(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 March 2014 (06.03.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/035956 A1

(51) International Patent Classification:
F01N 3/20 (2006.01)

(21) International Application Number:
PCT/US2013/056783

(22) International Filing Date:
27 August 2013 (27.08.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13/595,105 27 August 2012 (27.08.2012) US

(71) Applicant: **CONTINENTAL AUTOMOTIVE SYSTEMS, INC.** [US/US]; One Continental Drive, Auburn Hills, Michigan 48326 (US).

(72) Inventors: **BUGOS, Stephen C**; 7 Ellison Lane, Poquoson, Virginia 23662 (US). **HORNBY, Michael**; 4001 Elizabeth Killebrew, Williamsburg, Virginia 23188 (US). **VANVUURN, William Nicolaas**; 215 Pageland Drive, Yorktown, Virginia 23693 (US).

(74) Agent: **BENDER, Ronald P**; One Continental Drive, Auburn Hills, Michigan 48326 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: REDUCTANT DELIVERY UNIT FOR AUTOMOTIVE SELECTIVE CATALYTIC REDUCTION SYSTEMS- ACTIVE COOLING

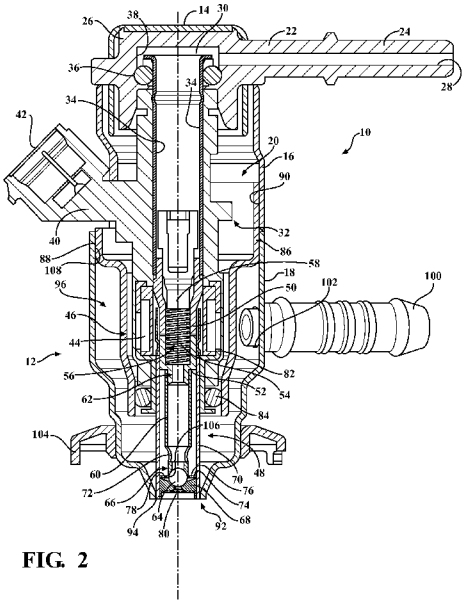


FIG. 2

(57) **Abstract**: A reductant delivery unit (RDU) delivers supplied reductant (aqueous urea solution) to the engine exhaust system. The delivered reductant is transformed into ammonia which then reacts with the exhaust oxides of nitrogen in a catalytic environment to produce nitrogen and H20. The reductant must be metered to coincide with the amount of NOx present in the exhaust, and also present sufficient spray quality of the delivered fluid to promote good mixing of the ammonia with the exhaust gas. The RDU is a liquid-cooled, making the RDU suitable for very high temperature environment applications.

WO 2014/035956 A1

REDUCTANT DELIVERY UNIT FOR AUTOMOTIVE SELECTIVE CATALYTIC REDUCTION SYSTEMS- ACTIVE COOLING

FIELD OF THE INVENTION

[0001] The invention relates generally to providing active cooling for a reductant delivery unit for an automotive selective catalytic reduction system.

BACKGROUND OF THE INVENTION

[0002] New emissions legislation in Europe and North America is driving the implementation of new exhaust aftertreatment systems, particularly for lean-burn technologies such as compression-ignition (diesel) engines, and stratified-charge spark-ignited engines (usually with direct injection) that are operating under lean and ultra-lean conditions. Lean-burn engines exhibit high levels of nitrogen oxide emissions (NOx), that are difficult to treat in oxygen-rich exhaust environments characteristic of lean-burn combustion. Exhaust aftertreatment technologies are currently being developed that treat NOx under these conditions.

[0003] One of these technologies includes a catalyst that facilitates the reactions of ammonia (NH_3) with the exhaust nitrogen oxides (NOx) to produce nitrogen (N_2) and water (H_2O). This technology is referred to as Selective Catalytic Reduction (SCR). Ammonia is difficult to handle in its pure form in the automotive environment, therefore it is customary with these systems to use a liquid aqueous urea solution, typically at a 32% concentration of urea ($CO(NH_2)_2$). The solution is referred to as AUS-32, and is also known under its commercial name of AdBlue. The urea is delivered to

the hot exhaust stream and is transformed into ammonia in the exhaust after undergoing thermolysis, or thermal decomposition, into ammonia and isocyanic acid (HNCO). The isocyanic acid then undergoes a hydrolysis with the water present in the exhaust and is transformed into ammonia and carbon dioxide (CO_2), the ammonia resulting from the thermolysis and the hydrolysis then undergoes a catalyzed reaction with the nitrogen oxides as described previously.

[0004] The delivery of the AUS-32 solution to the exhaust involves precise metering of the fluid and proper preparation of the fluid to facilitate the later mixing of the ammonia in the exhaust stream. Previous designs have included these exhaust-mounted concepts, which were improvements over even earlier remote-mount solutions.

[0005] Current systems are in limited volume production for the heavy-duty diesel engine sector. Some SCR systems include production of an injector for passenger car applications. Others include metering control carried out by an injector mounted in a control block. The metered fluid is transported via a tube to the exhaust. After the metering valve, the fluid is also exposed to compressed air to aid with atomization which ensures subsequent good mixing with the exhaust gas. The pressurized mixture is then injected into the exhaust.

[0006] Some systems do not use compressed air because compressed air is not expected to be available on many future applications of the SCR technology, so it is important to have delivery of the AUS-32 without air-assistance.

[0007] Some injection units that do not use compressed air are intended for mounting proximate to the exhaust line, but are passively cooled and thermally decoupled from the hot exhaust line. These designs include a thermally isolating gasket arrangement that prevents heat conduction through the mounting boss to the injector tip, where the urea solution is metered. The preferential conduction path leads toward the outer air-exposed shields, which often are exposed to fairly well-ventilated environments to assist in cooling. The injector tip itself also benefits from cooling provided by the working fluid, such as AUS-32.

[0008] However, in certain applications, the injector mounting location could be in a zone where ventilation is minimal, e.g. behind the engine. In this case, active cooling of the injector may be required to prevent excessive heating of the injector tip, and hence of the AUS-32 working fluid.

SUMMARY OF THE INVENTION

[0009] The present invention is a reductant delivery unit having active cooling. The reductant delivery unit has an upper shield, a lower shield connected to the upper shield, and an inner sleeve. An outer surface of the inner sleeve is connected to an inner surface of the upper shield, and an inner surface of the lower shield. The reductant delivery unit also includes an injector having a solenoid portion and a valve portion, and the valve portion has a lower valve body. A casing partially surrounds the lower valve body, and is part of the solenoid portion. An o-ring is in contact with the inner sleeve, and the o-ring surrounds the casing, providing a sealing function between the casing and the inner sleeve. The lower valve body is connected

to a portion of the lower shield at a connection point. A liquid cooling cavity is formed by the connection between the inner sleeve and the lower shield, the lower valve body and the lower shield, the o-ring and the inner sleeve, and the o-ring and the casing.

[0010] An inlet hydraulic connector is connected to the lower shield, and an outlet hydraulic connector connected to the lower shield. Coolant flows from the inlet hydraulic connector into the liquid cooling cavity to provide a cooling function to the injector, and the coolant exits the liquid cooling cavity through the outlet hydraulic connector.

