

(19)



(11)

**EP 3 653 866 A1**

(12)

**EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**20.05.2020 Bulletin 2020/21**

(51) Int Cl.:  
**F02M 55/02 (2006.01) F02M 61/16 (2006.01)**

(21) Application number: **18206634.0**

(22) Date of filing: **16.11.2018**

(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**

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(54) **A FUEL RAIL ASSEMBLY FOR A FUEL INJECTION SYSTEM FOR AN INTERNAL COMBUSTION ENGINE AND A METHOD FOR MANUFACTURING A FUEL RAIL ASSEMBLY**

(57) In a fuel rail assembly for a fuel injection system for an internal combustion engine, the fuel rail (2) comprises an elongate generally tubular body forming a fuel

reservoir and having a fuel inlet port (6), at least one or more fuel outlet ports (10) and a sensor port (18) located substantially within the fuel rail fuel reservoir.

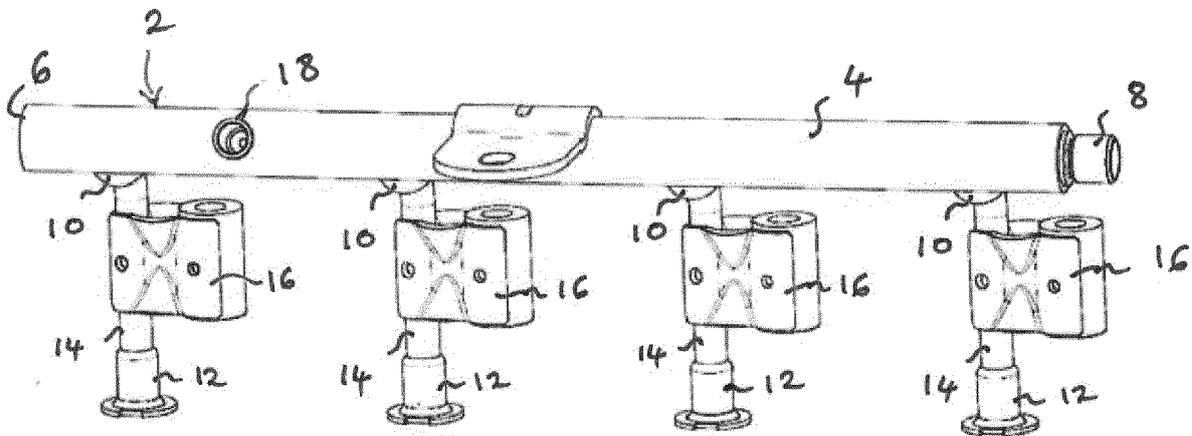


Fig. 1

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## Description

**[0001]** The present disclosure relates to a fuel rail assembly for a fuel injection system for an internal combustion engine and particularly but not exclusively to a fuel rail assembly for incorporation in a fuel injection system for a multicylinder direct injection internal combustion engine.

**[0002]** In known arrangements, the fuel rail comprises an elongate reservoir for fuel in which the fuel is supplied to a fuel inlet by a high-pressure fuel pump and the fuel rail has spaced along its length fuel outlets for supplying fuel to a fuel injector for injecting fuel directly into each cylinder of the engine. The volume of fuel in the fuel rail is intended to damp out fluctuations in the pressure of the fuel supplied by the pump so that the pressure at each outlet is equal and substantially constant.

**[0003]** In the known arrangements, the fuel rail is typically a substantial generally tubular element which has to be strong enough to cope with the stresses of the load applied to the fuel rail by the high pressure of fuel in the reservoir and also to cope with the additional operating stresses caused by the harsh environment in a vehicle caused by vibration of the engine and the high temperatures to which the fuel rail is subjected. As a result, the fuel rail tends to be heavy and costly to construct because of the amount of material used in its construction. These inherent problems are accentuated by the stress concentrations which inevitably arise in the region of the openings in the fuel rail providing the fuel inlet and outlets.

**[0004]** Because of the limitations of these existing production techniques, considerable restrictions are placed on the freedom in positioning the fuel rail assembly and the engine in the vehicle and locating other components which must of necessity be adjacent the engine. Components, which can cause packaging difficulties include, for example, a fuel inlet port, and at least one or more fuel outlet ports and are secured to the exterior of the fuel rail by brazing. The fuel rail may include a sensor port for a fuel pressure sensor which is brazed to the exterior of the fuel rail. Such ports increase the space required in the engine bay for the fuel rail assembly.

