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(54) **Combustor with annular bluff body**

(57) The present invention relates to a gas turbine combustor comprising: a flow sleeve (202); a combustion liner (204) located at least partially within the flow sleeve (202) thereby creating a main passage (206) between the flow sleeve (204) and the combustor liner (204); a dome (208) located forward of the flow sleeve and encompassing at least a part of the combustion liner (204), the dome (208) having a substantially rounded

head end (210) thereby forming a turning passage (212) between the liner (204) and the head end (210); and a swirler wall (214) aligned along a centerline (216) of the combustor (200), the swirler wall (214) projecting into the liner (204), characterized in that the swirler wall (214) and the rounded head end (210) are connected, wherein the connection forms an annular end face (218).

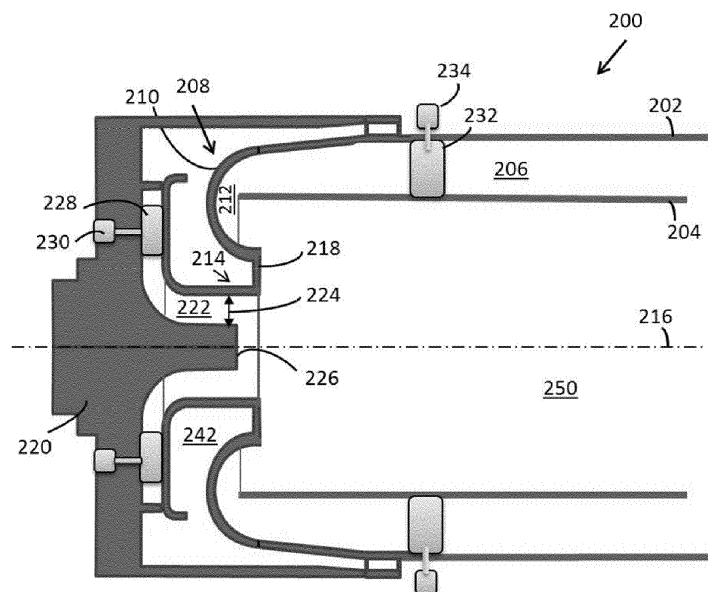


Fig.2a

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Description

TECHNICAL FIELD

[0001] The present invention relates generally to a system and method for improving combustion stability in a gas turbine combustor.

BACKGROUND

[0002] In an effort to reduce the amount of pollution emissions from gas-powered turbines, governmental agencies have enacted numerous regulations requiring reductions in the amount of oxides of nitrogen (NO_x) and carbon monoxide (CO). Lower combustion emissions can often be attributed to a more efficient combustion process, with specific regard to fuel injector location and mixing effectiveness.

[0003] Early combustion systems utilized diffusion type nozzles, where fuel is mixed with air external to the fuel nozzle by diffusion, proximate the flame zone. Diffusion type nozzles have been known to produce high emissions due to the fact that the fuel and air burn stoichiometrically at high temperature to maintain adequate combustor stability and low combustion dynamics.

[0004] An enhancement in combustion technology is the utilization of premixing, such that the fuel and air mix prior to combustion to form a homogeneous mixture that burns at a lower temperature than a diffusion type flame and produces lower NO_x emissions. Premixing fuel and air together before combustion allows for the fuel and air to form a more homogeneous mixture, which for a given combustor exit temperature will burn at lower peak temperatures, resulting in lower emissions. Example of such a gas turbine flamesheet combustion system with reduced emissions and improved flame stability at multiple load conditions is disclosed in US patent application US2004/0211186A1

[0005] While the combustors of the prior art have improved emissions levels and ability to operate at reduced load settings, thermoacoustics of the flamesheet combustors could still lead to instability modes (such as pulsation), which could restrict the operation window. Additionally, aerodynamics of the burner allows occasional flame attachment in the mixing zone under certain circumstances, causing flashback and overheating risk. Furthermore, current fuel staging strategies could cause asymmetrical heat load on the combustor liner, which could lead to creep problems.

[0006] In addition, measure which help against pulsation, as for example the staging of 1/3-2/3 groups in the main fuel supply can lead to asymmetrical liner heat loading, as well as to non-uniformities in the combustor exit temperature profile.

[0007] What is intended is a system that can provide further flame stability while also reducing thermoacoustic instabilities which can enlarge the operation window available of the current combustor designs. The embod-

iments described below are intended to widen the operation window beyond the currently available range, without sacrificing the low emission values.

5 SUMMARY OF THE INVENTION

[0008] It is one object of the present invention to provide a combustor with further improved stability and improved thermoacoustics characteristics.

10 **[0009]** The above and other objects of the invention are achieved by a gas turbine combustor comprising a flow sleeve, a combustion liner located at least partially within the flow sleeve thereby creating a main passage between the flow sleeve and the combustor liner, and a dome located forward of the flow sleeve and encompassing at least a part of the combustion liner, the dome having a substantially rounded head end thereby forming a turning passage between the liner and the head end, and a swirler wall aligned along a centerline of the combustor, the swirler wall projecting into a space delimited by the liner, wherein the swirler wall and the rounded head end are connected, and wherein the connection forms an annular end face.

15 **[0010]** According to one embodiment of the present invention, the combustor further comprises a center body positioned along the centerline and extending into the space delimited by the swirler wall, thereby forming a pilot passage between the swirler wall and the center body.

20 **[0011]** According to yet another embodiment of the present invention, width of the pilot channel is substantially constant along the length of the pilot channel.

25 **[0012]** According to another embodiment of the present invention, an area of the annular end face is 1.5 times to 5 times larger than an area of a cross section of the pilot passage.

30 **[0013]** According to yet another embodiment of the present invention, a fuel lance is arranged in the center body.

35 **[0014]** According to another embodiment of the present invention, the combustor further comprises a substantially cylindrical extension extending from a radially inner end of the rounded head end or the end face into the liner, wherein the extension is aligned with the centerline of the combustor. According to yet another embodiment of the present invention, the extension has substantially constant radius along the centerline of the liner, and/or the thickness of the extension is substantially equal to the thickness of the rounded head end.

40 **[0015]** According to another embodiment of the present invention, a recess delimited by the central body, the annular end face and the rounded head end comprises a Helmholtz damper or/and means for pilot oil injection.

45 **[0016]** According to yet another embodiment of the present invention, the combustion liner comprises a ring shaped rounded lip section and a curved middle section adapted to create a flame stabilization zone during op-

eration. According to another embodiment of the present invention the lip section comprises a Helmholtz damper and/or liquid fuel injection means.

[0017] According to another embodiment of the present invention, the pilot passage comprises a pilot swirler in fluid communication with at least one pilot fuel injector, and the pilot swirler is an axial swirler or a radial swirler. According to another embodiment of the present invention, the main passage or the turning passage comprises a main swirler in a fluid communication with at least one main fuel injector, and wherein the main swirler is an axial swirler or a radial swirler.

[0018] According to another embodiment of the present invention, the swirler wall is a part of a conical burner (e.g. EV burner or AEV burner).

[0019] The present application also provides for a gas turbine comprising the combustor described above.

[0020] In addition, the present application also provides for a method for operating the gas turbine combustor. The method comprising: supplying a first stream of fuel into the pilot channel or conical burner (e.g. EV burner or AEV burner) to mix with the first flow of air, and feeding the resulting first mixture into the combustion zone for providing pilot flame; supplying a second flow of air into the main passage; supplying a second stream of fuel into the main passage or turning passage to mix with the second flow of air, and feeding the resulting second mixture into the combustion zone for providing a main flame.

[0021] Additional advantages and features of the present invention will be set forth in part in a description which follows, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned from practice of the invention. The instant invention will now be described with particular reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0022] Preferred embodiments of the invention are described in the following with reference to the drawings, which are for the purpose of illustrating the present preferred embodiments of the invention and not for the purpose of limiting the same. In the drawings,

Figure 1 shows a cross section view of a gas turbine combustion system of the prior art.

Figure 2a shows a cross section view of a gas turbine combustor in accordance with an embodiment of the present invention.

Figure 2b shows an end view of a gas turbine combustor in accordance with an embodiment of the present invention.

Figure 2c shows a cross section view of a gas turbine combustor in accordance with an embodiment of the present invention schematically indicating flame fronts during operation.

Figure 3a shows a cross section view of a gas turbine

combustor in accordance with an embodiment of the present invention.

Figure 3b shows an end view of a gas turbine combustor in accordance with an embodiment of the present invention.

Figure 4a shows a cross section view of a gas turbine combustor in accordance with an embodiment of the present invention.