[0011] It is an object of the invention to provide delivery of AUS-32 to the engine exhaust for use in SCR exhaust aftertreatment systems on vehicles via an actively cooled reductant delivery unit (RDU).

[0012] It is another object of this invention to provide active cooling for an RDU from a separate liquid circuit. Although the source of the cooling liquid may be varied, it is within the scope of the invention that engine coolant from an existing engine coolant circuit is used with the RDU of the present invention.

[0013] It is another object of the invention to provide a solution to cooling the exhaust-mount injection units due to extreme high temperature mounting locations.

[0014] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while

indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0016] Figure 1 is a side view of a reductant delivery unit having active cooling, according to embodiments of the present invention;

[0017] Figure 2 is a sectional side view of a reductant delivery unit having active cooling, according to embodiments of the present invention;

[0018] Figure 3 is a side view of a reductant delivery unit having active cooling, according to a first alternate embodiment of the present invention;

[0019] Figure 4 is a sectional side view of a reductant delivery unit having active cooling, according to a first alternate embodiment of the present invention;

[0020] Figure 5A is a first perspective view of a reductant delivery unit having active cooling, according to a second alternate embodiment of the present invention;

[0021] Figure 5B is a top view of a reductant delivery unit having active cooling, according to a second alternate embodiment of the present invention;

[0022] Figure 5C is a second perspective view of a reductant delivery unit having active cooling, according to a second alternate embodiment of the present invention;

[0023] Figure 6Ais a first perspective view of a reductant delivery unit having active cooling, according to a third alternate embodiment of the present invention;

[0024] Figure 6B is a top view of a reductant delivery unit having active cooling, according to a third alternate embodiment of the present invention; and

[0025] Figure 6C is a second perspective view of a reductant delivery unit having active cooling, according to a third alternate embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] The following description of the preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0027] Referring to the Figures 1-2, an embodiment of a reductant delivery unit for an automotive selective catalytic reduction (SCR) system with active cooling is shown generally at 10. The reductant delivery unit 10 includes an outer shell or casing, shown generally at 12, and the shell 12 includes a retaining cap 14, which is connected to an upper shield 16, and a lower shield 18, which is connected to the upper shield 16. The retaining cap 14 and the shields 16,18 when connected together form a cavity, shown generally at 20, in which various components are disposed.

[0028] The cap 14 at least partially surrounds a hydraulic connector 22. The hydraulic connector 22 has an inlet pipe 24, and an inlet cup 26, which in this embodiment are integrally formed together, but it is within the scope of the invention that the inlet pipe 24 and inlet cup 26 may be formed separately. The inlet pipe 24 includes an aperture 28 which extends through the pipe 24 and is in fluid communication with an inner cavity 30 formed by the inlet cup 26, best seen in Figure 2. The inner cavity 30 is in fluid communication with an injector, shown generally at 32, which is disposed within the cavity 20.

[0029] The retaining cap 14 maintains the inlet cup 26 in place via a weld through the upper shield 16. The upper shield 16 is constructed so as to minimize heat transfer from the hot ambient environment to the inner volumes of the unit 10 and the AUS-32 fluid passages, particularly during heating transients (e.g. engine drop to idle after a mountain climb pulling a trailer). In so doing, the heat capacity of the upper shield 16 protects against short-term heating of the inner components of the injector 32. The upper shield 16 is joined to the lower shield 18, also via a laser weld, but also possibly by brazing.

[0030] The injector 32 includes an upper valve body 34, which is hollow and in fluid communication with the inner cavity 30. Part of the upper valve body 34 is surrounded by a first seal, which in this embodiment is an upper o-ring 36 which is in contact with the inner wall 38 of the inner cavity 30, to provide a seal connection between the upper valve body 34 and the inlet cup 26, ensuring all fluid that flows through the inlet cup 26 passes into the upper valve body 34.

[0031] The upper valve body 34 is partially surrounded by a housing 40 having a connector 42. The connector 42 is in electrical communication with a coil 44, and the coil 44 is part of a solenoid portion, shown generally at 46. The solenoid portion 46 is part of the injector 32, and controls the movement of a valve portion, shown generally at 48, which is also part of the injector 32. In addition to the coil 44, the solenoid portion 46 also includes a pole piece 50 surrounded by the coil 44, and a moveable armature 52. The pole piece 50 and the armature 52 are substantially hollow such that a return spring 54 is disposed in a cavity, shown generally at 56, formed by the pole piece 50 and armature 52. The return spring 54 biases the armature 52 downward when looking at Figure 2, and therefore biases the valve portion 48 toward a closed position. The return spring 54 is located between the armature 52 and a stopper 58.

[0032] The valve portion 48 includes a tube 60 connected to the armature 54 at a first end, shown generally at 62, and a ball 64 connected to a second end, shown generally at 66. The ball 64 is part of a valve, and the valve also includes a valve seat 68. The valve seat 68 is mounted in the lower end of a lower valve body 70, and the lower valve body 70 is connected to the pole piece 50, such that the lower valve body 70 is partially surrounded by the coil 44. Movement of the ball 64 is controlled by a guide 74. The guide 74 includes a guide aperture 106 through which the ball 64 moves, and also includes side apertures 76 which the fluid flows through. The valve seat 68 includes a conical-shaped portion 78, upon which the ball 64 rests when the valve is in the closed position. The valve seat 68 also includes a central aperture 80, through which the fluid passes as the fluid exits the injector 32.

[0033] During the operation of the injector 32, the valve, and more specifically the tube 60 and the ball 64, are biased by the return spring 54 to contact the valve seat 68, and therefore keep the valve in a closed position. When the coil 44 is energized, the armature 52 is drawn toward the pole piece 50. The energizing of the coil 44 generates enough force that the armature 52 overcomes the force of the return spring 54, and moves towards the pole piece 50. Because the tube 60 is connected to the armature 52, and the ball 64 is connected to the tube 60, the movement of the armature 52 towards the pole piece 50 moves the ball 64 away from the valve seat 68, opening the valve. When the valve is in an open position, the fluid flows from the aperture 28 through the inner cavity 30, the upper valve body 34, pole piece 50, armature 52, the tube 60 and out a plurality of exit apertures 72 formed as part of the tube 60. After the fluid flows out of the exit apertures 72, the fluid passes through the side apertures 76, and out the central aperture 80.

[0034] When the coil 44 is no longer energized, the return spring 54 forces the armature 52 away from the pole piece 50, and moves the armature 52, the tube 60 and the ball 64 such that the ball 64 is placed against the conical-shaped portion 78 of the valve seat 68, placing the valve in the closed position.

