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(54) **FUEL RAIL AND FUEL RAIL ASSEMBLY**

(57) A fuel rail (10) and a fuel rail assembly (1) comprising the fuel rail (10) are disclosed. The fuel rail assembly (1) comprises the fuel rail (10) and a plurality of adapter pieces (20) for hydraulically connecting fuel injectors (60) to the fuel rail (10). The adapter pieces (20) are brazed and/or welded to the fuel rail (10). The fuel rail (10) comprises a one-pieced, integrally formed tube (100) having a plurality of openings (120), each opening (120) perforating a circumferential sidewall (110) of the tube (100) and being configured for hydraulically coupling the fuel rail (10) to one of the adapter pieces (20). An external circumferential surface (112) of the sidewall (110) comprises a plurality of planar surface regions (114), each planar surface region (114) extending completely circumferentially around one of the openings (120) and being configured for being in a fullarea contact with the respective adapter piece (20).

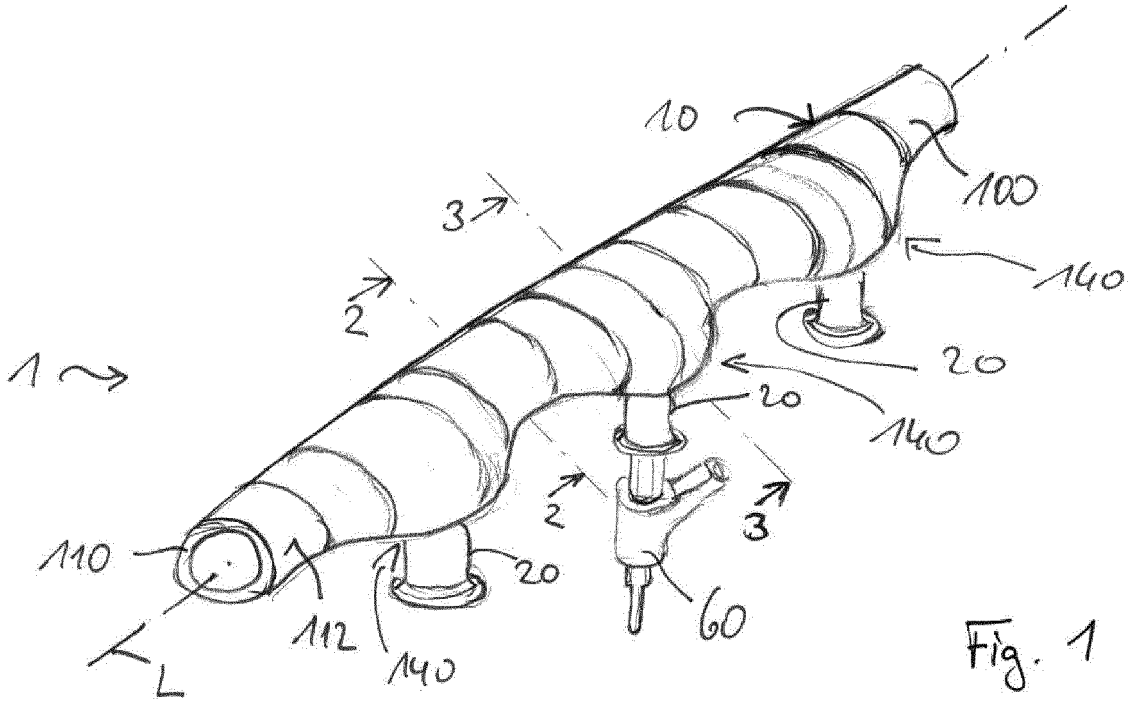

Fig. 1

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Description

[0001] The present disclosure relates to a fuel rail and to a fuel rail assembly.

[0002] A fuel rail assembly is known, for example, from EP 2466111 B1.

[0003] It is an object of the present disclosure to specify an improved fuel rail and fuel rail assembly. This object is achieved by a fuel rail and a fuel rail assembly having the features of the independent claims. Advantageous embodiments and developments of the fuel rail and the fuel rail assembly are specified in the dependent claims, in the following description and in the drawings.