**[0005]** The present disclosure seeks to provide a solution to reduce the space required for the fuel rail assembly.

**[0006]** According to the present disclosure, there is provided a fuel rail assembly for a fuel injection system for an internal combustion engine. The fuel rail assembly comprises a fuel rail comprising an elongate generally tubular body forming a fuel reservoir, a fuel inlet port and at least one or more fuel outlet ports and a sensor port. The sensor port is located at least partially within the interior volume of the fuel rail.

**[0007]** The sensor port has a body, which may be substantially tubular or cylindrical and has a bore for a sensor. By locating the sensor port at least partially within the interior volume of the fuel rail, the dimensions of the outer contour of the fuel rail are reduced compared to

embodiments in which the sensor port is arranged to the exterior of the fuel rail and protrudes from the wall of the fuel rail. Thus, the fuel rail occupies less space.

**[0008]** The sensor port may be sized and shaped to accommodate a sensor such as a fuel pressure sensor. The position of the sensor port in the fuel rail may be selected depending on the application, for example, depending on the position in the fuel rail that the pressure of the fuel should be measured. In some embodiments more than one sensor port may be provided. This enables the fuel pressure to be measured at different positions within the fuel rail. The sensor positioned in the sensor port is not limited to a fuel pressure sensor. Sensors for sensing other parameters of the fuel, for example, temperature may also be provided.

**[0009]** The location of at least part of the sensor port within the interior volume of the fuel rail provides an obstacle to the flow of fuel that may be used to dampen fluctuations in fuel pressure. Pressure variations may have adverse effects on the performance of the injectors which can lead to excessive fuel injection or too little fuel injection with the risk of causing potential damage to the engine. By dampening the pressure fluctuations, an improved harmonization of the internal pressure of the fuel rail is provided so as to better control the pressure of the fuel at the injector and better control the combustion process. Emissions can be reduced.

**[0010]** In some embodiments, the sensor port has a body, which may be substantially tubular or cylindrical and has a bore for a sensor. The sensor port is located in a hole in the wall of the fuel rail such that the body protrudes into the interior volume of the fuel rail. In some embodiments, the sensor port has an end that lies substantially flush with the exterior surface of the fuel rail. The opening for the sensor provided by the bore in the body, therefore, lies substantially flush with the exterior surface of the fuel rail.

**[0011]** In some embodiments, at least 50% or 75% of the volume of the sensor port is positioned within the interior volume of the fuel rail. In some embodiments, the opening of the sensor port through which the sensor is inserted may be flush with the exterior surface of the fuel rail so that the sensor port is positioned essentially entirely within the interior volume of the fuel rail, in particular within the tubular body.

**[0012]** In an embodiment, the disclosure provides a fuel rail assembly for a fuel injection system for an internal combustion engine, in which the sensor port has a generally cylindrical bore adapted to receive a sensor and has an axis at an angle to the longitudinal axis of the fuel rail, i.e. the axis of the sensor port is not parallel to the longitudinal axis of the fuel rail so that the sensor can be described as a radial sensor. In some embodiments, the axis of the sensor port is at 90° to the longitudinal axis of the fuel rail. The angle of the axis of the sensor port with respect to the longitudinal axis of the fuel rail may be selected depending on the engine design and/or position at which the sensor head should be positioned.

**[0013]** The sensor port may be provided as a separate component that is joined to the fuel rail, in particular inserted into a hole in the outer wall of the fuel rail so that it is located at least partially within the interior volume of the fuel rail. This separate component can be attached to the fuel rail in various ways in a fluid-tight manner.

**[0014]** In some embodiments, the sensor port is located in a hole in the wall of the fuel rail, extends into the interior volume of the fuel rail and is brazed to the wall of the fuel rail. The sensor port may have a peripheral slot or shoulder adapted to receive a brazing paste or ring. In another embodiment, a slot may be provided in the wall of the fuel rail adjacent the sensor port for receiving a brazing paste or ring. In some embodiments, the sensor port may be welded to the wall of the fuel rail at the periphery of the hole.