[0035] The solenoid portion 46 also includes a casing 82 which at least partially surrounds the coil 44 and the lower valve body 70. Surrounding part of the casing 82 is a second seal, which in this embodiment is a lower o-ring 84, and the lower o-ring 84 is surrounded by an inner sleeve 86. The inner sleeve 86 is disposed within the cavity 20, and part of the outer surface 88 of the inner sleeve 86 is connected (through the use of a weld) to both the

inner surface 90 of the upper shield 16, and the inner surface 108 of the lower shield 18. The lower end, shown generally at 92, of the lower shield 18 is shaped such that the lower end 92 contacts the lower valve body 70, and is welded to the lower valve body 70 at a connection point 94. The connection between the inner sleeve 86 and the lower shield 18 and the connection between the lower shield 18 and the lower valve body 70 forms a liquid cooling cavity, shown generally at 96.

[0036] The liquid cooling cavity 96 is also bounded by joining the injector 32 to the lower shield 18 via laser weld, and then by cooperation of the lower o-ring 84 with the inner sleeve 86.

[0037] The lower shield 18 has various contours and shapes, which not only forms the lower end 92 used for connection with the lower valve body 70, but also forms the shape of the liquid cooling cavity 96. There are also two apertures formed as part of the lower shield 18, into which two hydraulic connectors are fixedly mounted. More specifically, there is an inlet hydraulic connector 98 mounted in a coolant inlet aperture (not shown), and an outlet hydraulic connector 100 mounted in a coolant outlet aperture 102. The coolant outlet aperture 102 and the coolant inlet aperture are substantially similar, therefore only one is shown.

[0038] The lower shield 18 is joined hermetically to the inner sleeve 86 via laser weld or brazing. The outer surface 88 of the inner sleeve 86 and the inner surface 108 of the lower shield 18 comprise the principal boundary surfaces of the liquid cooling cavity 96. Liquid is brought to and evacuated from the cavity 96 via the inlet aperture and outlet aperture 102 in the lower

shield 18 equipped with hydraulic connectors 98,100, also joined to the lower shield 18, preferably by brazing.

[0039] The inner sleeve 86 is designed so as to minimize the space between the inside of the inner sleeve 86 and the various injector overmold surfaces. It is also understood that this volume could also be filled with a conductive compound to improve heat transfer to the liquid coolant in the cavity 96.

[0040] Mounted to the outer surface of the lower shield 18 is a v-clamp flange 104 which is used for mounting the reductant delivery unit 10 somewhere along the exhaust system. In one embodiment, the reductant delivery unit 10 may be mounted to an exhaust pipe, but it is within the scope of the invention that the reductant delivery unit 10 may be mounted to an exhaust manifold, or other exhaust system component. During the operation of the unit 10, engine coolant is pumped to the inlet hydraulic connector 98 and flows through the inlet hydraulic connector 98 into the liquid cooling cavity 96. The coolant then circulates through the liquid cooling cavity 96 and exits the liquid cooling cavity 96 through the outlet hydraulic connector 100. The coolant is prevented from contacting the solenoid portion 46 of the injector 32 because of the o-ring 84. This circulation of coolant into and out of the liquid cooling cavity 96 cools the reductant delivery unit 10, and provides the reductant delivery unit 10 with a more consistent operating temperature.

[0041] The interface with the exhaust line is shown here as one suited for the v-clamp flange 104. Other mounting configurations are also possible, including flanges with bolts. The v-clamp flange 104 (or other flange configurations) is joined to the lower shield 18, also preferably by brazing. It

is understood that a number of the braze operations could be accomplished simultaneously with one operation. The flanges 104 would then provide suitable surfaces and geometries for implementation of a sealing gasket to prevent exhaust gas leakage through the flange/boss interface.

[0042] An additional advantage of providing the reductant delivery unit 10 with liquid cooling is the unit 10 then has the ability to maintain a constant fluid temperature of the urea, as defined by the liquid cooling circuit. In this way, temperature corrections to adjust for density and viscosity changes in the working fluid can be greatly simplified, or even eliminated, as can be any temperature feedback systems that would be normally required (e.g. coil current measurements).

[0043] When in use, urea solution is fed through the inlet pipe 24, such that the urea solution passes through the inner cavity 30 and into the upper valve body 34 of the injector 32. In this embodiment, the inlet pipe 24 is depicted as being substantially perpendicular to the injector 32, which presents certain packaging advantages for some installations. However, the radial orientation of the inlet pipe 24 may be varied, as well as the axial orientation. In this embodiment, the inlet pipe 24 and the inlet cup 26 are integrated as one piece; however, a two piece construction (inlet pipe 24 and inlet cup 26) is also possible which may be advantageous from a construction standpoint.

[0044] An alternate embodiment of the invention is shown in Figures 3-4, with like numbers referring to like elements. However, in this embodiment, the hydraulic connectors 98,100 are located at different positions relative to the v-clamp flange 104 and the hydraulic connector 22.

More specifically, the inlet hydraulic connector 98 is located closer to the v-clamp flange 104 and the lower valve body 70 compared to the outlet hydraulic connector 100. This causes the coolant flowing into the liquid cooling cavity 96 to circulate differently compared to the embodiment described in Figures 1-2, and therefore provides a different manner of cooling. Furthermore, in the embodiment shown in Figures 3-4, the inlet pipe 24 and inlet cup 26 are formed as separate components, and then are assembled to form the hydraulic connector 22. This embodiment is also not limited to what is shown in Figures 3-4, the inlet pipe 24 and inlet cup 24 may be integrally formed together, as shown in Figures 1-2. Additionally, the inlet pipe 24 may be oriented to be substantially parallel with the injector 32, instead of being oriented perpendicularly, as shown in Figures 3-4.

[0045] Other embodiments of the invention are shown in Figures 5A-6C. One embodiment of the invention is shown in Figures 5A-5C, with like numbers referring to like elements. In Figures 5A-5C, the inlet pipe 24 is not only oriented parallel to the injector 32, the inlet pipe 24 is also substantially aligned with the injector 32.

[0046] Referring now to the embodiment shown in Figures 6A-6C, the unit 10 shown in these Figures is similar to the previous embodiments, with like numbers referring to like elements. However, the unit 10 shown in Figures 6A-6C is a high-volume unit 10, and is larger in size compared to the previously described embodiments. The unit 10 shown in Figures 6A-6C allows for a greater amount of urea solution to pass through the injector 32, and a greater amount of coolant to pass through the unit 10.

[0047] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. An apparatus, comprising:

a reductant delivery unit, comprising:

an outer shell;

a liquid cooling cavity disposed within the outer shell; and

an injector substantially surrounded by the liquid cooling cavity;

wherein coolant is circulated into and out of the liquid cooling cavity to control the temperature of the injector.

2. The apparatus of claim 1, the outer shell further comprising:

an upper shield; and

a lower shield connected to the upper shield, the lower shield forming a portion of the liquid cooling cavity.

3. The apparatus of claim 2, further comprising an inner sleeve, wherein a portion of the outer surface of the inner sleeve is connected to a portion of the inner surface of the upper shield and a portion of the inner surface of the lower shield, forming part of the liquid cooling cavity.

4. The apparatus of claim 3, the injector further comprising:

a solenoid portion substantially surrounded by the inner sleeve such that the inner sleeve separates the solenoid portion from the liquid cooling cavity, preventing coolant in the liquid cooling cavity from contacting the solenoid portion; and

a valve portion controlled by the solenoid portion, the valve portion having a lower valve body connected to a portion of the lower shield at a connection point, forming a portion of the liquid cooling cavity.