[0004] A fuel rail for a fuel rail assembly is disclosed according to one aspect of the present disclosure. According to another aspect, a fuel rail assembly comprising the fuel rail and a plurality of adapter pieces for hydraulically connecting fuel injectors to the fuel rail is disclosed. Preferably, the adapter pieces are brazed and/or welded to the fuel rail. The fuel rail assembly is preferably provided for leading fuel from a high pressure pump to the fuel injectors, the fuel injectors being in particular provided for injecting the fuel into one or more intake manifolds or, preferably, directly into the combustion chambers of an internal combustion engine.

[0005] The fuel rail comprises a one-pieced, integrally formed tube. The tube is preferably a metal tube, e.g. a stainless steel tube. That the tube is a "one-pieced, integrally formed" tube means in particular that the tube is manufactured from a single workpiece and not assembled from a plurality of parts to form the tube. In particular, the tube is a seamless metal tube. Preferably, the tube is elongated along a longitudinal axis. It may have a cylindrical - preferably a circular cylindrical - basic shape, in particular with the longitudinal axis as a center axis.

[0006] Expediently, the tube may be closed at one longitudinal end with an end plug of the fuel rail. At the other longitudinal end, a fuel inlet port of the fuel rail may be fixed to the tube. In one embodiment, the fuel rail comprises brackets for fixing the fuel rail with respect to an engine, for example with respect to a cylinder head of the engine. The brackets are fixed to the tube in one embodiment.

[0007] The tube has a circumferential sidewall and a plurality of openings, each opening perforating the circumferential sidewall of the tube. The openings are configured for hydraulically coupling the fuel rail to one of the adapter pieces. In other words, each opening represents a fuel outlet bore through the sidewall for feeding fuel from an interior of the fuel rail through the bore and the adapter piece to the fuel injector.

[0008] In one embodiment, each adapter piece is hydraulically connected to the fuel rail via an inlet opening at an upstream end of the adapter piece. In a preferred embodiment, the adapter pieces are fuel injector cups which are each configured for receiving an inlet end of one of the fuel injectors. Expediently, the fuel injector may be inserted into the respective adapter piece through an insertion opening at a downstream end of the adapter piece. It is also conceivable, that the adapter pieces represent fuel outlet ports to which the fuel injectors are hydraulically coupleable via respective injector cups and pipes, each pipe bridging a distance between the respective outlet port and the corresponding injector cup.

[0009] An external circumferential surface of the sidewall comprises a plurality of planar surface regions. Each planar surface region extends completely circumferentially around one of the openings and is preferably configured for being in a full-area contact with the respective adapter piece.

[0010] In one embodiment of the fuel rail assembly, each adapter piece has a generally ring-shaped flat connection surface which is in mechanical contact - in particular in full-area contact - with a respective one of the planar surface regions of the sidewall so that it circumferentially surrounds a respective one of the openings. The connection surface in particular extends completely circumferentially around the inlet opening of the adapter piece. In one embodiment, the flat connection surface delimits the adapter piece in upstream direction, i.e. the adapter piece has in particular no portion which protrudes beyond the flat connection surface towards or into the tube. Preferably, the fuel rail assembly comprises brazed seams and/or weld seams at the interfaces between the respective flat connection surfaces and planar surface regions.

[0011] With advantage, the fuel rail and the adapter piece both may have planar connection surfaces by means of which the adapter piece and the fuel rail abut one another. Therefore, a particular precise and easy joining is possible. The adapter piece may be laterally movable relative to the opening in the sidewall of the fuel rail, so that tolerances may be recoverable particularly well and/or over a particularly large range. Due to the surface region extending completely circumferentially around the opening, tolerances may be recoverable in all radial directions with respect to the central axis. Due to the advantageous shape of the interface between the tube and the adapter pieces, the risk of producing untight connections on manufacturing the fuel rail assembly may be particularly small so that scrap costs may be particularly low. At the same time, the tube of the fuel rail being a one pieced, integrally formed part, is particularly robust and well usable for particularly high fuel pressures.

[0012] In one embodiment, at least one of the openings has a central axis which is skew with respect to the longitudinal axis. For example, the central axis of the opening and the longitudinal axis are perpendicular and the central axis of the opening is radially offset with respect to the longitudinal axis.

