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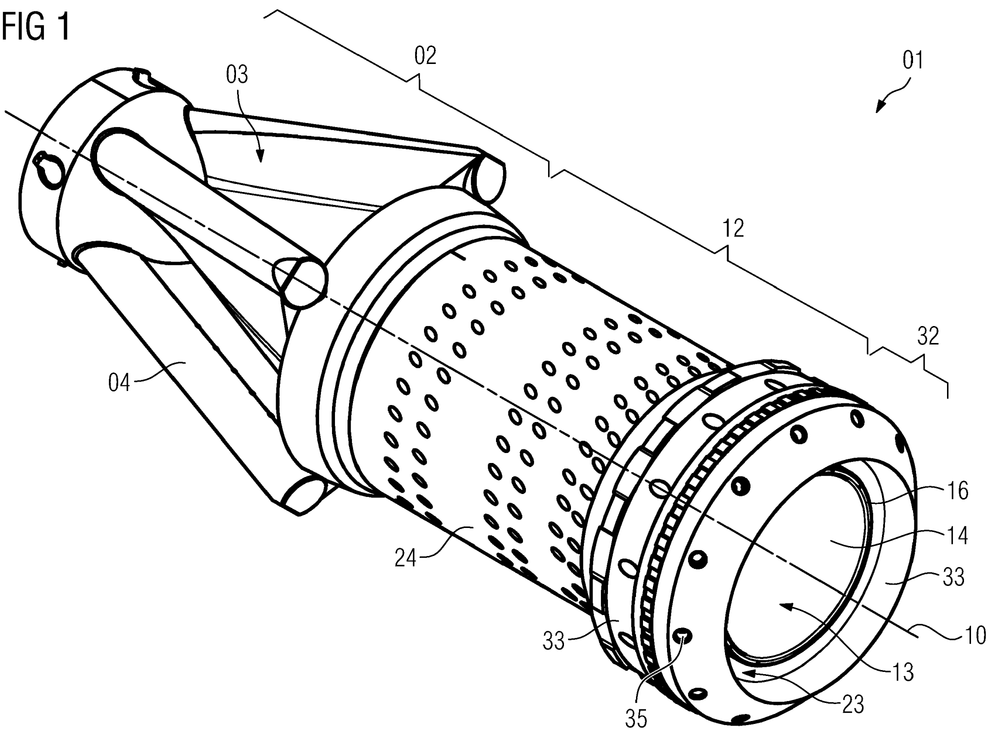
(54) **Burner with improved air-fuel mixing**

(57) Burner (01) for a combustor of a gas turbine, the burner (01) comprising in fluid flow sequence a swirler section (02) and a mixing section (12) and an outlet section (32) generally arranged around a burner axis (10). At the swirler section (02) air and fuel are introduced into the burner (01). The mixing section (12) is downstream of the swirler section (02) and comprises a tube (24) and defines a mixing volume (13) to mix the stream of air and fuel. The outlet section (32) comprises an annular bulge (34) and a burner outlet (33) therein to introduce the mixed stream of air and fuel into a combustion chamber. To enhance the mixing of air and fuel the mixing section (12) further comprises a sleeve (14) inside the tube (24) so that an annular channel (23) is defined between the sleeve (14) and the tube (24).

FIG 1



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Description

[0001] The invention relates to a burner of a gas turbine with a swirler section, where fuel and air are introduced into the burner, a mixing section, to enhance the mixing of fuel and air, and an outlet section, to bring the fuel-air-mixture into the combustion chamber.

[0002] In the state of the art there are several different burner types in use for gas turbines. A representative burner of that kind, which was the initiation for the invention, is described in the publication EP 2 815 184 B2. As any common burner, it extends along an axis and comprises in axial order the swirler section, a mixing section and an outlet section. The swirler section comprises a few swirler vanes to swirl a stream of fuel and air in an axial and circumferential direction into the burner interior. Therefore the swirler vanes comprise several fuel nozzles and are spaced apart from each other in circumferential direction to enable an air stream into the burner interior. The mixing section, downstream of the swirler section, comprises a mixing volume to enhance the mixing of fuel and air. At common burners of that kind the mixing section is realized by the usage of a tube. In connection with the mixing section is the outlet section which comprises the outlet of the burner to pass the fuel-air-mixture into the combustion chamber.

[0003] To achieve a high efficiency and the same time low emissions it is important to realize the best fuel-air-mixture. One possibility is the increase of length of the mixing section. But this bears the risk of a flashback from the combustion chamber into the mixing section. Other solutions increase the number of swirler vanes. But this slows down the flow speed, which is also a disadvantage.

[0004] Therefore the object of the invention is the enhancement of the fuel-air-mixture.

[0005] The task is solved by a burner according to the claim 1. The dependent claims respectively relate to preferred embodiments of the invention respectively inventive improvements.

[0006] The generic burner is determined for the usage at combustor of a gas turbine. Therefore the burner comprises in the fluid flow sequence a swirler section, a mixing section and an outlet section. Those three sections are generally arranged around a burner axis.