Figure 4b shows a cross section view of a gas turbine combustor in accordance with an embodiment of the present invention.

Figure 5 shows a cross section view of a gas turbine combustor in accordance with an embodiment of the present invention schematically indicating recirculation zones used for further flame stabilization.

Figures 6a, 6b, 6c show a cross section view of a part of a gas turbine combustor in accordance with embodiments of the present invention.

Figure 7a shows cross section view of a part of a gas turbine combustor comprising EV burner in accordance with embodiments of the present invention.

Figure 7b shows cross section view of a part of a gas turbine combustor comprising AEV burner in accordance with embodiments of the present invention.

Figure 8a shows a perspective view of a part of EV burner

Figure 8b shows a cross section view of a part of AEV burner.

DETAILED DESCRIPTION OF THE DRAWINGS

[0023] An example of a premixing flamesheet combustor 100 for a gas turbine of the prior art is shown in Fig. 1. The combustor 100 is a type of reverse flow premixing combustor utilizing a pilot nozzle 102, a radial inflow mixer 104, and a plurality of main stage mixers 108. The pilot portion of the combustor 100 is separated from the main stage combustion area by a center divider portion 110. The center divider portion 110 separates the fuel injected by the pilot nozzle 102 from the fuel injected by the main stage mixers 108. Correspondingly the air entering through the main and the pilot burner is separated by the divider 110. A flame front 120, which might occur for an off-design case, is shown schematically indicating interaction of pilot and main flame, which might cause thermoacoustic instabilities.

[0024] Fig. 2a shows a cross section view of a gas turbine combustor 200 in accordance with an embodiment of the present invention. The combustor 200 comprising a flow sleeve 202, a combustion liner 204 located at least partially within the flow sleeve 202 thereby creating a main passage 206 between the flow sleeve 204 and the combustor liner 204. The combustor 200 also comprises a dome 208 located forward of the flow sleeve and encompassing at least a part of the combustion liner 204. The dome 208 has a substantially rounded head

end 210 thereby forming a turning passage 212 between the liner 204 and the head end 210. The combustor 200 comprises also a swirler wall 214 aligned along a centerline 216 of the combustor 200, wherein the swirler wall 214 is projecting into the liner 204. The swirler wall 214 and the rounded head end 210 are connected, wherein the connection forms an annular end face 218. The structure and thickness of the end face 218 can vary, and in one embodiment the end face 218 is a thin plate, for example a sheet metal plate. In one embodiment the end face 218 has a flat surface substantially perpendicular to the centerline 216. In one embodiment of the present invention, the end face 218 is cooled via effusion and/or impingement cooling.

[0025] In one embodiment according to the invention, the combustor 200 further comprises a center body 220 positioned along the centerline 216 and extending into the space delimited by the swirler wall 214. The swirler wall 214 and the center body 220 form a pilot passage 222. The center body comprises a front surface 226 which can have different shapes, depending on the combustor design, such as bluff body shape. The width of the pilot channel 222 can vary, and preferably is substantially constant along the length of the pilot channel 222. The center body 220 could also comprise a fuel lance 608 (shown in Fig 6b) to create a central pilot flame.

[0026] Fig. 2b shows an end view of a gas turbine combustor in accordance with an embodiment of the present invention. The cross sections of different components are shown as a generally cylindrical, but they can have other shapes such as oval or elongated. An area of the annular end face 218 can vary in respect of the size of the other components of the combustor 200. In one preferred and non-limiting example, the area of the annular end face 218 is 1.5 times to 5 times larger than an area of a cross section of the pilot passage 222.

[0027] The combustor 200 according to the invention in one embodiment can comprise main fuel supply 234, pilot fuel supply 230, main swirler with injectors 232 and pilot swirler with injectors 228 to create a pilot flame and a main flame during an operation of the combustor. Figure 2c shows schematically flame fronts, inside a combustion zone 250, created during operation of the combustor 200 according to the present invention. Contrary to the prior art (Fig. 1) where the pilot flame and the main flame interacts, in the embodiment according to the invention a main flame 260 and a pilot flame 262 are clearly separated due to the advantageous design of the combustor 200 according to the invention.

[0028] Fig. 3a shows a cross section view of a gas turbine combustor 200 in accordance with another embodiment of the present invention which further comprises a substantially cylindrical extension 240 extending from a radially inner end of the rounded head end 210 into the liner 220. In an alternative embodiment, the extension 240 is extending from the end face 218. The extension is substantially aligned with the centerline 216 of the combustor 200. The extension 240 can vary in size,

length, radius and width depending on operating parameters of the combustor 200. In one embodiment, the extension 240 is cylindrical and it has substantially constant radius along the centerline 216 of the liner. In one embodiment according to the invention the extension 240 and head end 210 have substantially same thickness. The extension 240 and head end 210 could be made as two separate pieces or they can be made of a single piece of material. In one embodiment, the extension 240 and head end 210 are made of a sheet metal. The cooling of the extension 240 may be done by near wall cooling using channels in axial direction.

[0029] Fig. 3b shows an end view of a gas turbine combustor in accordance with an embodiment of the present invention shown in Fig 3a. In one embodiment, an average thickness of extension 240 is smaller than average thickness of a cross section of the end face 218.

[0030] Fig. 4a shows a cross section view of a gas turbine combustor 200 in accordance with yet another embodiment according to the present invention wherein the combustion liner 204 comprises a ring shaped rounded lip section 420 and a curved middle section 430. The liner 204 according to this embodiment could also comprise cooling holes 440. In this embodiment, the rounded lip section 420 is substantially hollow. Fig. 4b shows an alternative embodiment, wherein the rounded lip section is made of thin material, substantially of the same thickness as the main portion of the liner 204, for example of a sheet metal. In this way, reducing the thickness of the rounded lip 420, there is advantageously more room for a stabilization zone.

[0031] The embodiment comprising the ring shaped rounded lip section 420 and the curved middle section 430 is adapted to create an additional outer main flame stabilization zone 510 during operation as shown in Fig 5. Fig. 5 also shows a central pilot stabilization zone 530 and an outer pilot stabilization zone 520 created during operation of combustor 200 according to the invention. The extension 420 advantageously makes possible effective separation of two pilot stabilization zones 520 and 530.

[0032] Figures 6a, 6b and 6c show additional embodiments of the present invention. The lip section of the liner could comprise a Helmholtz damper 612 and/or liquid fuel injection means 606. A recess 242 delimited by the central body 214, the annular end face 218 and the rounded head end 210 could comprises a Helmholtz damper 610 or/and a means for pilot oil injection 604. In general, Helmholtz damper is designed according to an individually determined or predetermined damping requirement against the thermoacoustic oscillation frequencies occurring in the combustion chamber. The Helmholtz damper comprises a damper volume, a neck and a cooling channel. The pilot swirlers (228, 618) and the main swirlers (232, 620) in general could be axial or radial swirlers. In addition, the combustor 200 may comprise additional Helmholtz damper 602 and the fuel lance 608, both inside the center body 220, as shown in Fig.

6a and Fig. 6b.

[0033] The combustor 200 according to the invention could comprise a conical burner 702,704 device instead of the center body 220. Examples of these embodiments are shown in Fig. 7a and 7b, including EV burner (environmental burner from Alstom, disclosed in EP0321809) and AEV burner (advanced environmental burner from Alstom, disclosed in EP0704657) respectively. In these embodiments, the swirler wall 214 is a part of the conical burner 702,704.

[0034] Fig. 8a shows part of EV burner 702 wherein a conical column 5 of liquid fuel is formed in the interior 14 of the burner 702, which column widens in the direction of flow and is surrounded by a rotating stream 15 of combustion air which flows tangentially into the burner. Ignition of the mixture takes place at the burner outlet, a backflow zone 6 forming in the region of the burner outlet. The burner itself consists of at least two hollow part-cone bodies 1, 2 which are superposed on one another and have a cone angle increasing in the direction of flow. The part-cone bodies 1, 2 are mutually offset. A nozzle 3 placed at the burner head ensures injection of the liquid fuel 2 into the interior 14 of the burner. In one embodiment of the present invention, in the combustor 200 according to the invention, part cone body 1 of EV burner 702 corresponds to the swirler wall 212.

[0035] Fig. 8b shows part of AEV burner 704 comprising of at least part of the EV burner 702 and a mixing tube 802. The mixing tube comprises a tube 804. In one embodiment of the present invention, in the combustor 200 according to the invention, the tube 804 of AEV burner 704 corresponds to the swirler wall 212.

[0036] It should be apparent that the foregoing relates only to the preferred embodiments of the present application and that numerous changes and modifications may be made herein by one of ordinary skill in the art without departing from the general spirit and scope of the invention as defined by the following claims.

