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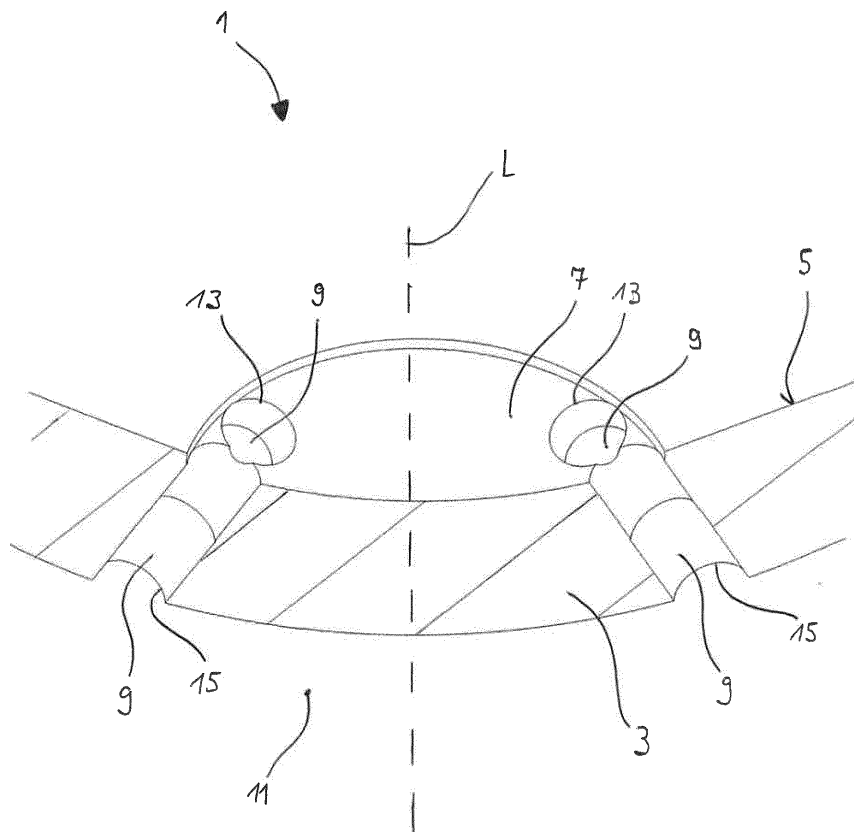
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(54) **Nozzle body, valve assembly and fluid injection valve**

(57) A nozzle body (3) for a fluid injection valve is disclosed. It comprises a wall (5) which forms a recess (7) of the nozzle body (3) and a plurality of flow holes (9) which penetrate the wall (5) from the recess (7) to an

outside area (11) of the nozzle body (3) to enable a streaming fluid pass through the wall (5). Two or more of the flow holes (9) share one common inlet opening (13).

FIG 3



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Description

[0001] The invention relates to an nozzle body for a fluid injection valve, to a valve assembly for a fluid injection valve and to a fluid injection valve for a combustion engine.

[0002] Fluid injection valves are in widespread use, in particular for combustion engines where they may be arranged in order to dose a fuel into an intake manifold of the combustion engine or directly into a combustion chamber of a cylinder of the combustion engine.

[0003] In general, a fluid injection valve has tough performance requirements to enable injection of accurate quantities of fluid and to fulfill pollution restrictions during an operation of the fluid injection valve and a corresponding combustion engine. Two main requirements are the ability to open at very high pressures, for example higher than 20 MPa, and to enable fast closing times in order to have a low flow and very low actuation time, for example less than 500 microseconds. In this context, closing times of fluid injection valves normally ranges between 200 and 800 microseconds, depending on application and pressure used during an operation of the respective fluid injection valve.

[0004] The mentioned requirements, for example concern hydraulic valves which can be solenoid or piezo actuated. In a solenoid injector a moving part, for example an armature and a needle, opens and closes an orifice or a nozzle to enable a fluid flow through the injector or to prevent it.

[0005] The injector for example opens due to a magnetic force generated by a coil and closes due to an elastic force given by a spring element wherein a hydraulic force also influences an opening and closing during an operation of the injector.

[0006] In this context, the magnetic force results from a magnetic circuit whose design is normally a tradeoff to enable a high force to open the injector even against high fluid pressure and to generate low inductance in order to have a fast response when the coil is deactivated to enable fast closing times. For example, the number of turns of the coil is one parameter to influence the possible opening pressure and the remaining inductance during operation of the injector. If the number of turns is high the induced magnetic force will be high but also the inductance.

[0007] One object of the invention is to create an nozzle body for a combustion engine to enable a reliable and accurate functioning of a fuel injection valve.

[0008] The object is achieved by the features of the independent claim. Advantageous embodiments of the invention are given in the dependent claims.