[0007] The swirler section comprises an air flow passage. Through the air flow passage a stream of air - oxygen containing fluid - can pass into the burner interior. To enable combustion in the combustor with the usage of the burner the necessary fuel is introduced at least partly into the swirler section, more precisely into the stream of air by the usage of a number of first fuel nozzles. Therefore the first fuel nozzles are located in the swirler section and are distributed around the air flow passage and/or within the air flow passage. The specific arrangement and the specific design of the first fuel nozzles are not relevant for the current invention and known solutions from the state of the art could be used.

[0008] The mixing section is arranged downstream of the swirler section and is realized first of all by the usage of a tube. The tube extends along the axis of the burner and has in general a constant inner and outer diameter. But the shape of the tube could also be different from that with a changing inner and outer diameter along the length of the tube and could have cutouts or additions. Relevant for the mixing section is the generation of a mixing volume, which is defined inside the tube of the mixing section. The mixing volume is downstream of the air fluid passage and conducts the stream of air and fuel from the air fluid passage through the mixing section. While the stream of air and fuel from the swirler section passes the mixing section the mixing of both fluids is enhanced.

[0009] The outlet section is downstream of the mixing section and comprises a burner outlet. The burner outlet builds the downstream end of the mixing volume and enables the discharge of the mixed stream of air and fuel from the mixing volume into a combustion zone downstream of the burner. To achieve a sufficient stability and to enable a fixation of the burner in the combustor the outlet section further comprises an annular bulge. The annular bulge is arranged at the downstream end of the tube and can therefore be realized by a thickening of the tube end.

[0010] According to the invention, to enhance the mixing of air and fuel for an optimized combustion, a sleeve supplements the mixing section. The sleeve is arranged radially inwardly of the tube. This arrangement establishes an annular channel between the tube and the sleeve. The arrangement of a sleeve inside of the tube further leads to the defining of the mixing volume inside the sleeve. In other words, the mixing section comprises two separated volumes inside and outside the sleeve, wherein one volume, the annular channel, substantially surrounds the other volume, the mixing volume.

[0011] The split of the generic mixing volume from the state of the art into a new mixing volume inside a sleeve and a further annular channel outside the sleeve gives the opportunity for a customized mixing of fuel and air further inside the mixing section and further outside the mixing section. As result the overall mixing of fuel and air for a best combustion with low emissions at high efficiency could be enhanced.

[0012] A further improvement could be achieved if the annular channel is closed at the upstream end. As result there is substantially no fluid connection between the air flow passage in the swirler section and the annular channel in the mixing section. In contrast the annular channel is open at the downstream end. As result the burner outlet connects the downstream end of both separated volumes, the mixing volume inside the sleeve and the annular channel outside the sleeve, so that one common stream of mixed air and fuel is discharged through the burner outlet of the outlet section.

[0013] To achieve the best joint mixing of fuel of air and fuel and the best distribution of air and fuel from the burner axis to the outside by the different streams of air and fuel on one hand through the mixing volume in the inside and on the other hand through the annular channel in the outside a preferred ratio of the cross-sectional area should be used.

[0014] First the annular channel needs a sufficient size to enable its positive effect on the mixing of air and fuel. In this case the annular channel should have preferably a cross-sectional area of at least 10% of the cross-sectional area defined by the mixing volume. Particular preferred the cross-sectional area defined by the annular channel is at least 20% of the cross-sectional area of the mixing volume.

[0015] On the other hand the annular channel should not be to oversized compared to the mixing volume, so that the stream of air and fluid from the air flow passage is not hindered by a to small size of the mixing volume. Therefore the cross-sectional area defined by the annular channel should not exceed 50% of the cross-sectional area of the mixing volume. Particular preferred the cross-sectional area of the annular channel should be not more than 40% of the cross-sectional area defined by the mixing volume.

[0016] At the swirler section air and fuel is introduced into the interior of the burner more precisely in the air flow passage. To archive an optimized mixing of air and fuel the swirler section comprises advantageous two or more swirler vanes, which are distributed in circumference. Those swirler vanes could be arranged at the beginning of the air flow passage and/or within the air flow passage. The swirler vanes are designed to increase a circumferential velocity component which leads to a better mixing of fuel and air especially in the downstream mixing section.

[0017] To enable the mixing of air and fuel, first fuel nozzles needs to be arranged at the swirler section, which are used to inject at least a portion of fuel in the swirler section. To archive an advantageous mixing the first fuel nozzles are distributed in the swirler section in axial direction and/or in circumferential direction. Thereby it is particularly advantageous if the first fuel nozzles are arranged within the swirler vanes. The first fuel nozzles could be used to introduce a first kind of fuel into the burner.

[0018] To archive a greater flexibility it is further possible to inject a further portion of the first kind of fuel and/or a different second kind of fuel directly into a combustion chamber downstream of the burner. Therefore the burner comprises preferably at the bulge at the downstream side of the burner a plurality of second fuel nozzles distributed around the circumference of the bulge. To archive an optimization of the combustion it is advantage to arrange the second fuel nozzles with an injection direction into the combustion chamber pointing at least radially outwardly.