List of designations

[0037]

1,2 Part cone bodies
3 Nozzle
5 Conical column
6 Backflow zone
14 Interior of a burner
15 Rotating stream
100 Combustor
102 Pilot nozzle
104 Radial inflow mixer
108 Main stage mixer
110 Divider
120 Flame front
200 Combustor
202 Flow sleeve
204 Combustion liner

206 Main passage
208 Dome
210 Head end
212 Turning passage
5 214 Swirler wall
216 Combustor centerline
218 End face
220 Center body
222 Pilot passage
10 226 Center body front surface
228 Pilot swirler with injectors
230 Pilot fuel supply
232 Main swirler with injectors
234 Main fuel supply
15 240 Extension
242 Recess
250 Combustion zone
260 Main flame
262 Pilot flame
20 420 Lip section
430 Curved middle section
440 Cooling holes
510 Main flame stabilization zone
520 Outer pilot stabilization zone
25 530 Central pilot stabilization zone
602 Helmholtz damper
604 Pilot oil injection
606 Oil injection
608 Fuel lance
30 610 Helmholtz damper
612 Helmholtz damper
614 Fuel injector
618 Pilot swirler
620 Main swirler
35 622 Fuel injector
702 EV burner
704 AEV burner
802 Mixing section
804 Tube

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Claims

1. A gas turbine combustor (200) comprising:

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a flow sleeve (202);
a combustion liner (204) located at least partially within the flow sleeve(202) thereby creating a main passage(206) between the flow sleeve (204) and the combustor liner (204);
50 a dome (208) located forward of the flow sleeve and encompassing at least a part of the combustion liner (204), the dome (208) having a substantially rounded head end (210) thereby forming a turning passage (212) between the liner (204) and the head end (210); and
55 a swirler wall (214) aligned along a centerline (216) of the combustor (200), the swirler

- wall(214) projecting into a space delimited by the liner (204), **characterized in that** the swirler wall (214) and the rounded head end (210) are connected, wherein the connection forms an annular end face (218).
2. The combustor (200) of claim 1 further comprising a center body (220) positioned along the centerline (216) and extending into the space delimited by the swirler wall (214), thereby forming a pilot passage (222) between the swirler wall (214) and the center body (220).
 3. The combustor (200) of claim 1 or 2 wherein a width (224) of the pilot channel (222) is substantially constant along the length of the pilot channel (222).
 4. The combustor (200) of any of the preceding claims, wherein an area of the annular end face (218) is 1.5 times to 5 times larger than an area of a cross section of the pilot passage (222).
 5. The combustor (200) of any of the preceding claims, wherein a fuel lance (608) is arranged in the center body (220).
 6. The combustor (200) of any of the preceding claims further comprising a substantially cylindrical extension (240) extending from a radially inner end of the rounded head end (210) or the end face (218) into the liner (220), wherein the extension is aligned with the centerline (216) of the combustor (200).
 7. The combustor (200) of claim 8, wherein the extension (240) has substantially constant radius along the centerline (216) of the liner, and/or wherein the thickness of the extension (240) is substantially equal to the thickness of the rounded head end (210).
 8. The combustor (200) of any of the preceding claims, wherein a recess (242) delimited by the central body (214), the annular end face (218) and the rounded head end (210) comprises a Helmholtz damper (610) or/and a means for pilot oil injection (604).
 9. The combustor (200) of any of the preceding claims, wherein the combustion liner (204) comprises a ring shaped rounded lip section (420) and a curved middle section (430) adapted to create a flame stabilization zone (510) during operation.
 10. The combustor (200) of claims 8 or 9, wherein the lip section (420) comprises a Helmholtz damper (612) and/or liquid fuel injection means (606).
 11. The combustor (200) of any of the preceding claims, wherein the pilot passage (222) comprises a pilot swirler (228, 618) in fluid communication with at least one pilot fuel injector (230, 614), and wherein the pilot swirler is an axial swirler or a radial swirler.
 12. The combustor (200) of any of the preceding claims, wherein the main passage (206) or the turning passage (212) comprises a main swirler (232,620) in a fluid communication with at least one main fuel injector (234,622), and wherein the main swirler (232,620) is an axial swirler or a radial swirler.
 13. The combustor (200) of claim 1, wherein the swirler wall (214) is a part of a conical burner (702,704).
 14. A gas turbine comprising the combustor (200) according to any of the preceding claims.
 15. A method for operating the gas turbine combustor (200) according to any of the preceding claims, the method comprising: supplying a first stream of fuel into the pilot channel (222) or the conical burner (702,704), and feeding the resulting first mixture into the combustion zone (250) for providing pilot flame; supplying a second flow of air into the main passage (206); supplying a second stream of fuel into the main passage (206) or turning passage (222) to mix with the second flow of air, and feeding the resulting second mixture into the combustion zone (250) for providing a main flame.