[0009] According to one aspect of the invention, a nozzle body for a fluid injection valve is specified. According to a further aspect, a valve assembly for the fluid injection valve is specified. The valve assembly comprises the nozzle body. For example, the nozzle body is fixed to a valve body of the valve assembly or it is in one piece with

the valve body. The valve assembly may further comprise a valve needle which is operable to prevent fluid flow out of the nozzle body in a closing position and to enable dispensing of fluid from the nozzle body in other positions.

According to yet another aspect, a fluid injection valve, in particular a fuel injection valve, for a combustion engine is specified. The fluid injection valve comprises the valve assembly and in particular an actuator assembly for actuating the valve needle

[0010] The nozzle body comprises a wall which forms a recess. The nozzle body further comprises a plurality of flow holes which penetrate the wall from the recess to an outside area - i.e. to an outer surface - of the nozzle body to enable a streaming fluid pass through the wall, in particular during an operation of the valve assembly or fluid injection valve, respectively. Moreover, two or more flow holes comprise one combined inlet, in particular to reduce a hydraulic force inside the nozzle during the operation of the nozzle body. In other words, two or more of the flow holes share one common inlet opening.

[0011] Such a configuration of the nozzle body describes a simple and reliable possibility to reduce the hydraulic force inside the nozzle body during an operation of the valve assembly or the fluid injection valve. In this context, the arrangement of the flow holes inside the nozzle has an important effect on the hydraulic force that is generated by the streaming fluid and acts, for example, on the valve needle. The described configuration of the at least two flow holes comprises one combined inlet that defines an entrance to the flow holes wherein each flow hole comprises an outlet that defines an exit of the corresponding flow hole which faces the outside area of the nozzle. Such an arrangement of the two or more flow holes can significantly reduce the hydraulic force that for example acts on a valve needle of the fluid injection valve comprising the nozzle body. It further enables to increase an absolute value of maximal fluid pressure where the nozzle body is still operable.

[0012] A velocity of the streaming fluid in a region proximate to the inlet of the flow holes is comparatively high so that the pressure of the fluid is reduced due to the fluid that enters the flow holes compared the fluid pressure in regions that are further away from the flow holes inside the nozzle body. Due to the arrangement of the flow holes according to the present disclosure, the fluid enters the common inlet opening with a comparatively low velocity so that the pressure drop in the region of the recess close to the flow holes is particularly small. Therefore, the resulting hydraulic force on the tip of the valve needle which pushes the valve needle to its closing position is particularly small.

[0013] For achieving the effect of reducing the hydraulic force, the flow holes have to have at least one more outlet opening than inlet openings. For instance two, three or four flow holes share one combined inlet but each flow hole comprises a separate outlet, the outlets being spaced from one another. In contrast, a number of flow holes as well as a shape and a positioning in refer-

ence to the longitudinal axis are variable.

[0014] Due to this elementary nozzle body there is no need for expensive electronic control systems which for example control the level of driving current of a coil of the actuator assembly in order to tune the magnetic force and the induced inductance. The described configuration of the flow holes of the nozzle body makes a contribution to realize rapid opening of the fluid injection valve and fast closing times and hence enables the fluid injection valve to accurately dose fluid for example. For this reason, by using the nozzle body according to the present disclosure, the electronic control for a magnetic circuit of the actuator assembly can be simplified or the functioning of the valve assembly or the injection valve can be increased concerning its flexibility.

[0015] According to one embodiment, one combined inlet comprises two or more outlets corresponding to the two or more flow holes of the nozzle. In other words, each of the two or more flow holes which share one common inlet opening comprises an individual outlet opening. The flow holes in particular extend in mutually different directions from the common inlet opening to their individual outlet openings. In this way, a particularly advantageous spray distribution is achievable.

[0016] This embodiment of the invention may describe one possible configuration of the two or more flow holes which share one combined inlet. In case of three or four symmetrically arranged flow holes each with circular shape sharing one combined inlet its shape may be compared to a trifoliate or four-leaved shamrock with respect to a top view substantially in direction of the longitudinal axis.

[0017] According to a further embodiment of the first aspect, the nozzle body comprises two or more combined inlets each corresponding to respective two or more flow holes which are arranged symmetrically with respect to the longitudinal axis. In other words, the nozzle body comprises a plurality of groups of two or more flow holes. The flow holes of each group share a common inlet opening and have individual outlet openings. The common inlet openings are circumferentially distributed - in particular evenly circumferentially distributed - on the wall around the longitudinal axis.

[0018] According to a further embodiment, the two or more combined inlets are circularly arranged around the longitudinal axis. In other words, they are arranged along an imaginary circle around the longitudinal axis. In particular, they are evenly distributed on the imaginary circle. "Arranged on the circle" and "evenly distributed on the circle" in particular refers to the position of a geometric center of gravity of the inlet openings in the present context.

