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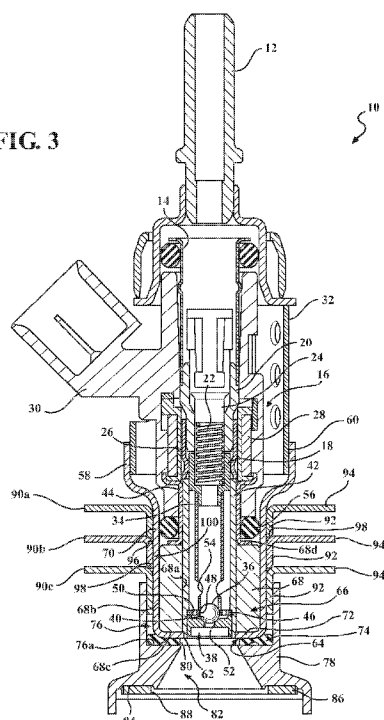
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) Title: HEAT DISSIPATION ELEMENTS FOR REDUCTANT DELIVERY UNIT FOR AUTOMOTIVE SELECTIVE CATALYTIC REDUCTION SYSTEM

FIG. 3



(57) Abstract: An injector having at least one heat dissipation element used for providing a highly conductive path for transferring heat away from a valve portion of an injector. In one embodiment, the heat dissipation element is a cylindrical element, or conductive plug, in contact with the injector valve body and the injector housing. In one embodiment, the heat dissipation element is a plurality of cooling fins, each being in direct contact with the injector housing. The fins may be used in combination with the cylindrical element to serve as an additional heat evacuation conduction path, allowing the heat to be dissipated by convection through the large surface area provided by the fins. The cylindrical element may be made of copper, but it is also within the scope of the invention that any suitable thermally conductive material may be used.

## HEAT DISSIPATION ELEMENTS FOR REDUCTANT DELIVERY UNIT FOR AUTOMOTIVE SELECTIVE CATALYTIC REDUCTION SYSTEM

### FIELD OF THE INVENTION

**[0001]** The invention relates generally to one or more heat dissipation elements which are components of an injector that is used in a reductant delivery unit, where the reductant delivery unit is part of a 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 (NO<sub>x</sub>), that are difficult to treat in oxygen-rich exhaust environments, which are characteristic of lean-burn combustion. Exhaust aftertreatment technologies are currently being developed that treat NO<sub>x</sub> under these conditions.

**[0003]** One of these technologies includes a catalyst that facilitates the reactions of ammonia (NH<sub>3</sub>) with the exhaust nitrogen oxides (NO<sub>x</sub>) to produce nitrogen (N<sub>2</sub>) and water (H<sub>2</sub>O). 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 ( $\text{CO}(\text{NH}_2)_2$ ). The solution is referred to as AUS-32, or diesel exhaust fluid (DEF), and is also known under its commercial name of AdBlue. The DEF 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 ( $\text{HNCO}$ ). The isocyanic acid then undergoes a hydrolysis with the water present in the exhaust and is transformed into ammonia and carbon dioxide ( $\text{CO}_2$ ), 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 DEF solution to the exhaust involves precise metering of the DEF and proper preparation of the DEF to facilitate the later mixing of the ammonia in the exhaust stream. The delivery of the DEF into the exhaust is typically achieved using some type of injector.

**[0005]** AUS-32 is known to decompose to various byproducts at elevated temperatures. These byproducts include biuret, cyanuric acid, melamine, and numerous others, as shown in Figure 1.

**[0006]** Also shown in Figure 1, the formation of biuret begins in earnest at temperatures somewhere in excess of  $150^\circ\text{C}$ . At temperatures in excess of  $190^\circ\text{C}$ , the initial formation of cyanuric acid (CYA) also occurs. These compounds are generally not easily soluble in water, and in large enough particles, could present a risk of functional degradation. If large enough particles do form, they could either obstruct the movement of the armature-tube-ball (ATB)

assembly (between armature and pole piece: injector stuck closed, or reduced lift; between ball and seat: injector stuck open), or even potentially block off the main fluid flow path of the injector.

**[0007]** There are various maximum operating temperature recommendations for using AUS-32. The ability to operate within these limits varies from application to application, and depends on many factors beyond the control of the injector manufacturer, including, but not limited to installation location of the injector, ventilation, and injector dosing strategy.