[0019] A best mixture of air and fuel at the burner outlet could be archived if fuel is further introduced into the annular channel. Therefore it is an advantage if the tube and/or the bulge comprise a plurality of third fuel nozzles distributed at around its circumference. Accordingly the third fuel nozzles need to be angled at least radially inwardly. With the third fuel nozzles it is possible to introduce the first and/or the second kind of fuel. Dependent on the to be burned fuels also a different third kind of fuel could be introduced into the annular channel with the third fuel nozzles.

[0020] The length of the sleeve within the mixing section could be different. It is advantageous if the upstream side the sleeve starts at about the end of the swirler section. At the downstream side the sleeve with the open end of the annular channel the sleeve comprises a downstream end. Thereby the downstream end should preferably extend close to the burner outlet and therefore the downstream end is preferably located in the outlet section. The sleeve could extend exactly to the end of the burner or the downstream end has a certain distance to the burner outlet.

[0021] The burner with the inventive sleeve makes it possible to add further fourth fuel nozzles in the sleeve distributed around the circumference of the sleeve. The fourth fuel nozzles could be used to introduce fuel into the mixing volume and/or into the annular channel.

[0022] Preferably the fourth fuel nozzles are arranged at the downstream end of the sleeve and in particular angled about parallel to the burner axis (which includes an angle to the burner axis up to 15°) to introduce the fuel into the combustion chamber located the downstream of the burner.

[0023] It is obvious advantageous to introduce air into the annular channel, in particular at the upstream side of the annular channel. To carry out the task it is particular advantageous to arrange a plurality of air openings at the tube. Those air openings need to be distributed around the circumference of the tube. Thereby it is obvious that the air openings pass through the tube and connects the outside of the tube with the annular channel.

[0024] To increase the efficiency by the implementation of the sleeve and the annular channel it is further advantageous if the air openings are formed to guide air at least partially in circumference and axially into the annular channel.

[0025] To increase the stability of the burner with the sleeve it is further advantageous if the sleeve is in connection with the tube by the usage of several connectors. The connectors are at least firmly attached to the tube and to the sleeve. Thereby they are distributed at least in circumference. It is possible to use those connectors only at one axial position along the length of the mixing section, but it is also possible to arrange the connectors axially offset with each other at two or more times. In this case the sleeve could be made as one piece together with the tube. But it is also possible, for example, to weld the tube and/or the sleeve to the connectors.

[0026] To avoid thermal stress by the usage of connectors or to simplify the buildup of the mixing section preferably spacers are used to keep a certain distance between the tube and the sleeve. Therefore several spacers are distributed at least in circumference, whereby they are connected with the tube and are in contact with the sleeve.

[0027] As further modification of the mixing of air and fuel could be archived if further air could be guided from outside of the tube into the mixing volume. Therefore preferably air lines are used which pass through the tube and the connectors and/or the spacers and next through the sleeve.

[0028] To provide the advantage fourth fuel nozzles with fuel fuel lines at least partly inside the sleeve are necessary. In a first possible solution, the fuel lines extend through the complete length of the sleeve from the upstream end to the downstream end to fourth fuel nozzles, respectively.

[0029] With the usage of connectors and/or spacers preferably the fuel lines pass through the tube and the connectors and/or the spacers and then through the sleeve down to the fourth fuel nozzles. If the fuel lines cross the spacers it could be acceptable if a part of the fuel is lost in the contact of the spacer at the sleeve into the annular channel.

[0030] A further variation of the mixing in the mixing volume and in the annular channel could be reached by the implementation of several mixing openings arranged in the sleeve distributed in circumference. Obviously the mixing openings pass through the sleeve to connect the annular channel with the mixing volume. Here it is advantageous to form shape of the mixing volume so that air from the annular channel is guided into the mixing volume at least partially in circumference and axially. Another solution offers the guidance of air, more precisely a mixture of air and fuel, from the mixing volume into the annular channel by a shape of the mixing openings which guide the air at least partially in circumference and axially into the annular channel.

[0031] To increase the mixing of the stream of air and fuel from the mixing volume with the stream of air and/or fuel from the annular channel the shape of the downstream end of the sleeve can be varied. Thereby it is advantageous if the downstream end has a corrugated shape around the circumference. By the usage of this preferably solution the distance between the tube and the downstream end of the tube varies in a repeating manner. Starting from a in particular circular shape of the tube and the sleeve upstream of the downstream end with a medium distance the least distance between the sleeve and the tube should be lower than 0,5 times the medium distance by the uses of a corrugated shape. At the same time the most distance should be at least 1,5 times the medium distance. It is particular advantageous, if the least distance is less than 0,25 and/or the most distance is more than 2 times the medium distance between the sleeve and the tube.

[0032] The inventive burner enables the building of a new inventive combustor by the usage of a burner according the preceding description.

[0033] Obviously the advantage combustor comprises further a combustion chamber, wherein the burner is arranged upstream of the combustion chamber. Here it is particular advantageous to arrange the bulge of the burner in the head end of the combustion chamber.

[0034] If the burner comprises second fuel nozzles arranged in the bulge and/or fourth fuel nozzles arranged in the downstream end of the sleeve, the fuel nozzles are preferably designed to conduct the fuel into the combustion chamber.