[0019] The positioning of the two or more inlets describes one possible symmetrical arrangement of the flow holes and the nozzle body. This exemplary embodiment might be advantageous for manufacturing reasons and for a combustion process due to a symmetrical fluid spray out of the nozzle into a combustion chamber of a

combustion engine. For example, there are three separate inlets arranged on an imaginary circle around the longitudinal axis, each inlet defines the entrance to two flow holes and, hence there are six outlets facing the outside area of the nozzle one for each flow hole. In addition, there may be three more separate inlets arranged on another imaginary circle around the longitudinal axis to have overall twelve separate outlets corresponding to twelve flow holes and six combined inlets.

[0020] According to a further embodiment, the two or more flow holes have a circular cross-sectional shape and the corresponding one or more shared inlet openings comprise a shape formed by an overlap of the circular cross-sectional shapes of the two or more flow holes.

[0021] This embodiment of the nozzle body describes a possible shape of the flow holes and the corresponding combined inlet or inlets. If there are, for example, two circularly shaped flow holes which share one combined inlet, the shape of the inlet may describe the shape of a figure eight without a stroke in the middle - in other words a bar-bell shape - with respect to a top view substantially in direction of the longitudinal axis.

[0022] If there are, for example, three or four flow holes arranged which share one combined inlet, the shape of the inlet might be comparable to the shape of a trifoliate or four-leaved shamrock respectively.

[0023] Exemplary embodiments of the invention are explained in the following with the aid of schematic drawings and reference numbers. Identical reference numbers designate elements or components with identical functions. The figures show:

- | | |
|-----------------|---|
| Figure 1 | exemplary embodiment of a fuel injection valve; |
| Figure 2 | a nozzle body for a fuel injection valve; |
| Figure 3 | a perspective view of the nozzle body for a fuel injection valve; |
| Figures 4a - 4b | a top view of a nozzle body for a fuel injection valve; and |
| Figures 5a - 5b | a perspective view of the nozzle body for a fuel injection valve. |

[0024] Figure 1 shows an exemplary embodiment of a fluid injection valve 20 which comprises an O-ring 22, a valve body 24, a spring element 26 and a coil 28. The fluid injection valve 20 further comprises a valve needle 21, a longitudinal axis L and a flow direction D which substantially describes the direction of a streaming fluid during an operation of the fluid injection valve 20.

[0025] The valve needle 21 may be connected to an armature and is axially movable in reference to the valve body 24 and with respect to the longitudinal axis L. By interaction with valve seat comprised by a nozzle body

3, the valve needle 21 prevents a fluid flow through the fluid injection valve 20 in a closed position or otherwise enables it.

[0026] The valve needle 21 is displaced from the closing position by means of a magnetic force generated by the coil 28 and moved to the closing position due to an elastic force given by the spring element 26 wherein a hydraulic force of the fluid in the fluid injection valve 20 also influences the opening and closing during an operation of the fluid injection valve 20.

[0027] The fluid injection valve 20 further comprises a valve assembly 1 which comprises the nozzle body 3. The nozzle body 3 has a wall 5 which forms a recess 7 and has an outside area 11 remote from the recess 7. More detailed illustrations of the nozzle body 1 will be described below with respect to figure 2 to 5.

[0028] In figure 2 one exemplary embodiment of the valve assembly 1 is illustrated wherein the nozzle body 3 comprises four flow holes 9 which penetrate the wall 5 of the nozzle 3 from the recess 7 to the outside area 11. The entrances of the flow holes 9 are defined by two inlet openings - in short "inlets" - 13. The flow holes 9 form two groups with two flow holes 9, each. Each group of flow holes 9 shares one of the inlets 13, whereas each flow hole 9 comprises one separate, individual outlet opening - in short "outlet" - 15. Hence, respective two flow holes 9 comprise one combined inlet 13 whereas each flow hole 9 comprises one corresponding separate outlet 15, the outlets 15 being formed with a distance to one another.

[0029] Such an arrangement of the flow holes 9 entrances, i.e. the inlets 13, at the inside of the nozzle body 3 has the effect that the hydraulic force that is generated by a streaming fluid and for example acts on the valve needle 21 during an operation of the fluid injection valve 20 is particularly small. It further enables to increase an absolute value of maximal fluid pressure where the valve assembly 1 or the fluid injection valve 20 is still operable.

[0030] Because of this configuration of the flow holes 9, a velocity of the streaming fluid in a region proximate to the inlets 13 of the flow holes 9 is only increased to a small extent and the pressure drop - compared to the pressure in regions that are further away from the flow holes 9 in the recess 7 inside the nozzle body 3 - is particularly small. This results in a particularly small hydraulic force that pushes a valve needle 21 towards its closing position.

