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(54) **Filter for a fuel injection valve, fuel injection valve and method for producing a filter for a fuel injection valve**

(57) A filter for a fuel injection valve (100) comprises a filter sleeve (102) formed integrally and consisting of a metal, the filter sleeve (102) comprising:
- a first part (103), the first part (103) being designed for being in direct contact with an element (114) of the fuel injection valve (114),
- a second part (104), the second part (104) comprising a multitude (106) of filter holes (105) reaching from an outside of the filter sleeve to an inside (113) of the filter sleeve.

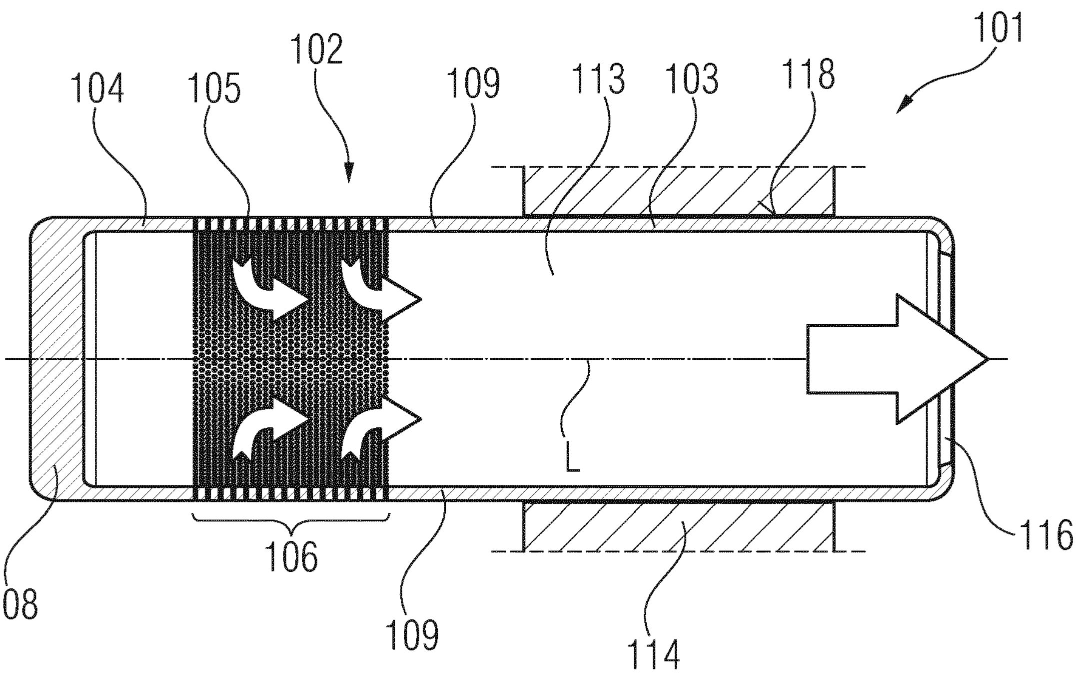

FIG 3

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Description

[0001] The invention relates to a filter for a fuel injection valve, a fuel injection valve and a method for producing a filter for a fuel injection valve.

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

[0003] Injection valves are manufactured in various forms in order to satisfy the various needs for the various combustion engines. Therefore, for example, their length, their diameter, and all the various elements of the injection valve being responsible for the way the fluid is dosed may vary in a wide range. In addition to that, injection valves can accommodate an actuator for actuating a needle of the injection valve, which may be, for example, an electromagnetic actuator or a piezoelectric actuator.

[0004] In order to enhance the combustion process in view of degradation of unwanted emissions, the respective injection valve may be suited to dose fluids under high pressures. The pressures may be in case of a gasoline engine, for example, in the range of up to 500 bar, and in case of a diesel engine, in the range of 2500 bar, and above.

[0005] In addition, in order to enhance the combustion process and/or to reduce the risk of malfunction, an injection valve normally comprises a fuel filter for filtering the fluid, and it also may comprise an adjusting member for adjusting the maximal load of a calibration spring of the injection valve. Filtering the fuel is necessary for keeping possible impurities of the fuel off from the needle and off from the injection nozzle. For these purposes it is known to provide a so-called adjusting fuel filter assembly comprising three parts: a frame, a bush, and a screen. Such an adjusting fuel filter assembly cooperates with a spring, which preloads the valve needle.

[0006] It is an object of the present disclosure to specify a filter for a fuel injection valve that is simple to be manufactured and which facilitates a reliable and precise function and a method for producing the filter.

[0007] This object is achieved by a filter for a fuel injection valve and a method having the features of the respective independent claims. Advantageous embodiments and developments of the filter, the fuel injection valve and the method are specified in the dependent claims and in the description.

[0008] A filter for a fuel injection valve is specified. The filter comprises a filter sleeve. The filter sleeve consists of a metal. The filter sleeve is formed integrally. That the filter sleeve is formed integrally means in particular that it consists of a single piece; it is in particular not assembled from a plurality of separately manufactured parts. The filter sleeve is preferably free of brazed or welded joints, of adhesive joints, of overmolded parts and the like.