5. The apparatus of claim 4, further comprising:

a casing at least partially surrounding the lower valve body; and

an o-ring surrounding the casing, providing a sealing function between the o-ring and the casing;

wherein the o-ring is in contact with the inner sleeve, providing a sealing function between the o-ring and the inner sleeve, and a portion of the liquid cooling cavity is formed by the sealing function between the o-ring and the casing and the sealing function between the o-ring and the inner sleeve.

6. The apparatus of claim 2, further comprising:

an inlet hydraulic connector connected to the lower shield; and

an outlet hydraulic connector connected to the lower shield;

wherein coolant flows through the inlet hydraulic connector into the liquid cooling cavity and from the liquid cooling cavity out of the outlet hydraulic connector.

7. The reductant delivery unit having active cooling of claim 6, wherein the inlet hydraulic connector is located at a different position relative to the injector compared to the outlet hydraulic connector.

8. The reductant delivery unit having active cooling of claim 6, wherein the inlet hydraulic connector is an angled inlet hydraulic connector.

9. The reductant delivery unit having active cooling of claim 6, wherein the outlet hydraulic connector is an angled outlet hydraulic connector.

10. The apparatus of claim 1, further comprising a v-clamp flange circumscribing the outer shell, the reductant delivery unit mounted for use as part of an exhaust system using the v-clamp flange.

11. The apparatus of claim 6, where in the v-clamp flange is used for mounting the reductant delivery unit to an exhaust manifold.

12. A reductant delivery unit, comprising:

an upper shield;

a lower shield connected to the upper shield;

an inner sleeve connected to the upper shield and the lower shield;

a liquid cooling cavity for receiving and circulating coolant, part of the liquid cooling cavity defined by the connection between the inner sleeve and the lower shield; and

an injector at least partially surrounded by the inner sleeve such that coolant in the liquid cooling cavity is prevented from contacting the injector;

wherein coolant flows into and out of the liquid cooling cavity, and coolant circulates through the liquid cooling cavity.

13. The reductant delivery unit of claim 12, the injector further comprising:

a solenoid portion;

a valve portion controlled by the solenoid portion; and

a lower valve body, the lower valve body being part of the valve portion;

wherein the lower shield is in contact with and connected to the lower valve body, forming a portion of the liquid cooling cavity.

14. The reductant delivery unit of claim 12, further comprising:

a casing at least partially surrounding the lower valve body; and

an o-ring surrounding and in contact with the casing, providing a sealing function between the o-ring and the casing;

wherein a portion of the inner sleeve substantially surrounds the o-ring, providing a sealing function between the inner sleeve and the o-ring.

15. The reductant delivery unit of claim 12, further comprising:

an inlet hydraulic connector connected to the lower shield; and

an outlet hydraulic connector connected to the lower shield;

wherein coolant flows through the inlet hydraulic connector into the liquid cooling cavity and from the liquid cooling cavity out of the outlet hydraulic connector.

16. The reductant delivery unit having active cooling of claim 15, wherein the inlet hydraulic connector is located at a different position relative to the injector compared to the outlet hydraulic connector.

17. The reductant delivery unit having active cooling of claim 15, wherein the inlet hydraulic connector is an angled inlet hydraulic connector.

18. The reductant delivery unit having active cooling of claim 8, wherein the outlet hydraulic connector is an angled outlet hydraulic connector

19. The apparatus of claim 12, further comprising a v-clamp flange circumscribing the outer shell, the reductant delivery unit mounted for use as part of an exhaust system using the v-clamp flange.

20. The apparatus of claim 19, where in the v-clamp flange is used for mounting the reductant delivery unit to an exhaust manifold, and the coolant circulated through the liquid cooling cavity.

21. A reductant delivery unit having active cooling, comprising:

an upper shield;

a lower shield connected to the upper shield;

an inner sleeve, an outer surface of the inner sleeve connected to an inner surface of the upper shield, and an inner surface of the lower shield;

an injector having a solenoid portion an a valve portion;

a lower valve body connected to a portion of the lower shield at a connection point, the lower valve body being part of the valve portion;

a casing partially surrounding the lower valve body, the casing being part of the solenoid portion;

an o-ring in contact with the inner sleeve, the o-ring substantially surrounding the casing, providing a sealing function between the casing and the inner sleeve;

an inlet hydraulic connector connected to the lower shield;

an outlet hydraulic connector connected to the lower shield; and

a liquid cooling cavity formed by the connection between the inner sleeve and the lower shield, the lower valve body and the lower shield, the o-ring and the inner sleeve, and the o-ring and the casing;

wherein coolant flows from the inlet hydraulic connector into the liquid cooling cavity to provide a cooling function to the injector, and the coolant exits the liquid cooling cavity through the outlet hydraulic connector.

22. The reductant delivery unit having active cooling of claim 21, further comprising a v-clamp flange connected to the lower shield, the v-clamp flange connecting the reductant delivery unit to an exhaust system.

23. The reductant delivery unit having active cooling of claim 21, wherein the inlet hydraulic connector is closer to the lower valve body than the outlet hydraulic connector.

24. The reductant delivery unit having active cooling of claim 21, wherein the inlet hydraulic connector is an angled inlet hydraulic connector.

25. The reductant delivery unit having active cooling of claim 21, wherein the outlet hydraulic connector is an angled outlet hydraulic connector.