[0013] In one development, at least one of the planar surface regions is positioned non-mirrorsymmetrically with respect to the longitudinal axis in top view along the respective central axis. For example, the planar surface region is rotationally symmetric with respect to the central axis of the corresponding opening, the central axis being

radially offset from the longitudinal axis.

[0014] With advantage, the fuel rail and the fuel rail assembly according to the present disclosure may have a particularly small number of parts while, at the same time, allowing the previously described positioning with skew axes. In conventional fuel rails, radial offset is often achieved with additional parts between the fuel rail and an injector cup, introducing additional tolerances and complexity, costly additional manufacturing steps for placing and fixing parts with and additional, potentially untight joints.

[0015] In one embodiment the sidewall has a plurality of bulges, each bulge comprising one of the openings and the corresponding planar surface region. In particular, the general circular cylindrical basic shape of the tube is modified by the bulges. Expediently, the cross-sectional area of the tube may be increased in the region of the bulges.

[0016] Preferably, on the side opposite of the respective planar surface region, the bulges comprise a convexly curved external surface of the sidewall of the tube. In one development, the bulges - in top view along the central axis of one of the openings - modify the cylindrical basic shape of the tube on that side of the longitudinal axis on which the central axis is positioned, and in one further development not on the other side.

[0017] In one embodiment, the sidewall of the tube has a generally oval cross-section in the region of the bulges and in particular a circular cross-section in a region between each two adjacent bulges. In one development, the geometric center of gravity of at least one of the bulges is offset from the longitudinal axis of the tube in direction towards said skew central axis of the opening comprised by the respective bulge or the geometric center of gravity is positioned on said skew central axis.

[0018] By means of such bulges, the planar surface regions and/or a radial offset of the central axes of the openings is particularly easily achievable. At the same time, the tube may remain particularly stable so that a particularly high pressure resistance of the fuel rail is achievable.

[0019] According to one aspect of the present disclosure, a method for manufacturing the fuel rail is disclosed. In one embodiment, the method comprises manufacturing of the bulges by means of a hydroforming process. Alternatively or additionally, it comprises manufacturing of the planar surface regions by stamping.

[0020] Further advantages, advantageous embodiments and developments of the fuel rail, the fuel rail assembly and the method will become apparent from the exemplary embodiments which are described below in association with schematic figures.

[0021] In the figures:

Figure 1 shows a schematic perspective view of a fuel rail assembly according to a first exemplary embodiment,

Figure 2 shows a first schematic cross-sectional view of the fuel rail assembly of figure 1,

Figure 3 shows a second schematic cross-sectional view of the fuel rail assembly of figure 1,

Figure 4 shows a schematic cross-sectional view of a portion of a fuel rail assembly according to a second exemplary embodiment, and

Figure 5 shows a schematic top view of a portion of the fuel rail of the second exemplary embodiment.

[0022] In the exemplary embodiments and figures, similar, identical or similarly acting elements are provided with the same reference symbols. In some figures, individual reference symbols may be omitted to improve the clarity of the figures. The figures are not regarded to be true to scale. Rather, individual elements in the figures may be exaggerated in size for better representability and/or better understanding.

[0023] Figure 1 shows a schematic cross-sectional view of a fuel rail assembly 1 according to a first exemplary embodiment of the invention. Figures 2 and 3 show schematic cross-sectional views of the fuel rail assembly 1 in planes perpendicular to the longitudinal axis L and comprising the lines 2-2 and 3-3, respectively. The fuel rail assembly 1 may in particular be configured for delivering fuel to an internal combustion engine (not shown in the figures).

[0024] The fuel rail assembly 1 comprises a fuel rail 10 which comprises a tube 100. The tube 100 is elongated along the longitudinal axis L and has a generally circular cylindrical basic shape, the longitudinal axis L representing a center axis of the cylindrical basic shape. In particular, the geometric centers of gravity of the longitudinal end surfaces of the tube 100 may preferably be positioned on the longitudinal axis L. The tube 100 is a one-pieced, integrally formed metal tube. For example, it is a seamless steel tube, for example manufactured by extrusion, piercing or gun drilling.