[0009] The filter sleeve comprises a first part and a second part. The first and second parts are preferably arranged subsequent to one another along a longitudinal axis of the filter sleeve. The longitudinal axis of the filter sleeve may coincide with the longitudinal axis of the injection valve.

[0010] The first part is designed for being in direct contact with an element of the fuel injection valve. In other words, the first part is operable to contact another component of the injection valve when the filter is installed in the injection valve, i.e. when the fuel injection valve is assembled. In particular, the filter is operable to establish a press-fit connection with the other component of the injection valve by means of the first part being in direct contact with the other component. With advantage, the filter may comprise a seat for a calibration spring of the injection valve in this way. The calibration spring is in particular operable to bias a valve needle of the injection valve towards a closing position. For example, the calibration spring forces the valve needle against a valve seat of the injection valve.

[0011] The second part that comprises a multitude of filter holes reaching from an outside of the filter sleeve to an inside of the filter sleeve. Preferably, the second part of the filter sleeve is spaced apart from the other components of the fuel injection valve when the filter is installed in the fuel injection valve.

[0012] Since the filter sleeve is made of metal, the filter sleeve has a good chemical resistance. For example, the filter sleeve is made of stainless steel. Therefore, the filter sleeve has a good chemical resistance against aggressive fuels.

[0013] According to further embodiments the filter holes of the multitude of filter holes comprise a mean diameter of 30 μm. According to further embodiments the filter holes comprise a different mean diameter, for example 20 μm or 40 μm. According to embodiments the filter holes comprise a mean diameter between 10 μm and 200 μm.

[0014] Since the filter sleeve is formed integrally and consists of a metal, the desired hole diameter of the filter holes and the number of filter holes can be defined depending on a desired filtering functionality. Further, the pitch among each filter hole of the multitude of filter holes can be defined in order to preserve a desired structural resistance for the filter sleeve.

[0015] According to further embodiments the filter sleeve has the shape of a hollow cylinder, which also can be denoted as a cylinder shell. One end base of the hollow cylinder is closed and the multitude of filter holes is located at the lateral side of the filter sleeve - in other words, the filter holes penetrate at least a portion of a circumferential side wall of the hollow cylinder. It is possible to position the multitude of filter holes at a desired position on the filter sleeve.

[0016] According to further embodiments, the filter sleeve comprises a projecting part and the first part is located at the projecting part. The projecting part in particular projects radially - i.e. in particular perpendicular to the longitudinal axis - beyond the second part. For example, the first part has a lateral edge portion which extends radially beyond the second part - and in particular extends completely circumferentially around the second part - in top view along the longitudinal axis. Thus, an outlet flow through the filter holes in a radial direction is possible although the first part is configured to contact directly another component of the injection valve.

[0017] According to a further aspect of the invention, a fuel injection valve comprises a filter as previously described. The first part of the filter sleeve is in direct contact with the element of the fuel injection valve. For example, the element of the fuel injection valve is a pole piece of an electromagnetic actuator of the fuel injection valve. It is also conceivable that the element with which the first part is in direct contact is a valve body of the fuel injection valve. In one development, the pole piece may be formed in one piece with the valve body. Preferably, the filter sleeve is received in an opening of the pole piece or of the valve body. It is possible to design the fuel injection valve with one equal diameter for the opening inside the element in which the filter sleeve is arranged. Thus, the manufacturing of the fuel injection valve is inexpensive.

[0018] According to further embodiments, the fuel injection valve comprises a fuel inlet and a fuel outlet. The opening in the element, in particular in the pole piece or the valve body, may expediently make part of an interior cavity of the injection valve which hydraulically connects the fluid inlet of the injection valve to the fluid outlet of the injection valve.

[0019] According to some embodiments the fuel flow is directed from the inside of the filter sleeve through the filter holes to the fuel outlet. Thus, an outlet flow in a radial direction is possible.

[0020] According to further embodiments, the filter is arranged between the fuel inlet and the fuel outlet such that a fuel flow direction is through the filter holes to an inside of the filter sleeve. With this fuel flow direction impurities of the fuel are kept outside of the filter sleeve during an operation state of the fuel injection valve. Thus, a blocking of the filter is prevented. In an advantageous embodiment, a trench is formed below the filter holes - i.e. in particular positioned subsequent to the filter holes in axial direction towards the fluid outlet - in the interior cavity. The trench extends circumferentially around the second part in top view along the longitudinal axis and is preferably open towards the fluid inlet. With advantage, the trench may be operable to accomodate residual particles which are filtered by the filter holes.

[0021] In one development, the trench is formed by a portion of an outer circumferential surface of the filter sleeve together with a portion of an inner circumferential surface of the element with which the filter sleeve is in direct contact and a surface portion of that element which extends radially with respect to the longitudinal axis. In another development, the trench is formed by a portion of the outer circumferential surface of the filter sleeve or together with a surface portion of the element with which the filter sleeve is in direct contact, which surface portion extends radially with respect to the longitudinal axis, and with a portion of a circumferential inner surface of the valve body. In yet another development, the trench is formed by a portion of the outer circumferential surface of the second part, a portion of the circumferential inner surface of the element of the injection valve with which the filter sleeve is in direct contact and by a surface portion of the projecting part which extends radially with respect to the longitudinal axis. A surface which extends radially with respect to the longitudinal axis in particular extends from an inner edge, facing the longitudinal axis, to an outer edge, further away from the longitudinal axis. It extends preferably perpendicular, obliquely or curved with respect to the longitudinal axis.