[0035] In the following figures shows an example for an inventive burner and a modification of it, wherein

Fig. 1	shows a perspective view on the example of the burner;
Fig. 2	shows a longitudinal cross section through the burner;
Fig. 3 and 4	shows the downstream end of a modified burner.

[0036] In figure 1 an example for a burner 01 according the invention is shown in a perspective view. The burner 01 extends along a burner axis 10 and could be divided into three different parts. Thereby it noteworthy, that there is no strict separation between the three parts and it is not relevant to define a dividing plane along the burner axis 10. The first part at the upstream end is build by a swirler section 02. At the swirler section 02 air and fuel, more precisely a first kind of fuel, are introduced into the burner. Therefore the swirler section 02 comprises in this example 4 swirler vanes 04, which define an air flow passage 03. The air flow passage 03 starts at the free space between the swirler vanes 04, where air can pass freely the swirler vanes, and goes up to the downstream end of the swirler section 02.

[0037] A mixing section 12 builds the second part of the burner 01 and is arranged downstream of the swirler section 02. The swirler section 12 is build first of all by a tube 24, which is in this example cylindrical. The tube 24 surrounds a mixing volume 13 as a free space inside the mixing section, which follows directly the air flow passage 03 to guide the stream of air and fuel - while mixing them - to the downstream of the burner 01 located combustion chamber 09.

[0038] The mixing section 12 is followed by the outlet section 32. A bulge 34 is arranged at the outlet section 32, which 34 is an extension of the tube 24 just with an enlarged outer diameter. The mixing volume 13 goes downstream into the outlet section 32 up to a burner outlet 33. The burner outlet 33 is the interface to a combustion chamber 09 downstream of the burner 01, whereby the stream of air and fuel is emitted from the burner 01 into the combustion chamber 09.

[0039] The key feature for the invention is the integration of a sleeve 14 in the mixing section 12 to divide the free space inside the tube 24 into the mixing volume 13 located inside the sleeve 14 and an annular channel 23 defined by the tube 24 on the outer side and by the sleeve 14 on the inner side. In this example the sleeve 14 extend on the downstream side up to a free downstream end 16, which 16 is located in the outlet section 32 in axial direction close to the burner outlet 33.

[0040] The inventive solution by the integration of the sleeve 14 could best be seen in figure 2, which shows an longitudinal cross section through the example of the burner 01 as shown in fig. 1.

[0041] The shown solution of the burner 01 presents in the cross section different details (in particular the connection between the tube 24 and the sleeve 14) at the same time, which should not all be combined if the invention should be realized.

[0042] On the left hand side of the drawing there is the swirler section 02 with the swirler vanes 03 shown. Starting from the swirler vanes 04 the air flow passage 03 extends as free space up the downstream end of the swirler section. The swirler vanes 03 are formed to guide the stream of air and fuel, which flows first of all in an axial direction, partly in circumferential direction to enhance the mixing of air and fuel. Each of the swirler vanes 04 comprises several first fuel nozzles 05, which 05 are distributed further along the axial extent of the swirler vanes 04.

[0043] The swirler section 02 is followed downstream by the mixing section 12 with the tube 24. Downstream of the mixing section 12 the outlet section 32 with the annular bulge 34 is located and shown on the right hand side of the drawing. As obvious shown the bulge 24 comprises in this example the same inner diameter as the tube 24 but with an increased outer diameter compared to the tube 24. The function of the bulge 34 is to enable the mounting inside the combustor on the head end side of the combustion chamber 09. Next the bulge 34 comprises an annular fuel line 36 and in connection with the fuel line 36 several second fuel nozzles 35. Those second fuel nozzles 35 are arranged on the downstream end of the outlet section 32 and are formed to inject the fuel partly in axial direction and partly radially outwards into the combustion chamber 09.

[0044] Compared to common solutions of a burner the tube 24 comprises several air openings 27, which 27 break through the tube 24 and is distributed around the circumference of the tube 24. The air openings 27 are formed to guide the air from outside of the tube to the inside of the tube partially in axial direction and partly in circumferential direction. On the upper side of the drawing a few air openings 27 spaced apart from each other in axial direction are shown.

[0045] The inventive sleeve 14 is arranged inside the tube 24 and extends downstream into the bulge 34 close to the burner outlet 33. With the sleeve 14 the free space inside the tube 24 (and bulge 34) is divided into the mixing volume 13 defined by the sleeve 14 and the annular channel 23 defined between the tube 24 on the radial outer side and sleeve 14 on the radial inner side.

[0046] In this example the annular channel 23 is closed at the upstream side, so that there is in particular no fluid connection to the air flow passage 03. On the downstream side at the downstream end 16 of the sleeve 14 the annular channel 23 is open, so that both streams of air and fuel pass through the mixing volume 13 first and second through the annular channel 23 together the burner outlet 33.

[0047] The drawing shows further different solutions to connect the sleeve 14 with the tube 24. At the lower side of the drawing close to the upstream end of the mixing section 12 a connector 26a is used to solidly connect the sleeve 14 with the tube 24. This will increase the stability of the solution, but the thermal expansion needs to be considered. The solid connection could be realized by an integral forming of the mixing section 12 with the tube 24 and the sleeve 14 as one piece. It is also possible, for example, to weld the connector 26a at the tube 24 and/or at the sleeve 14.

