(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 919 815 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.12.2021 Bulletin 2021/49

(21) Application number: **21174879.3**

(22) Date of filing: **20.05.2021**

(51) Int Cl.:
F23D 14/62 *(2006.01)* ***F23D 14/70*** *(2006.01)*
B01F 5/04 *(2006.01)* ***B05B 1/00*** *(2006.01)*

(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
Designated Validation States:
KH MA MD TN

(30) Priority: **28.05.2020 GB 202008039**
05.06.2020 GB 202008548

(71) Applicant: **Bosch Thermotechnology Ltd (UK)**
Worcester, Worcestershire WR4 9SW (GB)

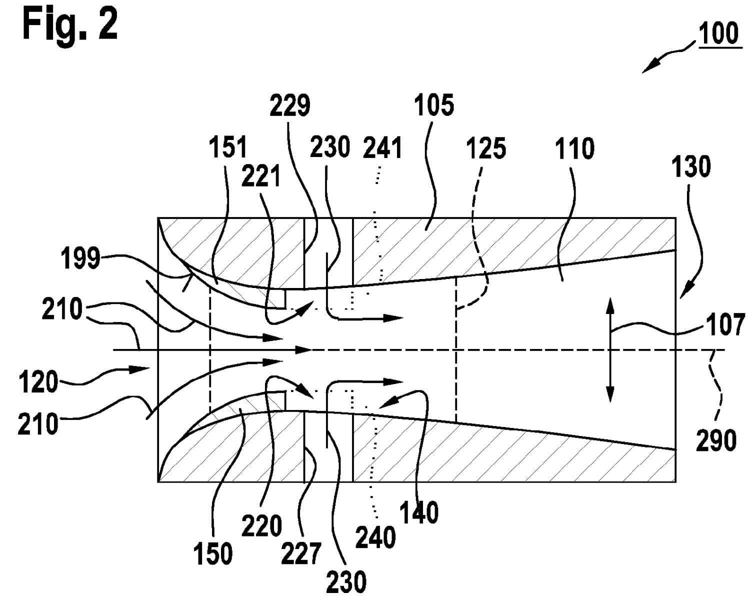
(72) Inventors:
- **Collins, Tom**
  Worcester, WR3 8XA (GB)
- **Hemmen, Patrick**
  7721 KG Dalfsen (NL)
- **Buta, Dom**
  17464 Sundbyberg (SE)

(74) Representative: **Bee, Joachim**
Robert Bosch GmbH, C/IPE
P.O. Box 30 02 20
70442 Stuttgart (DE)

(54) **VENTURI-TYPE MIXING NOZZLE AND COMBUSTION DEVICE WITH A VENTURI-TYPE MIXING NOZZLE**

(57) A Venturi-type mixing nozzle (100) with a nozzle body (105) that comprises a main flow passage (110) having an inlet end (120) and an outlet end (130), wherein a first fluid (210) enters the main flow passage (110) via the inlet end (120), the main flow passage (110) comprising a passage constriction (140) between the inlet end (120) and the outlet end (130) for creation of a negative pressure region (125) in the main flow passage (110), wherein the passage constriction (140) comprises at least one lateral inlet opening (220, 221) through which a second fluid (230) enters the main flow passage (110) for being mixed with the first fluid (210) in the main flow passage (110), and wherein at least one bluff body (150, 151) is arranged in the main flow passage (110).

Fig. 2



EP 3 919 815 A1

Description

Background of the Invention

[0001] The present invention relates to a Venturi-type mixing nozzle with a nozzle body that comprises a main flow passage having an inlet end and an outlet end, wherein a first fluid enters the main flow passage via the inlet end, the main flow passage comprising a passage constriction between the inlet end and the outlet end for creation of a negative pressure region in the main flow passage, wherein the passage constriction comprises at least one lateral inlet opening through which a second fluid enters the main flow passage for being mixed with the first fluid in the main flow passage. Moreover, the present invention relates to a combustion device having such a Venturi-type mixing nozzle.

[0002] Document WO 2018/015130 A1 describes a Venturi-type mixing nozzle having a nozzle body with a main flow passage that has an inlet end and an outlet end. The main flow passage includes a passage constriction between the inlet end and the outlet end for creation of a negative pressure region in the main flow passage. The passage constriction is provided with a plurality of lateral inlet openings. In operation, a first fluid enters the main flow passage via the inlet end and a second fluid enters the main flow passage via the lateral inlet openings for being mixed with the first fluid in the main flow passage.

[0003] Other Venturi-type mixing nozzles are e.g. described in documents US 2017/108213 A1, EP 3 006 827 A1, and WO 2016/194056 A1. All of these Venturi-type mixing nozzles are provided to allow mixing of a first fluid with a second fluid in a respective main flow passage provided by means of the Venturi-type mixing nozzles.

Summary of the Invention

[0004] The present invention relates to a Venturi-type mixing nozzle with a nozzle body that comprises a main flow passage having an inlet end and an outlet end, wherein a first fluid enters the main flow passage via the inlet end. The main flow passage comprises a passage constriction between the inlet end and the outlet end for creation of a negative pressure region in the main flow passage. The passage constriction comprises at least one lateral inlet opening through which a second fluid enters the main flow passage for being mixed with the first fluid in the main flow passage. At least one bluff body is arranged in the main flow passage between the inlet end and the at least one lateral inlet opening. The at least one bluff body extends in radial direction of the main flow passage towards a nozzle body central axis for creation of a low pressure zone that extends in the radial direction of the main flow passage along the at least one bluff body.

[0005] Advantageously, the at least one bluff body is positioned in the main flow passage upstream of the at least one lateral inlet opening such that its wake shields the at least one lateral inlet opening. The pressure in the shielded region of the at least one lateral opening may, thus, be reduced compared to the pressure in circumjacent unshielded regions of the passage constriction, such that pressure loss at the at least one lateral inlet opening is significantly reduced. As a result, injection of the second fluid into the main flow passage and, thus, mixing of the first and second fluids is improved and performed over a significantly reduced longitudinal length inside of the Venturi-type mixing nozzle.

[0006] According to one aspect, the low pressure zone is created such that the first fluid has a flow velocity in the low pressure zone that is at least reduced compared to a flow velocity that is otherwise attributed to the first fluid in the negative pressure region.

[0007] Thus, the second fluid is reliably injected close to the nozzle body central axis such that the first fluid will flow along the nozzle body wall, which improves boundary layer attachment, especially when the second fluid has a significantly lower flow density than the first fluid. More particularly, by injecting the second fluid close to the nozzle body central axis, the second fluid is directly and entirely surrounded by the first fluid for mixing of the first and second fluids. As a result, a respective surface area or shear layer between the first and second fluids is enlarged, which enhances the mixing of the first and second fluids. Thus, a respective volume of unburned fluid mix in an associated combustion device may advantageously be reduced, thereby reducing the severity of an unintended ignition inside the Venturi-type mixing nozzle.

[0008] According to one aspect, the at least one bluff body creates at least partly in the negative pressure region turbulences of the first fluid flowing around the at least one bluff body.

[0009] The creation of the turbulences further improves boundary layer attachment, thereby reducing an overall pressure drop of the Venturi-type mixing nozzle. More specifically, if the flow density of the second fluid is significantly lower than the flow density of the first fluid, e.g. if the first fluid is air and the second fluid is hydrogen, then a respective second fluid flow will tend to be laminar, having a lower Reynolds number than a given first fluid flow. As a result, the second fluid flow will be more susceptible to boundary layer separation than the first fluid flow. By creating the turbulences and injecting the second fluid close to the nozzle body central axis, the first fluid flow will be closer to the nozzle body wall than the second fluid flow. Because the denser first fluid flow is more turbulent (higher Reynolds number), it is therefore more resistant to boundary layer separation. Therefore, a respective downstream flow in the diverging part of the main flow passage will have better boundary layer attachment, and therefore a more uniform velocity profile and greater flow deceleration, resulting in a lower overall pressure drop. This lower overall pressure drop may advantageously be used to increase the operating range of the Venturi-type mixing nozzle and/or to reduce a required fan power for creation of the first fluid flow.

[0010] According to one aspect, the at least one bluff body is adapted to ensure that the second fluid is fully surrounded by the first fluid after having entered the main flow passage through the at least one lateral inlet opening.

[0011] Thus, a direct and entire surrounding of the second fluid by the first fluid upon its injection into the main flow passage can easily and reliably be achieved.

[0012] Preferably, the at least one bluff body is attached to, or integrally formed with, the nozzle body.

[0013] Accordingly, a robust and solid nozzle body may be provided, which may advantageously be manufactured using cost-effective processes, such as casting or injection moulding.

[0014] Alternatively, the at least one bluff body may be attached to, or integrally formed with, a bluff body support that is mounted to the nozzle body.

[0015] Thus, even retrofitting of existing Venturi-type mixing nozzles may be considered and the nozzle body may respectively be manufactured using cost-effective methods, such as casting, turning or extruding.

[0016] Preferably, the at least one lateral inlet opening is connected to a support channel that is arranged at a predetermined angle of more than 90° relative to the nozzle body central axis such that the second fluid is injected into the main flow passage in a direction that points away from the at least one bluff body.

[0017] Accordingly, the second fluid may directly be injected into turbulences of the first fluid flowing around the at least one bluff body such that mixing of the first and second fluids may further be improved.

[0018] According to a variant, the at least one lateral inlet opening is connected to a support channel that is arranged at a predetermined angle of less than 90° relative to the nozzle body central axis such that the second fluid is injected into the main flow passage in a direction that points towards the at least one bluff body.

[0019] Thus, the second fluid may be injected into the main flow passage such that it flows all along the at least one bluff body up to a closest possible point relative to the nozzle body central axis.

[0020] According to one aspect, the at least one bluff body may be wedge-shaped and may comprise an arc-shaped or straight surface that faces the nozzle body central axis. The at least one bluff body may also be pin-shaped and may comprise an arc-shaped surface that faces the inlet end. The at least one bluff body may also be plate-shaped.

[0021] Accordingly, various different forms and shapes are available for realization of the at least one bluff body.

[0022] The at least one bluff body may comprise an overhang that shields at least partly the at least one lateral inlet opening in direction of the nozzle body central axis.

