

(19)



(11)

EP 2 647 910 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

09.10.2013 Bulletin 2013/41

(51) Int Cl.:

F23R 3/14 (2006.01)

F23R 3/28 (2006.01)

F23R 3/12 (2006.01)

(21) Application number: **13161763.1**

(22) Date of filing: **28.03.2013**

(84) Designated Contracting States:

AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

Designated Extension States:

BA ME

• **Kraemer, Gilbert Otto**

Greenville, SC South Carolina 29615 (US)

• **Popovic, Predrag**

Greenville, SC South Carolina 29615 (US)

• **Menon, Arvind Venugopal**

Greenville, SC South Carolina 29615 (US)

(30) Priority: **04.04.2012 US 201213438851**

(71) Applicant: **General Electric Company**

Schenectady, New York 12345 (US)

(74) Representative: **Cleary, Fidelma**

GPO Europe

GE International Inc.

The Ark

201 Talgarth Road

Hammersmith

London W6 8BJ (GB)

(72) Inventors:

• **Baruah, Abinash**

560066 Bangalore, Karnataka (IN)

(54) **Diffusion combustor fuel nozzle**

(57) The present application thus provides a fuel nozzle (200) for use with one or more flows of fuel and a flow of air (20) in a combustor. The fuel nozzle (200) may include one or more gas fuel passages (310) for the one or more of flows of fuel (30), a swirler (280) with one or

more air chambers (300) therein surrounding the gas fuel passages (310), and a collar (330) with one or more curtain slots (350) surrounding the swirler (280). The flow of air is (20) divided between a swirler flow (370) through the air chambers (300) and a curtain flow (380) through the curtain slots (350).

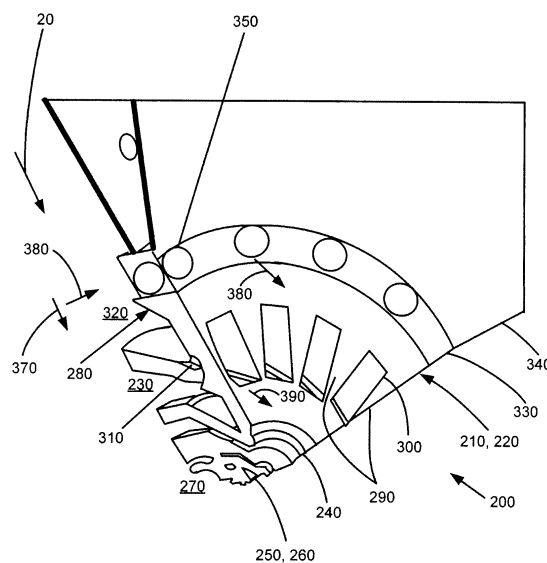


Fig. 5

EP 2 647 910 A2

Description

[0001] The present application and the resultant patent relate generally to gas turbine engines and more particularly relate to a diffusion combustor fuel nozzle using a flow of curtain air to reduce emissions such as nitrogen oxides and the like while maintaining efficient performance.

[0002] Operational efficiency in a gas turbine engine generally increases as the temperature of the combustion stream increases. Higher combustion stream temperatures, however, may result in the production of high levels of nitrogen oxides (NO_x) and other types of undesirable emissions. Such emissions may be subject to both federal and state regulations in the United States and also may be subject to similar regulations abroad. A balancing act thus exist between operating the gas turbine engine within an efficient temperature range while also ensuring that the output of nitrogen oxides and other types of regulated emissions remain well below mandated levels. Many other types of operational parameters also may be varied in providing such an optimized balance.

[0003] In a gas turbine engine that includes a diffusion-type combustor, i.e., non-premixed, fuel is injected into the air swirler. The air also flows through the swirler so as to mix with the fuel for downstream combustion. The fuel and the resultant hot combustion gases, however, may become entrained in a recirculation zone downstream of the swirler. As a result, the liner surrounding the fuel nozzles and the combustion chamber may experience relatively high-head end temperatures. Moreover, the relatively high head-end temperatures may be increased even further when the combustor burns certain types of liquid fuels. Such high temperatures may have an impact on the integrity and the lifetime of the liner and other components.

[0004] There is thus a desire for an improved fuel nozzle for use in a combustor, particularly a diffusion type combustor in a gas turbine engine. Such a fuel nozzle for a diffusion combustor may efficiently combust the fuel and the air streams therein with limited emissions while also limiting liner temperatures for increased component lifetime.

[0005] The present invention provides a fuel nozzle for use with one or more flows of fuel and a flow of air in a combustor. The fuel nozzle may include one or more gas fuel passages for the one or more of flows of fuel, a swirler with one or more air chambers therein surrounding the gas fuel passages, and a collar with one or more curtain slots surrounding the swirler. The flow of air is divided between a swirler flow through the air chambers and a curtain flow through the curtain slots.