[0022] According to a further aspect of the invention, a method for producing the filter comprises: providing a metal sleeve; bringing in a multitude of filter holes into the metal sleeve by one of laser drilling, electrical discharge machining, punching, drilling and stamping. Thus, the pitch among the filter holes can be regulated in order to preserve a desiderated structural resistance for the filter sleeve. Further, the desired hole diameter for the filter holes can be regulated easily. Further, the position of the multitude of filter holes can be varied on the filter sleeve.

[0023] Exemplary embodiments of the invention are explained in the following with the aid of schematic drawings. These are as follows:

Figure 1	a fuel injection valve in a longitudinal sectional view according to a first exemplary embodiment;
Figure 2	an enlarged section of the filter of Figure 1;
Figure 3	a schematic sectional view of the filter of the injection valve according to the first exemplary embodiment;
Figure 4	a schematic sectional view of a filter according to a second embodiment;
Figures 5A to 5C	a schematic sectional view of the filter sleeve for the filter of figure 3 during manufacturing according to an exemplary embodiment.

[0024] Elements of the same design and function that appear in different figures may be identified by the same reference numerals.

[0025] Figure 1 shows a fluid injection valve 100 according to an embodiment. The fluid injection valve 100 is in particular suitable for dosing fuel into an internal combustion engine of a vehicle, i.e. it is a fuel injection valve 100.

[0026] The fuel injection valve 100 comprises a valve body 120 with a central longitudinal axis L. The injection valve 100 has an interior cavity 130 extending along the longitudinal axis L from a fuel inlet 111 to a fuel outlet 112 and hydraulically connects the fuel inlet 111 to the fuel outlet 112. The interior cavity 130 is defined at least by an axially extending recess in the valve body 120.

[0027] The fuel injection valve 100 comprises a valve needle 140 that can be actuated by an electromagnetic actuator 119. The valve needle 140 is in particular arranged in the interior cavity 130. The valve needle 140 can be moved within the fuel injection valve 100 along the central longitudinal axis L to prevent a fuel flow through a fuel outlet 112 in a closing position and releasing the fuel flow through the fuel outlet 112 in further positions.

[0028] In an operating state, fuel is provided by a fuel pump, for example via a fuel rail, to the fuel inlet 111 of the fuel injection valve 100 and enters the interior cavity 130. From the fuel inlet 111 the fuel flow goes to a filter 101. The filter 101 filters the incoming fuel when it passes the filter 101. After passing the filter 101, the fuel flows further through the interior cavity 130 and/or through a recess of the valve needle 140 to the fuel outlet 112. When the valve needle 140 is displaced away from the closing position, fuel may leave the injection valve 100 through the fuel outlet 112.

[0029] The filter 101 is at least partly arranged in a pole piece 114 of the electromagnetic actuator 119. The pole piece 114 is received in the valve body 120 and positionally fixed with respect to the valve body 120 so that a central, axially extending opening of the pole piece 114 defines a portion of the interior cavity 130 of the injection valve 100. Alternatively (not shown in the figures), the pole piece 114 can be in one piece with the valve body 120.

[0030] The filter 101 comprises a filter sleeve 102. The filter sleeve 102 is in contact with a calibration spring 115 of the injection valve 100. The opposite end of the calibration spring 115 is in contact with the valve needle 140. For example, the valve needle 140 has a collar with which the calibration spring 115 is in contact. The collar may be in one piece with a shaft of the valve needle 140 or it may be a separately manufactured part which is fixed to the shaft. The calibration spring 115 is arranged to exert a force onto the valve needle 140 in the direction of the longitudinal axis L. By means of the force exerted on the valve needle 140, the calibration 115 is operable to bias the valve needle 140 towards the closing position.

[0031] Figure 2 shows an enlarged section of the injection valve 100 of figure 1 with the filter 101 in the pole piece 114. The filter sleeve 102 comprises a first part 103 and a second part 104. The first part 103 and the second part 104 are arranged subsequent to one another along the central longitudinal axis L of the injection valve 100 which is also the longitudinal axis L of the filter 100. The first part 103 is arranged at one side of the filter sleeve 102 and the second part 104 is arranged at the other side of the filter sleeve 102 along the longitudinal axis L.

[0032] The first part 103 is in direct contact with the pole piece 114. The pole piece 114 and the first part 103 of the filter sleeve 102 comprise a common contact area 118. The pole piece 114 contacts the metal of the filter sleeve 102.

[0033] During manufacturing the injection valve 100, the filter 101 is moved towards the fuel outlet 112 until a desired preload of the calibration spring 115 is achieved. By means of the direct contact between the first part 103 of the filter sleeve 102 with the pole piece 114, a press-fit connection is established which is configured to be strong enough to resist the force of the calibration spring 115 on the filter 101 so that the filter 101 is retained in a fixed position with respect to the pole piece 114 during operation of the injection valve 100. In this way it is possible to adjust the fuel injection valve 100.