[0023] Such an overhang may advantageously be provided for initially guiding the second fluid after injection through the at least one lateral inlet opening into the main flow passage.

[0024] Preferably, the at least one lateral inlet opening is punctiform or slot-shaped.

[0025] Thus, the at least one lateral inlet opening may be manufactured using a cost-effective process, such as e.g. drilling or milling.

[0026] According to one aspect, at least one additional bluff body is arranged in the main flow passage downstream of the at least one lateral inlet opening.

[0027] Such an additional bluff body may advantageously create swirl or turbulence of the second fluid, thereby further improving mixing of the first and second fluids.

[0028] According to one aspect, the at least one bluff body has a width that amounts at least to half of a hydraulic diameter of the at least one lateral inlet opening, and at most to twice the hydraulic diameter. Preferably, the at least one bluff body has a height that amounts at least to half of a hydraulic diameter of the at least one lateral inlet opening, and at most to a radial distance between the nozzle body and the nozzle body central axis at the passage constriction.

[0029] Thus, the at least one bluff body may easily be optimised for proper functioning, at least to the greatest possible extent.

[0030] A longitudinal distance between the at least one bluff body and the at least one lateral inlet opening preferably amounts at most to a hydraulic diameter of the at least one lateral inlet opening.

[0031] Accordingly, creation of the low pressure zone that extends in the radial direction of the main flow passage from the at least one lateral inlet opening along the at least one bluff body may reliably be achieved.

[0032] Preferably, the hydraulic diameter of the at least one lateral inlet opening is less than the Maximum Experimental Safety Gap of the second fluid.

[0033] If the second fluid is a combustible gas, this advantageously prevents a flame from being able to travel in operation upstream the Venturi-type mixing nozzle into the associated lateral inlet opening, thereby safely preventing a flame flashback event.

[0034] Preferably, the first fluid is air and the second fluid is a combustible gas.

[0035] Thus, the Venturi-type mixing nozzle may advantageously be used with a combustion device that is adapted for combustion of a gas/air mixture, e.g. a hydrogen/air mixture.

[0036] According to one aspect, the passage constriction comprises a plurality of lateral inlet openings, wherein the at least one bluff body is arranged in the main flow passage between the inlet end and two or more of the plurality of lateral inlet openings.

[0037] Thus, a simplified construction of the Venturi-type mixing nozzle may advantageously be enabled, wherein provision of a separate bluff body for each lateral inlet opening can be omitted.

[0038] According to one embodiment, the nozzle body central axis is a plane of symmetry.

[0039] Accordingly, a symmetrical nozzle body may easily be provided.

[0040] Preferably, the at least one bluff body has the shape of a saw tooth, a rounded unsymmetrical tooth, a pyramidal tooth, a dome, a conical tooth, or a wedge-type fin.

[0041] Thus, the at least one bluff body may be provided with a shape selected out of various different available shapes, which may easily be formed in an efficient and uncomplicated manner.

[0042] According to one embodiment, the at least one bluff body extends in radial direction of the main flow passage at least partly from the nozzle body towards the nozzle body central axis.

[0043] Thus, an improved shielding of the at least one lateral inlet opening by means of the at least one bluff body's wake may be obtained. The pressure in the shielded region of the at least one lateral opening may, thus, further be reduced compared to the pressure in circumjacent unshielded regions of the passage constriction, such that pressure loss at the at least one lateral inlet opening is significantly reduced.

[0044] Preferably, the low pressure zone created by the at least one bluff body extends in the radial direction of the main flow passage from the at least one lateral inlet opening along the at least one bluff body.

[0045] Thus, a required supply pressure for the second fluid may advantageously be reduced.

[0046] Furthermore, the present invention relates to a combustion device with a Venturi-type mixing nozzle as described above.

[0047] In this case, the at least one bluff body of the Venturi-type mixing nozzle has preferably a shape that is designed dependent on the size of an associated lateral inlet opening, such that the associated lateral inlet opening has a hydraulic diameter that is smaller than a so-called "Maximum Experimental Safe Gap" of the second fluid. This advantageously prevents a flame from being able to travel in operation of the combustion device upstream the Venturi-type mixing nozzle into the associated lateral inlet opening, thereby safely preventing a flame flashback event.

Brief Description of the Drawings

[0048] Exemplary embodiments of the present invention are described in detail hereinafter with reference to the attached drawings. In these attached drawings, identical or identically functioning components and elements are labelled with identical reference signs and they are generally only described once in the following description.

Fig. 1	shows a perspective view of a Venturi-type mixing nozzle with bluff bodies according to a first embodiment,
Fig. 2	shows a sectional view of the Venturi-type mixing nozzle of Fig. 1,
Fig. 3	shows a schematic view of exemplary flows of first and second fluids in the Venturi-type mixing nozzle of Fig. 1 and Fig. 2,
Fig. 4	shows a perspective view of a Venturi-type mixing nozzle with bluff bodies according to a second embodiment,
Fig. 5	shows a perspective view of a Venturi-type mixing nozzle with bluff bodies according to a third embodiment,
Fig. 6	shows sectional views of a bluff body and exemplary support channels,
Fig. 7	show perspective views of exemplary bluff bodies,
Fig. 8 and Fig. 9	show sectional views of exemplary bluff bodies,
Fig. 10 and Fig. 11	show sectional views of exemplary arrangements with an additional bluff body,
Fig. 12	shows a perspective view of a Venturi-type mixing nozzle with bluff bodies according to a fourth embodiment,
Fig. 13	shows a partial sectional view of the Venturi-type mixing nozzle of Fig. 1, and

Fig. 14 shows a schematic view of a constriction passage of the Venturi-type mixing nozzle of Fig. 1 with a plurality of bluff bodies having exemplarily differing shapes.

Detailed Description

[0049] Fig. 1 shows an exemplary Venturi-type mixing nozzle 100 with a nozzle body 105 that forms a main flow passage 110. According to one aspect, the Venturi-type mixing nozzle 100 is used for mixing of a combustible gas, e. g. hydrogen, with air in an associated combustion device at a desired concentration or ratio. Such a combustion device may e.g. be used in building heating systems.

[0050] The main flow passage 110 has an inlet end 120 and an outlet end 130 and is illustratively formed along the longitudinal direction of the nozzle body 105. More specifically, the main flow passage 110 in the nozzle body 105 is generally formed as a tubular channel with a smooth inner surface 199.

[0051] According to one aspect, the main flow passage 110 has a passage constriction 140 that is arranged between the inlet end 120 and the outlet end 130. Illustratively, the main flow passage 110 is funnel-shaped between the inlet end 120 and the passage constriction 140 and, thus, having a converging inflow section. Between the passage constriction 140 and the outlet end 130, the main flow passage 110 is illustratively conical and, thus, having a diverging outflow section.

[0052] Preferably, at least one bluff body is arranged in the main flow passage 110 between the inlet end 120 and the passage constriction 140, i.e. in the converging inflow section. Illustratively, a plurality of bluff bodies is provided but, however, only two bluff bodies are separately labelled with the reference signs 150, 151, for simplicity and clarity of the drawing. In the following description, reference is generally made to one or both of the bluff bodies 150, 151, representative for all respectively provided bluff bodies.

[0053] The bluff bodies 150, 151 protrude illustratively from the smooth inner surface 199 of the main flow passage 110 and are preferably attached to, or integrally formed with, the nozzle body 105. In other words, the bluff bodies 150, 151 are formed as bumps or dents on the otherwise smooth inner surface 199 inside of the main flow passage 110 and, thereby, form additional constrictions of the main flow passage 110.

[0054] Fig. 2 shows the Venturi-type mixing nozzle 100 of Fig. 1 with the nozzle body 105 that forms exemplarily along its nozzle body central axis 290 the main flow passage 110 having the inlet end 120, the outlet end 130, and the passage constriction 140. Illustratively, the nozzle body central axis 290 is a plane of symmetry.

[0055] The passage constriction 140 is arranged between the inlet end 120 and the outlet end 130 for creation of a negative pressure region 125 in the main flow passage 110 during operation of the Venturi-type mixing nozzle 100. The negative pressure region 125 is only by way of example and for illustration purposes delimited by means of two dashed lines.

[0056] According to one aspect, the passage constriction 140 comprises at least one lateral inlet opening. Preferably, a plurality of lateral inlet openings is provided but, however, only two lateral inlet openings are illustrated and separately labelled with the reference signs 220, 221, for simplicity and clarity of the drawing. In the following description, reference is generally made to one or both of the lateral inlet openings 220, 221, representative for all respectively provided lateral inlet openings.

[0057] As described above at Fig. 1, the bluff bodies are arranged in the main flow passage 110 between the inlet end 120 and the passage constriction 140. More specifically, the bluff bodies 150, 151 are preferably arranged in the main flow passage 110 between the inlet end 120 and the lateral inlet openings 220, 221. The bluff body 150 is illustratively arranged between the inlet end 120 and the lateral inlet opening 220, and the bluff body 151 is illustratively arranged between the inlet end 120 and the lateral inlet opening 221.

[0058] According to one aspect, one bluff body is provided for each lateral inlet opening. However, at least one bluff body may alternatively also be provided for two or more lateral inlet openings. In other words, it is possible to provide a single bluff body for all lateral inlet openings.

[0059] Each one of the bluff bodies 150, 151 preferably extends at least partly from the nozzle body 105 and, more particularly, from the smooth inner surface 199 of the main flow passage 110 towards the nozzle body central axis 290, preferentially in radial direction 107 of the main flow passage 110, for creation of an associated low pressure zone during operation of the Venturi-type mixing nozzle 100. At least one of the bluff bodies 150, 151 may be attached to, or integrally formed with, the nozzle body 105. Alternatively, at least one of the bluff bodies 150, 151 may be attached to, or integrally formed with, a bluff body support that is adapted to be mounted to the nozzle body. Furthermore, at least one of the bluff bodies 150, 151 may be in contact with the nozzle body 105 or, alternatively, be spaced apart therefrom.