[0006] The present invention further provides a method of operating a fuel nozzle in a combustor. The method may include the steps of providing one or more flows of fuel through the fuel nozzle, providing a flow of air about the fuel nozzle, and dividing the flow of air into a swirler

flow through a swirler and a curtain flow through a collar such that the curtain flow surrounds a mixed fuel-air flow of the swirler flow and the one or more flows of fuel.

[0007] The present invention further provides a fuel nozzle for use with one or more flows of fuel and a flow of air in a diffusion combustor. The fuel nozzle may include one or more gas fuel passages for the flows of fuel, a swirler surrounding the gas fuel passages, and a collar surrounding the swirler. The swirler may include a number of swirl vanes that define a number of air chambers therein. The collar may include a number of curtain slots. The flow of air may be divided between a swirler flow through the air chambers and a curtain flow through the curtain slots.

[0008] These and other features and improvements of the present application and the resultant patent will become apparent to one of ordinary skill in the art upon review of the following detailed description when taken in conjunction with the several drawings and the appended claims.

Fig. 1 is a schematic diagram of a gas turbine engine showing a compressor, a combustor, and a turbine.

Fig. 2 is a side view of an example of the combustor such as that shown in Fig. 1.

Fig. 3 is a side cross-sectional view of a fuel nozzle that may be used in the combustor of Fig. 2.

Fig. 4 is a front plan view of the fuel nozzle of Fig. 3.

Fig. 5 is a partial perspective view of a fuel nozzle as may be described herein.

Fig. 6 is a perspective view of a nozzle collar for use with the fuel nozzle of Fig. 5.

[0009] Referring now to the drawings, in which like numerals refer to like elements throughout the several views, Fig. 1 shows a schematic view of gas turbine engine 10 as may be used herein. The gas turbine engine 10 may include a compressor 15. The compressor 15 compresses an incoming flow of air 20. The compressor 15 delivers the compressed flow of air 20 to a combustor 25. The combustor 25 mixes the compressed flow of air 20 with a pressurized flow of fuel 30 and ignites the mixture to create a flow of combustion gases 35. Although only a single combustor 25 is shown, the gas turbine engine 10 may include any number of combustors 25. The flow of combustion gases 35 is in turn delivered to a turbine 40. The flow of combustion gases 35 drives the turbine 40 so as to produce mechanical work. The mechanical work produced in the turbine 40 drives the compressor 15 via a shaft 45 and an external load 50 such as an electrical generator and the like. Other configurations and other components may be used herein.

[0010] The gas turbine engine 10 may use natural gas,

various types of syngas, and/or other types of fuels. The gas turbine engine 10 may be any one of a number of different gas turbine engines offered by General Electric Company of Schenectady, New York, including, but not limited to, those such as a 7 or a 9 series heavy duty gas turbine engine and the like. The gas turbine engine 10 may have different configurations and may use other types of components. Other types of gas turbine engines also may be used herein. Multiple gas turbine engines, other types of turbines, and other types of power generation equipment also may be used herein together.

[0011] Fig. 2 shows an example of the combustor 25 that may be used with the gas turbine engine 10 and the like. The combustor 25 may include a number of fuel nozzles 55 therein. As described above, each of the fuel nozzles 55 may direct the flow of air 20, the flow of fuel 30, and optional flows of other fluids for combustion therein. Any number of the fuel nozzles 55 may be used in any configuration. The fuel nozzles 55 may be attached to an end cover 60 near a head-end 65 of the combustor 25. The flows of the air 20 and the fuel 30 may be directed through the end cover 60 and the head-end 65 into each of the fuel nozzles 55 so as to distribute a fuel-air mixture downstream thereof.

[0012] The combustor 25 also may include a combustion chamber 70 therein. The combustion chamber 70 may be defined by a combustion casing 75, a combustion liner 80, a flow sleeve 85, and the like. The liner 80 and the flow sleeve 85 may be coaxially positioned with respect to one another so as to define an air pathway 90 for the flow of air 20 therethrough. The combustion chamber 70 may lead to a downstream transition piece 95. The flows of the air 20 and the fuel 30 may mix downstream of the fuel nozzles 55 for combustion within the combustion chamber 70. The flow of combustion gases 35 then may be directed via the transition piece 95 towards the turbine 40 so as to produce useful work therein. Other components and other configuration also may be used herein.