[0025] The fuel rail 10 may further comprise at least one element of the group consisting of a fuel inlet port, an end plug, a sensor port, at least one bracket for fixing the fuel rail to a cylinder head of the engine (none of these elements are shown in the figures).

[0026] The cylindrical basic shape of the tube 100 is modified by a plurality of bulges 140. Each of the bulges 114 comprises a planar surface region 114 of the external surface 112 of the sidewall 110 of the tube 100 and an opening 120 which perforates the sidewall 110 and is completely circumferentially surrounded by the planar surface region 114 in top view along a central axis A of the opening 120.

[0027] While the tube 100, in particular its sidewall 110, has a circular cross section C in regions where the basic circular cylindrical shape is not modified by the bulges 140, the cross-sectional shape is modified so that it has

an oval shape 0 with an increased area content in the region of the bulges 140. This is best visible in figure 3, where also the unmodified circular cross-section C is visible behind the bulge 140.

[0028] A geometric center of gravity G of each of the bulges 140 is radially offset with respect to the longitudinal axis L in a direction D towards the central axis A of the opening 120 which is comprised by the respective bulge 140. The central axis A of the opening 120 is perpendicular to the longitudinal axis L and offset with respect to the longitudinal axis L the direction D so that the central axis A and to the longitudinal axis L do not intersect and are not parallel, i.e. they are skew with respect to one another. In particular, the geometric center of gravity G of the bulge 140 is positioned on the central axis A of the corresponding opening 120.

[0029] Due to the central axis A being offset with respect to the longitudinal axis L in the direction D, the planar surface region 114 - which surrounds the opening 120 in rotationally symmetric fashion with respect to the central axis A - is arranged non-mirrorsymmetrically with respect to the longitudinal axis L in top view along the central axis A. Rather, also the planar surface region 114 is radially offset in the direction D with respect to the longitudinal axis L. Further, the fuel rail assembly 1 comprises a plurality of adapter pieces 20, which are injector cups in the present embodiment. The adapter pieces 20 are configured for hydraulically connecting the fuel injector 60 to the fuel rail 10. In figure 1, only one fuel injector 60 is shown for the sake of simplicity. However, also each of the other adapter pieces 20 is provided for receiving a respective fuel injector 60. The fuel injectors 60 are preferably provided for injecting fuel directly into combustion chambers of the internal combustion engine.

[0030] A fuel inlet end of the respective fuel injectors 60 is inserted into the adapter piece 20 through an insertion opening 220 at an end of the adapter piece 20 remote from the fuel rail 10. The fuel rail assembly may comprise fixation elements (not shown in the figures) for fixing the fuel injectors 60 to the respective adapter pieces 20 and/or spring clips (not shown in the figures) for pushing the fuel injectors 60 towards the cylinder head of the engine.

[0031] At its axial end facing towards the fuel rail 10 and being in direct mechanical contact with the fuel rail 10, each adapter piece 20 has a generally ring-shaped flat connection surface 201 which is in contact with a respective one of the planar surface regions 114 of the fuel rail 10. A "ring-shaped" surface is in particular understood to mean a surface which is delimited by and extends between concentric and coplanar circular edges of different diameter.

[0032] In the present embodiment, the connection surface 201 is in a full-area contact with the respective planar surface region 114 so that it defines an interface I between each adapter piece 20 and the fuel rail 10. Each connection surface 201 extends completely circumferentially around the respective opening 120 of the fuel rail 10 and also around an inlet opening 210 of the adaptor piece 20 in top view along its central axis A. The inlet opening 210 of the adaptor piece 20 is preferably arranged coaxially to the opening 120 of the fuel rail 10 with respect to the corresponding central axis A.

[0033] At the interface I between each adapter piece 20 and the fuel rail 10, a brazed seam 40 is formed which extends completely circumferentially around the respective planar surface region 114 and the respective connection surface 201 for mechanically and fluid-tightly connecting the adapter piece 20 to the fuel rail 10. In one embodiment, spot welded connections may be produced between the fuel rail 10 and the adapter pieces 20 adjacent to the edges of the respective planar surface region 114 and the respective connection surface 201, before the fluid tight brazed seam 40 is manufactured.