[0034] The second part 104 comprises a multitude of filter holes 105 for filtering the fuel. For assembling the fuel injection valve 100 during its manufacture, the filter sleeve 102 is axially moved along the longitudinal axis L in order to exert a force on the valve needle in the direction of the longitudinal axis L. This is to preload the calibration spring 115 with a desired amount of spring force. Thus, the maximum amount of needle lift of the valve needle can be precisely calibrated. For example, the filter sleeve 102 is press-fitted into the pole piece 114.

[0035] Figure 3 shows the filter 101 in a schematic sectional view which is rotated counter-clockwise by 90° in the drawing plane with respect to figures 1 and 2. In an operating state the fuel comes from the inlet 111 through the filter holes 105 to an inside 113 of the filter sleeve 102.

[0036] The filter sleeve 102 is in the shape of a hollow cylinder. An end base 108 of the filter sleeve 102 is closed. For example, the end base 108 that is nearer to the multitude 106 of filter holes 105 is closed. The opposite end of the filter sleeve 102 comprises an opening 116. In other words, the filter sleeve 102 has a radially extending lid portion 108 at one axial end, the lid portion 108 merging with a circumferential side wall 109, and an opening 116 at the opposite axial end, the opening 116 at least partially exposing the lid portion in top view along the longitudinal axis L. The closed end of the filter sleeve 102 faces towards the fluid inlet 111 and the open end with the opening 116 faces towards the fluid outlet 112.

[0037] After passing the filter holes 105 the fuel flows through the inside 113 and leaves the filter sleeve 102 through the opening 116 to the outlet 112. In particular, the fuel passes the filter holes 105 in radial direction and leaves the opening 116 in axial direction, as roughly indicated in figure 3 by the arrows.

[0038] The multitude 106 of filter holes 105 is arranged at a lateral side 109 of the filter sleeve 102. In other words, the filter holes 105 perforate the circumferential side wall 109. At the first part 103 the lateral side of the filter sleeve 102 is in direct contact with the pole piece 114 at the common contact area 118. In other words, a portion of the circumferential side wall 109 which is comprised by the first part 103 has a common interface with the pole piece 114. Since the fuel enters the inside 113 of the filter sleeve 102 through the filter holes 105, only already filtered fuel is in the filter sleeve 102. Impurities of the fuel stay outside of the filter sleeve 102. Thus, a dumping of the filter may be prevented. No impurities are collected inside the filter sleeve 102.

[0039] A trench 135 is formed below the filter holes in the interior cavity 130 (cf. figures 1 and 2). The trench 135 extends circumferentially around the second part in top view along the longitudinal axis and is preferably open towards the fluid inlet to accommodate residual particles which are filtered by the filter holes 105. In the present embodiment, the trench 135 is defined by a portion of the outer circumferential surface of the filter sleeve 102 together with a surface portion of the pole piece 114 which faces towards the fluid inlet 111 and extends radially with respect to the longitudinal axis, and together with a portion of a circumferential inner surface of the valve body 120.

[0040] Figure 4 shows a schematic sectional view of a filter sleeve 102 according to a second exemplary embodiment. In contrast to the embodiment described with respect to Figures 1 to 3, the filter sleeve 102 comprises a projecting part 110. The first part 103 is arranged at the projecting part 110. For example, the first part 103 is represented by or comprised by the projecting part 110. The projecting part 110 is achieved by the circumferential side wall 109 having a step. The inner diameter and the outer diameter of the filter sleeve 102 are larger in the region of the projecting part 110 than the inner diameter and the outer diameter, respectively, of the filter sleeve 102 in the region of the second part 104. The common contact area 118 of the filter sleeve 102 with the pole piece 114 or the valve body 120 is comprised by the projecting part 110.

[0041] The filter 101 according to the present embodiment may be arranged in the interior cavity 130 in such fashion that the first part 103 and the projecting part 110 precede the second part 104 in axial direction L from the fluid inlet 111 to the fluid outlet 112. In this way, the axial end of the filter sleeve 102 which comprises the opening 116 faces towards the fluid inlet 111 and the closed end base 108 faces towards the fluid outlet 112.

[0042] The fuel enters the inside 113 of the filter sleeve 102 through the opening 116. The fuel leaves the inside 113 through the filter holes 105. The inlet flow occurs in the axial direction and the outlet flow occurs in the radial direction, as roughly indicated in figure 4 by the arrows.

[0043] Figures 5A to 5C show the filter sleeve 102 of figures 1 to 3 during a production process according to an exemplary embodiment.

[0044] As shown in Figure 5A a metal sleeve 117 is provided. The metal sleeve 117 has a hollow cylindrical shape extending along a longitudinal axis L with a closed end base, closed by a lid portion 108 at one axial end and an opening 116 at an axially opposite end base. A circumferential side wall 109 extends along the longitudinal axis L from the closed end base 108 to the axially opposite end. For example, the metal sleeve 117 is provided by stamping or turning a metal body. Thus, the metal sleeve 117 is made in one piece. For example the metal sleeve 117 consists of stainless steel.

[0045] The multitude 106 of filter holes 105 is brought into the metal sleeve 117 as shown in Figure 5B so that they perforate the circumferential side wall 109, preferably in radial direction. According to one embodiment, the filter holes 105 are brought into the metal sleeve 117 by laser drilling. According to further embodiments the filter holes are made by electrical discharge machining (EDM), punching, drilling, or stamping. The filter holes 105 comprise a mean diameter 107 (Figure 5C) in the range of 30 μm. The mean diameter may be less than 30 μm, for example in the range of 20 μm. The mean diameter may be more than 30 μm, for example in the range of 50 μm.