[0013] Figs. 3 and 4 show an example of the fuel nozzle 55 that may be used with the combustor 25 and the like. The fuel nozzle 55 may be a diffusion fuel nozzle 100. More specifically, the fuel nozzle 55 may be a dual fuel nozzle 105. Given such, the flow of fuel 30 may include one or more flows of a gas fuel 110 such as natural gas and one or more flows of a liquid fuel 115 such as a syngas and the like. Other types of fuel flows and other types of combinations of fuel flows may be used herein.

[0014] The fuel nozzle 55 may include an outer tube 120. The outer tube 120 may lead to a downstream face 125 with a fuel nozzle tip 130. The outer tube 120 may include a number of fuel, air, and water passages therein. Specifically, a number of gas fuel passages 135 may extend therethrough and may be axially positioned about the downstream face 125. The gas fuel passages 135 may be in communication with the flow of gas fuel 110. A number of tip outlets 140 also may extend therethrough and may be positioned about the fuel nozzle tip 130. The

tip outlets 140 may include a liquid fuel outlet 145 in communication with the flow of liquid fuel 115. The tip outlets 140 also may include an atomizing air outlet 150 in communication with a flow of atomizing air as well as a water outlet 155 in communication with a flow of water. Other components and other configurations may be used herein.

[0015] A swirler 160 may be positioned about the downstream face 125 of the fuel nozzle 55. The swirler 160 may include a number of swirl vanes 165. The swirl vanes 165 may define a number of air chambers 170. The air chambers 170 may be in communication with the flow of air 20 from the end cover 60. A number of swirler passages 175 may extend from the gas fuel passages 135 to the air chambers 170 for at least a portion of the flow of gas fuel 110. The flow of air 20 and the flow of gas fuel 110 thus may begin to mix about the swirler 160 for combustion within the downstream combustion chamber 70. Generally described, all of the flow of air 20 thus passes through the air chambers 170 of the swirler 160 as a swirler flow 180. A collar 185 may surround the swirler 160. A cone (not shown) may extend from the fuel nozzle 55 to the liner 80. Other types of fuel nozzles 55 and other types of combustors 25 may be used herein with differing types of fuel. Likewise, other components and other configurations may be used herein.

[0016] Fig. 5 and Fig. 6 show a fuel nozzle 200 as may be described herein. The fuel nozzle 200 may be a diffusion nozzle 210 with little to no upstream fuel-air premixing. The fuel nozzle 200 also may be a dual fuel nozzle 220 for use with both the flow of gas fuel 110 and the flow of the liquid fuel 115. Other types of flows may be used herein. In a manner similar to that described above, the fuel nozzle 200 thus includes one or more gas fuel passages 230 extending therethrough. The gas fuel passages 230 may extend towards a downstream face 240. The fuel nozzle 200 also may include a number of tip outlets 250. The tip outlets 250 may be positioned about a fuel nozzle tip 260 about the downstream face 240. The tip outlets 250 may include one or more liquid fuel outlets 270 as well as outlets for atomizing air, water, and the like. Other components and other configurations also may be used herein.

[0017] The fuel nozzle 200 also may include a swirler 280 positioned about the downstream face 240 thereof. The swirler 280 surrounds fuel nozzle tip 260. The swirler 280 may include a number of swirl vanes 290 that define a number of air chambers 300 extending therethrough. The swirl vanes 290 and the air chambers 300 may have any size, shape, or configuration. Any number of the swirl vanes 290 and the air chambers 300 may be used herein. A number of swirl vane gas fuel passages 310 may extend from one or more of the gas fuel passages 230 to the air chambers 300 for at least a portion of the flow of gas fuel 110 therethrough. An air inlet 320 may be defined on the upstream end of the swirler 280 in communication with the flow of air 20 from the end cover 60. The air inlet 320 may have any size, shape, or con-

figuration. Other components and other configurations also may be used herein.

[0018] The fuel nozzle 200 also may include a collar 330 surrounding the swirler 280. A cone 340 may extend from the collar 330 towards the liner 80. The collar 330 may include a number of curtain slots 350 extending therethrough. The curtain slots 350 may include an angled configuration 360. The curtain slots 350 may have any size, shape, or configuration. Any number of the curtain slots 350 may be used herein. The curtain slots 350 may extend from about the air inlet 320 to the downstream face 240. The flow of air 20 thus may be divided into a swirler flow 370 passing through the air chambers 300 of the swirler 280 and a curtain flow 380 extending through the curtain slots 350 of the collar 330. The respective proportions of the swirler flows 370 and the curtain flows 380 may vary. Other components and other configurations may be used herein.