[0048] A different kind of a connector 26b is shown at the end of the tube 24 on the lower side of the drawing. This connector 26b formed like a strap will increase the flexibility especially in radial direction, so that different thermal expansion in radial direction could not destroy the connection between the tube 24 and the sleeve 14.

[0049] On the other hand it is possible to use spacers 28, which 28 is shown on the upper side of the drawing. Those spacers could be solidly connected to the tube 24 but are only in contact to the sleeve 14. With this solution the concentricity of the sleeve 14 to the tube 24 could be ensured but compared to the connectors 26 thermal stress because of different thermal expansion is avoided.

[0050] As further detail the drawing shows different solutions to guide air from the outside of the burner 01 into the mixing section 12. As one solution downstream of the air openings 27 breaking though the tube 24 a plurality of mixing openings 17 could be arranged in the sleeve 14, whereby the mixing openings 17 are also distributed in circumferential direction. In accordance with the air openings 27 the mixing openings 17 could be arranged two or more times along the axis of the burner. In this example the mixing openings are formed to guide air from the annular channel 23 into the mixing volume 13 partly in axial direction and also partly in circumferential direction.

[0051] Even if not shown, it is also possible to use different mixing openings to guide air and fuel from the mixing volume 13 into the annular channel 23 again partly in axial direction and partly in circumferential direction.

[0052] For another solution to guide air into the mixing volume 13 within the connector 26a and the spacer 28 air lines 18 are used. The air lines 18 pass through the tube 24 and next though the connector 26a respectively through the spacer 28 and then through the sleeve 14.

[0053] To enable the possibility for an optimized combustion within the combustor and to enable the usage of a different kind of fuel the burner further comprises third fuel nozzles 15 and fourth fuel nozzles 25. The third fuel nozzles 15 are arranged at the downstream end 16 of the sleeve 14 pointing downstream parallel to the burner axis 10 into the combustion chamber 09. The fuel supply is realized by the integration of a branched fuel line partly through the tube 24, next to a connector 26b and partly through the sleeve 14. To induct fuel into the annular channel 23 several fourth fuel nozzles 25 are arranged into the bulge 34, which each point into the annular channel 23 partly in axial direction and partly in circumferential direction. The fuel nozzles 25 are in fluid connection with a further annular fuel line 37 inside the bulge 34.

[0054] To enhance the mixing it is possible to vary the design of the sleeve 64 as shown in the figures 3 and 4, with shows a further example of a burner 51 at the downstream side whereby other details than the modification have been omitted.

[0055] The sleeve 64 inside the tube 74 again divides the space into the mixing volume 63 and the annular channel 73. The difference to the solution shown in the fig. 1 is characterized by the shape of the free downstream end 66 of the sleeve 13. Instead of a simple cylindrical sleeve 13 the sleeve 64 in this example features a corrugated downstream end 66. As a result the distance between the downstream end 66 of the sleeve 64 and the annular bulge 84 varies between about 0,4 and about 2,0 of the medium distance between the sleeve 64 and the tube 74.

Claims

1. Burner (01, 51) for a combustor of a gas turbine, the burner (01, 51) comprising in fluid flow sequence a swirler section (02) and a mixing section (12, 62) and an outlet section (32, 82) generally arranged around a burner axis (10),

- the swirler section (02) comprises an air flow passage (03) and a plurality of first fuel nozzles (05) that are distributed around and/or within the air flow passage (03),
- the mixing section (12, 62) is downstream of the swirler section (02) and comprises a tube (24, 74) and defines a mixing volume (13, 63), the mixing volume (13, 63) is in fluid communication with the air flow passage (03),
- the outlet section (32, 82) is downstream of the mixing section (12, 62) and comprises an annular bulge (34, 84) at the downstream end of the tube (24, 74) and a burner outlet (33, 83) downstream of the mixing volume (13, 63),

characterized in that
the mixing section (12, 62) further comprises a sleeve (14, 64) located radially inwardly of the tube (24, 74) and an annular channel (23, 73) is defined between the sleeve (14, 64) and the tube (24, 74), wherein the mixing volume (13, 63) is defined radially inwardly of the sleeve (14, 64).

2. Burner (01, 51) according to claim 1,
wherein
the annular channel (23, 73) is closed at its upstream end and is open at its downstream end.

3. Burner (01, 51) according to claim 1 or 2,
wherein
the annular channel (23, 73) has a cross-sectional area of at least 10%, in particular at least 20%, and/or not more than 50%, in particular not more than 40%, of the cross-sectional area of the mixing volume (13, 63).

4. Burner (01) according to any of the claims 1 to 3,
wherein
the swirler section (02) comprises swirler vanes (04) at the beginning and/or within the air flow passage (03) to swirl air and/or fuel at least partially in circumferential direction, wherein in particular the first fuel nozzles (05) are arranged within the swirler vanes (04).

5. Burner (01) according to any of the claims 1 to 4,
wherein
the bulge (34) comprises a plurality of second fuel nozzles (35) distributed around its circumference and angled at least radially outwardly.