[0031] The fluid pressure in the inlets 13 is thus increased to be closer to a feeding pressure of the fluid for example supplied by a rail, as compared to a configuration with flow holes having individual inlet openings. This leads to a reduction of the total hydraulic load acting on the needle 21 of the fluid injection valve 20 and hence increases the possible useable maximal fluid pressure.

[0032] Hence, the described configuration of the nozzle body 3 realizes in a simple and competitive way a reduction of the hydraulic force inside the nozzle body 3 during an operation of the valve assembly 1 and the fluid

injection valve 20. The nozzle body 3 enables a reliable and secure functioning of the fluid injection valve 20 to open at high pressures and at the same time it enables fast closing times for example in order to dose fluid accurately. In this context, samples have been constructed to prove the above mentioned configuration and an increase of around 20 bar of the maximal useable fluid pressure has been measured.

[0033] Using such an arrangement of the nozzle body 3 further enables to simplify an electronic control, for example of the coils 28 and the magnetic circuit, or it increases a flexibility in a way that the electronic control does not have to be adapted in a way that the driving current has to be high at high pressures and low at low pressures to induce a low inductance for example. Hence, it is not necessary to include an expensive and difficult control system for controlling the fluid injection valve 20.

[0034] In figure 3 the nozzle body 1 of figure 2 is illustrated in a perspective sectional view to illustrate the combined inlets 13 of the four flow holes 9. It is apparent that the two respective inlets 13 of the four flow holes 9 comprise a combined shape with a constriction in the middle but no separation by a wall for instances.

[0035] For achieving the effect of reducing the hydraulic force, the nozzle body 3 has to comprise at least one more outlet 15 than combined inlets 13 of the flow holes 9. In this exemplary embodiment there are groups of two flow holes 9 which share one combined inlet 13. But it is also possible that three or four flow holes 9 share one combined inlet 13 wherein each flow hole 9 comprises one separate outlet 15, the outlets 15 being spaced from one another. A number of flow holes 9 as well as a shape and a positioning in reference to the longitudinal axis L are variable and hence other embodiments are possible, too.

[0036] Figures 4a and 4b illustrate another exemplary embodiment of the nozzle body 3. Fig. 4a shows a top view along the longitudinal axis L from an inside of the fluid injection valve 20. In this embodiment, six flow holes 9 are symmetrically arranged along an imaginary circle around the longitudinal axis L. As already mentioned, each flow hole 9 comprises one separate outlet 15 that is shifted in radial and angular direction with respect to the longitudinal axis L relative to the corresponding common inlet 13. In this example, respective two flow holes 9 share one combined inlet 13 which has an 8-form without a stroke in the middle, i.e. the shape of the outer contour of an "8" or a bar-bell shape. With respect to the top view in direction of the longitudinal axis L the three inlets 13 substantially describe an isosceles triangle.

[0037] In figure 4b the nozzle body 3 of figure 4a is illustrated, but in an isometric view on the outside area 11 of the nozzle 3. In this view, the six individual and mutually distanced outlets 15 of the six flow hole 9 are visible.

[0038] Figures 5a and 5b show another exemplary embodiment of the nozzle body 3 in a longitudinal section

view. In Figure 5a two flow holes 9 are arranged which penetrate the wall 5 of the nozzle body 3 from the recess 7 to the outside area 11 and which share one combined inlet 13 the shape of which resembles a figure eight. The two corresponding outlets 15 are formed with space from each another.

[0039] In figure 5b another exemplary embodiment of arranging two flow holes 9 of the nozzle body 1 is illustrated. In this example the flow holes 9 comprise a rectangular shape and again they share one combined inlet 13 and two separated outlets 15.

7. Fluid injection valve comprising a valve assembly (1) according to the preceding claim.

Claims

1. Nozzle body (3) for a fluid injection valve, the nozzle body (3) comprising a wall (5) which forms a recess (7) of the nozzle body (3) and a plurality of flow holes (9) which penetrate the wall (5) from the recess (7) to an outside area (11) of the nozzle body (3) to enable a streaming fluid pass through the wall (5), wherein two or more of the flow holes (9) share one common inlet opening (13). 15
2. Nozzle body (3) in accordance with claim 1, wherein 25
 - each of the two or more flow holes (9) which share one common inlet opening (13) comprises an individual outlet opening (15). 30
3. Nozzle body (3) in accordance with one of the preceding claims, wherein 35
 - the nozzle body (3) comprises a plurality of groups of two or more flow holes (9) 40
 - the flow holes (9) of each group share a common inlet opening (13) and have individual outlet openings (15), and 45
 - the common inlet openings (13) are circumferentially distributed on the wall (5) around a longitudinal axis (L). 50
4. Nozzle body (1) in accordance with claim 3, wherein the combined inlets (13) are arranged along an imaginary circle around the longitudinal axis (L) and in particular evenly distributed on the circle in angular direction. 55
5. Nozzle body (1) in accordance with one of the preceding claims, wherein the two or more flow holes (9) have a circular cross-sectional shape and the shared common inlet opening (13) has a shape formed by an overlap of the circular cross-sectional shapes of the two or more flow holes (9). 60
6. Valve assembly (1) for a fluid injection valve comprising a nozzle body according to one of the preceding claims. 65