[0046] The filter sleeve 102 is formed integrally and consists of metal, preferably of stainless steel. Therefore, the filter 101 comprises a high chemical resistance according to the chemical resistance of the stainless steel of the filter sleeve 102. Since the filter holes 105 are brought into the metal sleeve 117 by one of laser drilling, electrical discharge machining, punching, drilling or stamping, the pitch of the holes, i.e. in particular the distance between each two adjacent filter holes 105, can be regulated such that the circumferential side wall 109 has a good structural resistance. Further, these kinds of processing allow to easily regulate the desired mean diameter 107 for the holes 105 and the number of the filter holes 105. Thus, the desired filtering functionality can be obtained easily. Further, the multitude 106 of filter holes 105 can be positioned at a desired position on the metal sleeve 117. Thus, the filter 101 is resistant against aggressive fuel and comprises a simplified shape.

Claims

1. Filter for a fuel injection valve (100), comprising a filter sleeve (102) formed integrally and consisting of a metal, the filter sleeve (102) comprising:

    - a first part (103), the first part (103) being designed for being in direct contact with an element (114) of the fuel injection valve (114),
    - a second part (104), the second part (104) comprising a multitude (106) of filter holes (105) reaching from an outside of the filter sleeve to an inside (113) of the filter sleeve.

2. Filter according to claim 1, wherein the filter sleeve (102) comprises the form of a hollow cylinder, one end base (108) of the hollow cylinder being closed and the multitude (106) of filter holes (105) being located at the lateral side (109) of the filter sleeve.

3. Filter according to one of claims 1 and 2, wherein the filter sleeve (102) comprises a projecting part (110), the first part (103) being located at the projecting part (110).

4. Filter according to any of the preceding claims, wherein the filter holes (105) of the multitude (106) of filter holes (105) comprise a mean diameter (107) of thirty micrometres.

5. Fuel injection valve, comprising a filter (101) according to any of the preceding claims, the first part (103) of the filter sleeve (102) being in direct contact with the element (114) of the fuel injection valve (100).

6. Fuel injection valve according to claim 5, comprising a fuel inlet (111) and a fuel outlet (112) wherein the filter (101) is arranged between the fuel inlet (111) and the fuel outlet (112) such that a fuel flow direction is through the filter holes (105) to an inside (113) of the filter sleeve (102).

7. Fuel injection valve according to claim 5, comprising a fuel inlet (111) and a fuel outlet (112) wherein the filter (101) is arranged between the fuel inlet (111) and the fuel outlet (112) such that a fuel flow direction is from an inside (113) of the filter sleeve (102) through the filter holes (105).

8. Fuel injection valve according to one of claims 5 to 7, wherein the element (114) is a pole piece of an electromagnetic actuator (119) of the fuel injection valve (100).

9. Method for producing a filter (101) for a fuel injection valve (100), comprising:

   - providing a metal sleeve (102);
   - bringing in a multitude (106) of filter holes (105) into the metal sleeve (117) by one of laser drilling, electrical discharge machining, punching, drilling and stamping.

10. Method according to claim 9, comprising:

   - providing of a metal body,
   - stamping or turning the metal body so as to make the metal sleeve (117).