6. Burner (01, 51) according to any of the claims 1 to 5,
wherein
the tube (24) and/or the bulge (34) comprises a plurality of third fuel nozzles (25) distributed at around its circumference angled at least radially inwardly.

7. Burner (01, 51) according to any of the claims 1 to 6,
wherein
the sleeve (14, 64) comprises a downstream end (16, 66) located in the outlet section (32, 82).

8. Burner (01, 51) according to any of the claims 1 to 7,
wherein
the sleeve (14) comprises a plurality of fourth fuel nozzles (15) distributed around its circumference.

9. Burner (01, 51) according to claim 8,
wherein
the fourth fuel nozzles (15) are arranged at the downstream end (16), in particular angled about parallel to the burner axis (10).

10. Burner (01, 51) according to any of the claims 1 to 9,
wherein
the tube (24) comprises a plurality of air openings (27) distributed around its circumference, wherein in particular the air openings (27) are formed to guide air at least partially in circumference and axially into the annular channel (23).

11. Burner (01, 51) according to any of the claims 1 to 10, wherein several connectors (26) are distributed at least in circumference connecting the tube (24) with the sleeve (14); and/or wherein several spacers (28) are distributed at least in circumference connected with the tube (24) and are in contact with the sleeve (14).

12. Burner (01, 51) according to claim 11, wherein air lines (18) pass through the tube (24) and the connectors (26) and/or the spacers (28) and the sleeve (14) to guide air into the mixing volume (13); and/or wherein fuel lines pass through the tube (24) and the connectors (26) and/or the spacers (28) and the sleeve (14) to guide fuel to the fourth fuel nozzles (15).

13. Burner (01, 51) according to any of the claims 1 to 12, wherein the sleeve (14) comprises several mixing openings (17) distributed in circumference , wherein in particular the mixing openings (17) are formed to guide air at least partially in circumference and axially from the annular channel (23) into the mixing volume (13) and/or from the mixing volume (13) into the annular channel (23).

14. Burner (51) according to any of the claims 7 to 13, wherein the downstream end (66) has a corrugated shape around the circumference whereby the distance to the tube (74) respectively the bulge (84) varies repeating between lower than 0,5, in particular lower than 0,25, and higher than 1,5, in particular higher than 2,0, of the medium distance of the sleeve (64) to the tube (74).

15. Combustor for a gas turbine, **characterized by** the usage of at least one burner (01, 51) according to any of the proceeding claims.

16. Combustor to according claim 15, wherein the combustor comprises a combustion chamber, wherein the burner (01, 51) is arranged upstream of the combustion chamber, in particular the bulge (34, 84) is arranged in the head end of the combustion chamber (09).

17. Combustor according wherein the second fuel nozzles (35), and in particular the fourth fuel nozzles (15), pointing into the combustion chamber (09).