[0060] A respective low pressure zone that is associated with the bluff body 150 is illustratively labelled with the reference sign 240, and a respective low pressure zone that is associated with the bluff body 151 is illustratively labelled with the reference sign 241. Each one of the associated low pressure zones 240, 241 extends along the respectively associated bluff body 150, 151, preferably from its associated lateral inlet opening 220, 221 along the respectively associated bluff body 150, 151, and preferentially in the radial direction 107 of the main flow passage 110.

[0061] In an exemplary operation of the Venturi-type mixing nozzle 100, a first fluid 210 enters the main flow passage

110 via the inlet end 120 and a second fluid 230 enters the main flow passage 110 via the lateral inlet openings 220, 221 for being mixed with the first fluid 210 in the main flow passage 110. By way of example, the first fluid 210 is air and the second fluid 230 is a combustible gas, e.g. hydrogen. More specifically, the first fluid 210 that enters the main flow passage 110 via the inlet end 120 backs up in the converging section between the inlet end 120 and the passage constriction 140 such that the negative pressure region 125 is created due to an acceleration of the first fluid 210 by means of the nozzle effect. Since the lateral inlet openings 220, 221 open into the passage constriction 140, the second fluid 230 is drawn into the main flow passage 110, where the second fluid 230 is mixed with the first fluid 210. Illustratively, the second fluid 230 is guided to the lateral inlet openings 220, 221 via associated support channels 227, 229, which are exemplarily arranged at an angle of 90° relative to the nozzle body central axis 290.

[0062] According to one aspect, the bluff bodies 150, 151 are provided for creation of the low pressure zones 240, 241 in the negative pressure region 125 such that the first fluid 210 has a flow velocity in the low pressure zones 240, 241 that is at least reduced compared to a flow velocity that is otherwise attributed to the first fluid 210 in the negative pressure region 125. More particularly, the bluff bodies 150, 151 are preferably adapted to ensure that the second fluid 230 is fully surrounded by the first fluid 210 after having entered the main flow passage 110 through the lateral inlet openings 220, 221.

[0063] Fig. 3 shows a section of the main flow passage 110 with the smooth inner surface 199 that is formed by the nozzle body 105 of the Venturi-type mixing nozzle 100 of Fig. 1 and Fig. 2. Illustratively, the bluff body 150 protrudes from the smooth inner surface 199 of the main flow passage 110 at a predetermined position upstream of the lateral inlet opening 220. The bluff body 150 is preferably attached to, or integrally formed with, the nozzle body 105.

[0064] According to one aspect, the bluff body 150 creates at least partly turbulences 310 of the first fluid 210 flowing around the bluff body 150. Preferably, the turbulences 310 are at least created in the negative pressure region 125.

[0065] In an exemplary operation of the Venturi-type mixing nozzle 100, the second fluid 230 is drawn through the lateral inlet opening 220 along the bluff body 150 into the main flow passage 110 such that the first fluid 210 flows along the smooth inner surface 199 and directly surrounds the second fluid 230 downstream of the lateral inlet opening 220. By creating the turbulences 310 of the first fluid 210 around the second fluid 230, mixing of the first and second fluids 210, 230 is significantly improved.

[0066] Fig. 4 shows a Venturi-type mixing nozzle 400 with a nozzle body 405 that forms a main flow passage 410 having an inlet end 420 and a passage constriction 440 that is illustratively provided with a plurality of lateral inlet openings 421. The Venturi-type mixing nozzle 400 is illustratively provided with a plurality of bluff bodies. However, for simplicity and clarity of the drawing only a single bluff body is separately labelled with the reference sign 451.

[0067] According to one aspect, the Venturi-type mixing nozzle 400 is embodied similar to the Venturi-type mixing nozzle 100 of Fig. 1 to Fig. 3 so that a detailed description of the Venturi-type mixing nozzle 400 may be omitted for brevity and conciseness. However, in contrast to the Venturi-type mixing nozzle 100 of Fig. 1 to Fig. 3, the bluff body 451 of the Venturi-type mixing nozzle 400 is attached to, or integrally formed with, a bluff body support 450 that is adapted to be mounted to the nozzle body 405. By way of example, the bluff body support 450 is ringshaped and at least partly funnel-shaped.

[0068] Fig. 5 shows a Venturi-type mixing nozzle 500 with a nozzle body 505 that forms a main flow passage 510 having an inlet end 520, an outlet end 530, and a passage constriction 540 that is illustratively provided with a plurality of lateral inlet openings 521. The Venturi-type mixing nozzle 500 is illustratively provided with a plurality of bluff bodies. However, for simplicity and clarity of the drawing only a single bluff body is separately labelled with the reference sign 551.

[0069] According to one aspect, the Venturi-type mixing nozzle 500 is embodied similar to the Venturi-type mixing nozzle 100 of Fig. 1 to Fig. 3 so that a detailed description of the Venturi-type mixing nozzle 500 may be omitted for brevity and conciseness. However, in contrast to the Venturi-type mixing nozzle 100 of Fig. 1 to Fig. 3, the bluff body 551 of the Venturi-type mixing nozzle 500 is attached to, or integrally formed with, a bluff body support 550 that is adapted to be mounted to the nozzle body 505. Illustratively, the bluff body support 550 is cruciform and consists of two crossing bars, each supporting two exemplary bluff bodies.

[0070] By way of example, the bluff body support 550 is provided with one or more positioning members 555. The positioning members 555 preferably interact with associated counterpart members 525 provided at the nozzle body 505 in order to enable an adequate positioning of the bluff body support 550 at the nozzle body 505. Illustratively, the associated counterpart members 525 are slots and the positioning members 555 are extensions of the crossing bars of the bluff body support 550 that fit into the slots.

[0071] Fig. 6 shows the nozzle body 105 of Fig. 1 to Fig. 3 that forms the main flow passage 110 having the nozzle body central axis 290. The nozzle body 105 is provided with the bluff body 150 and the lateral inlet opening 220.

[0072] Part (A) of Fig. 6 further illustrates an exemplary support channel 610 which may e.g. be used instead of the support channel 227 of Fig. 2. By way of example, the support channel 610 is connected to the lateral inlet opening 220 and preferably arranged at a predetermined angle 620 of more than 90° relative to the nozzle body central axis 290 such that the second fluid (230 of Fig. 2) is injected into the main flow passage 110 in a direction that points away from the bluff body 150.

[0073] Part (B) of Fig. 6 further illustrates another exemplary support channel 615 which may e.g. be used instead of the support channel 227 of Fig. 2. By way of example, the support channel 615 is connected to the lateral inlet opening 220 and preferably arranged at a predetermined angle 625 of less than 90° relative to the nozzle body central axis 290 such that the second fluid (230 of Fig. 2) is injected into the main flow passage 110 in a direction that points towards the bluff body 150.

[0074] Fig. 7 shows the bluff body 150 and the lateral inlet opening 220 formed on/in the nozzle body 105 of Fig. 1 to Fig. 3. In parts (A) to (D) of Fig. 7, different possible forms and shapes of the bluff body 150 are illustrated.

[0075] In part (A), the bluff body 150 is exemplarily wedge-shaped and has an arc-shaped surface 710 that faces the nozzle body central axis (290 in Fig. 2), as well as a straight surface 715 that faces the lateral inlet opening 220. In other words, the bluff body 150 has a sawtooth-like shape.

[0076] In part (B), the bluff body 150 is exemplarily wedge-shaped and has a straight surface 720 that faces the nozzle body central axis (290 in Fig. 2), as well as a straight surface 725 that faces the lateral inlet opening 220. In other words, the bluff body 150 has at least approximatively a V-shaped form.

[0077] In part (C), the bluff body 150 is exemplarily pin-shaped and has an arc-shaped surface 730 that faces the inlet end (120 in Fig. 2), as well as a straight surface 735 that faces the lateral inlet opening 220. In other words, the bluff body 150 has the shape of a half or semi-circular cylinder.

[0078] In part (D), the bluff body 150 is exemplarily plate-shaped. Illustratively, the plate-shaped bluff body 150 has two opposing flat surfaces 740, 745, wherein the flat surface 745 faces the lateral inlet opening 220.

[0079] Fig. 8 shows the bluff body 150 and the lateral inlet opening 220 formed on/in the nozzle body 105 of Fig. 1 to Fig. 3. The bluff body 105 protrudes from the nozzle body 105 into the main flow passage 110.

[0080] More specifically, part (A) of Fig. 8 is a sectional view of part (B) of Fig. 7, which further illustrates the straight surfaces 720, 725 of the exemplarily wedge-shaped bluff body 105. By way of example, the straight surface 725 is at least approximately arranged at an angle of 90° relative to the nozzle body 105.

[0081] Part (B) of Fig. 8 is a sectional view of part (A) of Fig. 7, which further illustrates the arc-shaped surface 710 and the straight surface 715 of the exemplarily wedge-shaped bluff body 105. By way of example, the straight surface 715 is at least approximately arranged at an angle of 90° relative to the nozzle body 105.

[0082] Fig. 9 shows the bluff body 150 and the lateral inlet opening 220 formed on/in the nozzle body 105 of Fig. 1 to Fig. 3. The bluff body 105 protrudes from the nozzle body 105 into the main flow passage 110 having the nozzle body central axis 290. According to one aspect, the bluff body 150 is provided with an overhang that shields at least partly the lateral inlet opening 220 in direction of the nozzle body central axis 290.

[0083] More specifically, part (A) of Fig. 9 is a sectional view of part (B) of Fig. 7, which further illustrates the exemplarily wedge-shaped bluff body 105 with the straight surface 720. However, instead of the straight surface 725 of part (B) of Fig. 7 that is at least approximately arranged at an angle of 90° relative to the nozzle body 105, a straight surface 910 is provided that is exemplarily arranged at an angle of 45° relative to the nozzle body 105 and embodied such that it shields the lateral inlet opening 220 at least partly in direction of the nozzle body central axis 290 by extending the wedge-shaped bluff body 105 over the lateral inlet opening 220. The angle may be selected in an application-specific manner and, thus, be smaller or greater than 45°.

[0084] Part (B) of Fig. 9 is a sectional view of part (A) of Fig. 7, which further illustrates the exemplarily wedge-shaped bluff body 105 with the arc-shaped surface 710. However, instead of the straight surface 715 of part (A) of Fig. 7 that is at least approximately arranged at an angle of 90° relative to the nozzle body 105, an arc-shaped surface 920 is provided that is embodied such that it shields the lateral inlet opening 220 at least partly in direction of the nozzle body central axis 290 by extending the wedge-shaped bluff body 105 over the lateral inlet opening 220.