[0034] Figure 4 shows a portion of a fuel rail assembly 1 according to a second exemplary embodiment of the invention in a schematic cross-sectional view. The fuel rail assembly 1 according to the second exemplary embodiment corresponds in general to that of the first embodiment. Figure 5 shows a schematic top view of a portion of the fuel rail 10 of the fuel rail assembly 1 of the second exemplary embodiment in the region of one of the bulges 140.

[0035] Contrary to the first embodiment, the geometric centers of gravity G of the bulges 140 are not laterally displaced with respect to the longitudinal axis L of the tube 100 in the present embodiment. Rather, the oval cross-section 0 of each bulge 140 is centered with respect to the longitudinal axis L so that the bulges 140, the openings 120 and the planar surface regions 114 are arranged mirrorsymmetrically with respect to the longitudinal axis L in top view along the respective central axes A of the openings 120. Yet, also in the present embodiment, the area content of the oval cross section 0 in the region of the bulges 140 is larger than the area content of the circular cross-section C in the longitudinal end regions of the tube 100 and in the regions between the bulges 140.

[0036] The invention is not limited to specific embodiments by the description on basis of these exemplary embodiments. Rather, it comprises any combination of elements of different embodiments. Moreover, the invention comprises any combination of claims and any combination of features disclosed by the claims.

Claims

1. Fuel rail (10) for a fuel rail assembly (1), the fuel rail assembly (1) comprising the fuel rail (10) and a plurality of adapter pieces (20) for hydraulically connecting fuel injectors (60) to the fuel rail (10), the adapter pieces (20) being brazed and/or welded to the fuel rail (10), wherein
   the fuel rail (10) comprises a one-pieced, integrally formed tube (100),

the tube (100) has a plurality of openings (120), each opening (120) perforating a circumferential sidewall (110) of the tube (100) and being configured for hydraulically coupling the fuel rail (10) to one of the adapter pieces (20), and
an external circumferential surface (112) of the sidewall (110) comprises a plurality of planar surface regions (114), each planar surface region (114) extending completely circumferentially around one of the openings (120) and being configured for being in a full-area contact with the respective adapter piece (20).

2. Fuel rail (10) according to the preceding claim, wherein the tube (100) is elongated along a longitudinal axis (L) and at least one of the openings (120) has a central axis (A) being skew with respect to the longitudinal axis (L).

3. Fuel rail (10) according to the preceding claim, wherein at least one of the planar surface regions (114) is positioned non-mirrorsymmetrically with respect to the longitudinal axis (L) in top view along the respective central axis (A).

4. Fuel rail (10) according to one of the preceding claims wherein the sidewall (110) has a plurality of bulges (140), each bulge (140) comprising one of the openings (120) and the corresponding planar surface region (114).

5. Fuel rail (10) according to claim 4, wherein the sidewall (110) has a generally oval cross-section (0) in the region of the bulge (140) and in particular a circular cross-section (C) in a region between each two adjacent bulges (140).

6. Fuel rail (10) according to one of claims 4 and 5 and to one of claims 2 and 3, wherein a geometric center of gravity (G) of at least one of the bulges (140) is offset from the longitudinal axis (L) of the tube (100) in direction (D) towards said skew central axis (A) or is positioned on said skew central axis (A).

7. Fuel rail assembly (1) comprising the fuel rail (10) according to one of the preceding claims and the plurality of adapter pieces (20), each adapter piece (20) having a generally ring-shaped flat connection surface (201) which is in full-area contact with a respective one of the planar surface regions (114) of the sidewall (110) so that it circumferentially surrounds a respective one of the openings (120).

8. Fuel rail assembly (1 according to the preceding claim comprising brazed seams and/or weld seams (40) at the interfaces (I) between the respective flat connection surfaces (201) and planar surface regions (114).