FIG 1

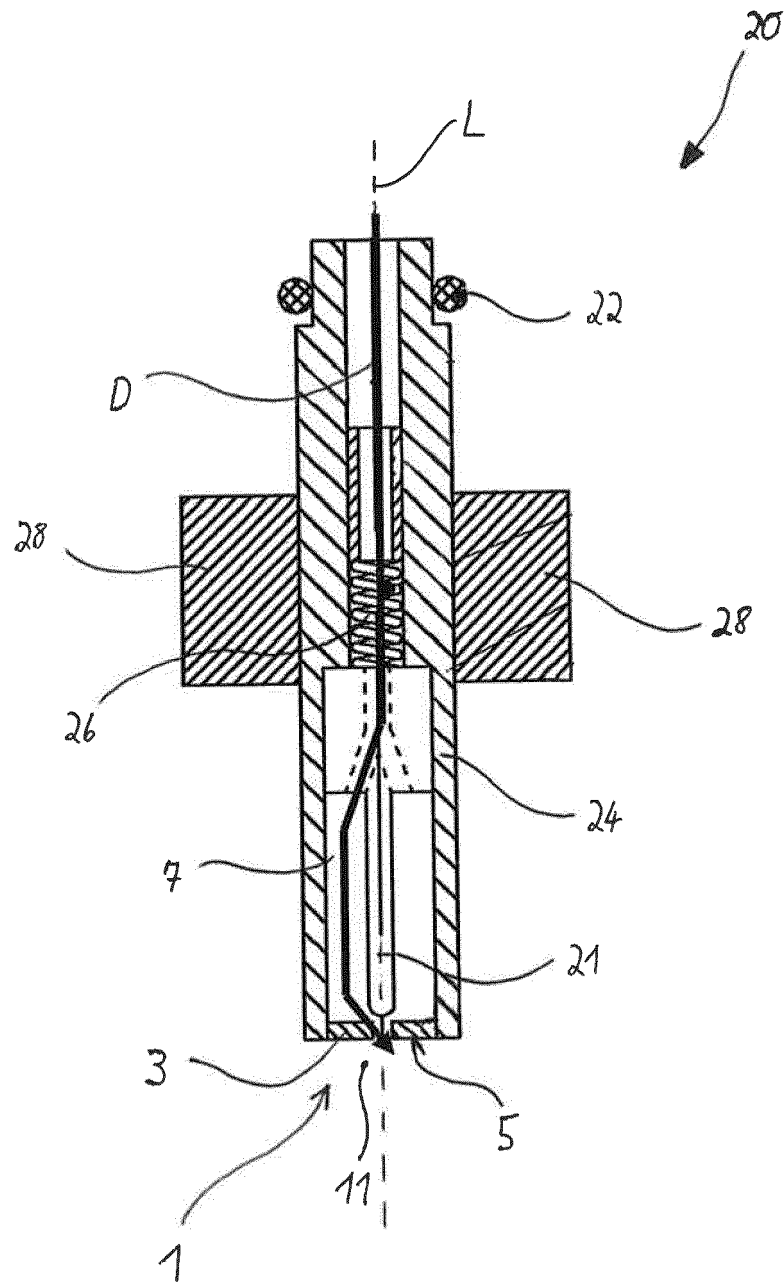


FIG 2

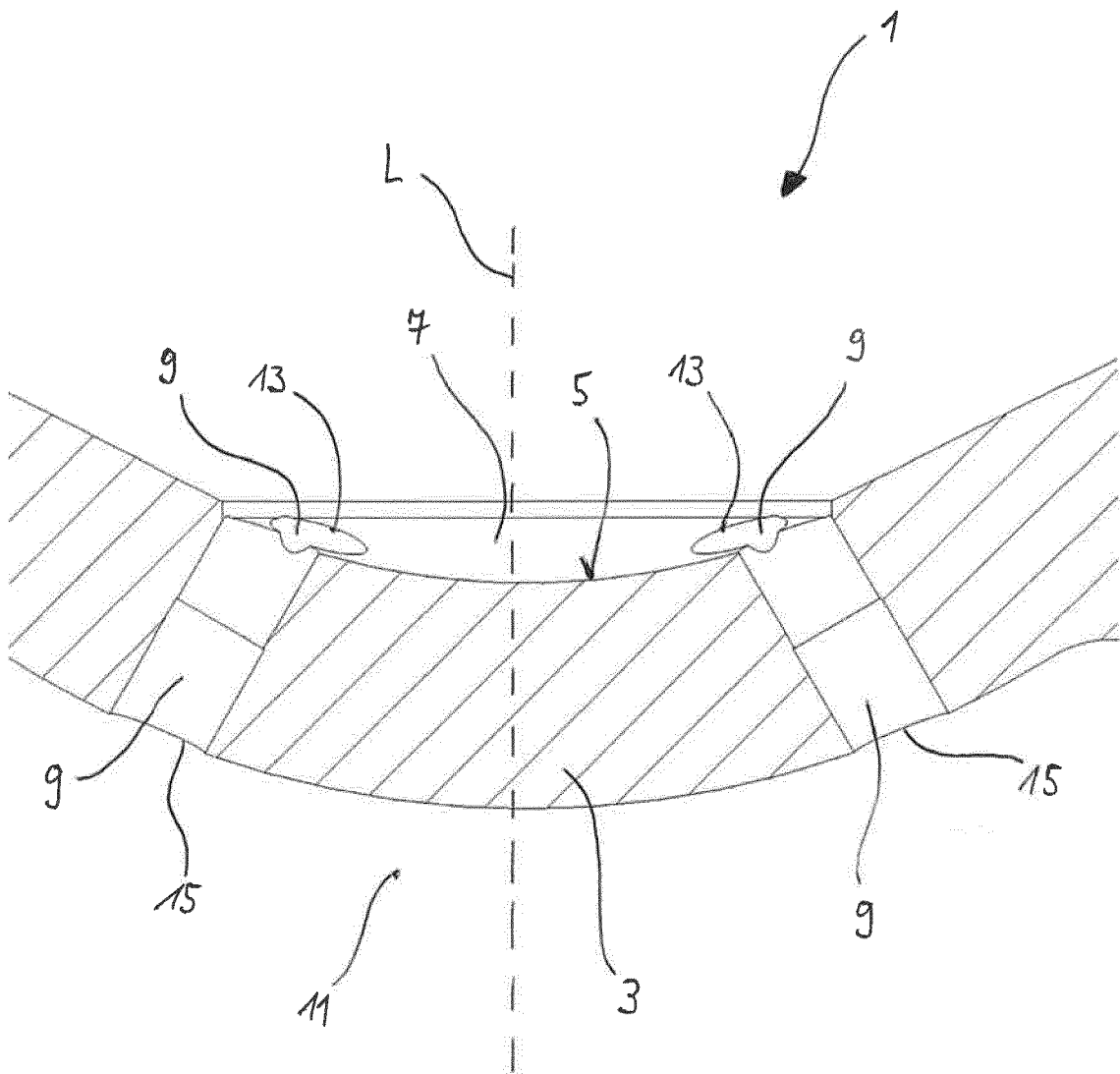


FIG 3

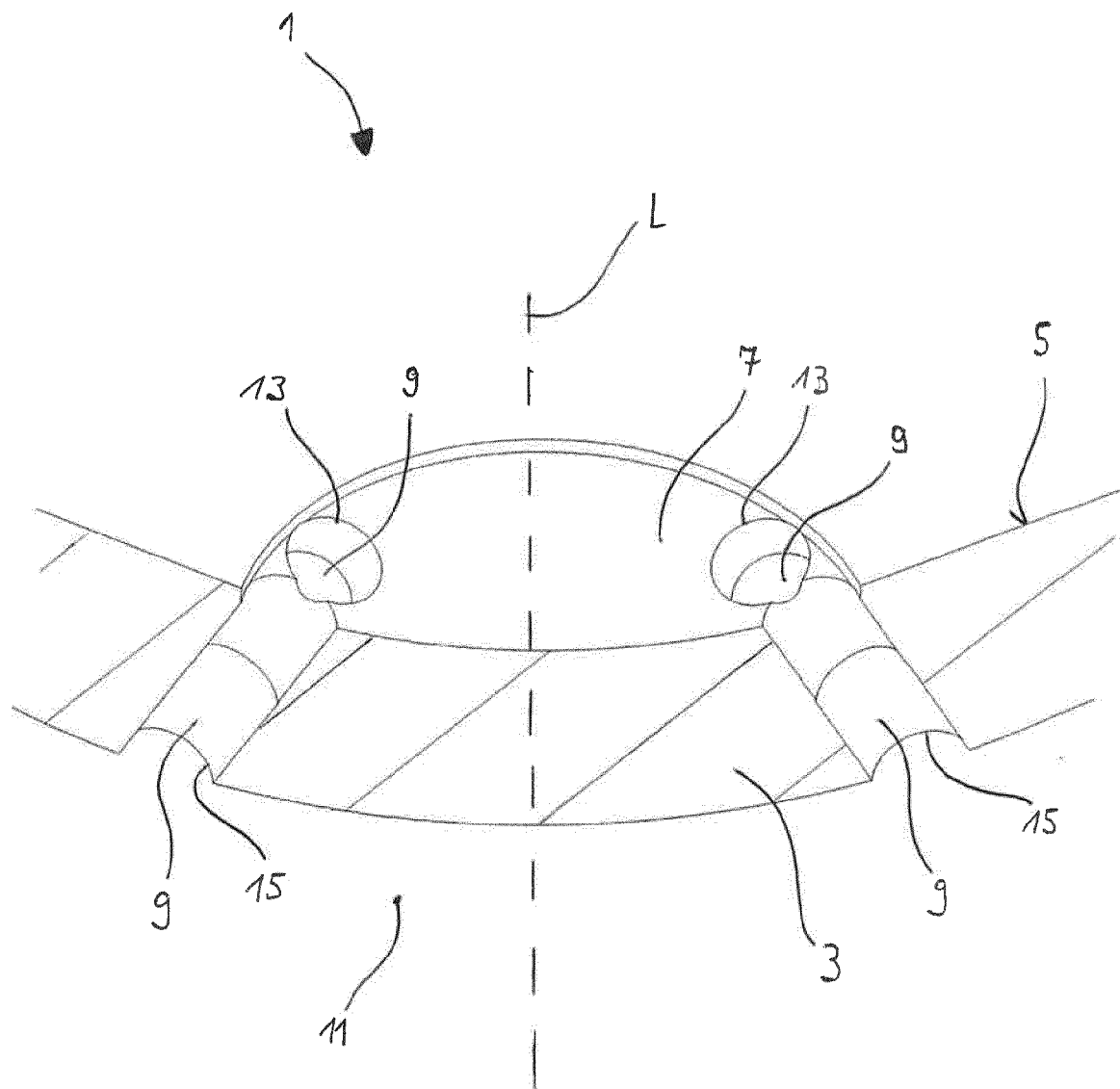