**[0015]** In another embodiment, the sensor port is provided with a peripheral flange on its outer end which has a diameter larger than the diameter of the hole in the fuel rail, which serves to locate the sensor port on the fuel rail wall. In some embodiments, the peripheral flange may have a peripheral slot adjacent the exterior surface of the fuel rail. The slot is adapted to receive a brazing paste or brazing ring by which the sensor port is secured to the fuel rail. In another form, the peripheral slot is formed in the wall of the fuel rail.

**[0016]** In some embodiments, the sensor port is located with a press fit in the hole in the fuel rail wall. In yet another form of the sensor port, the sensor port is arranged to abut the opposing interior surface of the fuel rail thereby to locate the sensor port in the desired position. The sensor port may extend across the interior diameter of the fuel rail to abut the opposing interior surface of the fuel rail. In this arrangement, the axis of the sensor port extends perpendicularly to the longitudinal axis of the fuel rail. In other embodiments, the sensor portion may extend at a tangent to the interior wall and not cross the longitudinal axis of the fuel rail.

**[0017]** In some embodiments, the sensor port is integrally formed with the tubular body. The fuel rail assembly may be formed by an additive manufacturing technology in order to form the sensor port integrally with the tubular body. The fuel rail may be formed of a synthetic plastics material or a metal such as stainless steel or other alloy. In an embodiment, the additive manufacturing technology uses alternative materials for certain parts of the fuel rail assembly.

**[0018]** Additive manufacturing techniques may be used to build up the fuel rail layer by layer. For example, the elongate body and the sensor port may be built up layer by layer using 3D (Three-dimensional) printing or Powder Bed Fusion or Directed Energy Deposition. The fuel rail may be built up layer by layer by movement of the metal jet print head, laser or electron beam controlled according to a three dimensional model of the fuel rail.

**[0019]** The sensor port is positioned partially or completely inside the main gallery of the fuel rail. A fuel rail and a fuel rail assembly with reduced overall dimensions

are provided which simplifies installation of the fuel rail in the engine environment. The fuel rail is applicable for embodiments in which the sensor port is not parallel to the main or longitudinal axis of the fuel rail or main gallery, for example the sensor port protrudes radially from the longitudinal axis. Additionally, the weight and cost of the fuel rail is reduced due to reduction in the use of the material.

**[0020]** The sensor port may be brazed to the main gallery or fuel rail. The sensor port can be positioned with respect to its axis by, for example, a press fit or a loose fit and attached to the main gallery by welding which may be inside the main gallery, or with a mechanical stop. The mechanical stop may be achieved by the sensor port having a portion having an external diameter larger than the diameter of the hole in the wall of the fuel rail which is used to position the sensor port with respect to the main gallery. The mechanical stop may be, for example, a flange at the opening to the sensor port. Alternatively, the bottom surface of the sensor port may act as a mechanical stop.

**[0021]** In some embodiments, the lower part of the sensor port is shaped so as to affect the flow of the fluid to provide a desired flow. The position of the sensor port within the fuel rail as well as the shape of the sensor port including the bottom part can provide benefits in terms of reducing pressure oscillation by interrupting or splitting the total interior volume.

**[0022]** In some embodiments, two flat parallel surfaces are provided in the external portion of the sensor, which allow the application of the sensor tightening torque without stressing the brazed connection between the sensor port and the fuel rail.

**[0023]** Embodiments of the present invention will now be described with reference to the accompanying drawings.

Figure 1 shows a schematic view of a fuel rail assembly,

Figure 2A shows a side sectional view of the fuel rail and a sensor port,

Figure 2B shows an end view of the fuel rail and a sensor port,

Figures 3A to 3C show sectional side views of three embodiments of the sensor port,

Figures 4A to 4C show sectional side views of three embodiments of the sensor port, and

Figure 5 shows a sectional side view of a sensor port formed by an additive manufacturing technology.

**[0024]** Referring now to Figure 1, there is shown a fuel rail assembly 2 which consists of an elongate generally tubular fuel rail 4 which has a fuel inlet port 6 at one end.

At the other end, the fuel rail 4 is closed by a blanking plug 8. Spaced along the fuel rail 4 is a plurality of outlet ports 10 including an injector cup 12 each adapted to receive a fuel injector (not shown). Each injector cup 12 is connected to the fuel rail through a fuel outlet passage 14. Each fuel outlet passage 14 is secured to a mount 16 by which the fuel rail assembly is secured to the engine.