[0019] In use, at least a portion of the flow of gas fuel 110 extends through the gas fuel passages 230, through the swirler vane gas fuel passages 310, and into the air chambers 300 of the swirler 280. Likewise, the flow of liquid fuel 115, the atomizing airflow, and the water flow pass through the tip outlets 250. The flow of air 20 flows through the air inlet 320 and then may be split into the swirler flow 370 passing through the air chambers 300 and the curtain flow 380 passing through the curtain slots 350 of the collar 300. The flow of gas fuel 110 and the swirler flow 370 begin to mix within the air chambers 300 of the swirler 280 to create a mixed fuel-air flow 390 extending into the combustion chamber 70. The curtain flow 380 may be injected at an angle given the angled configuration 360 of the curtain slots 350. The curtain flow 380 thus serves to blanket this mixed fuel-air flow 390.

[0020] Injecting the curtain flow 380 prevents the mixed fuel-air flow 390 and/or the flow of combustion gases 35 from being entrained in a recirculation zone about the fuel nozzle 200. The blanketing effect of the curtain flow 380 thus may provide a reduction in NO_x emissions and the like. Specifically, the flammable value of the fuel-air flow 390 may be reduced so as to improve emissions and also extend the useful lifetime of the liner 80 and other components in the hot gas path. The water to fuel ratio also may be reduced herein.

[0021] The fuel nozzle 200 described herein thus provides low natural gas emissions with wide liquid fuel flexibility. As opposed to the current approach of increasing fuel-air premixing, the fuel nozzle 200 described herein actually lowers premixing so as to improve overall NO_x emissions. This non-intuitive approach of lowering fuel-air premixing is distinct from such current fuel nozzle designs and operational theories. The use of the curtain flow 380 herein thus improves emissions and overall component lifetime.

[0022] It should be apparent that the foregoing relates only to certain embodiments of the present application and the resultant patent. 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 and the equivalents thereof.

[0023] Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. A fuel nozzle for use with one or more flows of fuel and a flow of air in a diffusion combustor, comprising:

one or more gas fuel passages for the one or more of flows of fuel;
a swirler surrounding the one or more gas fuel passages;
the swirler comprising a plurality of swirl vanes defining a plurality of air chambers therein; and
a collar surrounding the swirler;
the collar comprising a plurality of curtain slots; wherein the flow of air is divided between a swirler flow through the plurality of air chambers and a curtain flow through the plurality of curtain slots.

2. The fuel nozzle of clause 1, wherein the plurality of swirl vanes comprises a plurality of gas fuel passages therethrough.

3. The fuel nozzle of any preceding clause, further comprising an air inlet in communication with the plurality of air chambers and the plurality of curtain slots.

4. The fuel nozzle of any preceding clause, wherein the collar comprises a cone extending therefrom.

5. The diffusion combustor of any preceding clause, wherein the one or more curtain slots comprise an angled configuration.

Claims

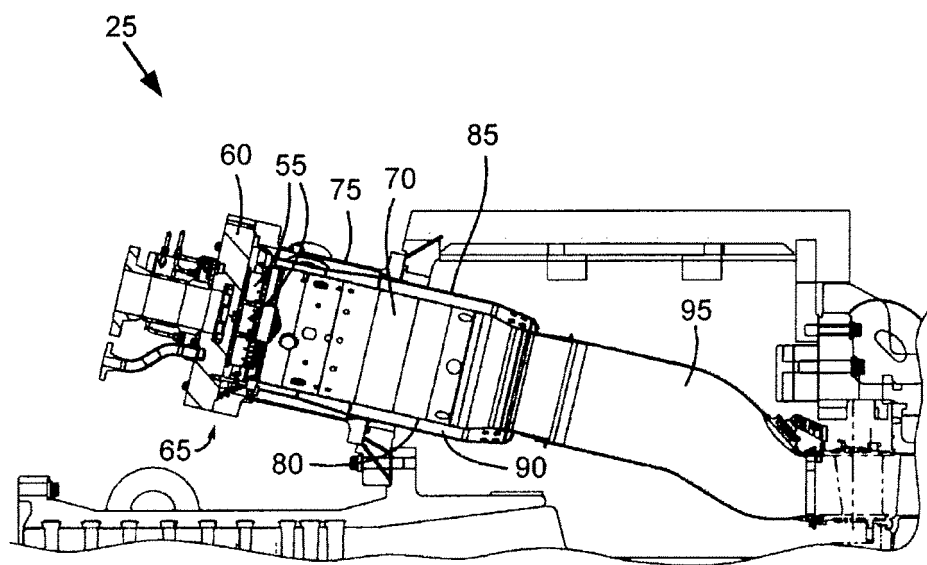
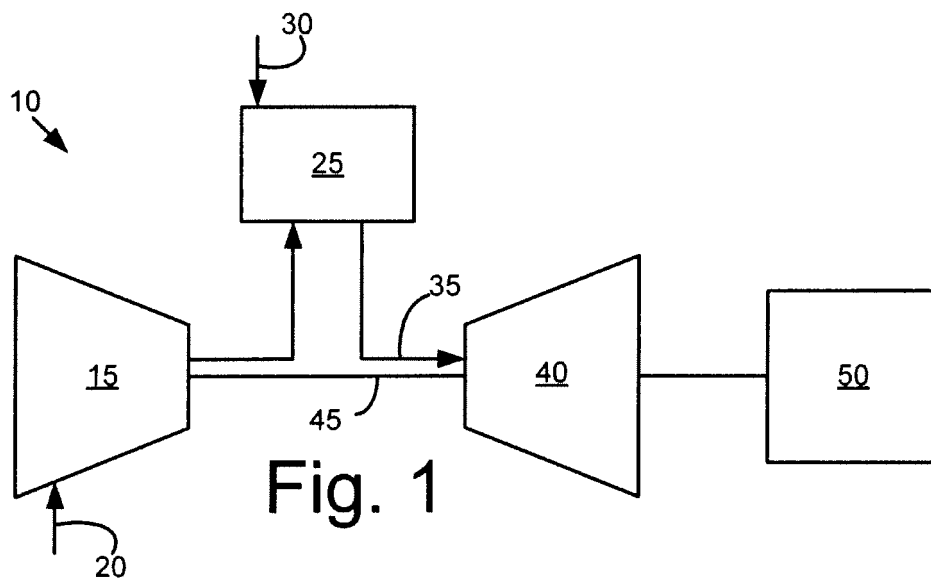
1. A fuel nozzle (100,200) for use with one or more flows of fuel (30) and a flow of air (20) in a combustor (25), comprising:

one or more gas fuel passages (135,230) for the one or more of flows of fuel (30);
a swirler (160) surrounding the one or more gas fuel passages (135,230), the swirler (160) comprising one or more air chambers (170) therein; and
a collar (185) surrounding the swirler (160), the collar (185) comprising one or more curtain slots (350);
wherein the flow of air (20) is divided between a swirler flow (180) through the one or more air chambers (170) and a curtain flow (380) through the one or more curtain slots (350).

2. The fuel nozzle of claim 1, wherein the fuel nozzle (100,200) comprises a dual fuel nozzle (105,220) in a diffusion combustor (25).
3. The fuel nozzle of claim 1 or 2, wherein the one or more flows of fuel (30) comprise a gas fuel (110) flowing through the one or more gas fuel passages (135,230). 5
4. The fuel nozzle of claim 3, wherein the one or more gas fuel passages (230) extend towards a downstream face (240). 10
5. The fuel nozzle of any of claims 1 to 4, wherein the one or more flows of fuel comprise a liquid fuel (115) flowing through a liquid fuel outlet (270). 15
6. The fuel nozzle of claim 5, wherein the liquid fuel outlet (270) comprises a tip outlet (250) positioned about a fuel nozzle tip (260). 20
7. The fuel nozzle of any preceding claim, wherein the swirler (160,280) comprises a plurality of swirl vanes (165,290) defining the one or more air chambers (170,300). 25
8. The fuel nozzle of claim 7, wherein the plurality of swirl vanes (165,290) comprises a plurality of gas fuel passages (310) therethrough. 30
9. The fuel nozzle of any preceding claim, further comprising an air inlet (320) in communication with the one or more air chambers (300) and the one or more curtain slots (350). 35
10. The fuel nozzle of any preceding claim, wherein the collar (330) comprises a cone (340) extending therefrom.
11. The fuel nozzle of any preceding claim, wherein the one or more curtain slots (350) comprise an angled configuration (360). 40
12. The fuel nozzle of any preceding claim, wherein the curtain flow (380) surrounds the swirler flow (370). 45
13. The fuel nozzle of any preceding claim, wherein the curtain flow (380) surrounds a fuel-air flow (390) of the swirler flow (370) and the one or more flows of fuel. 50
14. The fuel nozzle of any preceding claim, wherein the curtain flow (380) extends along a liner (80).
15. A method of operating a fuel nozzle (100,200) in a combustor (25), comprising: 55

providing one or more flows of fuel (30) through

the fuel nozzle (100,200);
 providing a flow of air (20) about the fuel nozzle (100,200); and
 dividing the flow of air into a swirler flow (370) through a swirler and a curtain flow (380) through a collar (330) such that the curtain flow (380) surrounds a fuel-air flow (390) of the swirler flow (370) and the one or more flows of fuel (30).