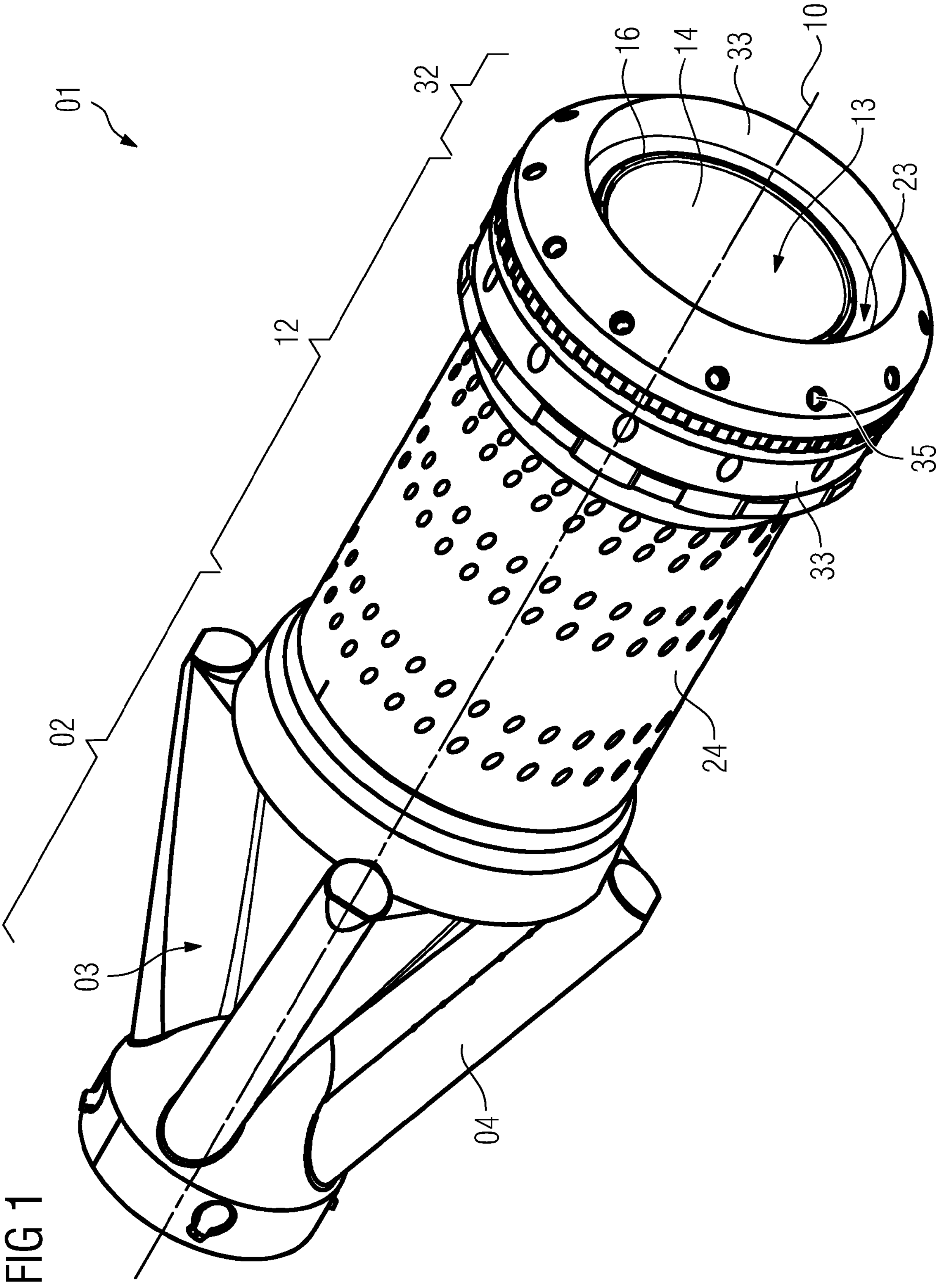

FIG 1

FIG 2

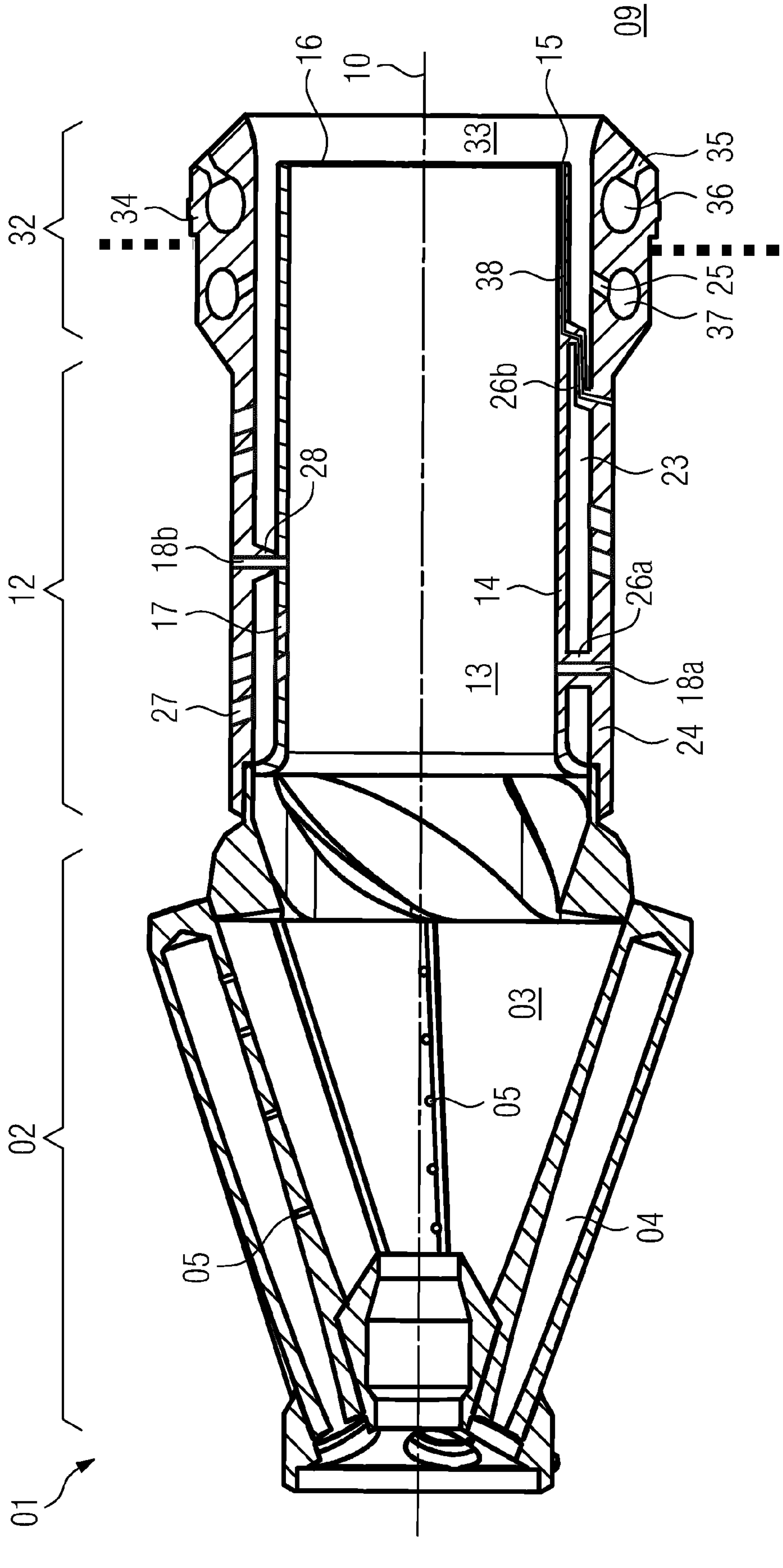
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FIG 3