**[0008]** Accordingly, there exists a need for an injector which allows for greater flexibility such that the injector may be used in different applications, such as harsher environments, while maintaining a suitable operating temperature that is below the recommended limits.

## SUMMARY OF THE INVENTION

**[0009]** The present invention is an injector having at least one heat dissipation element used for providing a highly conductive path for transferring heat away from a valve portion of the injector. In one embodiment, the heat dissipation element is a cylindrical element, or conductive plug, in contact with the injector valve body and the injector housing. In one embodiment, the cylindrical element is made of copper, but it is within the scope of the invention that any suitable thermally conductive material may be used, such as steel, nickel, aluminum, or the like. It is also within the scope of the invention that the heat dissipation element may be made of a thermally insulating material in the

event that over-temperature conditions are likely to arise from hot soak ambient conditions, where the thermally insulating material serves to prevent the ambient heat from arriving at the injector fluid path.

**[0010]** In one embodiment, the injector includes cooling fins, each being in direct contact with the injector housing. The fins may be used in combination with the cylindrical element to serve as an additional heat evacuation conduction path, allowing the heat to be dissipated by convection through the large surface area provided by the fins.

**[0011]** In one embodiment, the present invention is an injector which includes an actuator, a valve portion, where the movement of the valve portion controlled by the actuator, and a lower valve body. The valve portion is disposed in the valve body, and there is a thermally conductive plug which substantially surrounds a portion of the valve body. The injector also includes an outer lower shield, and the thermally conductive plug is located in a cavity formed as part of the outer lower shield. At least one fin is attached to the outer lower shield, and the thermally conductive plug and the at least one fin transfer heat away from the valve portion.

**[0012]** The thermally conductive plug includes a through-aperture, and a portion of the lower valve body extends through the though-aperture. The thermally conductive plug also includes an outer surface in contact with an outer wall of the outer lower shield, and a lower surface which is adjacent to the outer surface, such that the lower surface is in contact with a lower wall of the outer lower shield.

**[0013]** The at least one fin includes a circular mounting flange portion attached to the outer lower shield and a circular projecting flange portion integrally formed with the circular mounting flange portion. Heat is transferred away from the outer lower shield through the circular mounting flange portion. In one embodiment, the circular mounting flange portion is substantially perpendicular to the circular projecting flange portion.

**[0014]** In one embodiment, there are a plurality of fins, such as a first fin, a second fin, and a third fin, where each of the fins are attached to and circumscribe the outer lower shield.

**[0015]** In one embodiment, each of the fins includes a circular mounting flange portion and a circular projecting flange portion, where the circular mounting flange portion of the first fin is adjacent the circular mounting flange portion of the second fin, and the circular mounting flange portion of the second fin is adjacent the circular mounting flange portion of the third fin.

**[0016]** The circular mounting flange portion of the first fin, the circular mounting flange portion of the second fin, and the circular mounting flange portion of the third fin form an outer circumferential wall connected to the outer lower shield. Heat is transferred away from the valve portion by the thermally conductive plug and each of the fins, preventing the valve portion and other parts of the injector from being exposed to undesired temperatures.

**[0017]** 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

**[0018]** The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

**[0019]** Figure 1 is graph depicting the various changes in physical properties of diesel exhaust fluid when exposed to different temperatures;

**[0020]** Figure 2 is a perspective view of an injector having at least one heat dissipation element, according to embodiments of the present invention; and

**[0021]** Figure 3 is a sectional view of an injector having at least one heat dissipation element, according to embodiments of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0022]** 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.

**[0023]** An injector having a heat dissipation device according to the present invention is shown in Figures 2-3, generally at 10. The injector 10 has an inlet port 12 which receives diesel exhaust fluid (DEF). The injector 10 also includes an inlet tube 14, where the DEF is able to flow through the inlet tube 14. Disposed within the inlet tube 14 is an actuator, which in this embodiment is a

solenoid, shown generally at 16. The solenoid 16 includes an armature 18 partially disposed in the inlet tube 14. The armature 18 is adjacent a pole piece 20, and moves relative to the pole piece 20. The armature 18 includes a cavity, and partially disposed in the cavity is a return spring 22, and the return spring 22 is also partially surrounded by the pole piece 20. The return spring 22 is also adjacent a stopper 24 such that the return spring 22 applies force to the stopper 24 and the armature 18.