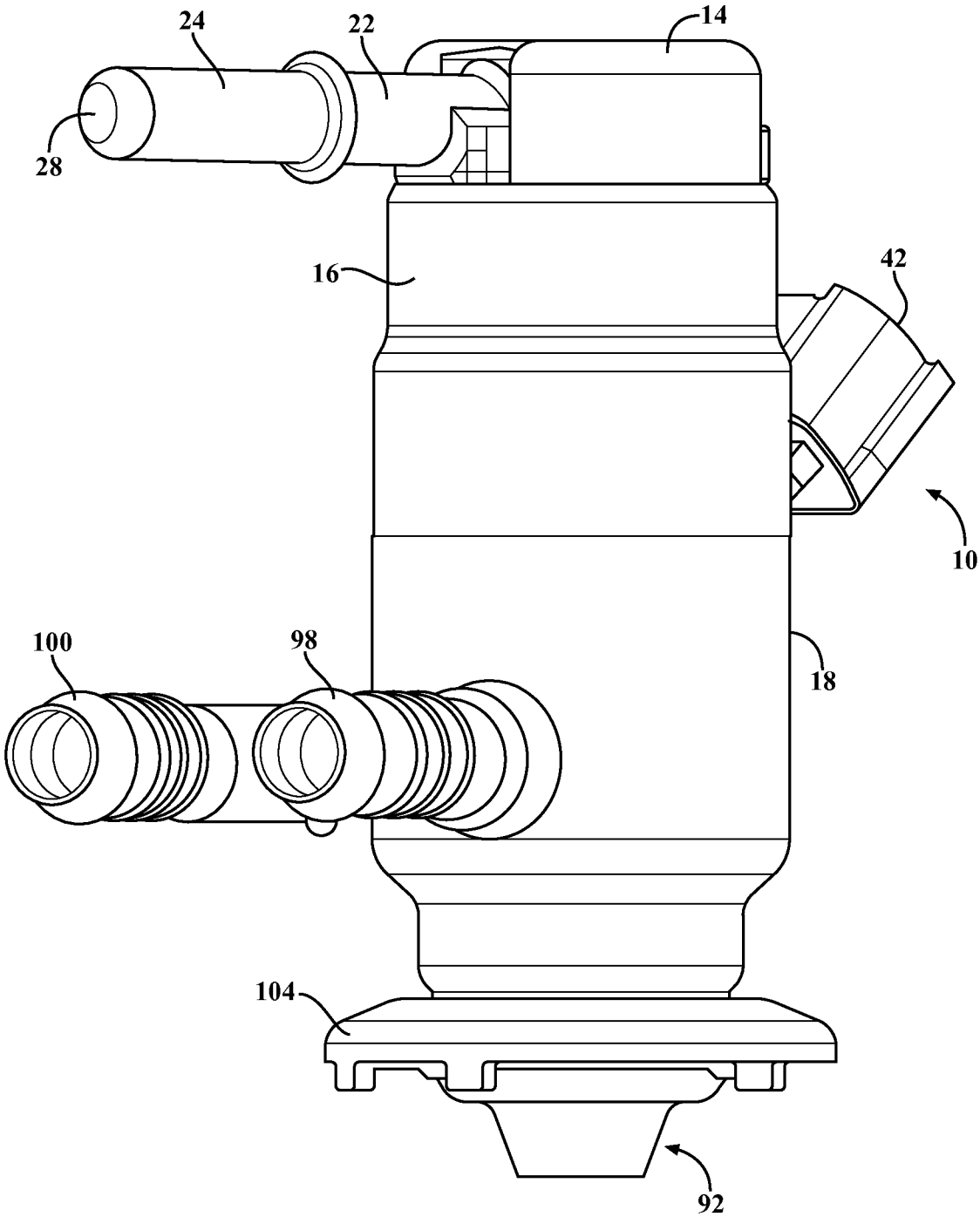


FIG. 1

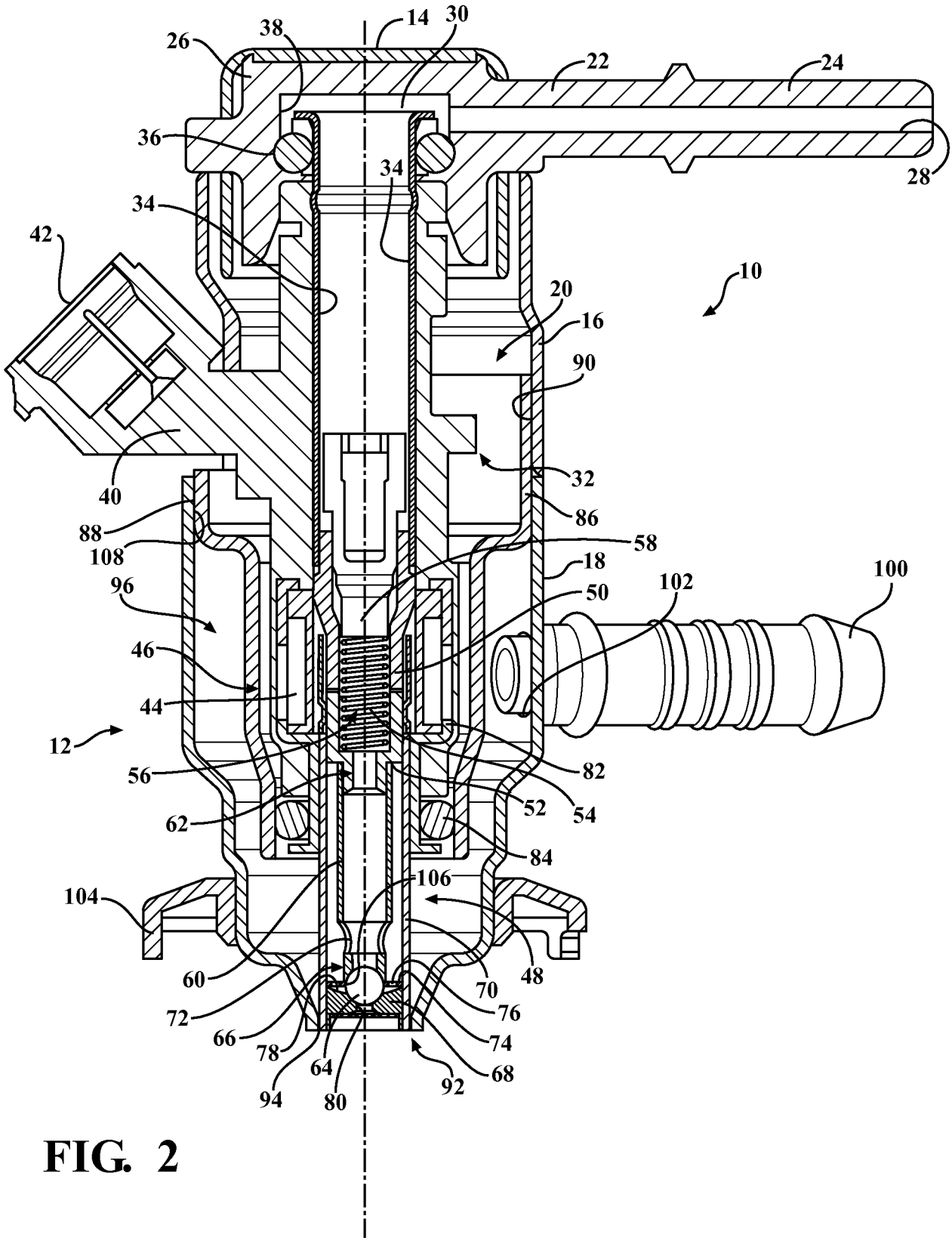

26
38
14
30
22
24
36
34
28
34
42
10
20
16
90
40
32
86
88
58
108
18
100
96
102
50
46
44
12
82
56
52
54
62
84
106
104
48
60
70
72
76
66
74
78
64
68
94
80
92