**[0025]** A sensor port 18 is secured in the wall of the fuel rail 4 so as to be located at least partially, and preferably entirely, within the volume of the reservoir in the fuel rail 4 so as to be substantially flush with the exterior surface of the fuel rail 4.

**[0026]** Referring now to Figures 2A and 2B, there is shown a cross-sectional side view of the fuel rail assembly 2 of Figure 1 showing a sensor port 18 located within the interior volume of the fuel rail 4 which is secured to the wall 20 of the fuel rail. Although not shown, it is possible for the exterior surface of the sensor port 18 located in the fuel rail 4 to be shaped so as to assist damping pressure fluctuations occur the fuel being pumped into the fuel rail 4. As shown, the sensor port 18 has a generally cylindrical shape terminating at its lower end in a frusto-conical profile. The sensor port 18 has a cylindrical chamber open at its external end which lies substantially flush with the exterior surface of the fuel rail 4. The sensor port 18 is adapted to receive a sensor (not shown), such as a fuel pressure sensor.

**[0027]** As shown particularly in Figure 2B, the sensor port 18 is located almost entirely within the volume of the fuel rail 4. In this embodiment, the internal end of the sensor port 18 is clear of and spaced apart from the opposite interior surface of the wall 20 of the fuel rail 4. In other embodiments (not shown), the sensor port 18 abuts the opposing interior surface of the wall 20 of the fuel rail 4, which serves to locate the sensor port 18 in the correct position relative to the exterior surface of the fuel rail 4.

**[0028]** Referring now to Figures 3A to 3C, there is shown sectional side views of part of the fuel rail 4 and a sensor port 18 secured in the wall 20 of the fuel rail. In Figure 3A, the sensor port 18 is a press fit in a hole in the wall 20 where it is further secured by brazing. In Figure 3B, the sensor port 18 has a peripheral groove or slot 22 which is aligned with the wall 20 of the fuel rail. The slot 22 is filled with a brazing paste or a brazing ring such as a copper ring to facilitate securely brazing the sensor port 18 to the wall 20 of the fuel rail 4.

**[0029]** In Figure 3C, the slot 22 is formed in the wall 20 of the fuel rail 4 and in the same way as the embodiment of Figure 3B, the slot 22 is filled with a brazing paste or brazing ring to facilitate securely brazing the sensor port 18 to the wall 20.

**[0030]** Referring now to Figures 4A to 4C, there is shown an alternative embodiment in which the sensor port 18 has a peripheral flange 24 which has a diameter larger than the diameter of the hole in which the sensor port 18 sits so that the flange 24 abuts the outer surface 26 of the wall 20 of the fuel rail 4 to locate the sensor port

18 in the desired position. In Figure 4A, the sensor port 18 is a press fit in the hole in the wall 20 where it is preferably secured by brazing. In Figure 4B, the peripheral flange 24 has a peripheral undercut which forms a slot 22 between the outer surface 26 of the wall 20 and the lower surface of the peripheral flange 24. The slot 22 may be filled with a brazing paste or a brazing ring to facilitate the secure brazing of the sensor port 18 to the wall 20 of the fuel rail. In Figure 4C a peripheral slot 22 is formed in the outer surface 26 of the wall 20 of the fuel rail 4 and the slot 22 is filled with a brazing paste or brazing ring which abuts the underside of the peripheral flange 24 to facilitate the secure brazing of the sensor port 18 to the wall 20 of the fuel rail 4.

**[0031]** Referring now to Figure 5, there is shown an alternative construction in which the sensor port 18 is formed integrally with the wall 20 of the fuel rail 4. This integral construction may be formed by an additive manufacturing technology. By the use of additive manufacturing, it is possible to adjust the wall thickness of the wall 20 and the sensor port 18 by forming a radiused fillet in the region of the junction between the two portions, i.e. the sensor port 18 and the wall 20. This curved contour may be used to prevent a stress concentration point and to eliminate the possibility of leaks occurring at the junction between the sensor port 18 and the wall 20 of the fuel rail, which may occur when two separate components are brazed together.

**[0032]** The sensor port 18 is positioned at least partially and, in some embodiments, substantially entirely within the interior volume of the fuel rail 4. Therefore, the space occupied by the fuel rail assembly 2 is reduced.