[0085] Fig. 10 shows the bluff body 150 and the lateral inlet opening 220 formed on/in the nozzle body 105 of Fig. 1 to Fig. 3. The bluff body 105 protrudes from the nozzle body 105 into the main flow passage 110. The bluff body 105 is exemplarily embodied wedge-shaped according to Fig. 7, part (B), with the straight surfaces 720, 725. According to one aspect, at least one additional bluff body 1010 is arranged in the main flow passage 110 downstream of the lateral inlet opening 220.

[0086] More specifically, in part (A) of Fig. 10 a single additional bluff body 1010 is arranged downstream of the bluff body 105. By way of example, the single additional bluff body 1010 has a shape that is similar to the shape of the bluff body 105. In part (B) of Fig. 10, the single additional bluff body 1010 is simply horizontally mirrored.

[0087] It should be noted that in Fig. 10 the additional bluff body 1010 is only by way of example wedge-shaped with straight surfaces, such that it exhibits a triangular cross section, but not for limiting the invention accordingly. Instead, the additional bluff body 1010 may have various suitable shapes and forms, as exemplarily described hereinafter with reference to Fig. 11.

[0088] Fig. 11 shows the bluff body 150 and the lateral inlet opening 220 formed on/in the nozzle body 105 of Fig. 1 to Fig. 3. The bluff body 105 protrudes from the nozzle body 105 into the main flow passage 110. The bluff body 105 is exemplarily wedge-shaped according to Fig. 7, part (B), with the straight surfaces 720, 725. Furthermore, the additional bluff body 1010 of Fig. 10 is arranged in the main flow passage 110 downstream of the lateral inlet opening 220.

[0089] More specifically, in part (A) of Fig. 11 the single additional bluff body 1010 is illustratively pin-, plate- or bloc-shaped, e.g. similar to Fig. 7, part (C) or (D). In part (B) of Fig. 11 the single additional bluff body 1010 is illustratively wedge-shaped with an arc-shaped surface and a straight surface, e.g. similar to Fig. 7, part (A).

[0090] Fig. 12 shows the Venturi-type mixing nozzle 400 of Fig. 4 with the nozzle body 405 that forms the main flow passage 410 having the inlet end 420, an outlet end 430, and the passage constriction 440. The Venturi-type mixing nozzle 400 further incudes the bluff body support 450 with the bluff body 451.

[0091] However, in contrast to Fig. 4 the lateral inlet opening 421 is now exemplarily slot-shaped instead of being punctiform. In other words, in all variants of the present invention that are described in detail with reference to the drawings, one or more slot-shaped lateral inlet openings may be provided instead of, or in addition to, respective punctiform lateral inlet openings.

[0092] Fig. 13 shows the lower part of Fig. 2 with the bluff body 150 and the lateral inlet opening 220 formed on/in the nozzle body 105. The bluff body 105 is illustratively embodied according to part (A) of Fig. 7 with the straight surface 715 and protrudes from the nozzle body 105 into the main flow passage 110 having the nozzle body central axis 290. Furthermore, the lateral inlet opening 220 is connected to the support channel 227 at the passage constriction 140.

[0093] According to one aspect, the bluff body 150 has a height H that amounts at least to half of a hydraulic diameter D of the lateral inlet opening 220, and at most to a radial distance R between the nozzle body 105 and the nozzle body central axis 290 at the passage constriction 140. In addition, or alternatively, a longitudinal distance L between the bluff body 150 and the lateral inlet opening 220 preferably amounts at most to the hydraulic diameter D of the lateral inlet opening 220. The hydraulic diameter D is preferably smaller than a so-called "Maximum Experimental Safe Gap" of the second fluid (230 of Fig. 2).

[0094] Fig. 14 shows the Venturi-type mixing nozzle 100 of Fig. 1 to Fig. 3, with the nozzle body 105 that forms the main flow passage 110 having the passage constriction 140, wherein the lateral inlet opening 220 and the support channel 227 are formed according to Fig. 2. Upstream of the lateral inlet opening 220 and the support channel 227, the wedge-shaped bluff body 150 with the arc-shaped surface 710 according to part (A) of Fig. 7 is exemplarily arranged. Preferably, the bluff body 150 has a width W that amounts at least to half of the hydraulic diameter D of the lateral inlet opening 220 according to Fig. 13, and at most to twice the hydraulic diameter D.

[0095] By way of example, the Venturi-type mixing nozzle 100 is provided with five additional support channels 1410, 1420, 1430, 1440, 1450 that are connected to respectively associated lateral inlet openings which, however, are not separately labelled for simplicity and clarity of the drawings. Illustratively, the support channels 1410, 1430, 1440, 1450, and 227 are radially oriented with respect to the main flow passage 110, while the support channel 1420 is inclined with respect to the radial direction of the main flow passage 110.

[0096] According to one aspect, the support channel 1410 is associated with a bluff body 1415 that is formed as a wedge-type fin and that is moveably arranged close to the support channel 1410 for acting as a Vortex generator. The support channel 1420 is exemplarily associated with a bluff body 1425 in the form of a rounded unsymmetrical tooth having its height direction oriented along the inclination of the support channel 1420. Furthermore, the support channel 1430 is illustratively associated with a bluff body 1435 in the form of a pyramidal tooth, the support channel 1440 with a dome- or mushroom-shaped bluff body 1445, and the support channel 1450 is illustratively associated with a bluff body 1455 in the form of a conical tooth.

Claims

1. Venturi-type mixing nozzle (100) with a nozzle body (105) that comprises a main flow passage (110) having an inlet end (120) and an outlet end (130), wherein a first fluid (210) enters the main flow passage (110) via the inlet end (120), the main flow passage (110) comprising a passage constriction (140) between the inlet end (120) and the outlet end (130) for creation of a negative pressure region (125) in the main flow passage (110), wherein the passage constriction (140) comprises at least one lateral inlet opening (220, 221) through which a second fluid (230) enters the main flow passage (110) for being mixed with the first fluid (210) in the main flow passage (110), and wherein at least one bluff body (150, 151) is arranged in the main flow passage (110) between the inlet end (120) and the at least one lateral inlet opening (220, 221), the at least one bluff body (150, 151) extending in radial direction (107) of the main flow passage (110) towards a nozzle body central axis (290) for creation of a low pressure zone (240, 241) that extends in the radial direction (107) of the main flow passage (110) along the at least one bluff body (150, 151).

2. Venturi-type mixing nozzle of claim 1, wherein the low pressure zone (240, 241) is created such that the first fluid (210) has a flow velocity in the low pressure zone (240, 241) that is at least reduced compared to a flow velocity that is otherwise attributed to the first fluid (210) in the negative pressure region (125).

3. Venturi-type mixing nozzle of claim 1 or 2, wherein the at least one bluff body (150, 151) creates at least partly in the negative pressure region (125) turbulences (310) of the first fluid (210) flowing around the at least one bluff body (150, 151).

4. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one bluff body (150, 151) is adapted to ensure that the second fluid (230) is fully surrounded by the first fluid (210) after having entered the main flow passage (110) through the at least one lateral inlet opening (220, 221).

5. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one bluff body (150, 151) is attached to, or integrally formed with, the nozzle body (105).

6. Venturi-type mixing nozzle of any one of claims 1 to 4, wherein the at least one bluff body (451; 551) is attached to, or integrally formed with, a bluff body support (450; 550) that is mounted to the nozzle body (405; 505).

7. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one lateral inlet opening (220) is connected to a support channel (610) that is arranged at a predetermined angle (620) of more than 90° relative to the nozzle body central axis (290) such that the second fluid (230) is injected into the main flow passage (110) in a direction that points away from the at least one bluff body (150).

8. Venturi-type mixing nozzle of any one of claims 1 to 7, wherein the at least one lateral inlet opening (220) is connected to a support channel (615) that is arranged at a predetermined angle (625) of less than 90° relative to the nozzle body central axis (290) such that the second fluid (230) is injected into the main flow passage (110) in a direction that points towards the at least one bluff body (150).

9. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one bluff body (150) is wedge-shaped and comprises an arc-shaped or straight surface (710, 720) that faces the nozzle body central axis (290).

10. Venturi-type mixing nozzle of any one of claims 1 to 8, wherein the at least one bluff body (150) is pin-shaped and comprises an arc-shaped surface (730) that faces the inlet end (120).

11. Venturi-type mixing nozzle of any one of claims 1 to 8, wherein the at least one bluff body (150) is plate-shaped (740).

12. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one bluff body (150) comprises an overhang (910, 920) that shields at least partly the at least one lateral inlet opening (220) in direction of the nozzle body central axis (290).

13. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one lateral inlet opening (220; 421) is punctiform or slot-shaped.

14. Venturi-type mixing nozzle of any one of the preceding claims, wherein at least one additional bluff body (1010) is arranged in the main flow passage (110) downstream of the at least one lateral inlet opening (220).

15. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one bluff body (150) has a width (W) that amounts at least to half of a hydraulic diameter (D) of the at least one lateral inlet opening (220), and at most to twice the hydraulic diameter (D).

16. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one bluff body (150) has a height (H) that amounts at least to half of a hydraulic diameter (D) of the at least one lateral inlet opening (220; 421), and at most to a radial distance (R) between the nozzle body (105) and the nozzle body central axis (290) at the passage constriction (140).

17. Venturi-type mixing nozzle of any one of the preceding claims, wherein a longitudinal distance (L) between the at least one bluff body (150) and the at least one lateral inlet opening (220) amounts at most to a hydraulic diameter (D) of the at least one lateral inlet opening (220; 421).

18. Venturi-type mixing nozzle of any one of claims 15 to 17, wherein the hydraulic diameter (D) of the at least one lateral inlet opening (220; 421) is less than the Maximum Experimental Safety Gap of the second fluid (230).

19. Venturi-type mixing nozzle of any one of the preceding claims, wherein the first fluid (210) is air and the second fluid (230) is a combustible gas.