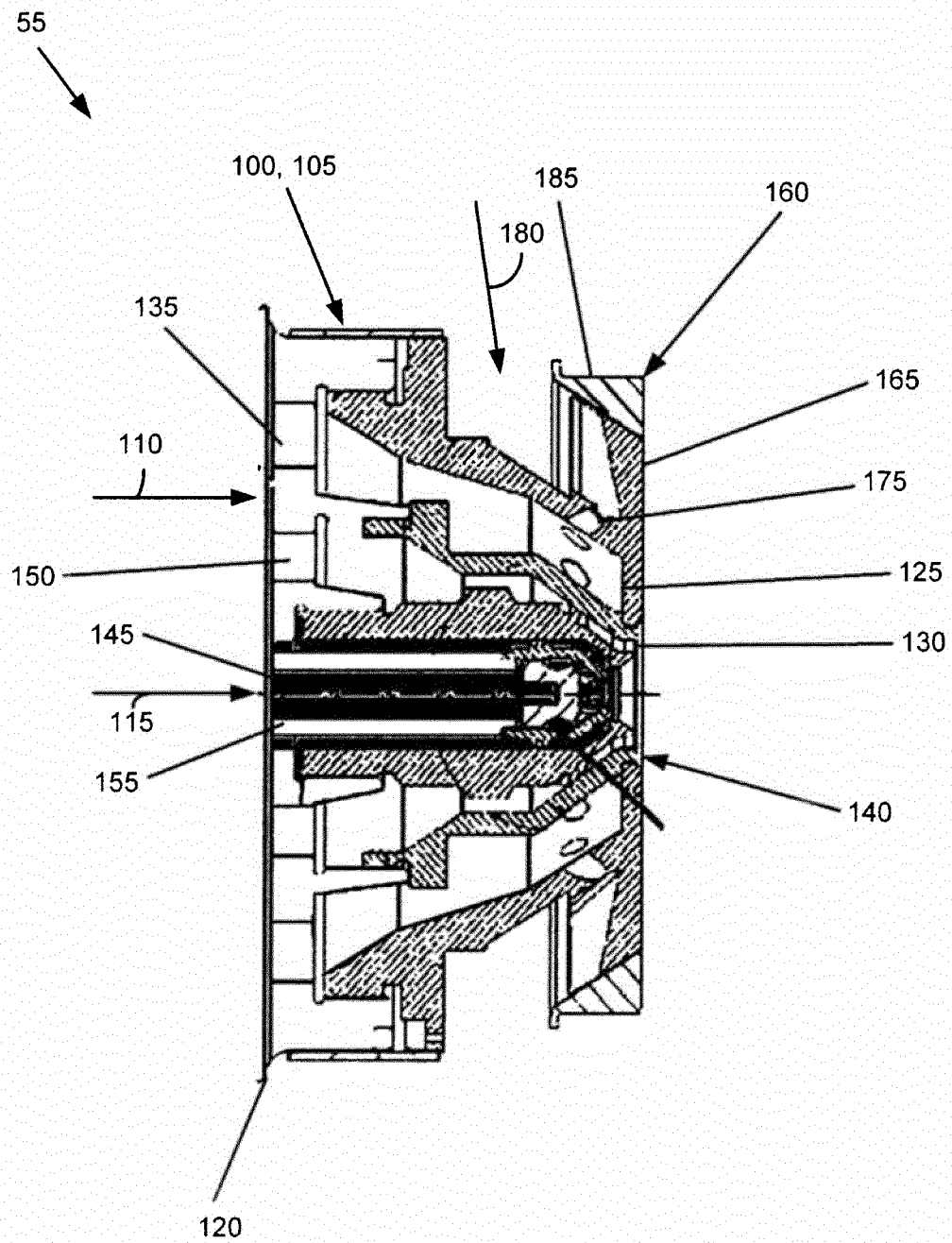


Fig. 3