## REFERENCES

### [0033]

2	Fuel rail assembly
4	Fuel rail
6	Fuel inlet port
8	Blanking plug
10	Outlet port
12	Injector cup
14	Outlet passage
16	Mount
18	Sensor port
20	Fuel rail wall
22	Slot
24	Peripheral flange
26	Outer surface

## Claims

1. A fuel rail assembly for a fuel injection system for an internal combustion engine, having a fuel rail (4) comprising an elongate generally tubular body forming a fuel reservoir and having a fuel inlet port (6)

- and at least one or more fuel outlet ports (10) and a sensor port (18), the sensor port (18) being located at least partially within the interior volume of the fuel rail (4).
2. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to claim 1, in which the sensor port (18) has a generally cylindrical bore adapted to receive a sensor and has an axis at an angle to the longitudinal axis of the fuel rail (4). 10
  3. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to claim 2 wherein the axis of the sensor port (18) is at 90° to the longitudinal axis of the fuel rail (4). 15
  4. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to any one of claims 1 to 3, wherein the sensor port (18) is located in a hole in the wall (20) of the fuel rail (4) so as to lie substantially flush with the exterior surface of the fuel rail (4). 20
  5. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to any one of claims 1 to 4, wherein the sensor port (18) is brazed to the wall of the fuel rail (4). 25
  6. A fuel rail assembly for a fuel injection system for an internal combustion engine according to claim 5, wherein a peripheral slot (22) or shoulder adapted to receive a brazing paste or ring is located at the junction between the fuel rail wall (20) and the sensor port (18). 30
  7. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to claim 6, wherein a slot (22) is provided in the wall of the fuel rail (4) adjacent the sensor port (18) for receiving a brazing paste or ring. 35
  8. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to any one of claims 1 to 7, wherein the sensor port (18) is provided with a peripheral flange (24) on its outer end which has a diameter larger than the diameter of the hole, which flange serves to locate the sensor port (18) on the fuel rail wall (20). 40
  9. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to claim 8, wherein the peripheral flange (24) has a peripheral slot (22) adjacent the exterior surface of the fuel rail (4) adapted to receive a brazing paste or brazing ring by which the sensor port (18) is secured to the fuel rail (4). 45
  10. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to claim 8 wherein the peripheral slot (22) is formed in the wall (20) of the fuel rail (4). 50
  11. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to any one of the preceding claims, wherein the sensor port (18) is located with a press fit in the hole in the fuel rail wall (24). 55
  12. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to any one of the preceding claims, wherein the sensor port (18) is arranged to abut the opposing interior surface of the fuel rail (4) thereby to locate the sensor port (18) in the desired position.
  13. A fuel rail assembly for a fuel injection system for an internal combustion engine, according to any one of the preceding claims, wherein fuel rail (4) is formed of a synthetic plastics material or a metal such as stainless steel or other alloy.
  14. A method of forming a fuel rail assembly according to any one of the preceding claims by the use of an additive manufacturing technology.
  15. A method of forming a fuel rail according to claim 14, wherein the additive manufacturing technology uses alternative materials for certain parts of the fuel rail assembly.