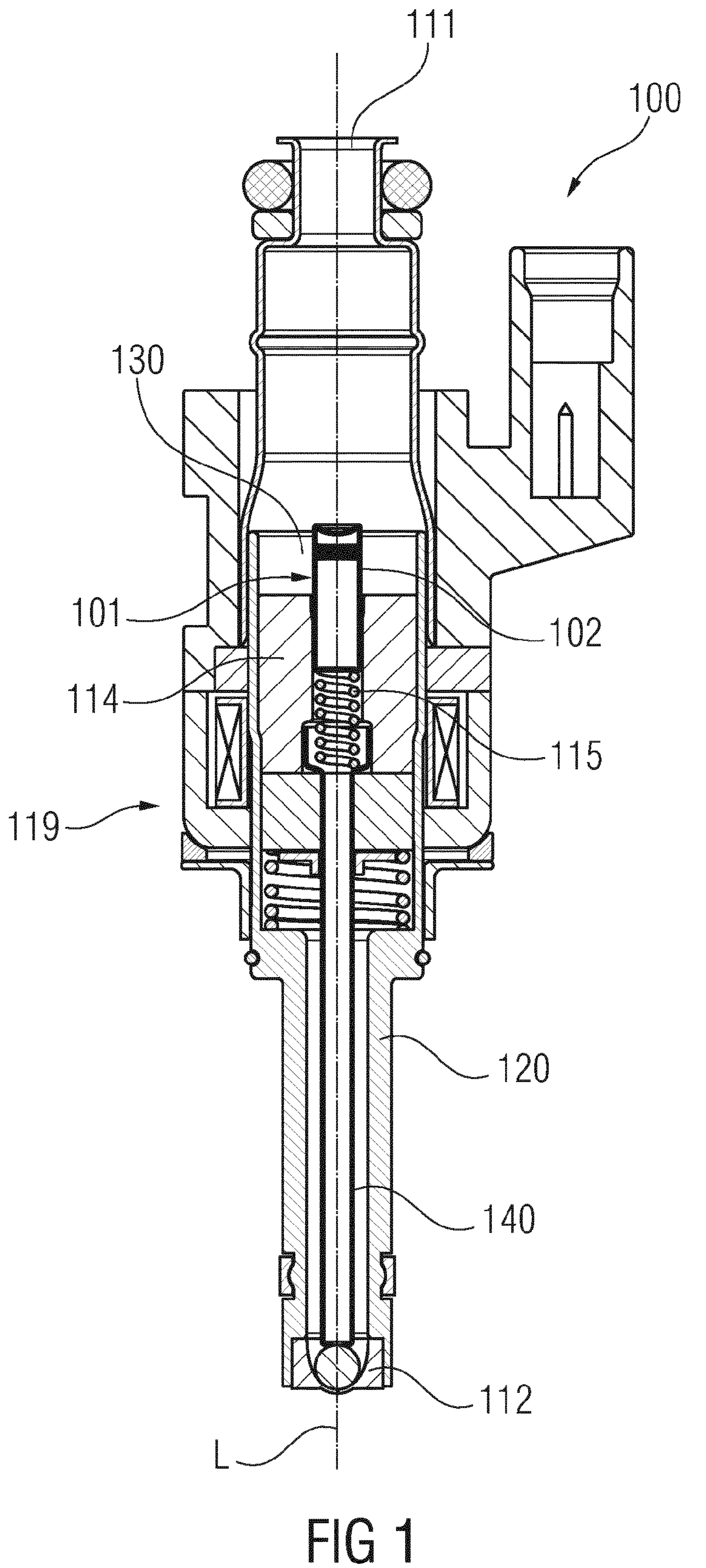

FIG 1

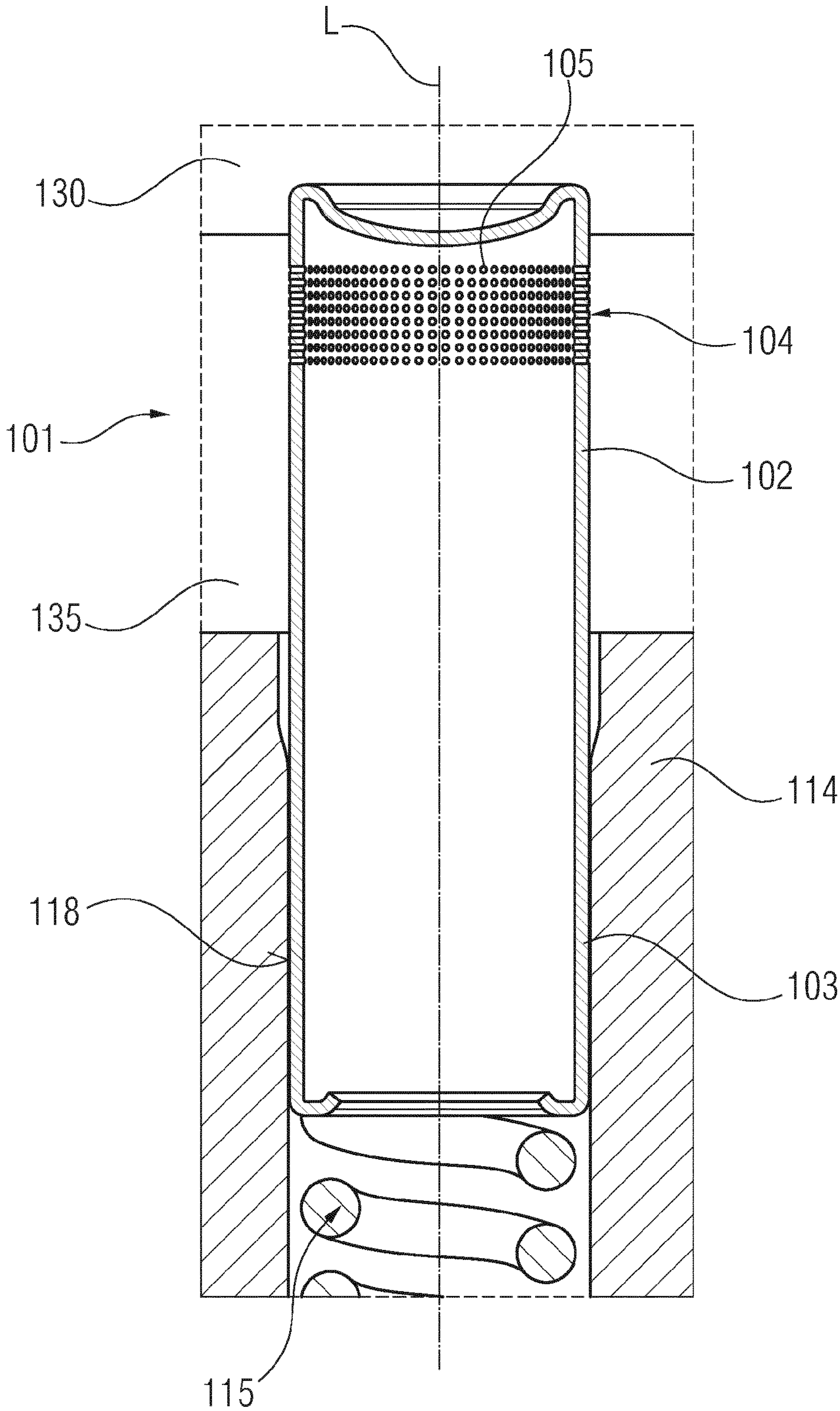

FIG 2

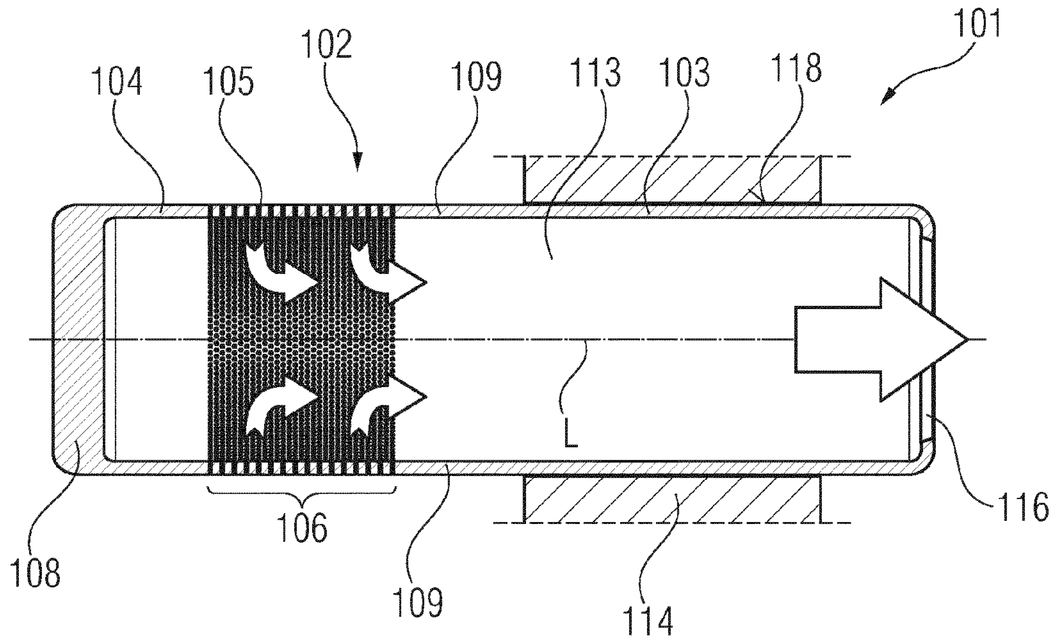