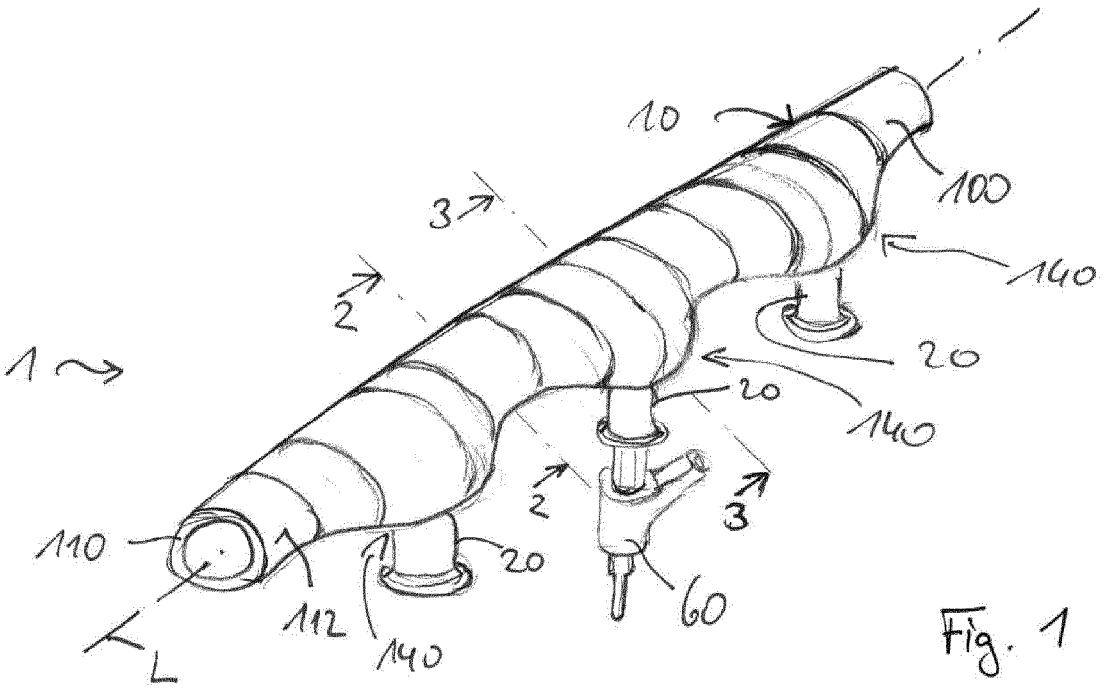

Fig. 1

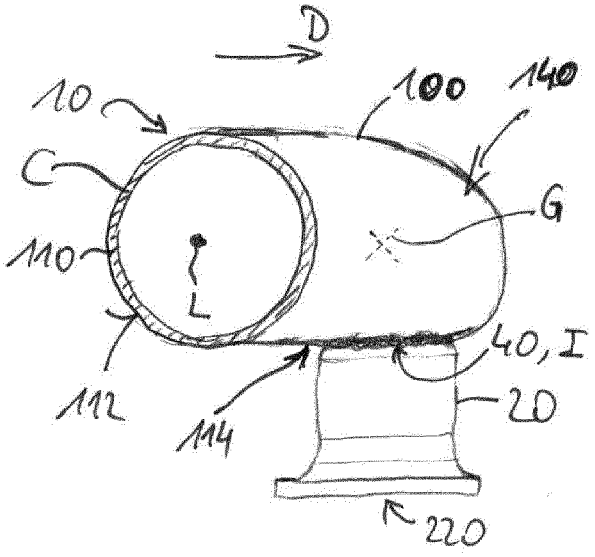

Fig. 2

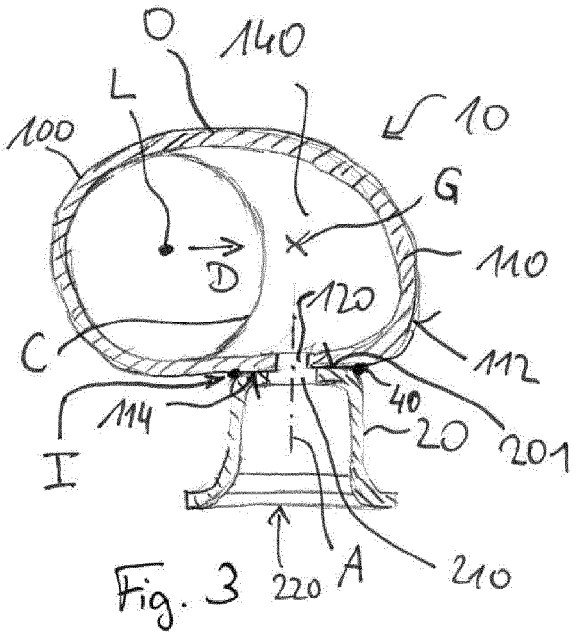

Fig. 3

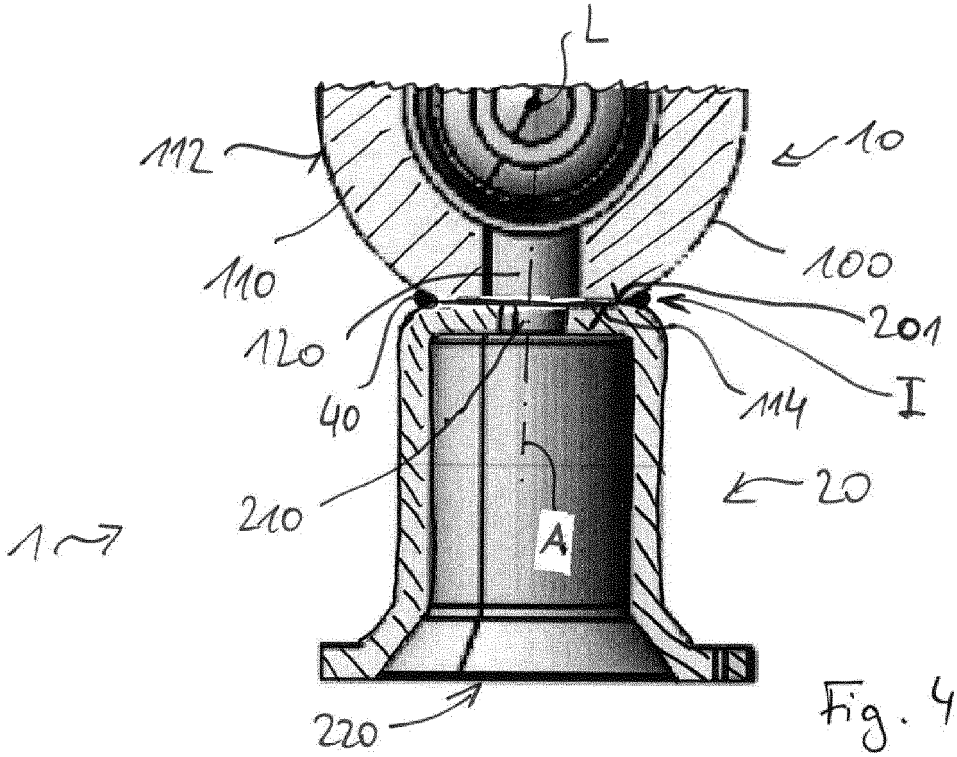

Fig. 4

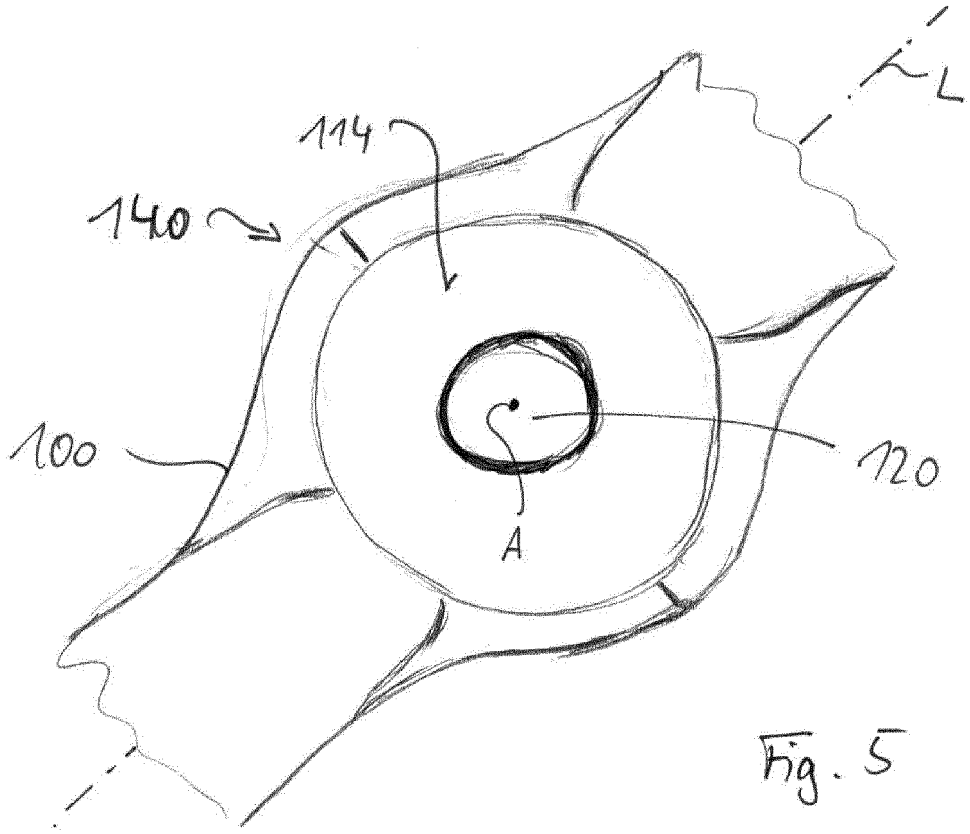

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 16 16 4823

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	JP 2006 336490 A (USUI KOKUSAI SANGYO KK) 14 December 2006 (2006-12-14) * claims 1,2,11,12,16 * * abstract; figures 9,10 * * paragraph [0028] * * paragraph [0039] - paragraph [0041] *	1-8	INV. F02M55/02
X	EP 2 728 160 A1 (OTICS CORP [JP]) 7 May 2014 (2014-05-07) * abstract; figures 2,3,4,5 * * claims 1,4,5,6 * * paragraph [0035] * * paragraph [0036] - paragraph [0038] *	1-5,7,8	