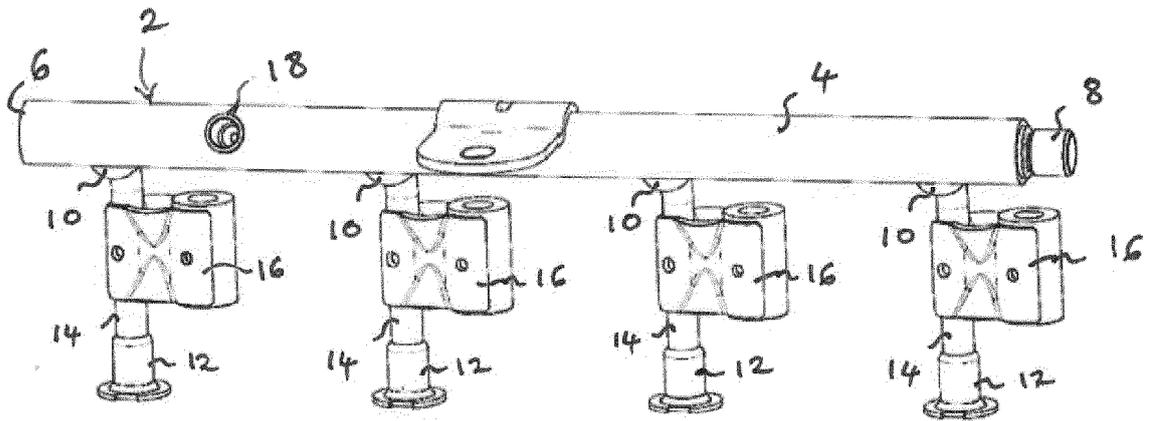


Fig. 1

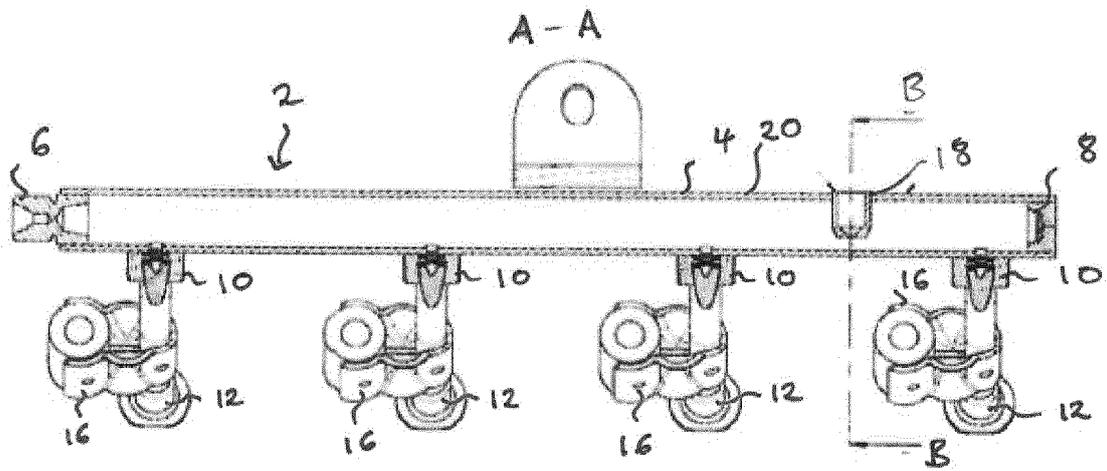


Fig. 2A

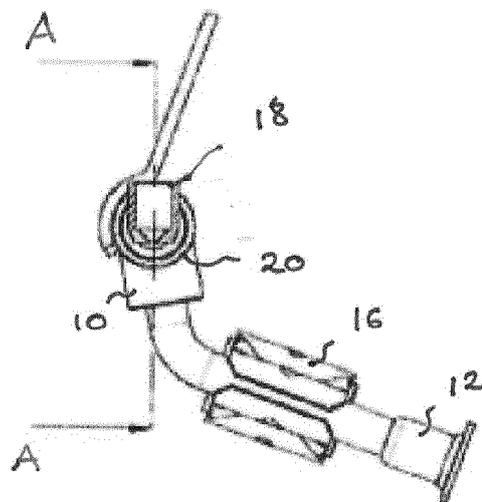


Fig. 2B

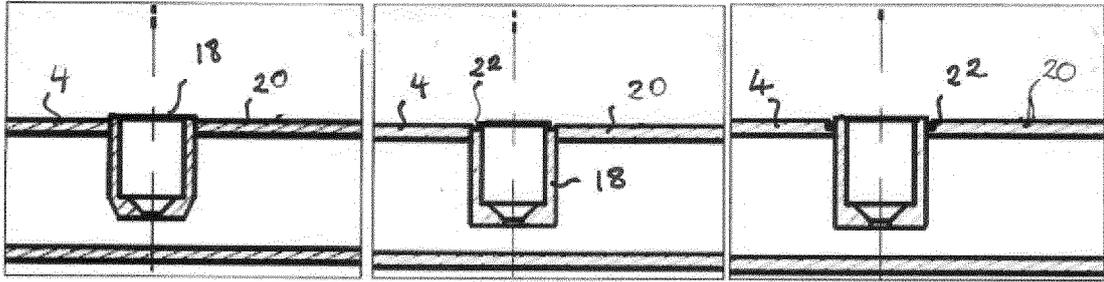


Fig. 3A

Fig. 3B

Fig. 3C

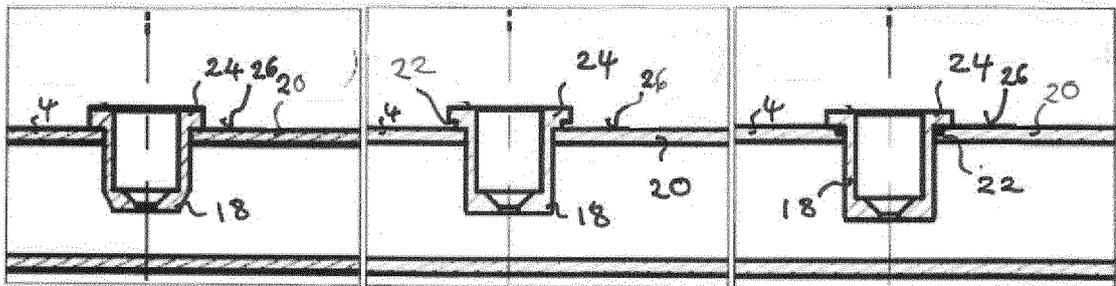


Fig. 4A

Fig. 4B

Fig. 4C

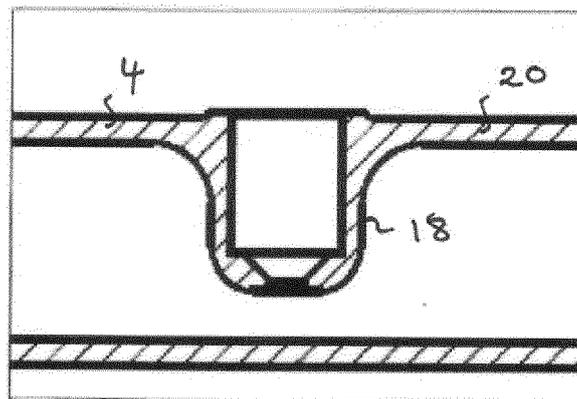


Fig. 5



EUROPEAN SEARCH REPORT

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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 2013 217328 A (MARUYASU & CO LTD) 24 October 2013 (2013-10-24) * paragraphs [0021], [0027], [0028], [0030]; figures 1, 2, 4 *	1-3, 5-10,13	INV. F02M55/02 F02M61/16
X	DE 10 2017 205691 A1 (BOSCH GMBH ROBERT [DE]) 4 October 2018 (2018-10-04) * paragraphs [0002], [0005]; claims 1, 8; figure 2 *	1,4, 13-15	
Y	-----	11	
X	EP 2 333 302 A1 (USUI KOKUSAI SANGYO KK [JP]) 15 June 2011 (2011-06-15) * paragraphs [0003], [0010]; figures 1, 10 *	1-3, 5-11,13	
X	DE 10 2008 035494 A1 (DAIMLER AG [DE]) 4 February 2010 (2010-02-04) * paragraphs [0064], [0065]; figures 16, 17 *	1-3	
X	US 2017/342950 A1 (CAREY PAUL G [US]) 30 November 2017 (2017-11-30) * paragraphs [0013], [0024]; figure 3 *	1	