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FIG 3

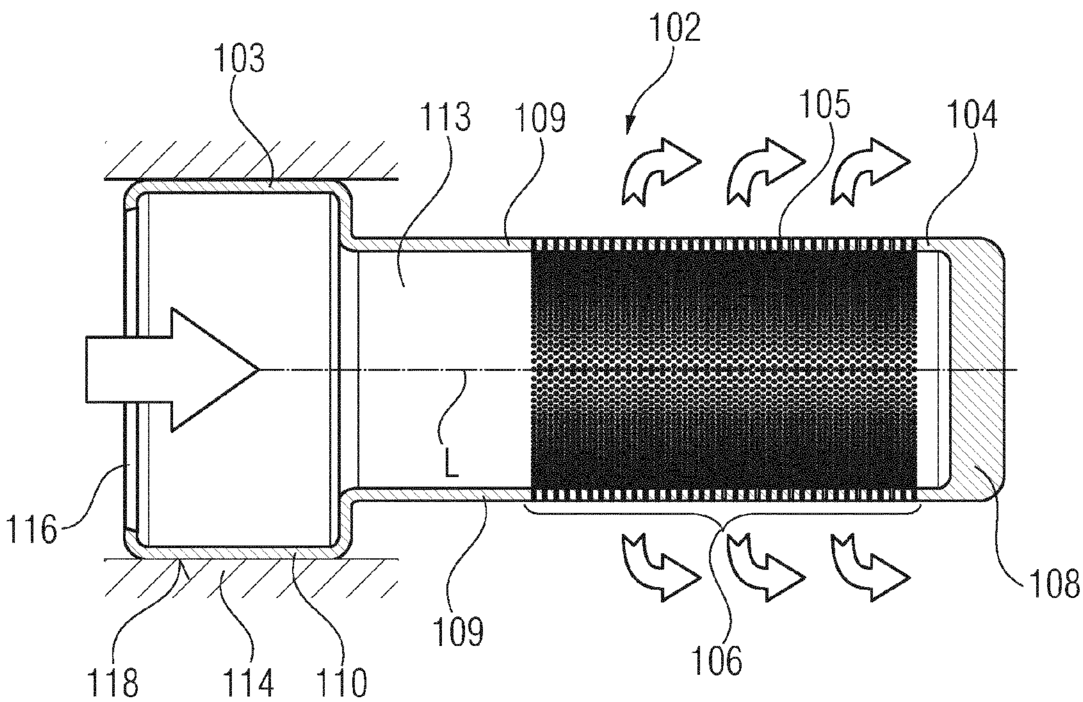
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FIG 4