FIG. 2

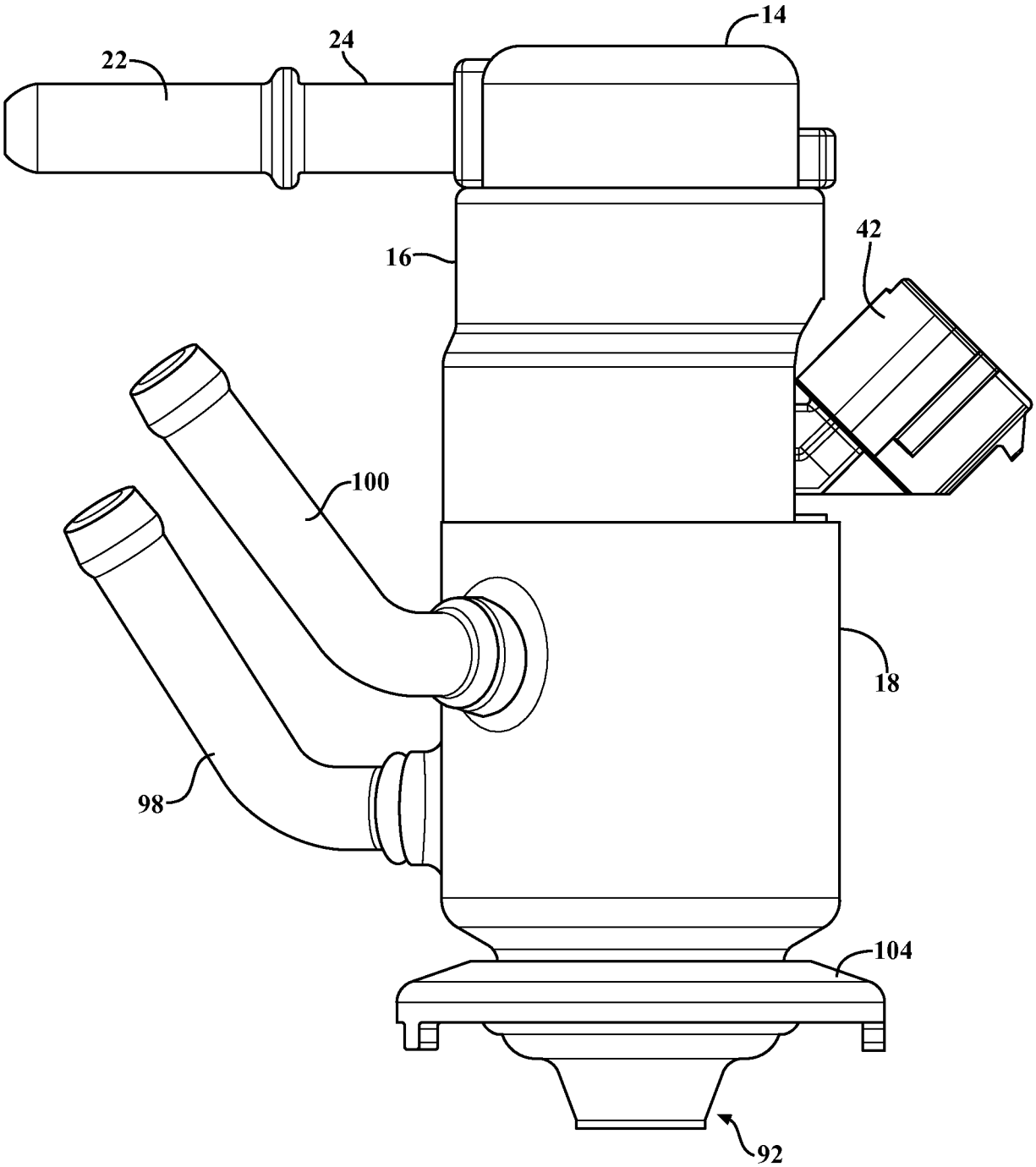


FIG. 3

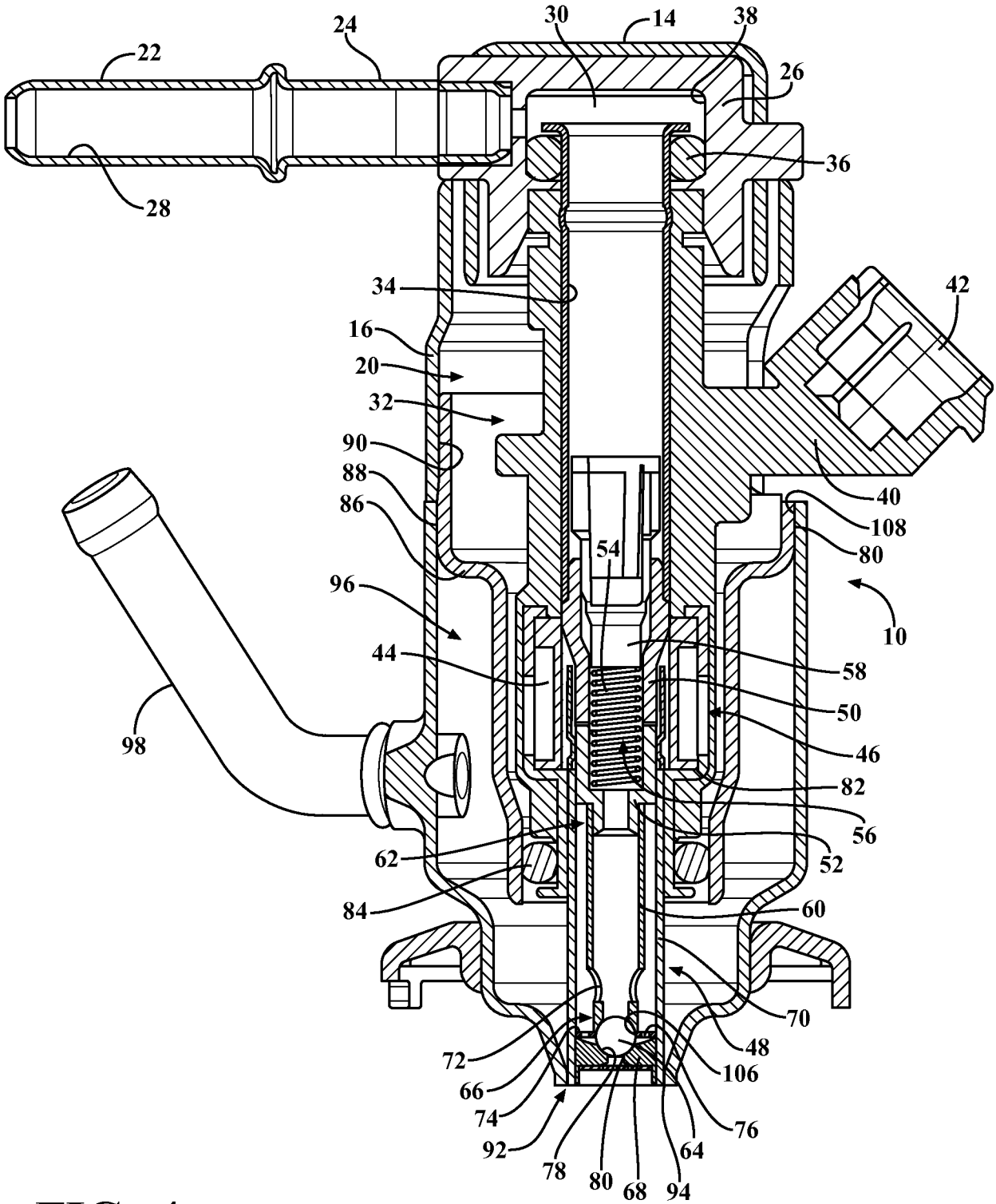

22
24
30
14
38
26
36
28
34
42
16
20
32
90
88
86
40
108
80
54
96
10
44
58
50
46
98
82
56
62
52
84
60
70
48
72
106
66
74
76
92
64
78
80
68
94

