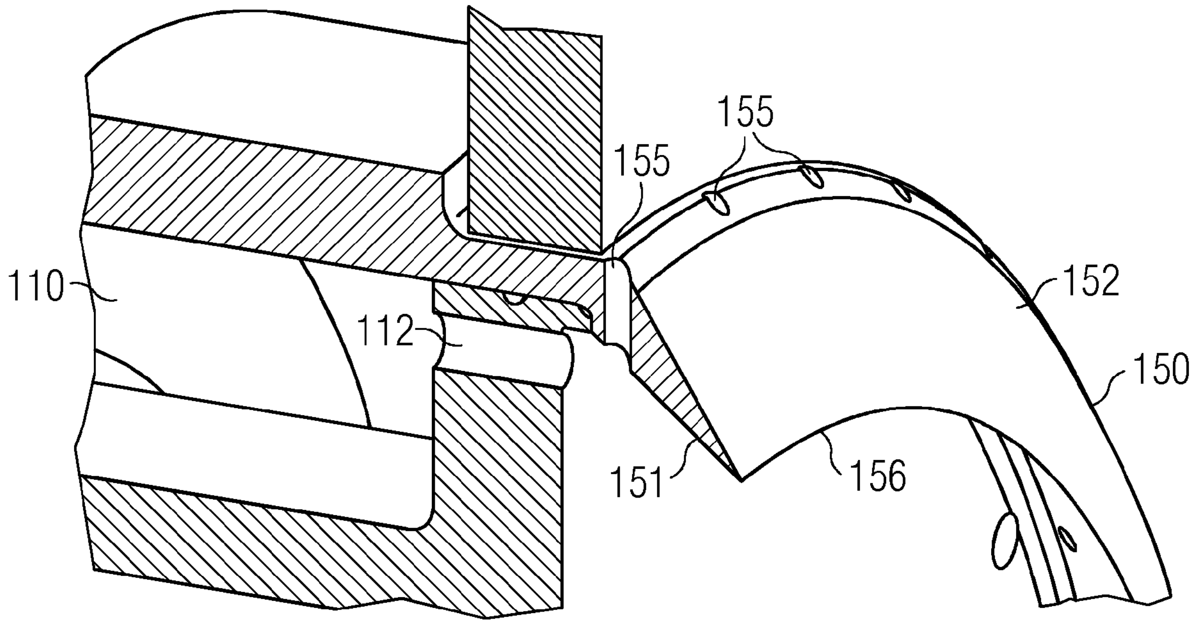


FIG 6

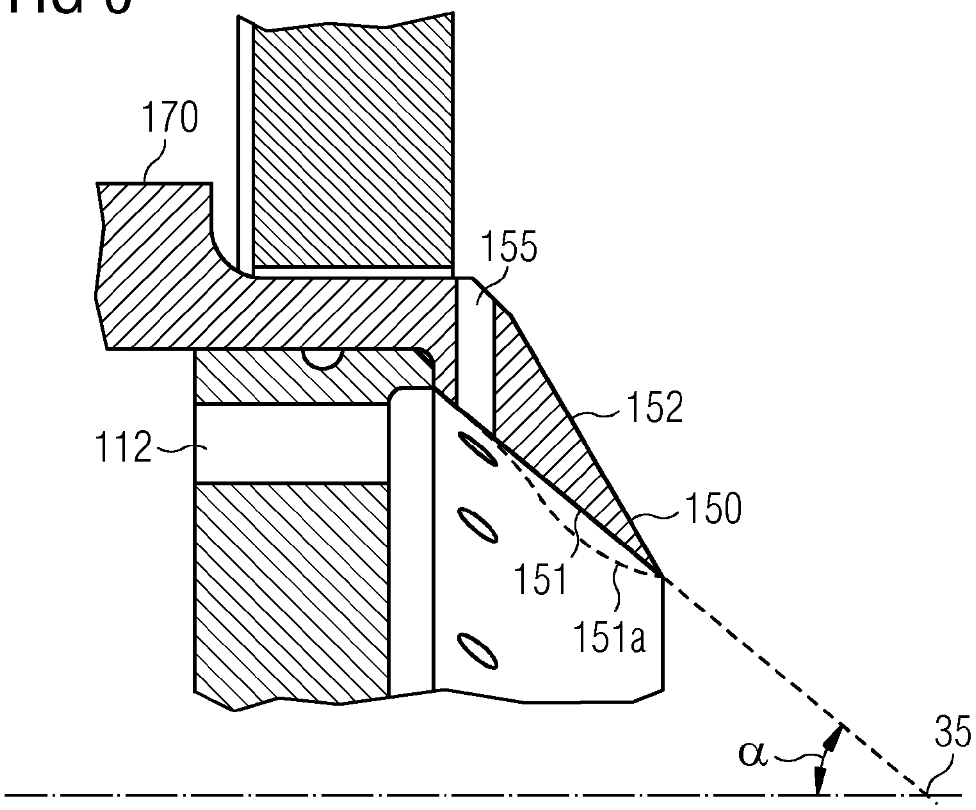


FIG 7

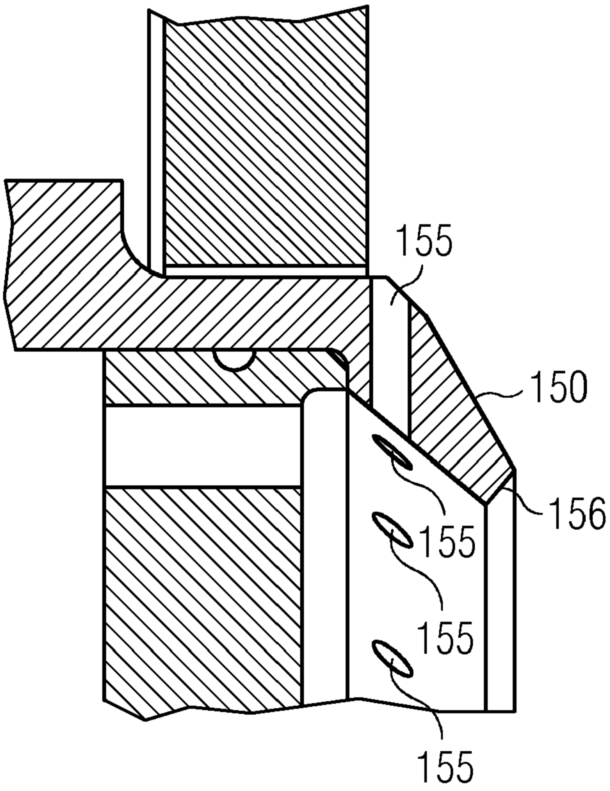


FIG 8

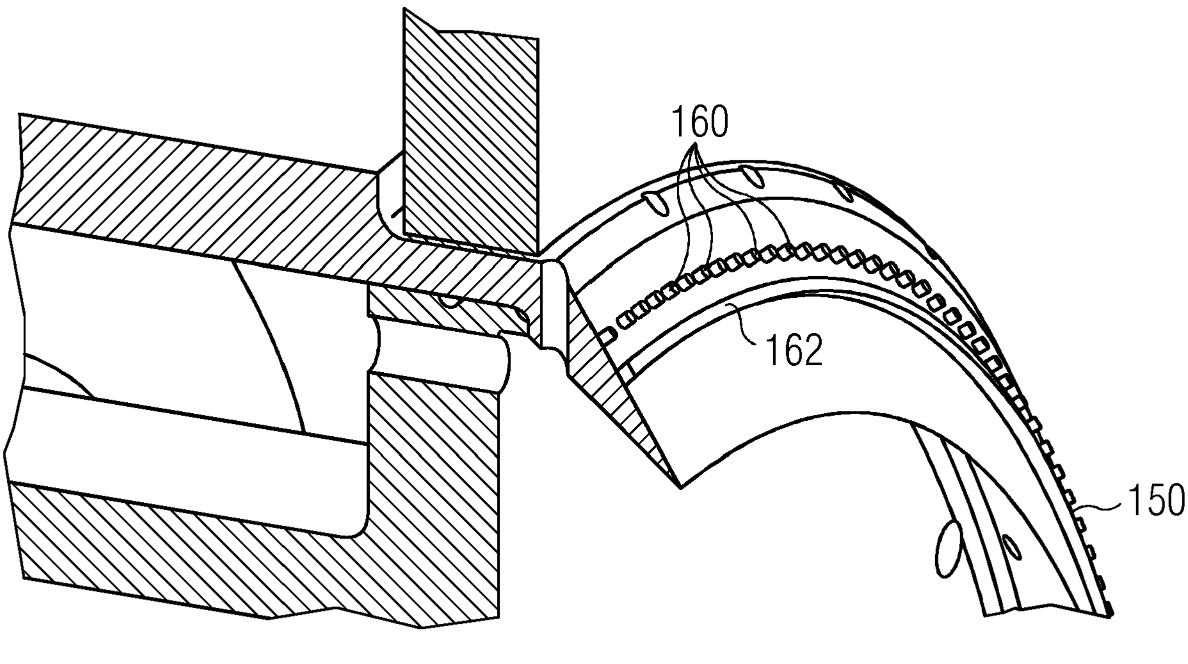