20. Venturi-type mixing nozzle of any one of the preceding claims, wherein the passage constriction (140) comprises a plurality of lateral inlet openings (220, 221), and wherein the at least one bluff body (150, 151) is arranged in the main flow passage (110) between the inlet end (120) and two or more of the plurality of lateral inlet openings (220, 221).

21. Venturi-type mixing nozzle of any one of the preceding claims, wherein the nozzle body central axis (290) is a plane of symmetry.

22. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one bluff body (150, 1415, 1425, 1435, 1445, 1455) has the shape of a saw tooth, a rounded unsymmetrical tooth, a pyramidal tooth, a dome, a conical tooth, or a wedge-type fin.

23. Venturi-type mixing nozzle of any one of the preceding claims, wherein the at least one bluff body (150, 151) extends in radial direction (107) of the main flow passage (110) at least partly from the nozzle body (105) towards the nozzle body central axis (290).

24. Venturi-type mixing nozzle of any one of the preceding claims, wherein the low pressure zone (240, 241) created by the at least one bluff body (150, 151) extends in the radial direction (107) of the main flow passage (110) from the at least one lateral inlet opening (220, 221) along the at least one bluff body (150, 151).

25. Combustion device with a Venturi-type mixing nozzle (100) according to any one of the preceding claims.

Fig. 1

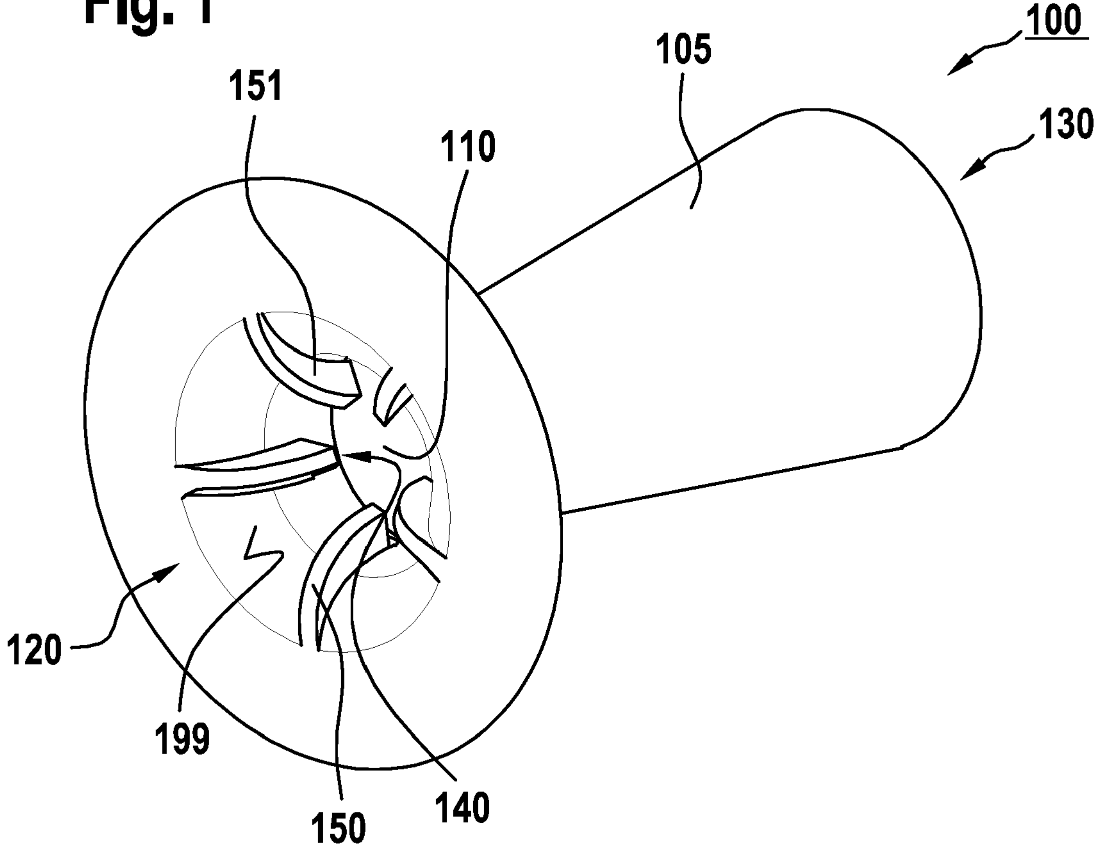

100
105
130
151
110
120
199
150
140

Fig. 2

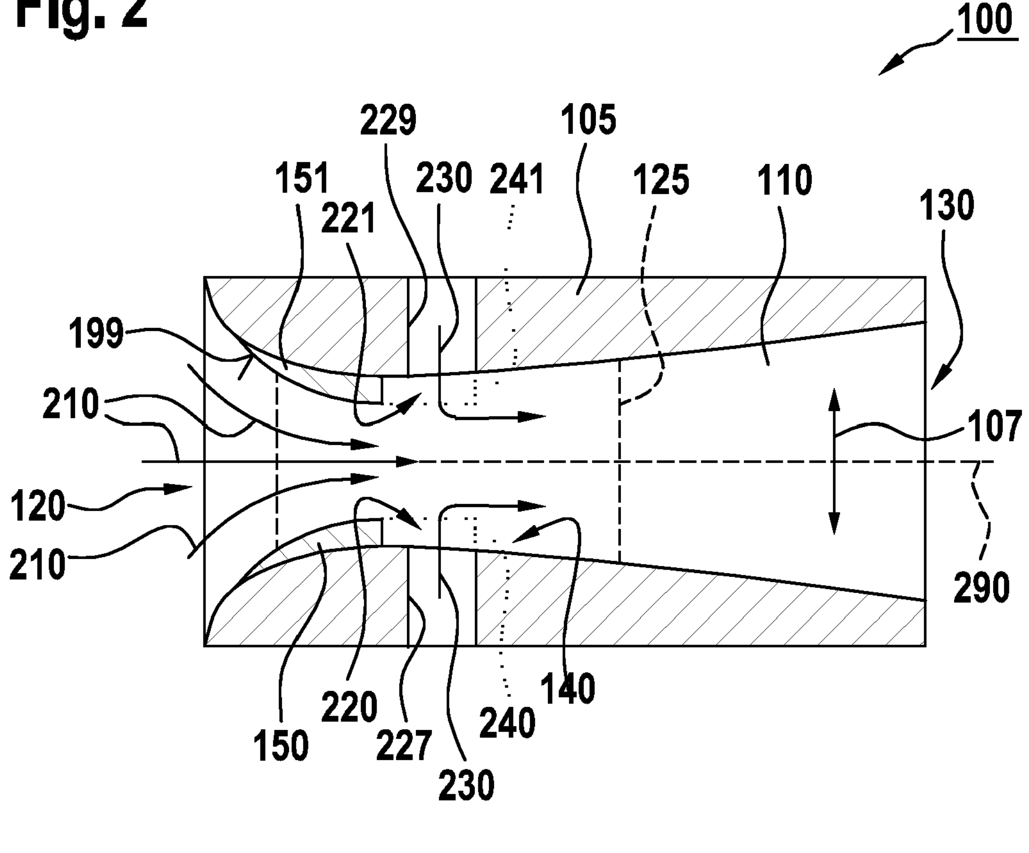

100
229
105
151
230
241
125
110
130
221
199
210
107
120
210
290
140
150
220
227
240
230