FIG 4a

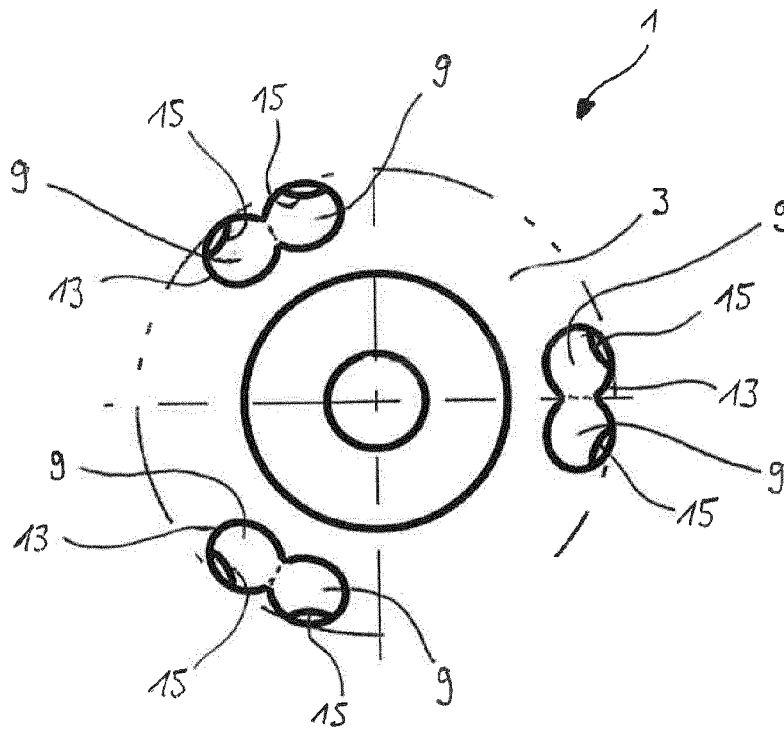


FIG 4b

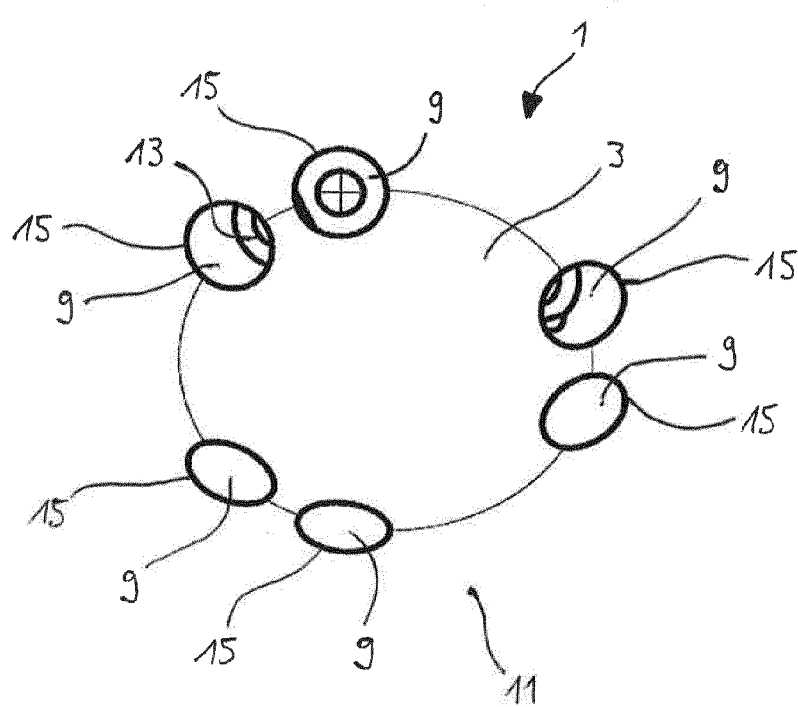


FIG 5a