FIG 9

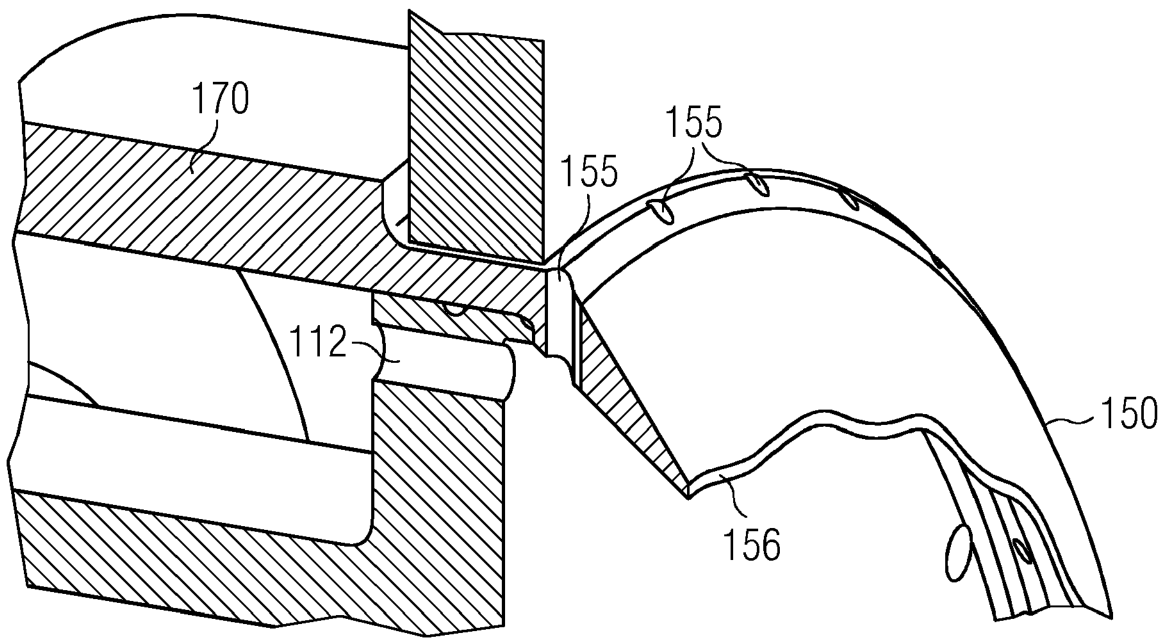
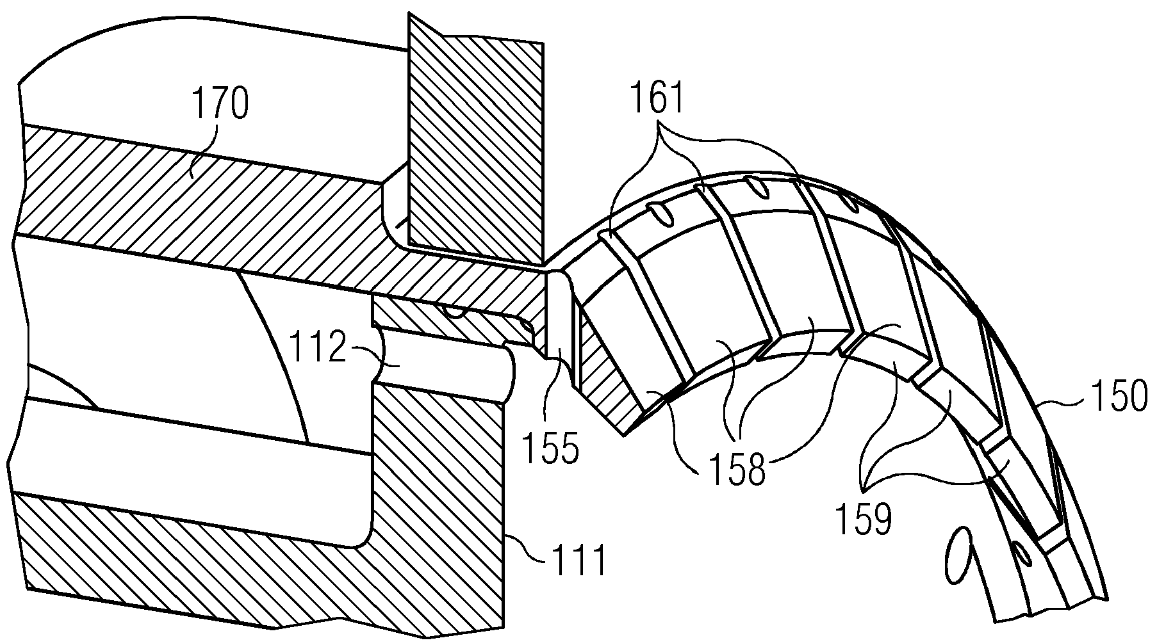


FIG 10



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EUROPEAN SEARCH REPORT

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

Place of search	Date of completion of the search	Examiner
Munich	9 June 2016	Theis, Gilbert

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