Fig. 3

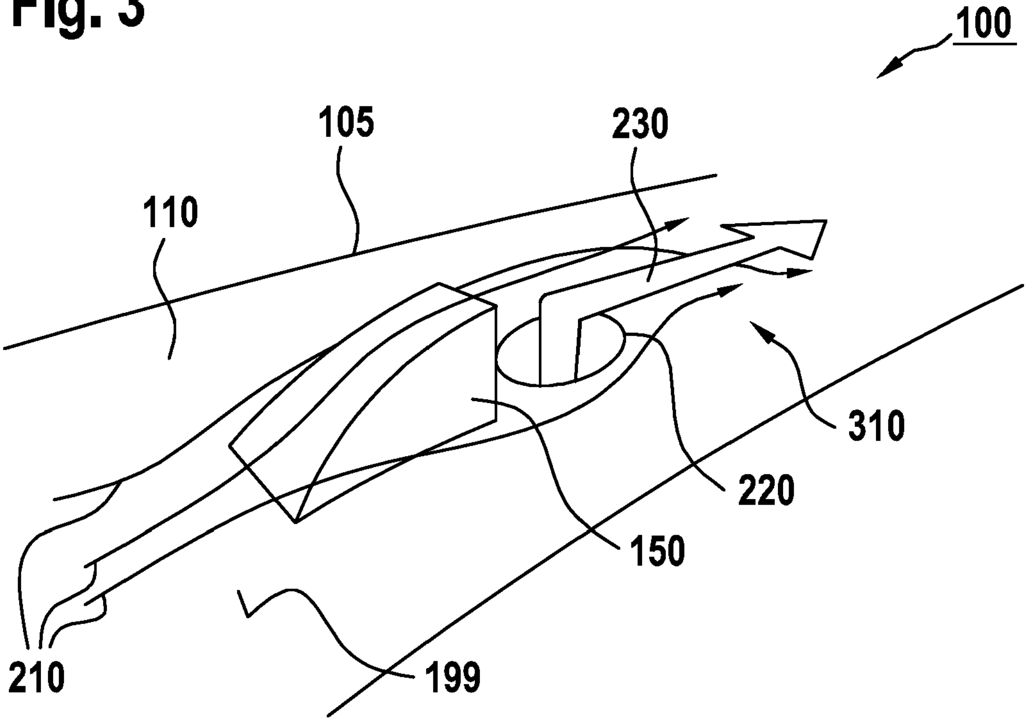

100
105
230
110
310
220
150
210
199

Fig. 4

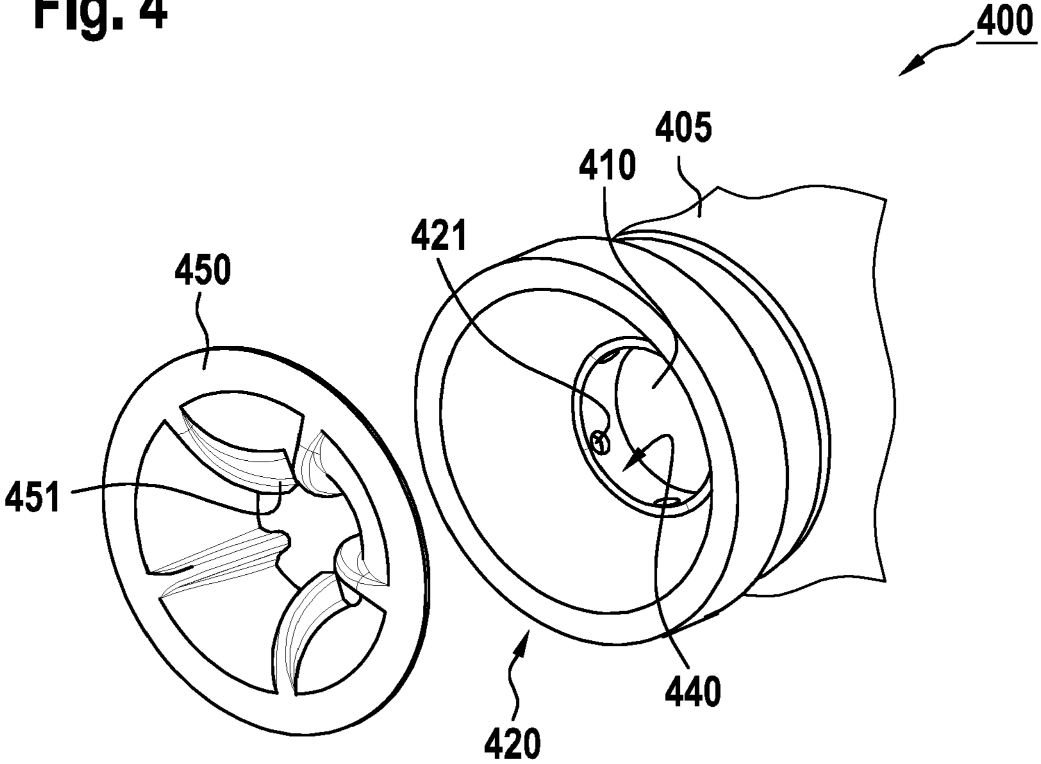

400
405
410
421
450
451
440
420

Fig. 5

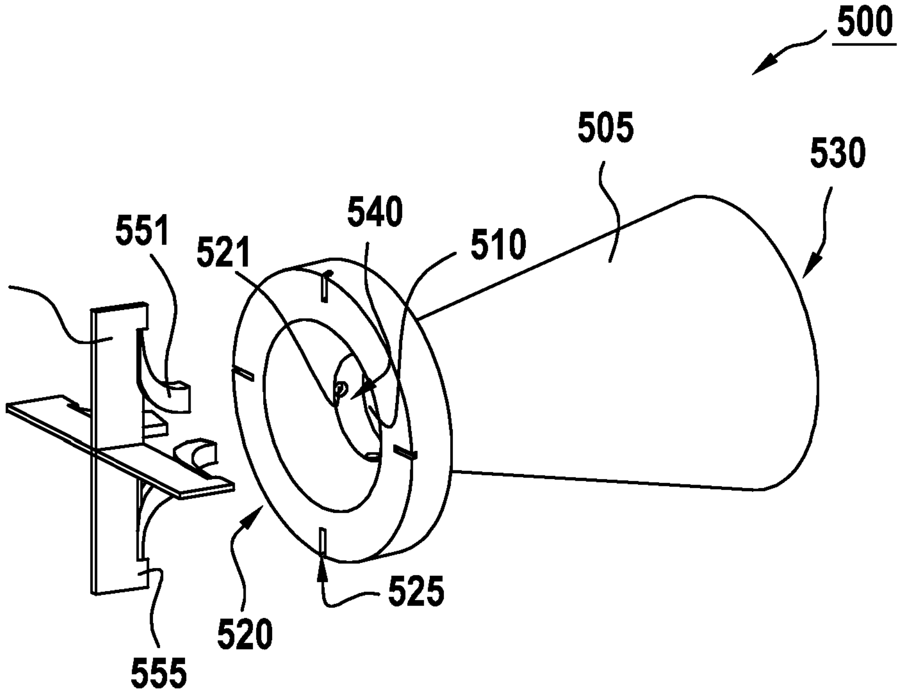

500
505
530
540
510
551
521
550
525
520
555

Fig. 6

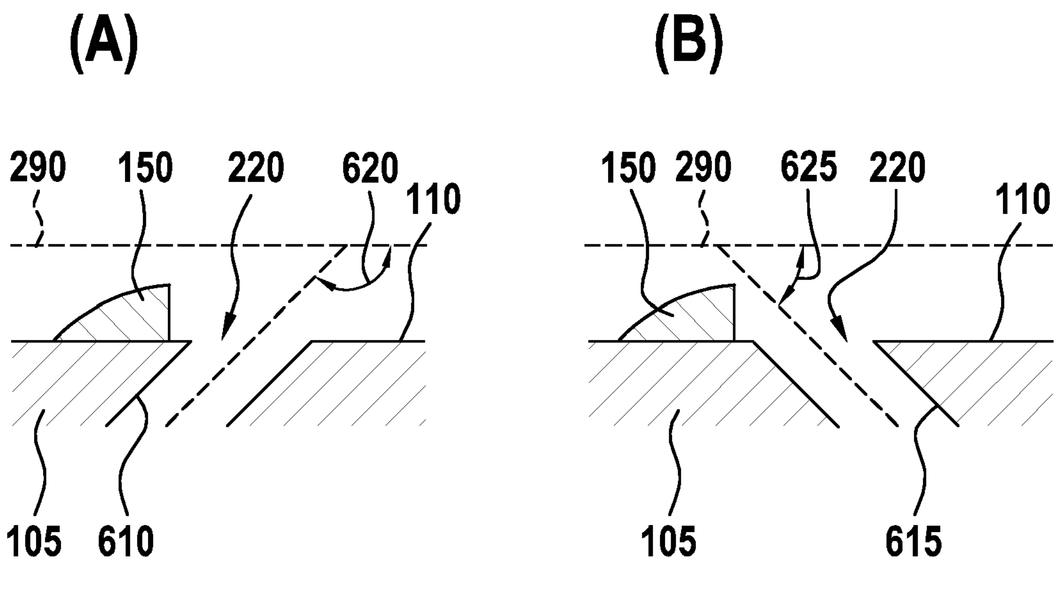

(A)
(B)
290
150
220
620
110
105
610