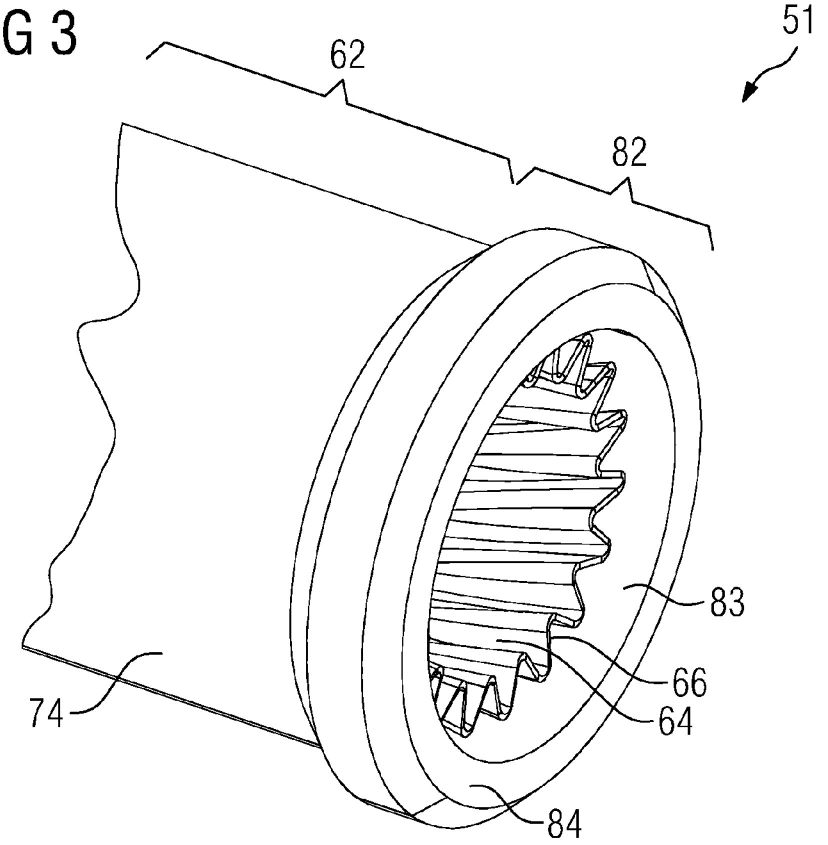
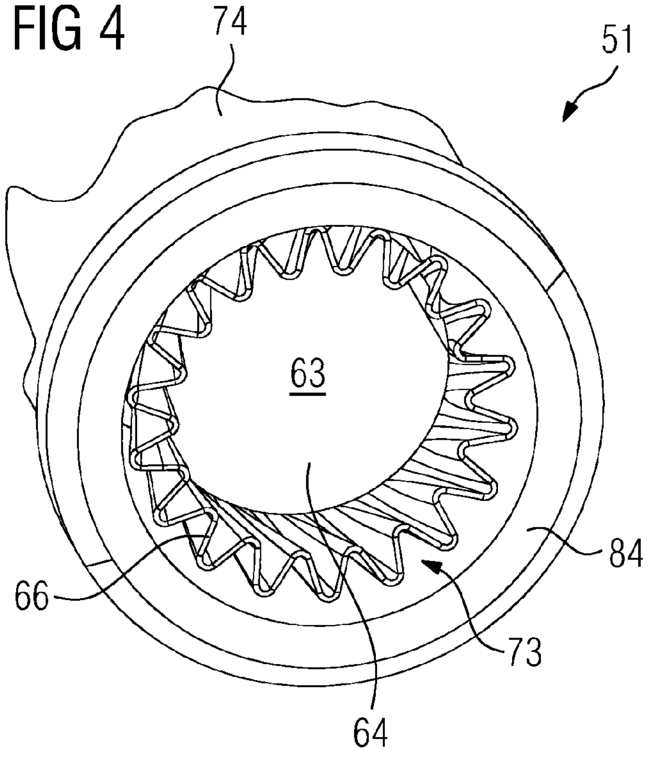


FIG 4



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EUROPEAN SEARCH REPORT

Application Number
EP 18 19 2157

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	EP 3 290 804 A1 (SIEMENS AG [DE]) 7 March 2018 (2018-03-07) * paragraph [0040] - paragraph [0043]; figure 1 * * paragraph [0057]; figure 8 * * paragraph [0053]; figure 6 * * paragraph [0058]; figure 8 * * paragraph [0052]; figure 5 * * paragraph [0062]; figure 8 * * paragraph [0047]; figure 1 * * paragraph [0002] * -----	1-13, 15-17 14	INV. F23R3/12 F23R3/28 F23C7/00
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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	8 October 2018	Mendão, João

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