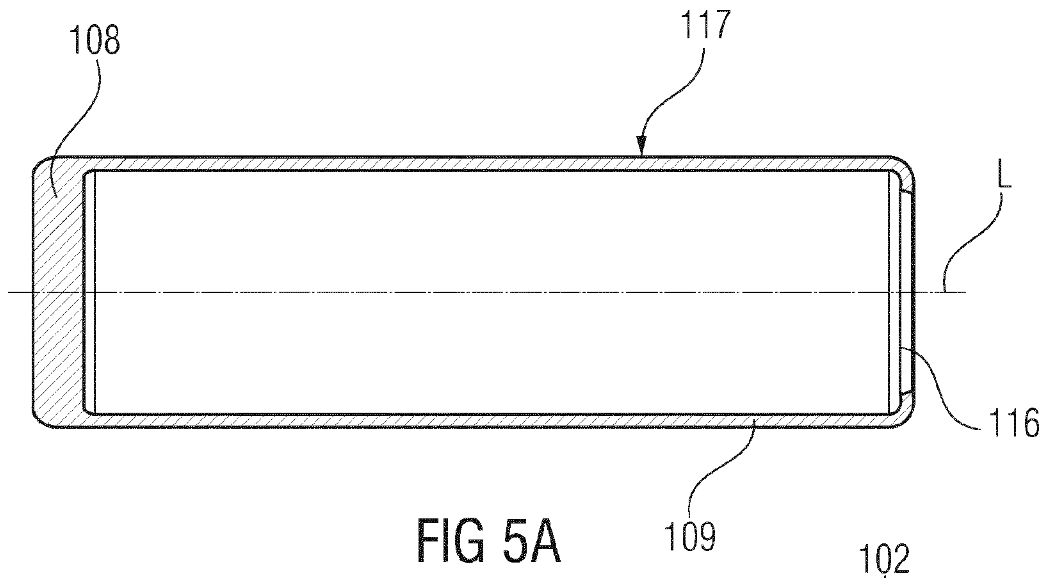

FIG 5A

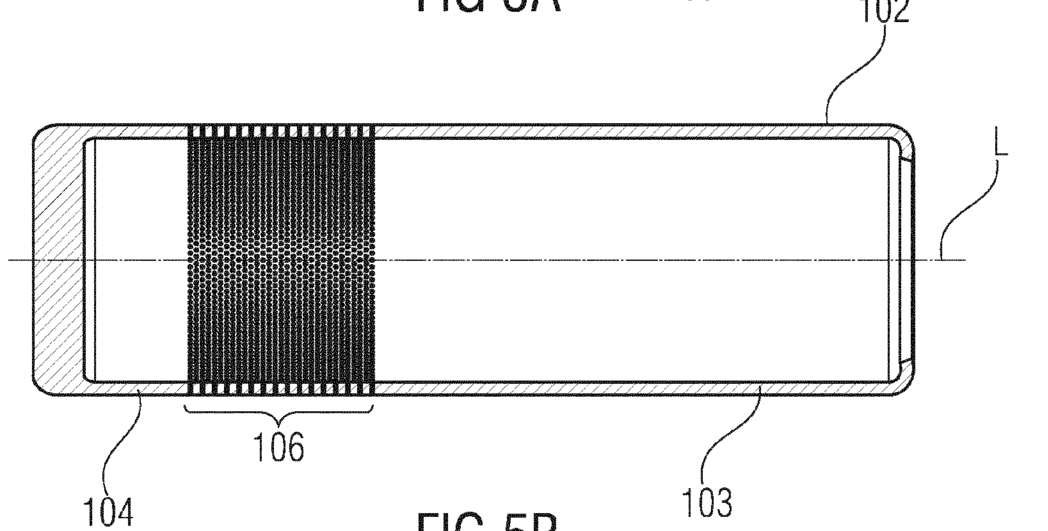

FIG 5B

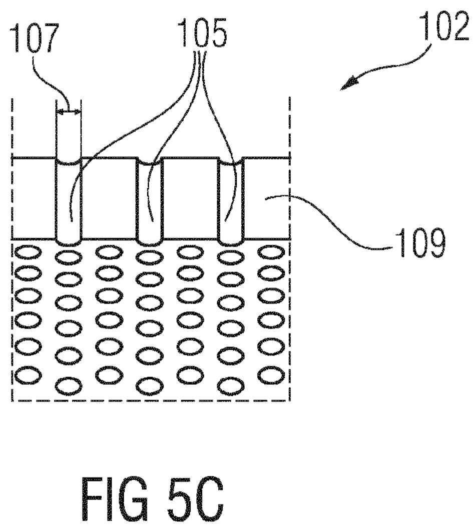

FIG 5C

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 0421

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X	DE 102 20 632 A1 (DENSO CORP [JP]) 12 December 2002 (2002-12-12) * column 3, paragraph 0037-0040; figures 1,2,5 * * column 5, paragraph 0047 *	1-3,5-7,9,10	
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TECHNICAL FIELDS SEARCHED (IPC)

F02M

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	3 September 2013	Etschmann, Georg

CATEGORY OF CITED DOCUMENTS

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