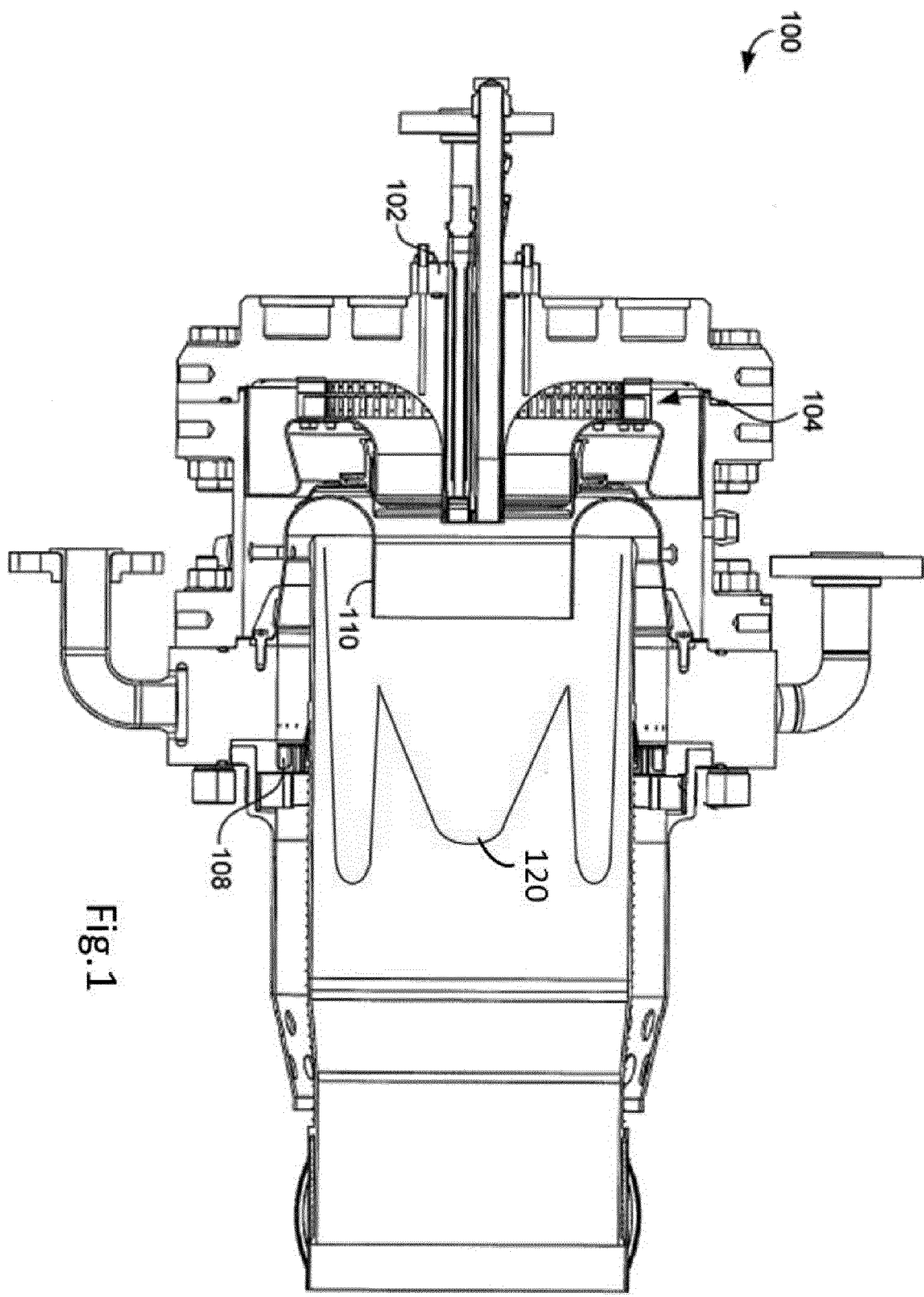


Fig. 1

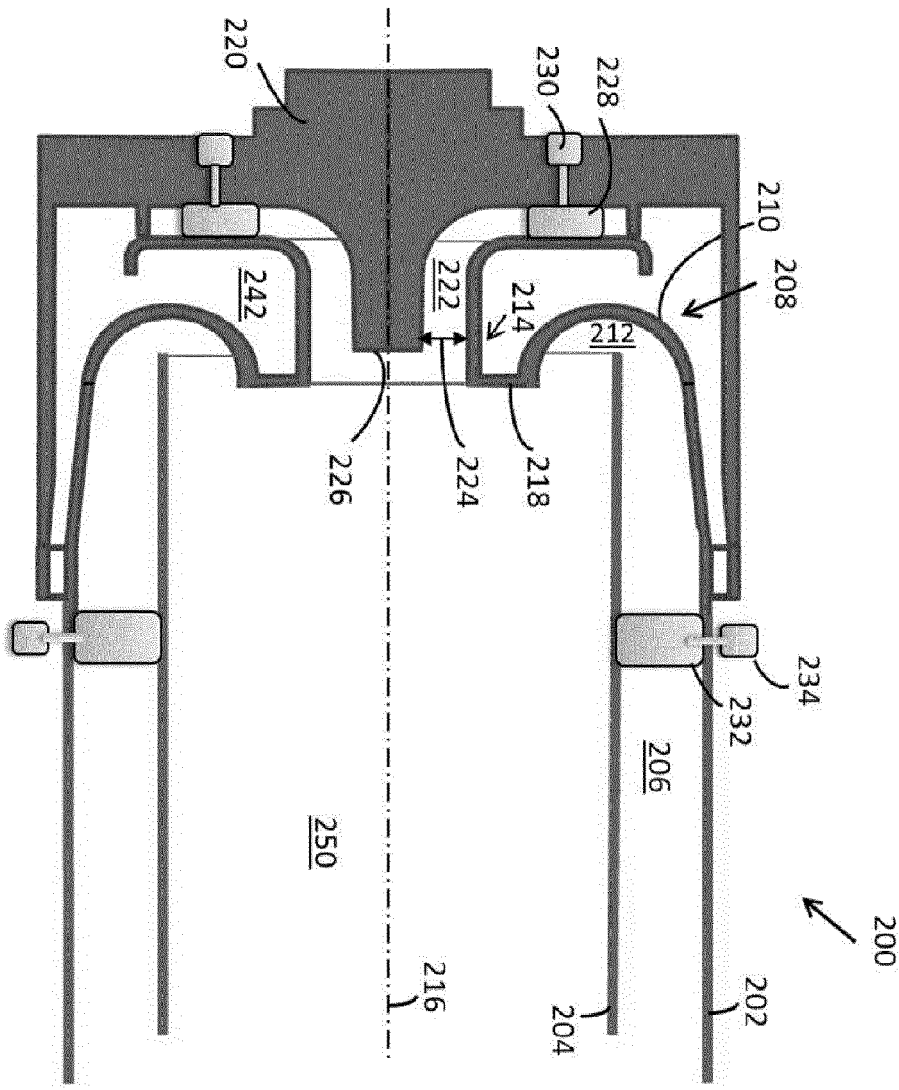


Fig. 2a

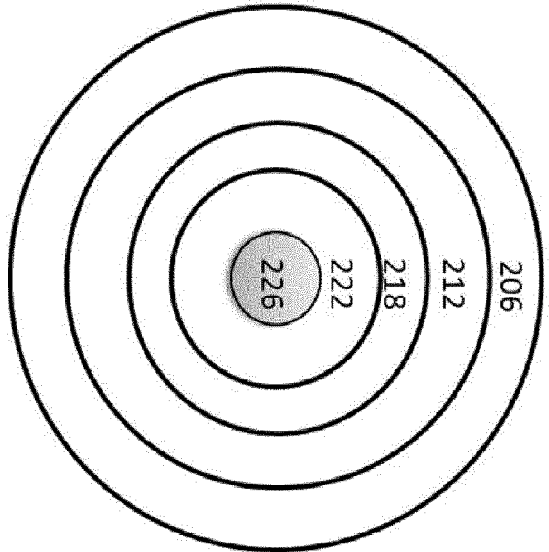


Fig. 2b

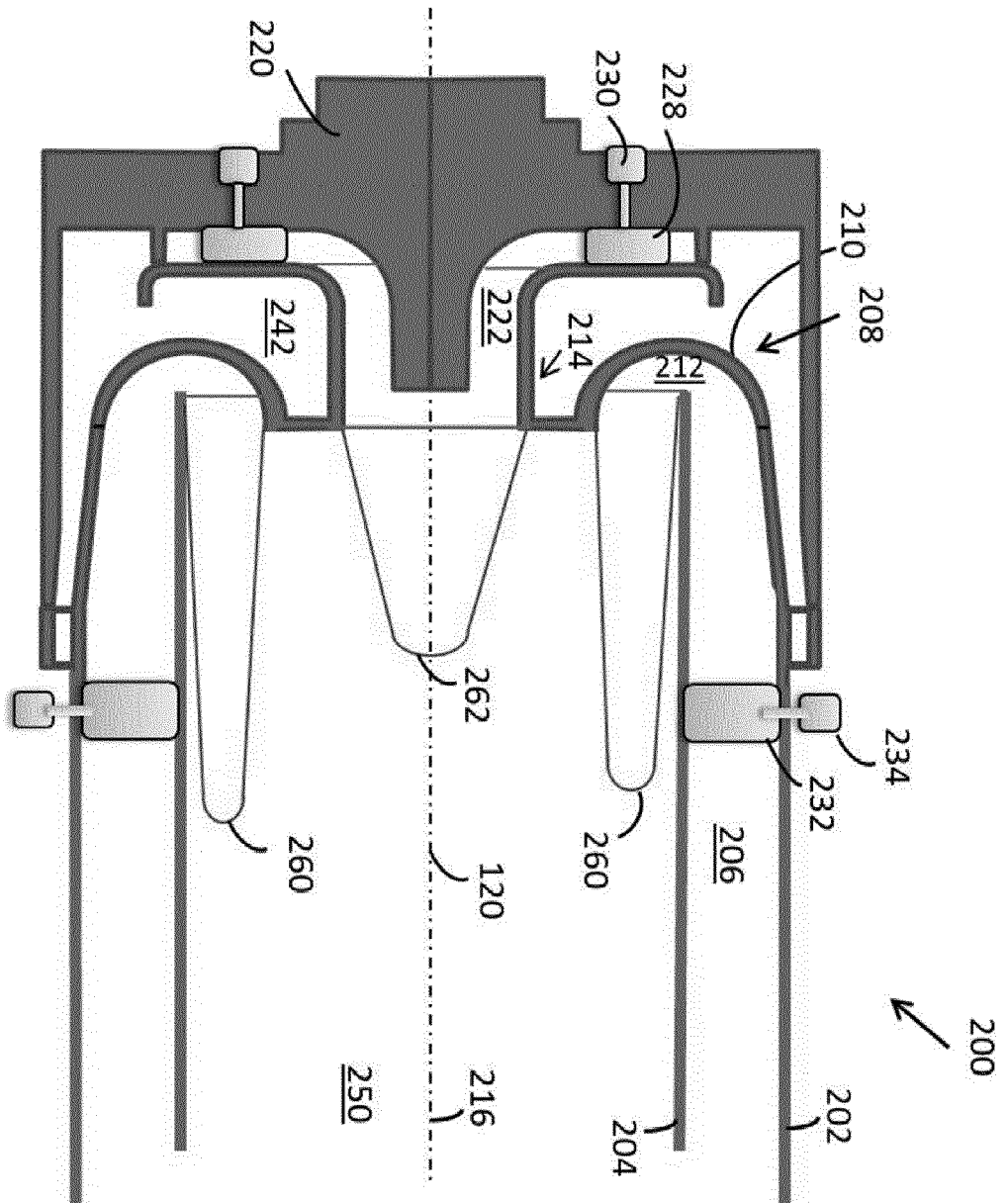


Fig. 2c

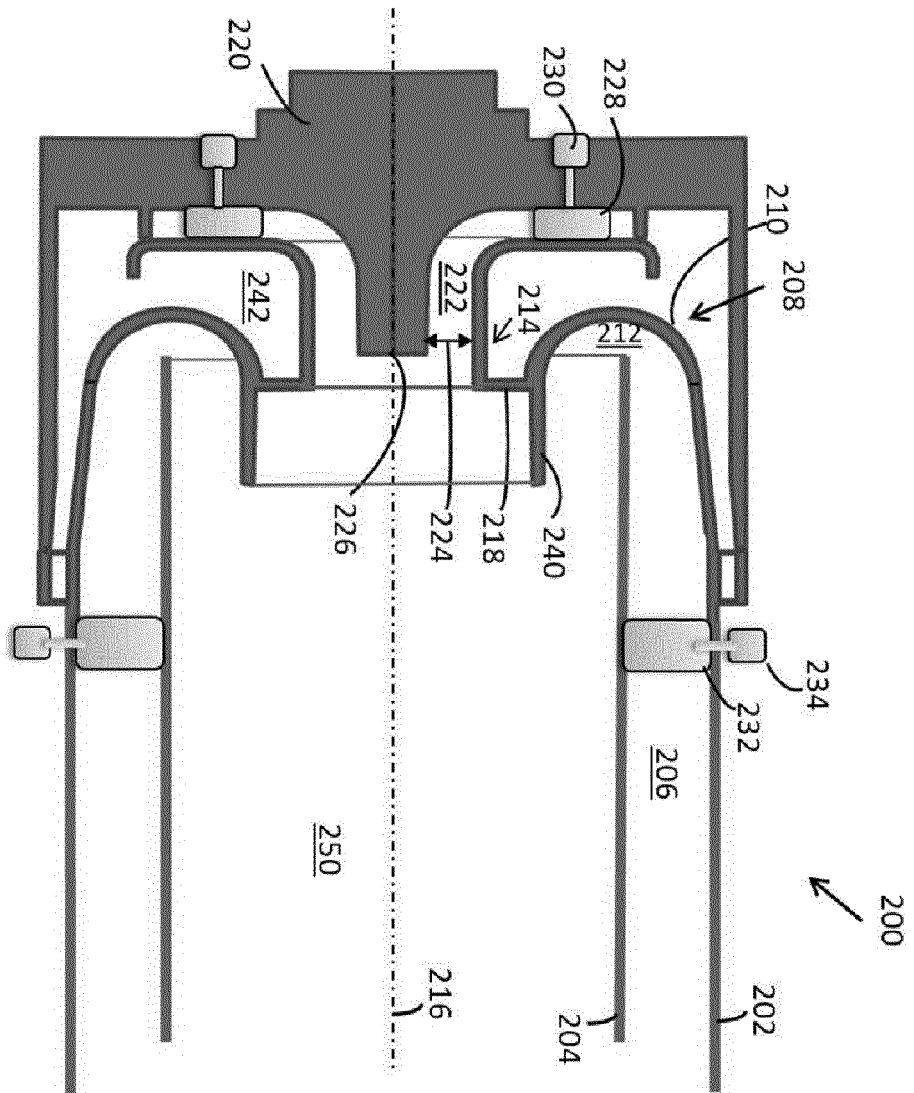


Fig. 3a

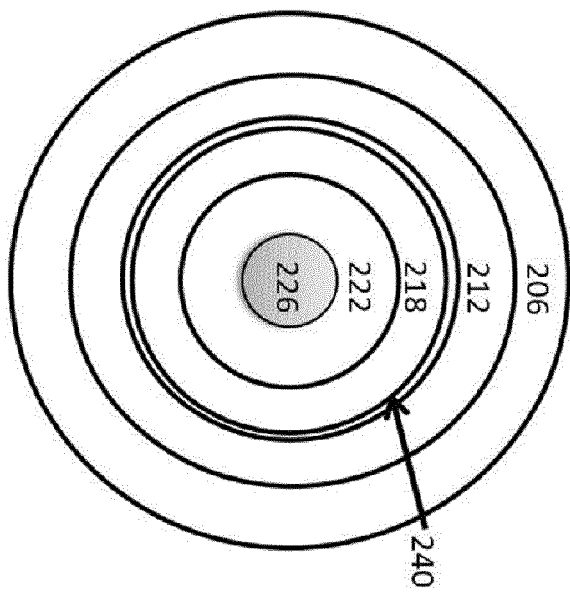


Fig. 3b

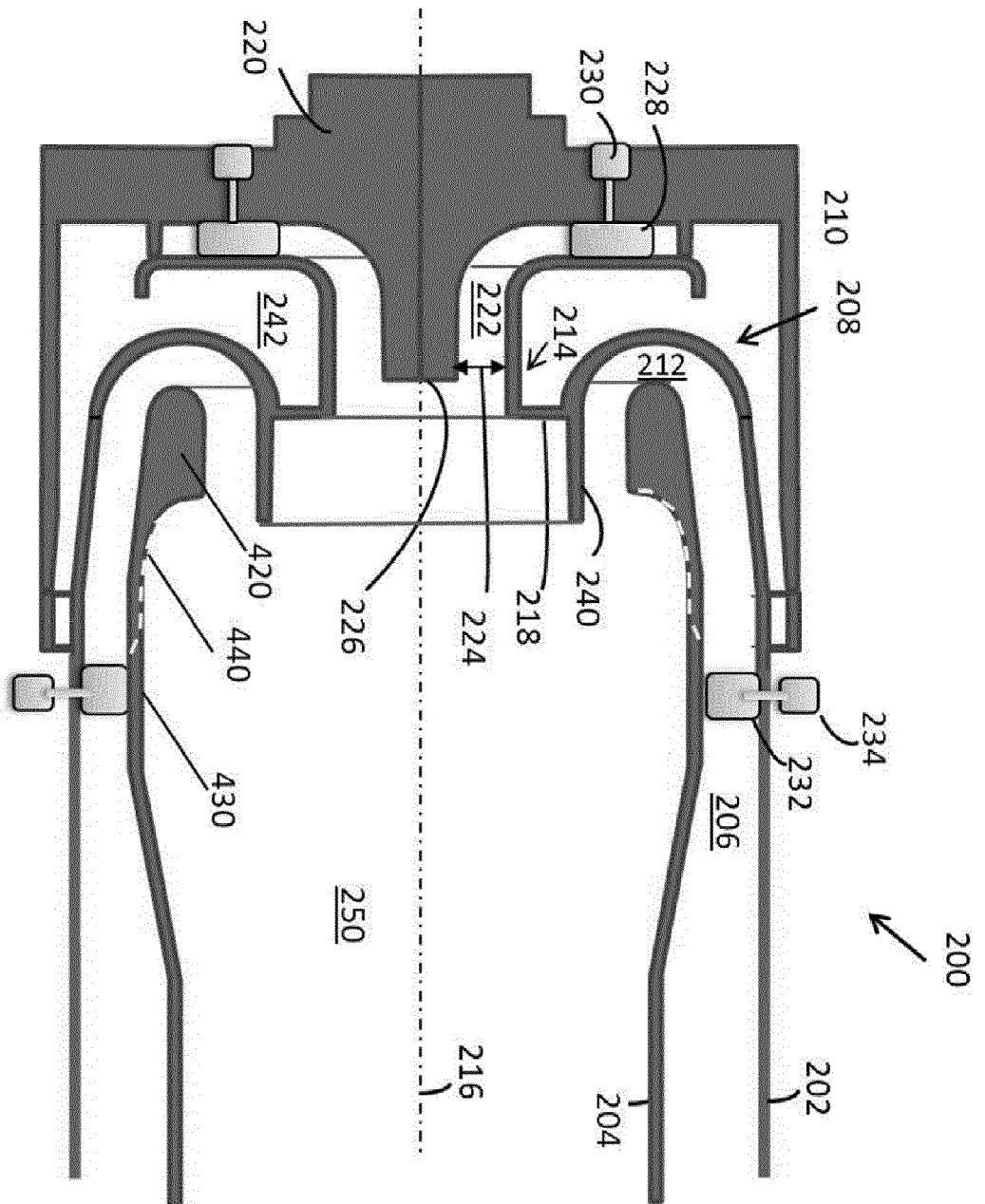


Fig. 4a

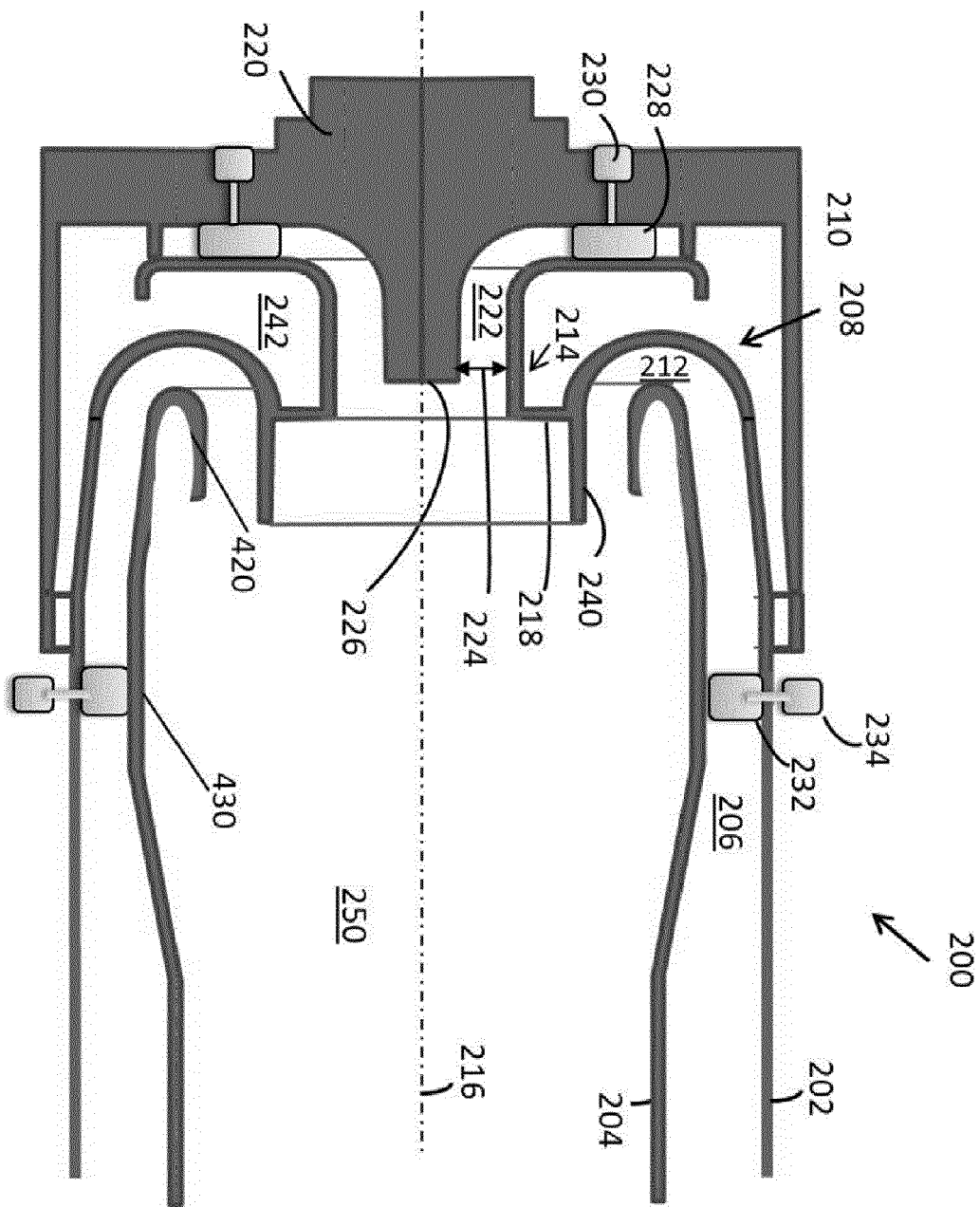