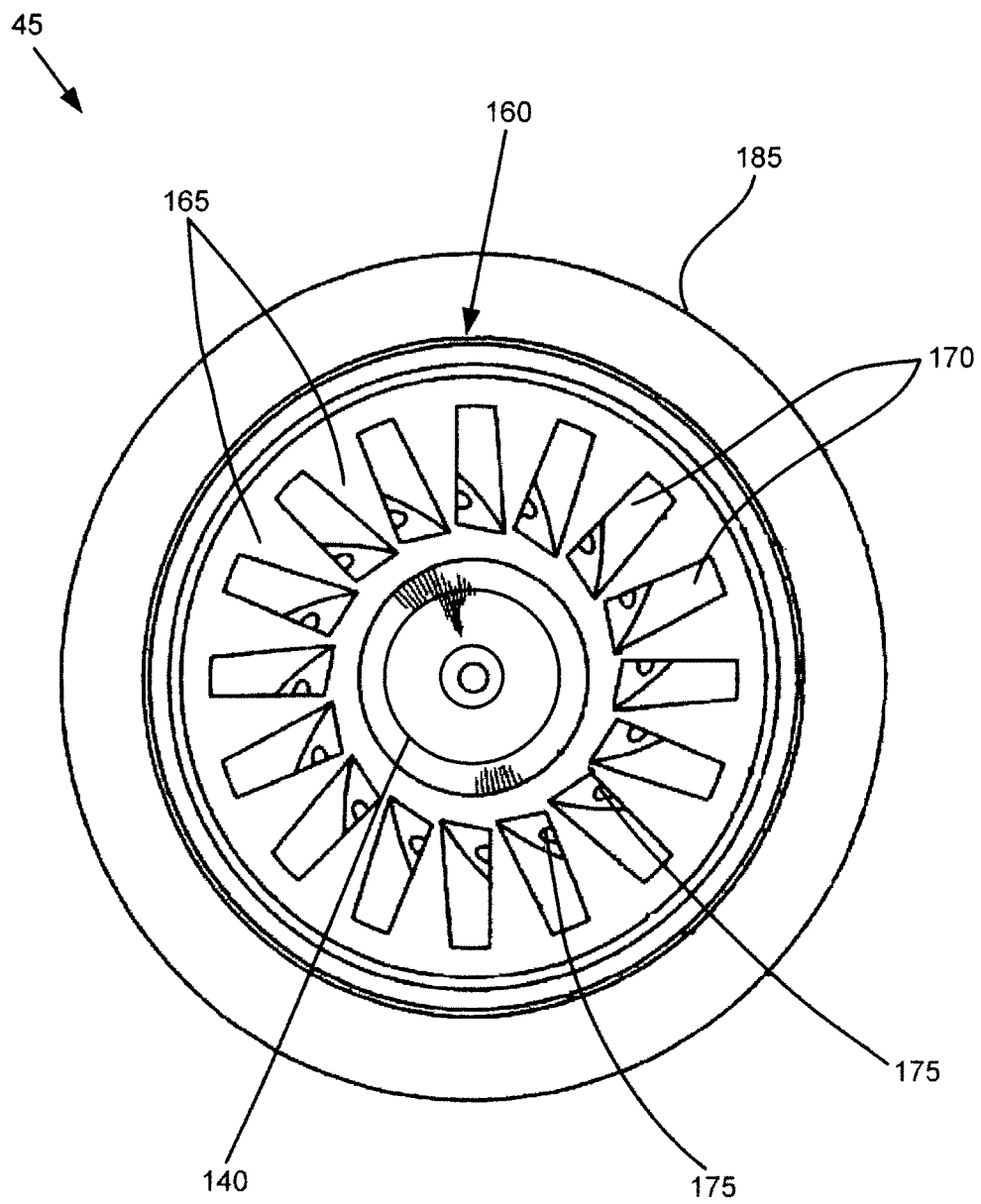


Fig. 4

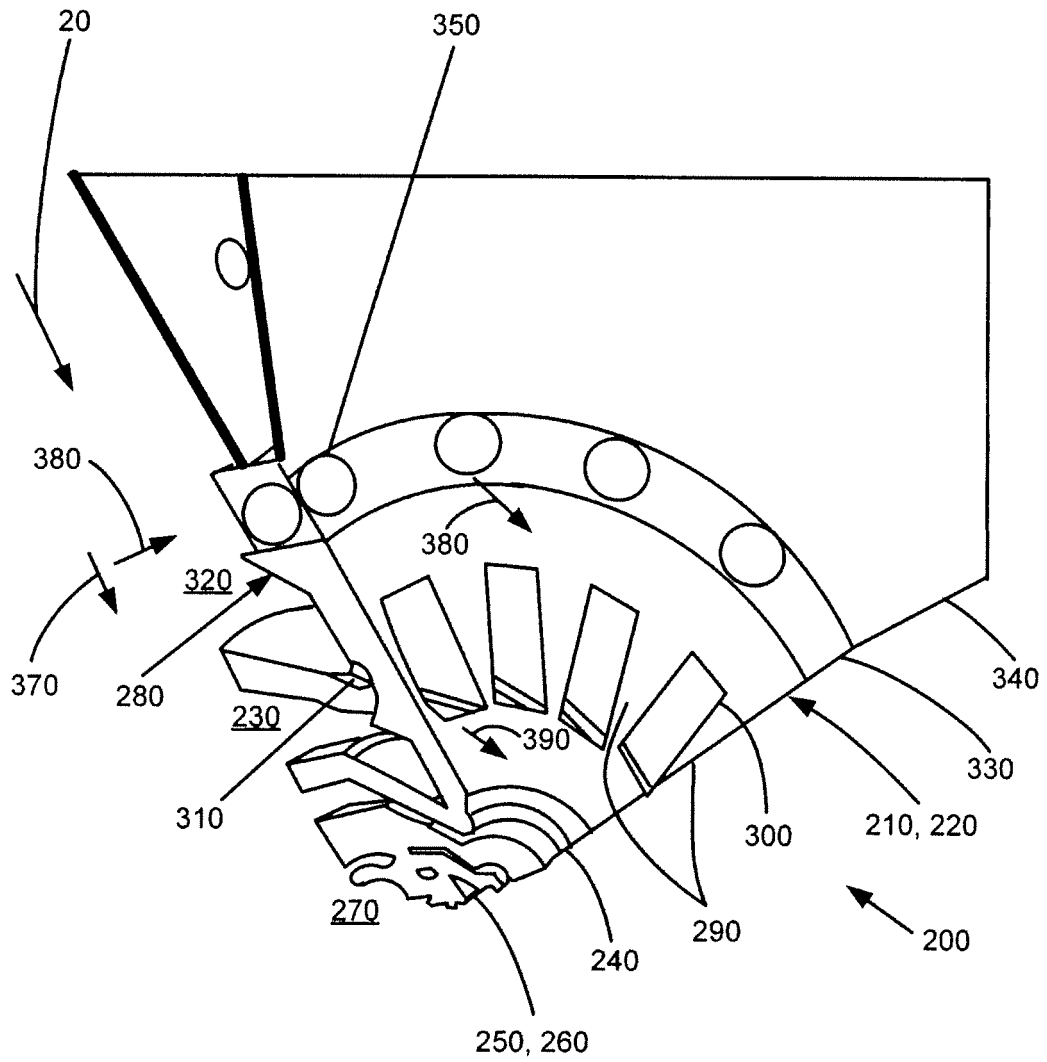