150
290
625
220
110
105
615

Fig. 7

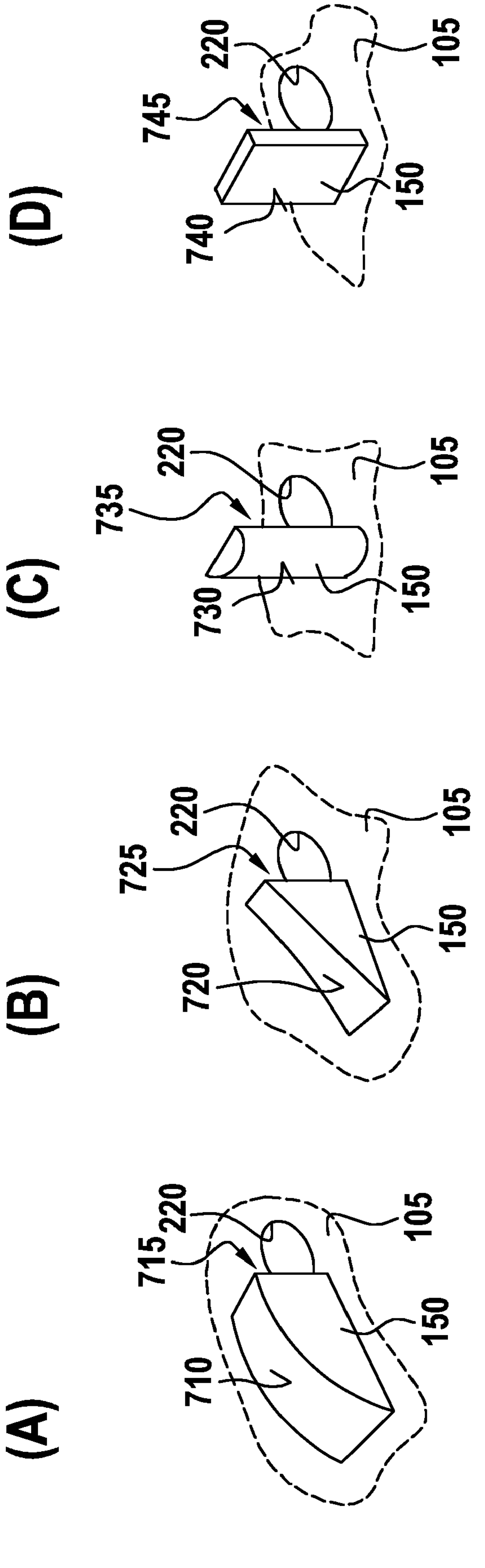

(A)
710
715
220
150
105
(B)
720
725
220
150
105
(C)
730
735
220
150
105
(D)
740
745
220
150
105

Fig. 8

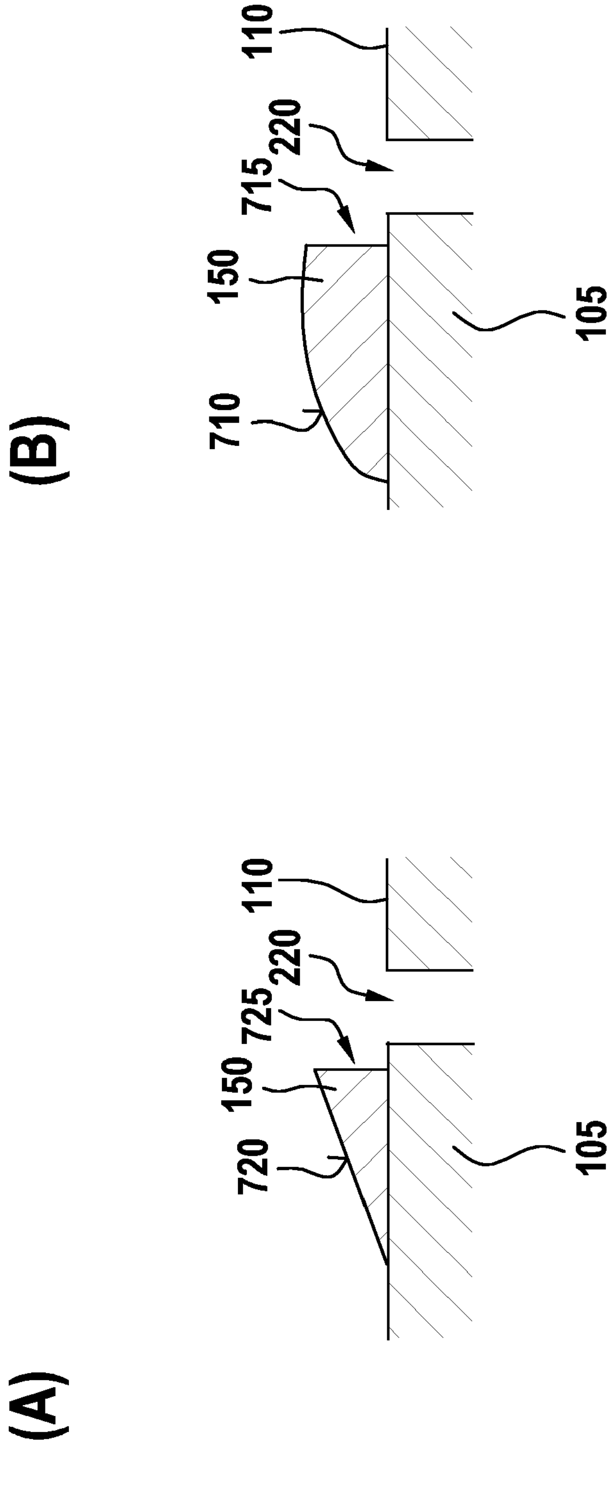


Fig. 9

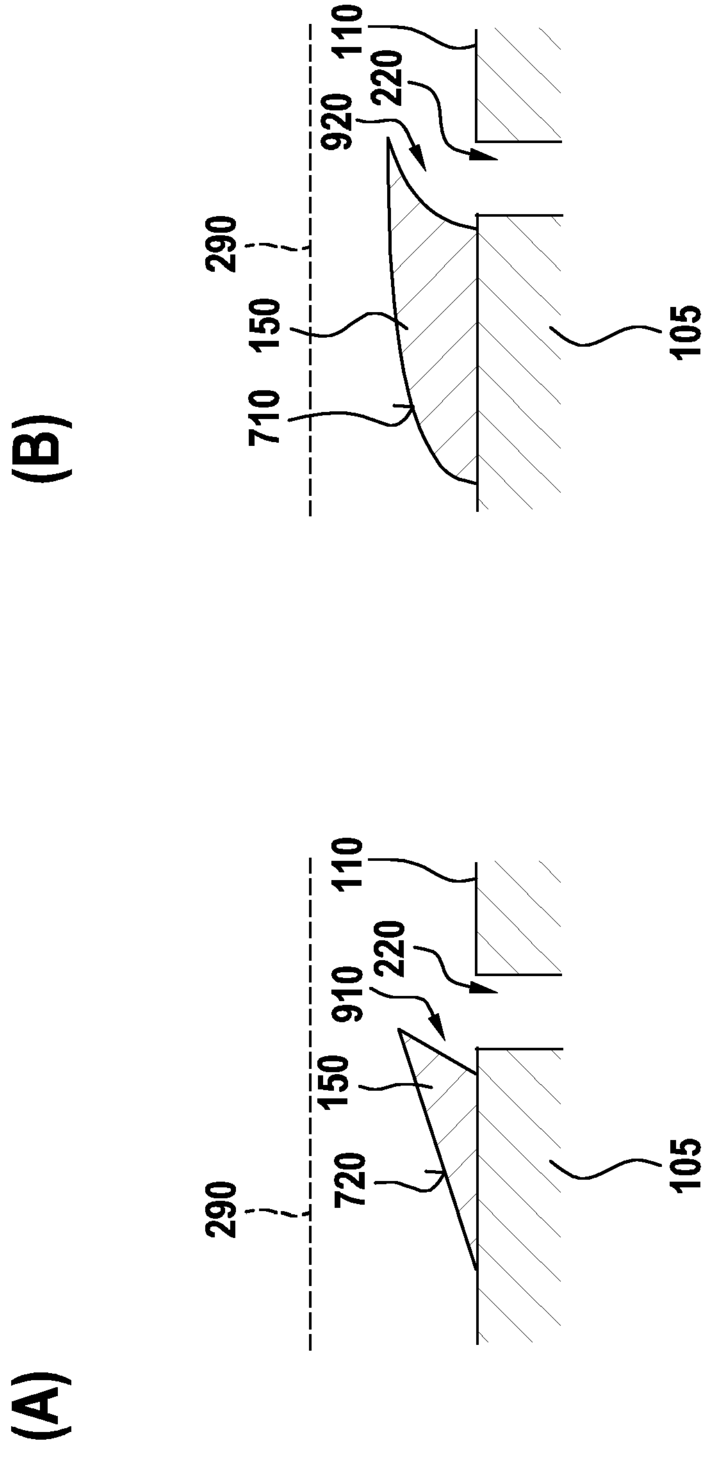


Fig. 10

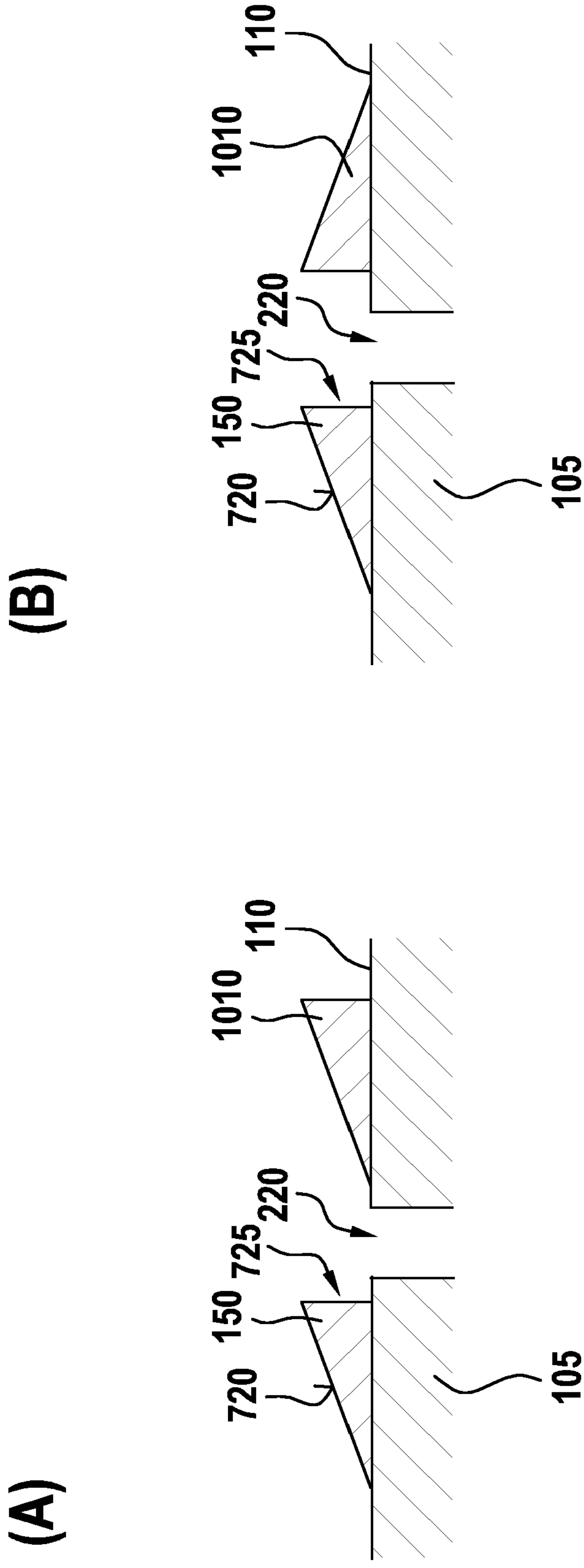


Fig. 11

(A)

(B)