X	JP 2011 247132 A (MARUYASU & CO LTD) 8 December 2011 (2011-12-08) * abstract; figures 1,2,3,4 * * claim 1 * * paragraph [0020] - paragraph [0022] *	1-5,7,8	
X	EP 1 550 805 A1 (USUI KOKUSAI SANGYO KK [JP]) 6 July 2005 (2005-07-06) * abstract; figures 1,6,22 * * claims 1,4,9,10 * * paragraph [0067] * * paragraph [0073] * * paragraph [0077] *	1-3,7,8	TECHNICAL FIELDS SEARCHED (IPC) F02M
X	EP 1 524 428 A2 (BOSCH GMBH ROBERT [DE]) 20 April 2005 (2005-04-20) * abstract; figures 1,2,3 * * claims 1,3,4,5,6 * * paragraph [0008] * * paragraph [0017] *	1,4,5,7,8	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 July 2016	Barunovic, Robert

CATEGORY OF CITED DOCUMENTS

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18-07-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2006336490 A	14-12-2006	JP 4488517 B2	23-06-2010
		JP 2006336490 A	14-12-2006
EP 2728160 A1	07-05-2014	EP 2728160 A1	07-05-2014
		JP 2014092077 A	19-05-2014
		US 2014123949 A1	08-05-2014
JP 2011247132 A	08-12-2011	NONE	
EP 1550805 A1	06-07-2005	AU 2003272943 A1	04-05-2004
		DE 10393459 T5	01-09-2005
		EP 1550805 A1	06-07-2005
		EP 2325474 A1	25-05-2011
		EP 2333300 A1	15-06-2011
		JP 4275134 B2	10-06-2009
		KR 20050069930 A	05-07-2005
		US 2005257774 A1	24-11-2005
		US 2007169754 A1	26-07-2007
		WO 2004033894 A1	22-04-2004
EP 1524428 A2	20-04-2005	DE 10347946 A1	19-05-2005
		EP 1524428 A2	20-04-2005

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2466111 B1 **[0002]**