Fig. 5

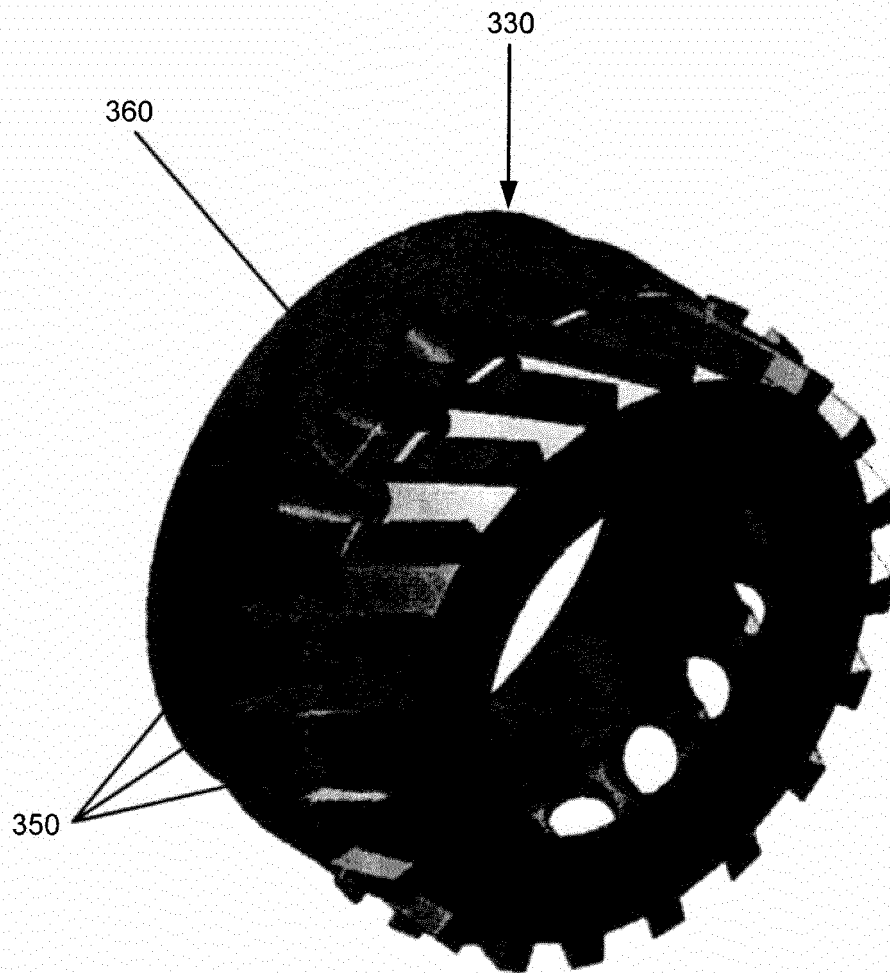


Fig. 6