FIG. 4

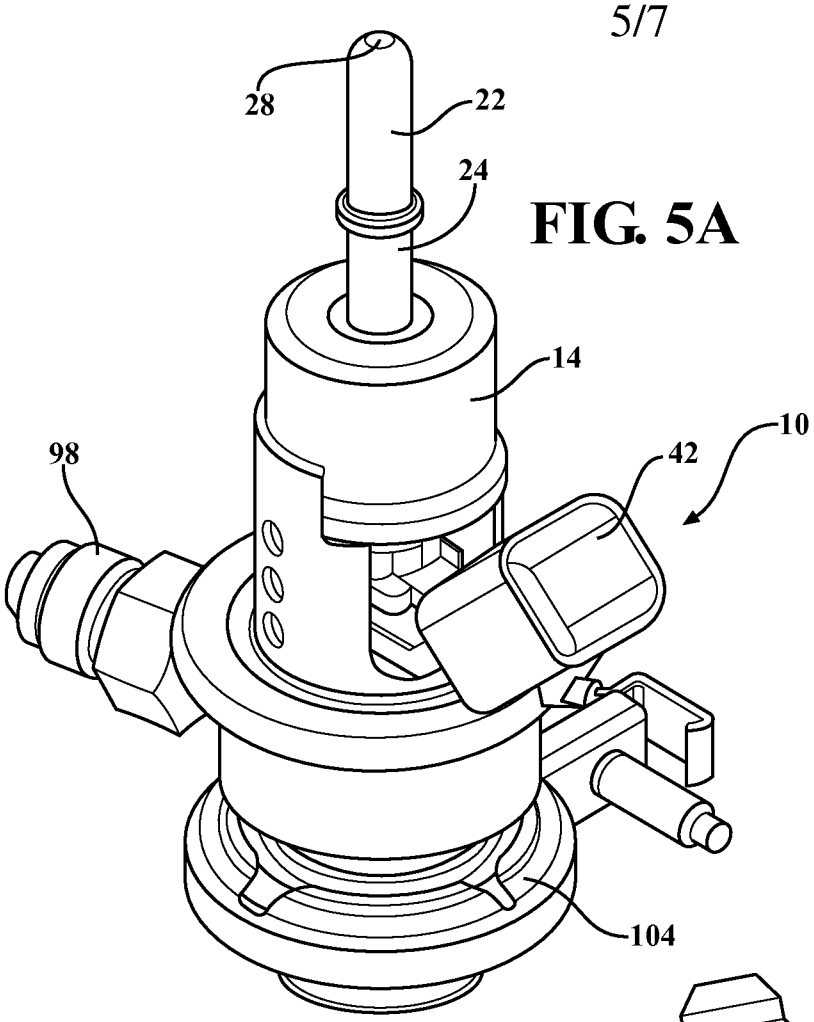


FIG. 5A

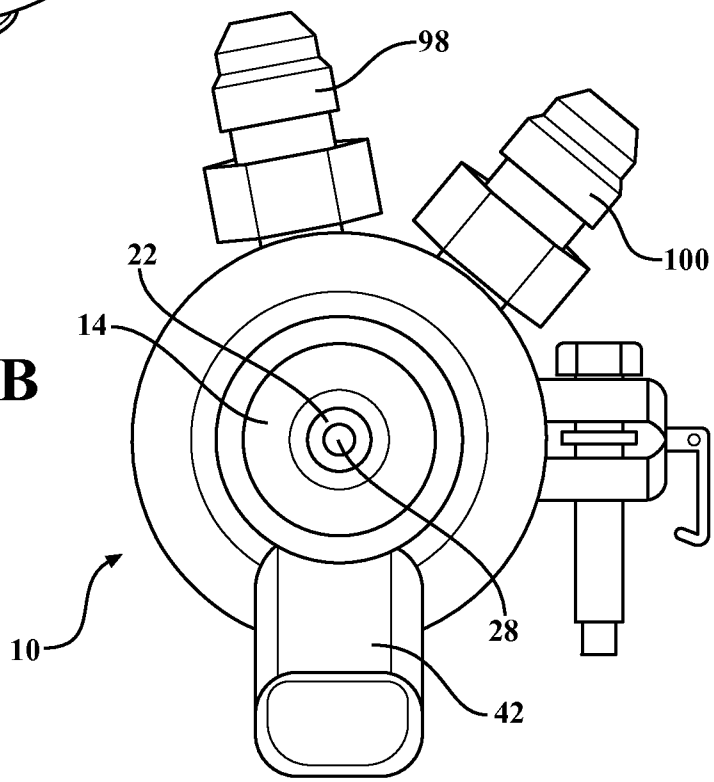


FIG. 5B

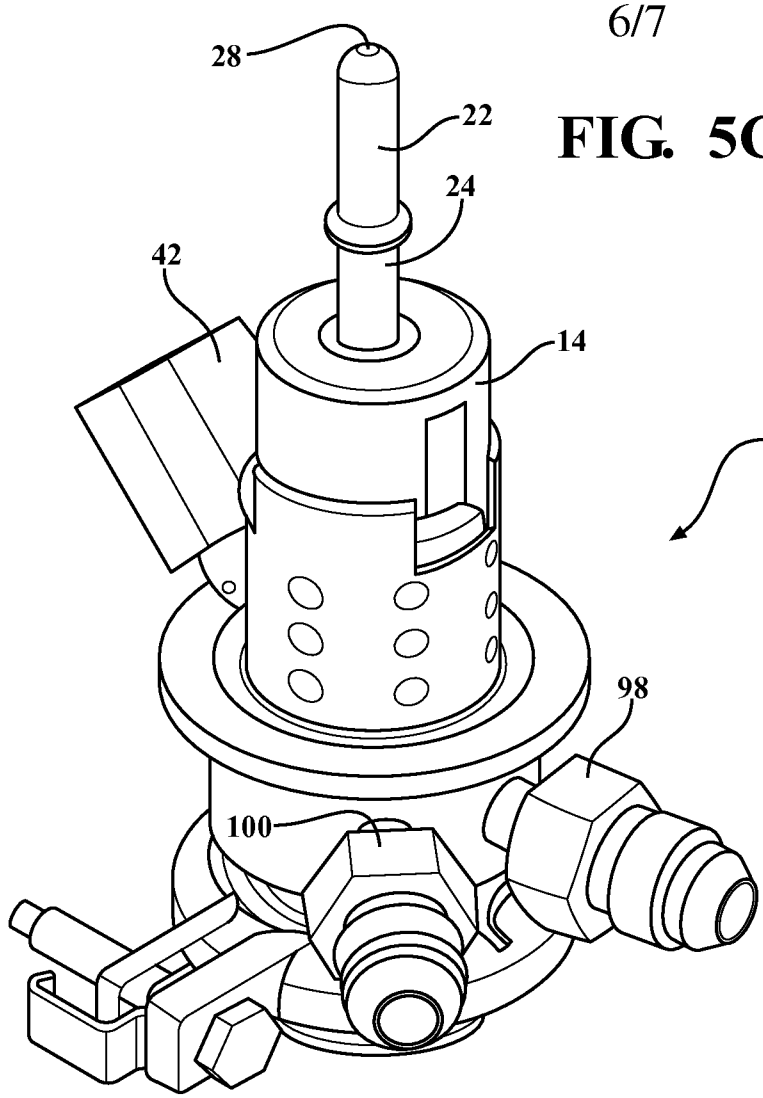


FIG. 5C

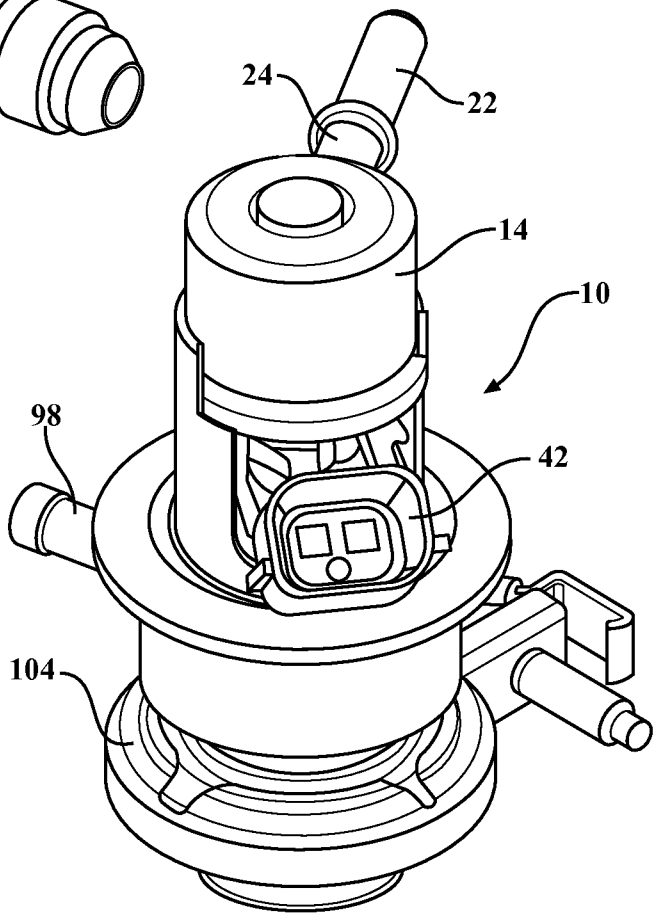


FIG. 6A

FIG. 6B

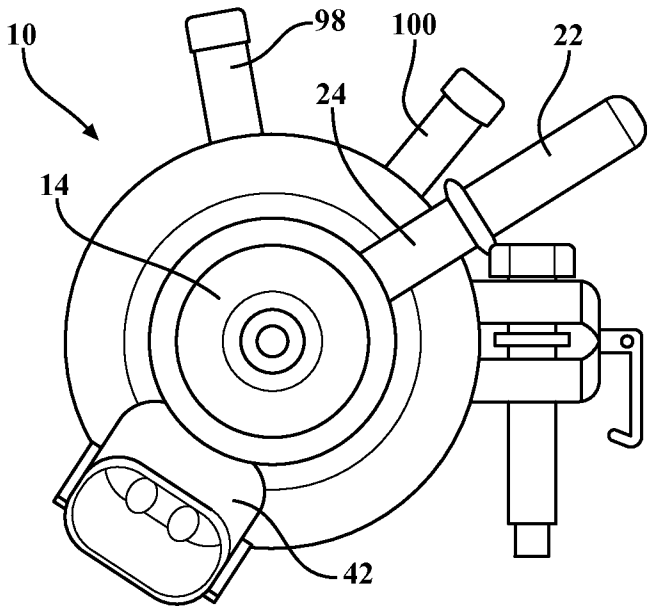
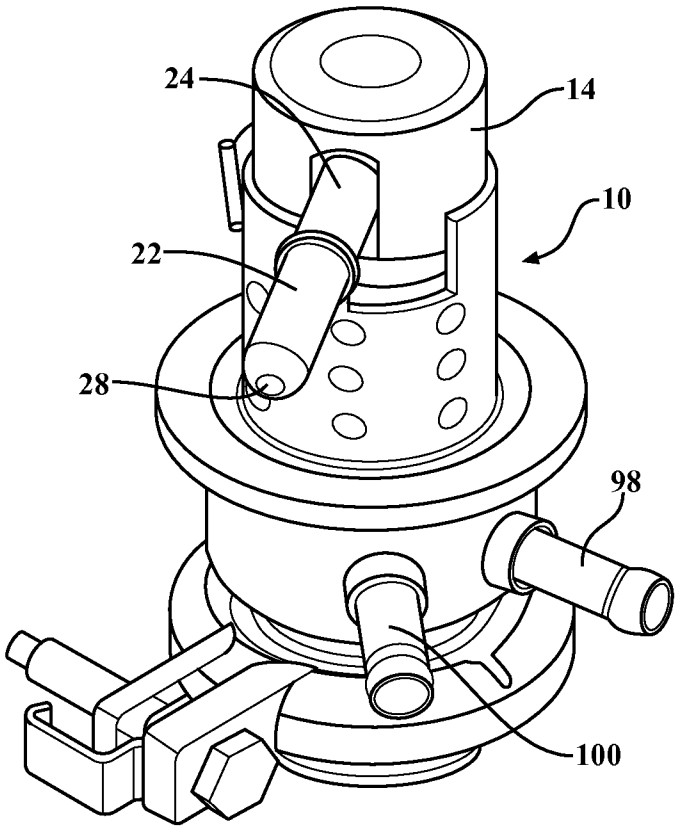


FIG. 6C



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/056783

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N3/20
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2010 051656 A1 (EMITEC EMISSIONSTECHNOLOGIE [DE]) 24 May 2012 (2012-05-24) paragraph [0025] - paragraph [0028]; figure 1 abstract -----	1-25
X	DE 10 2007 011686 A1 (BOSCH GMBH ROBERT [DE]) 11 September 2008 (2008-09-11) paragraph [0026] - paragraph [0028]; figure 1 abstract ----- -/--	1-4,6,7, 12,13, 15,16,21

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 October 2013	07/11/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hermens, Sjoerd

1

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/056783

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	DE 10 2011 078504 A1 (BOSCH GMBH ROBERT [DE]) 3 January 2013 (2013-01-03) paragraph [0023]; figure 1 abstract -----	1-8, 12-17, 21,23,24
A,P	DE 10 2012 201203 A1 (BOSCH GMBH ROBERT [DE]) 1 August 2013 (2013-08-01) the whole document -----	1-25

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/056783

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102010051656 A1	24-05-2012	NONE	
DE 102007011686 A1	11-09-2008	DE 102007011686 A1	11-09-2008
		WO 2008110407 A1	18-09-2008
DE 102011078504 A1	03-01-2013	DE 102011078504 A1	03-01-2013
		WO 2013004477 A1	10-01-2013
DE 102012201203 A1	01-08-2013	DE 102012201203 A1	01-08-2013
		WO 2013110484 A1	01-08-2013