A	JP 2007 016668 A (USUI KOKUSAI SANGYO KK) 25 January 2007 (2007-01-25) * paragraph [0012]; figures 1-7 *	1-13	F02M
Y	DE 10 2012 205397 A1 (KENDRION VILLINGEN GMBH [DE]) 10 October 2013 (2013-10-10) * claim 1 *	11	
-----			
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 15 April 2019	Examiner Tortosa Masiá, A
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	

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ON EUROPEAN PATENT APPLICATION NO.

EP 18 20 6634

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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.

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2013217328 A	24-10-2013	JP 5891094 B2 JP 2013217328 A	22-03-2016 24-10-2013
DE 102017205691 A1	04-10-2018	DE 102017205691 A1 WO 2018184799 A1	04-10-2018 11-10-2018
EP 2333302 A1	15-06-2011	CN 102066742 A EP 2333302 A1 JP 5510992 B2 JP 2010007651 A US 2011108005 A1 WO 2010001810 A1	18-05-2011 15-06-2011 04-06-2014 14-01-2010 12-05-2011 07-01-2010
DE 102008035494 A1	04-02-2010	NONE	
US 2017342950 A1	30-11-2017	NONE	
JP 2007016668 A	25-01-2007	NONE	
DE 102012205397 A1	10-10-2013	NONE	

EPO FORM P0459

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