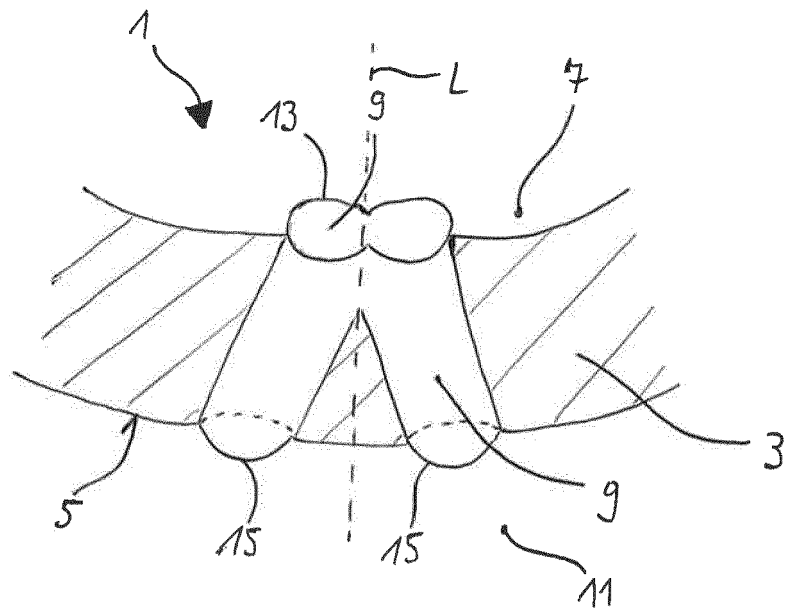
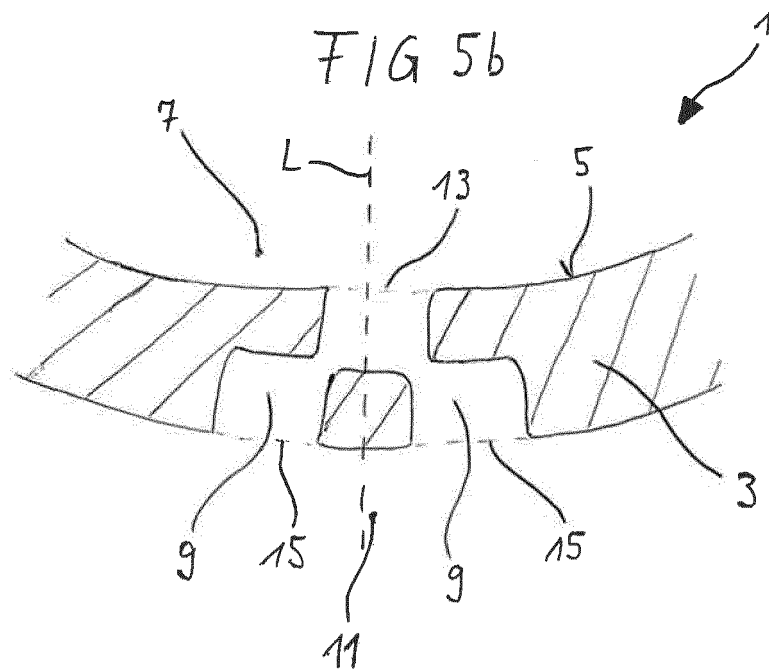


FIG 5b





EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 23 January 2015	Examiner Hermens, Sjoerd
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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