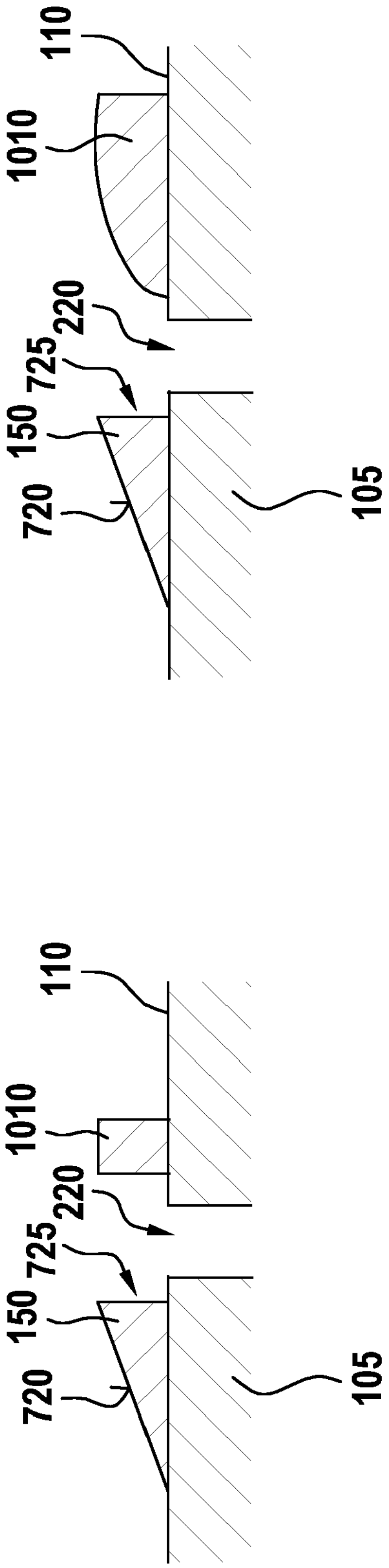


Fig. 12

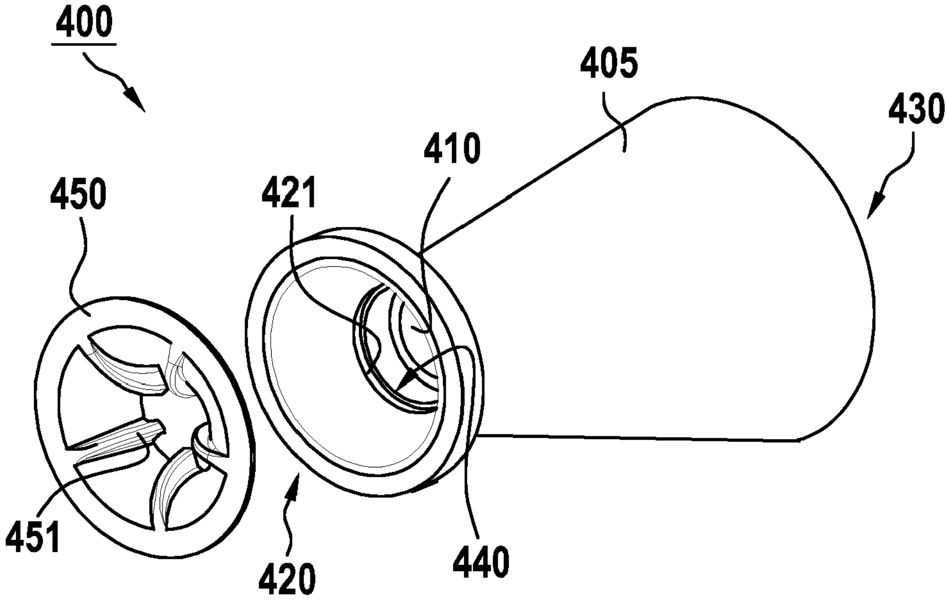

400
405
430
410
421
450
451
420
440

Fig. 13

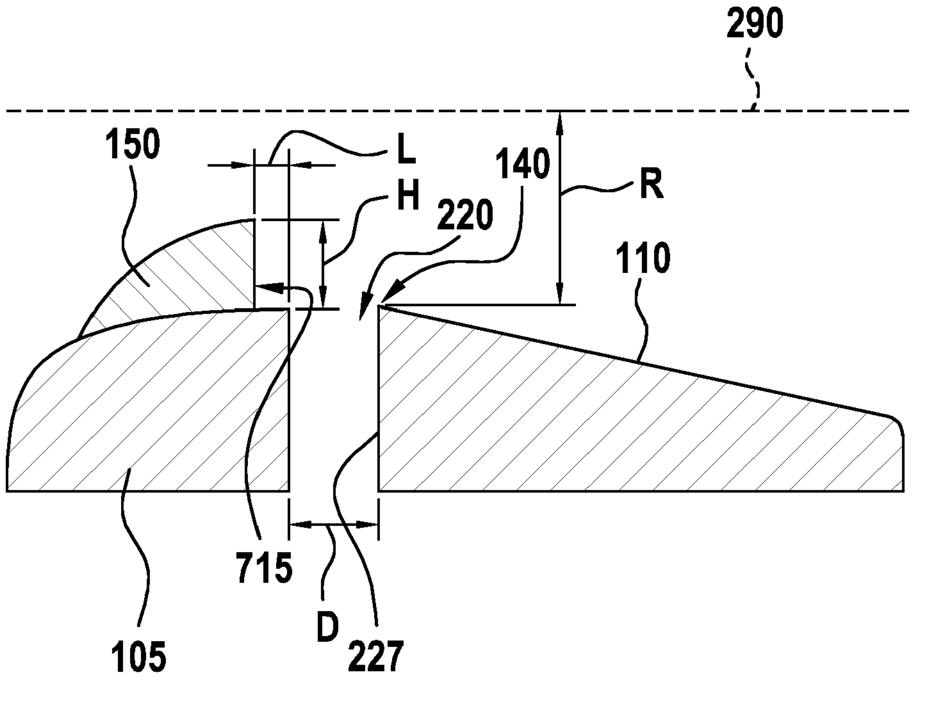
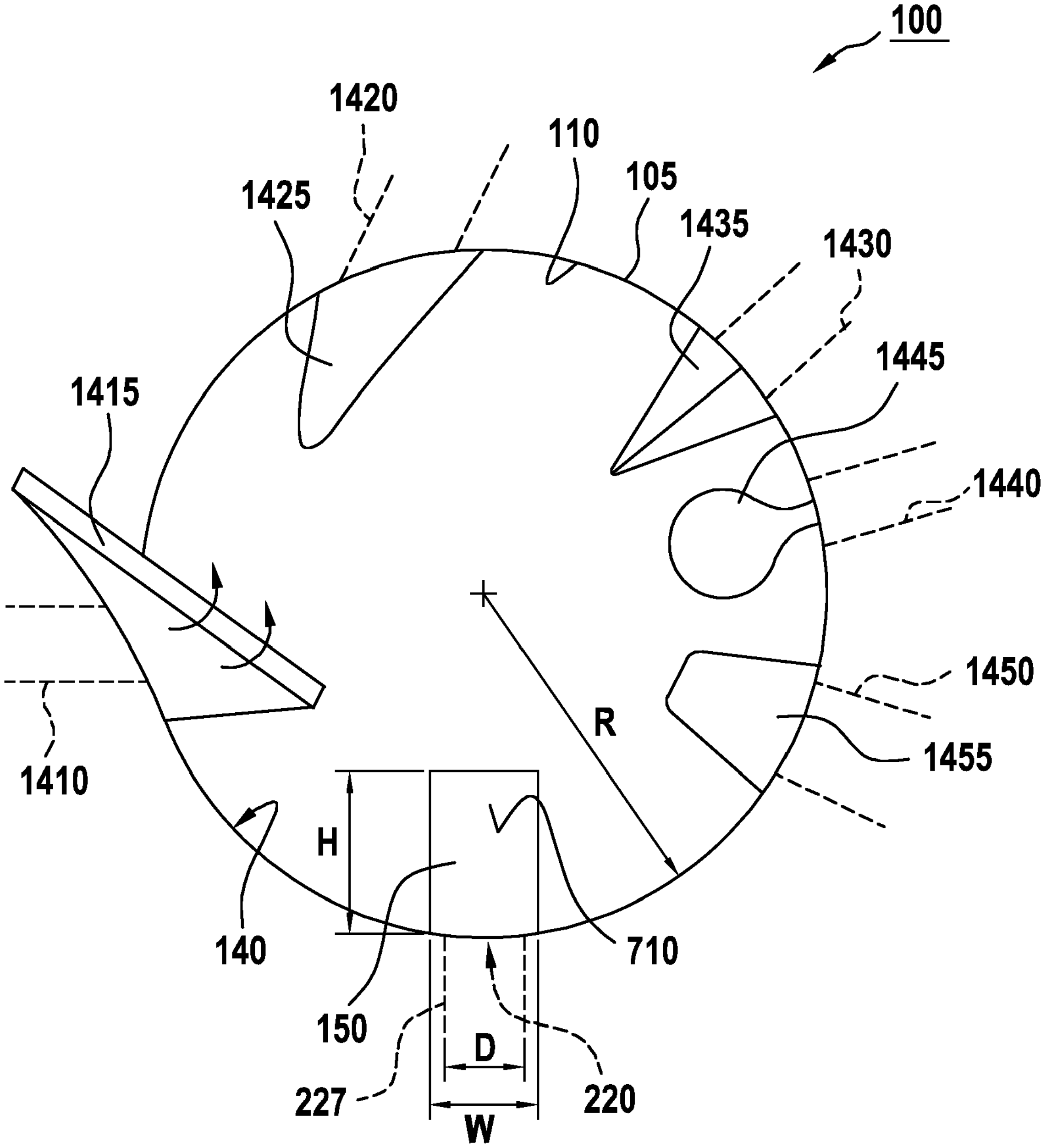

290
150
L
H
140
R
220
110
715
D
105
227

Fig. 14


100
1420
110
105
1425
1435
1430
1445
1415
1440
1450
R
1455
1410
H
140
710
150
D
227
220
W

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 17 4879

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 2006/245296 A1 (NISHIOKA AKIRA [JP] ET AL) 2 November 2006 (2006-11-02) * page 4, paragraph 57 - page 14, paragraph 135 * * figures 1-3, 6-13, 16-25 *	1-8, 11-13, 15-21, 23-25	INV. F23D14/62 F23D14/70 B01F5/04 B05B1/00
X	DE 100 19 414 A1 (XCELLSIS GMBH [DE]) 31 October 2001 (2001-10-31) * column 3, paragraph 26 - column 6, paragraph 48 * * figure 6 * * column 2, paragraph 17 *	1-6,9, 11-13, 17, 19-21, 23-25	
X	WO 02/18773 A1 (VARIVENT INNOVATIONS AB [SE]; BERGGREN GUSTAV [SE] ET AL.) 7 March 2002 (2002-03-07) * page 5, line 10 - page 8, line 11 * * figures 1, 4, 5 *	1,2,5,6, 13,17, 21,25	

TECHNICAL FIELDS SEARCHED (IPC)

F23D
B01F
B65D
B05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 October 2021	Rudolf, Andreas

2

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 21 17 4879

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-10-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006245296 A1	02-11-2006	EP 1716918 A1	02-11-2006
		JP 4989062 B2	01-08-2012
		JP 2006326571 A	07-12-2006
		US 2006245296 A1	02-11-2006
DE 10019414 A1	31-10-2001	NONE	
WO 0218773 A1	07-03-2002	AT 330119 T	15-07-2006
		AU 8280801 A	13-03-2002
		DE 60120721 T2	06-06-2007
		EP 1313939 A1	28-05-2003
		JP 2004507659 A	11-03-2004
		JP 2012154341 A	16-08-2012
		US 2004099257 A1	27-05-2004
		WO 0218773 A1	07-03-2002

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2018015130 A1 **[0002]**
- US 2017108213 A1 **[0003]**
- EP 3006827 A1 **[0003]**
- WO 2016194056 A1 **[0003]**