Fig.4b

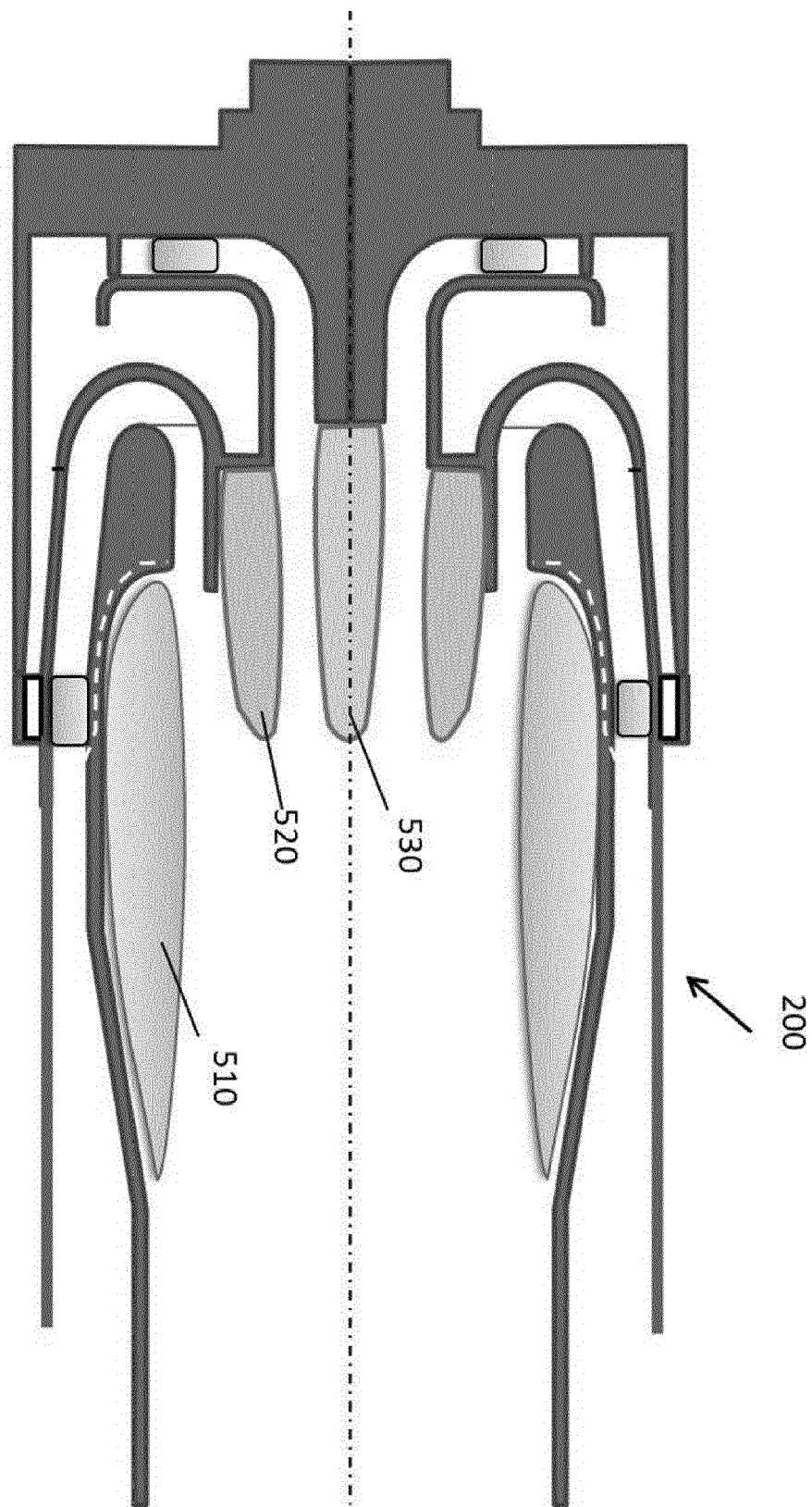


Fig.5

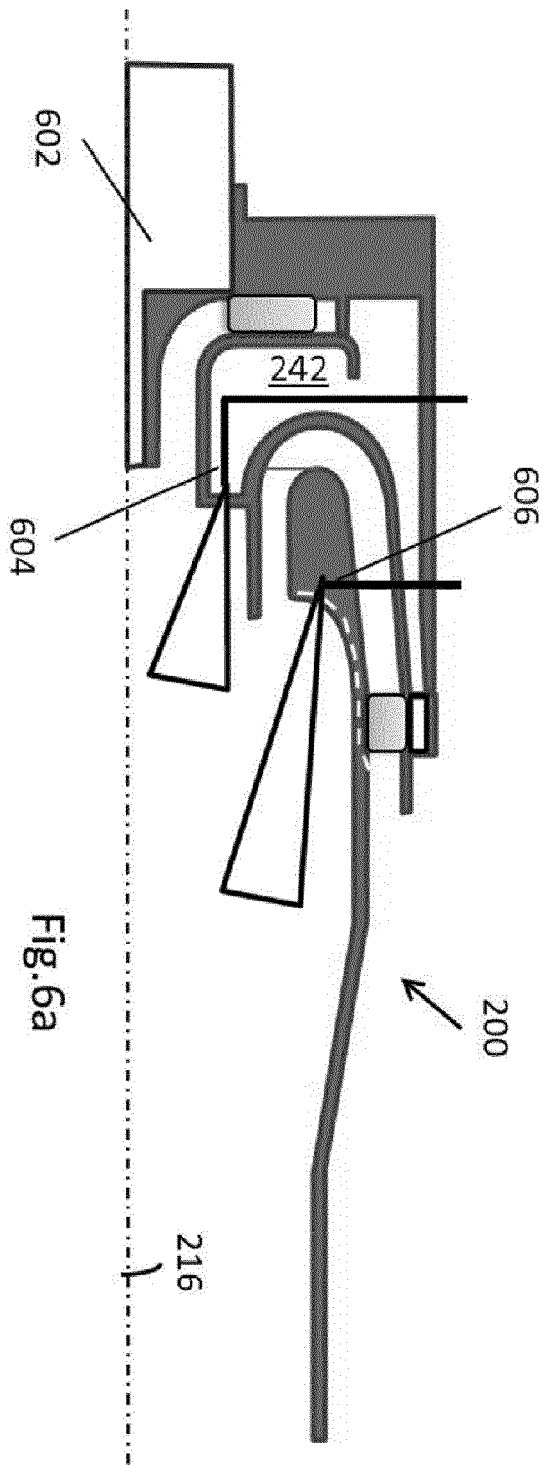


Fig. 6a

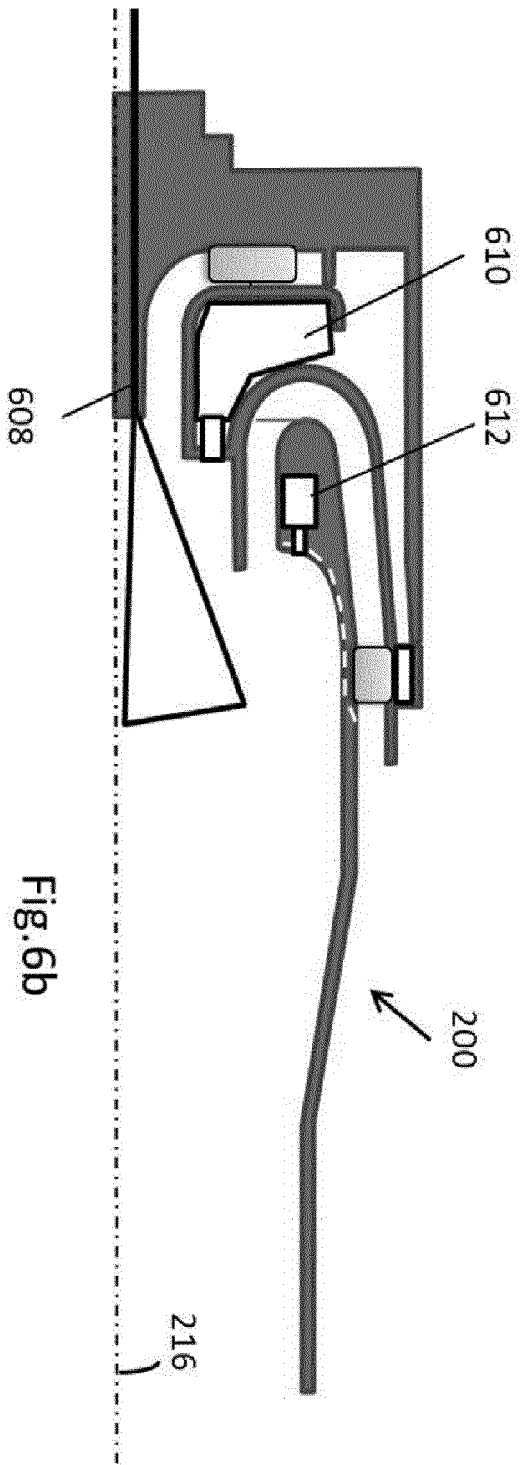


Fig. 6b

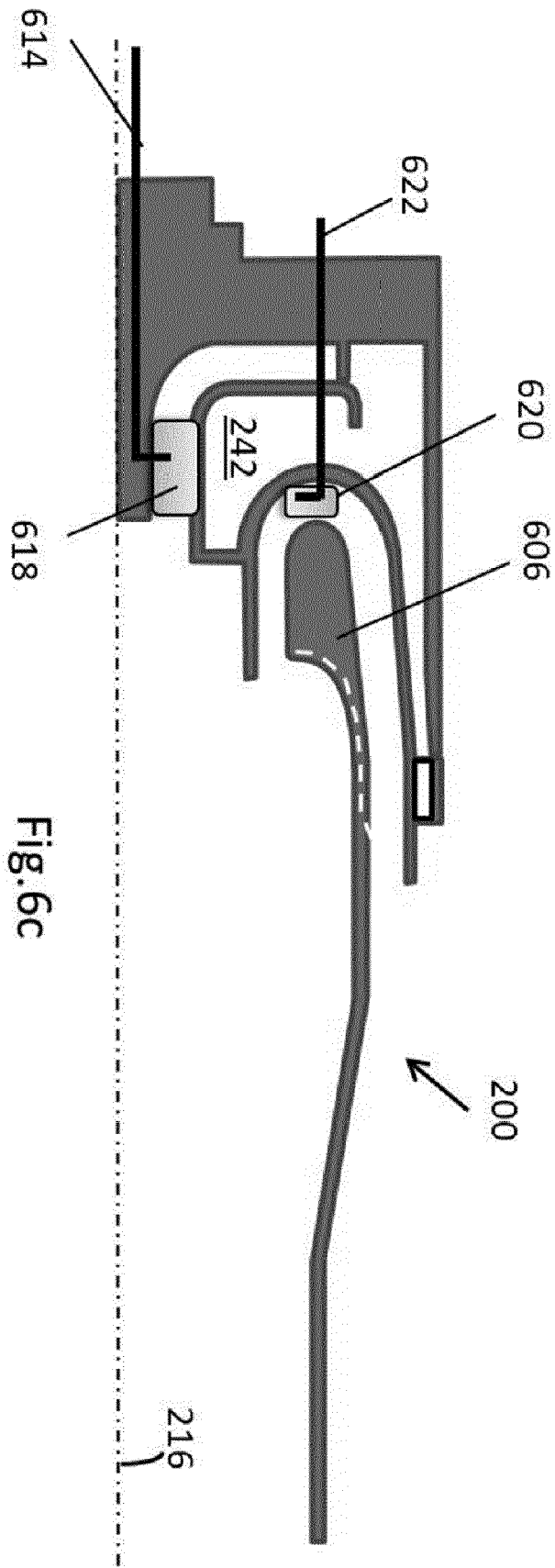
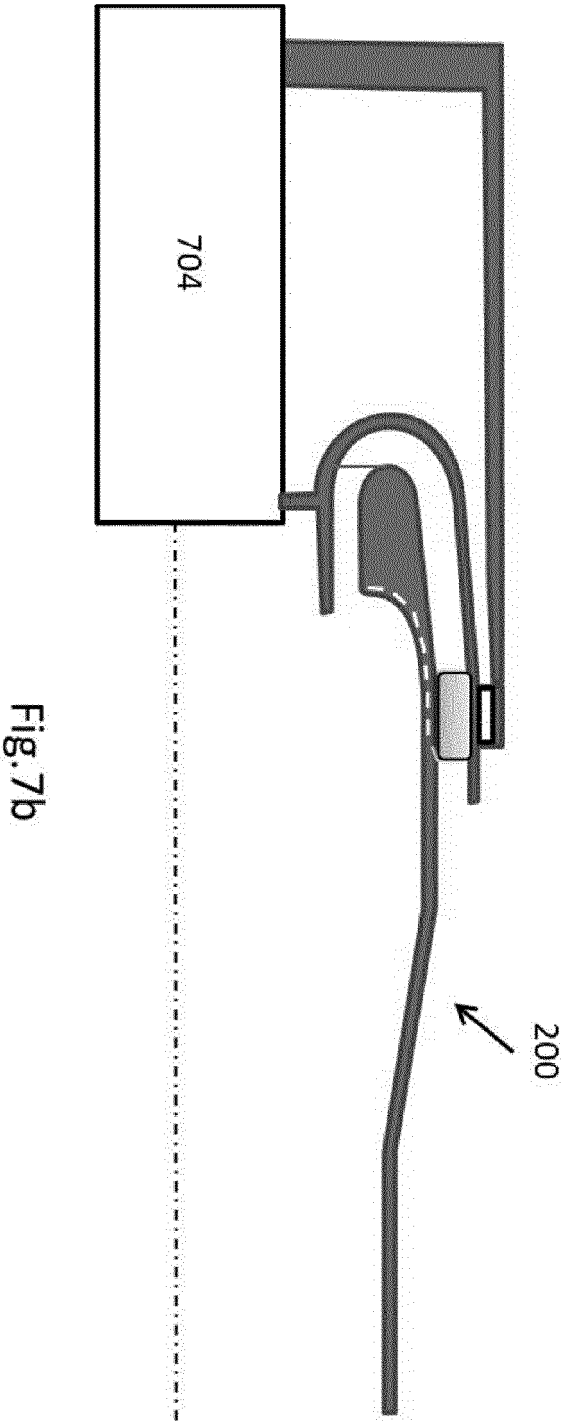
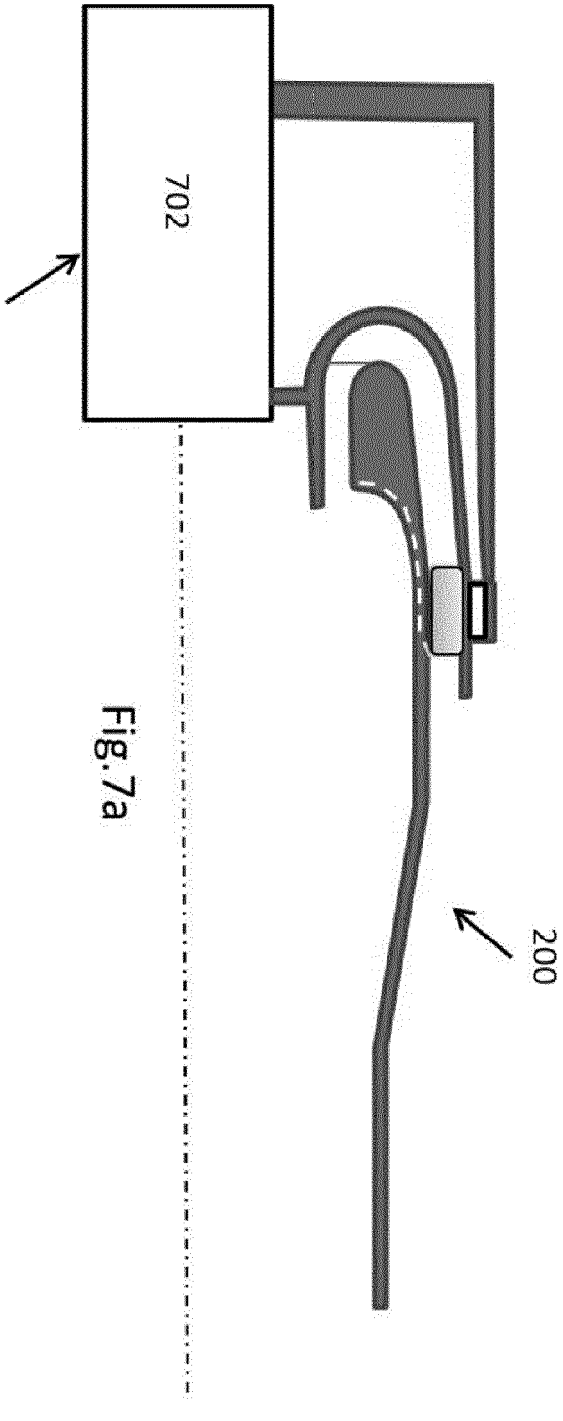
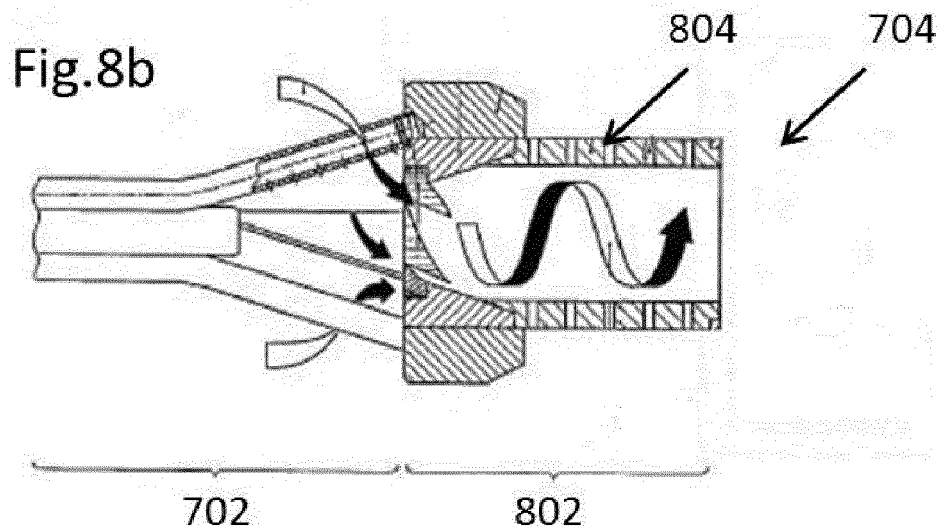
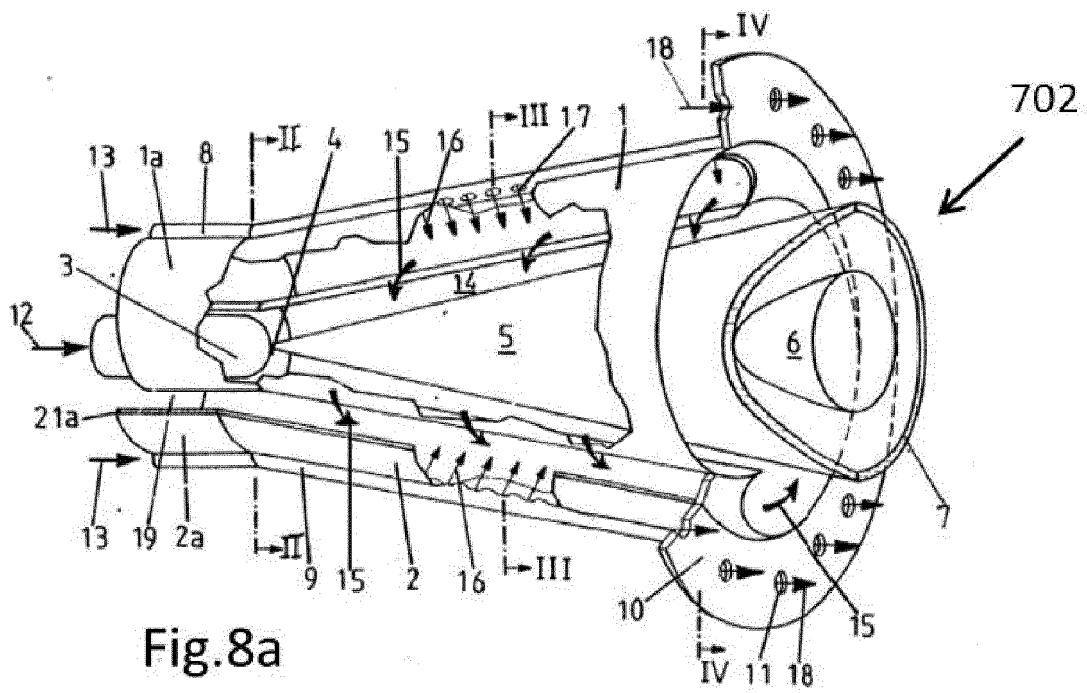


Fig. 6c







EUROPEAN SEARCH REPORT

 Application Number
 EP 14 19 4792

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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	US 2014/090389 A1 (STUTTAFORD PETER JOHN [US] ET AL) 3 April 2014 (2014-04-03)	1-3,5-7, 11,12,14	INV. F23R3/54 F23R3/14
Y	* page 2, paragraph 29-33 * * figures 1-4 *	15	
X	US 4 199 935 A (HAKLUYTT JOHN P D [GB]) 29 April 1980 (1980-04-29) * the whole document *	1-3,12, 14	
Y	US 2006/260316 A1 (STUTTAFORD PETER J [US] STUTTAFORD PETER JOHN [US]) 23 November 2006 (2006-11-23)	15	
A	* page 1, paragraph 10 - page 2, paragraph 13 * * figures 1, 2 *	1-14	
A	US 6 430 933 B1 (KELLER JAKOB [CH]) 13 August 2002 (2002-08-13) * column 6, line 66 - column 13, line 37 * * figures 1-11 *	1,8,13, 14	TECHNICAL FIELDS SEARCHED (IPC)
			F23R
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 12 May 2015	Examiner Rudolf, Andreas
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
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 19 4792

5 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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12-05-2015

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