**[0024]** Partially surrounding the inlet tube 14 is a bobbin 26, and surrounding the bobbin 26 is a coil 28. Portions of both the bobbin 26 and the coil 28 are surrounded by a housing 30, which is made of plastic, and also surrounds portions of the inlet tube 14. The housing 30 is also partially surrounded by an upper shield 32, which provides convection cooling to the parts of the injector 10 surrounded by the upper shield 32.

**[0025]** An upper end of a tube 34 is connected to the armature 18 through any suitable connection, which in this embodiment is a weld connection. The lower end of the tube 34 is welded to a ball 36, which functions as part of a valve portion, shown generally at 38. The valve portion 38 also includes a valve seat 40. The valve seat 40 is mounted in the lower end of a lower valve body 42, and the lower valve body 42 is adjacent the inlet tube 14, such that the lower valve body 42 is partially surrounded by a lower inner shield 44. Movement of the ball 64 is partially controlled by a guide 46. The guide 46 includes a guide aperture 48 through which the ball 36 moves, and also includes side apertures 50 which the DEF flows through. The ball 36 rests on the valve seat 40 when the

valve portion 38 is in the closed position. The valve seat 68 also includes a central aperture 52, through which the DEF passes as the fluid exits the injector 10.

**[0026]** During the operation of the injector 32, the valve portion 38, and more specifically the tube 34 and the ball 36, are biased by the return spring 22 to contact the valve seat 40, and therefore keep the valve portion 38 in a closed position. When the coil 28 is energized, the armature 18 is drawn toward the pole piece 20. Energizing the coil 28 generates enough force to overcome the force of the return spring 22, and the armature 18 moves towards the pole piece 20. Because the tube 34 is connected to the armature 18, and the ball 36 is connected to the tube 34, the movement of the armature 18 towards the pole piece 20 moves the ball 36 away from the valve seat 40, opening the valve portion 38. When the valve portion 38 is in an open position, the fluid flows from the inlet port 12 through the inlet tube 14, pole piece 20, armature 18, the tube 34, and out a plurality of exit apertures 54 formed as part of the tube 34. After the fluid flows out of the exit apertures 54, the fluid passes through the side apertures 50, and out the central aperture 52.

**[0027]** When the coil 28 is no longer energized, the return spring 22 forces the armature 18 away from the pole piece 20, and moves the armature 18, the tube 34 and the ball 36 such that the ball 36 is placed against the valve seat 40, placing the valve portion 38 in the closed position.

**[0028]** Surrounding part of the lower inner shield 44 is a seal, which in this embodiment is a lower o-ring 56, and the lower o-ring 56 is surrounded by

and in contact with an outer lower shield 58. The outer lower shield 58 is connected to the upper shield 32, and is also connected to the lower end of the lower valve body 42, as shown in Figure 3. More specifically, the outer lower shield 58 is connected to the upper shield 32 at a first weld point 60, and is connected to the lower valve body 42 at a second weld point 62. The outer lower shield 58 has a lower end, shown generally at 64, that surrounds the lower end of the lower valve body 42, such that the second weld point 62 provides a seal, preventing any DEF from leaking out of the injector 10 around the lower valve body 42. The lower o-ring 56 also provides a sealing function to prevent any diesel exhaust fluid from migrating to the outer areas of the solenoid 16.

**[0029]** The outer lower shield 58 is formed such that the outer lower shield 58 has a cavity, shown generally at 66, and the lower valve body 42 and valve portion 38 are disposed in the cavity 66. Also disposed in the cavity 66 is a first heat dissipation element, which in this embodiment is a thermally conductive plug 68, which is in contact with and surrounds the lower valve body 42. The thermally conductive plug 68 is generally cylindrical in shape, and has a through aperture 68a, through which a portion of the lower valve body 42 extends. An outer surface 68b of the plug 68 is also in contact with an outer wall 70 of the outer shield 58, a lower surface 68c is in contact with a lower wall 72 (which is part of the lower end 64) of the outer shield 58, and an upper surface 68d of the plug 68 is also in contact with the lower inner shield 44.

**[0030]** The injector 10 also includes an internal gasket 74 which is in contact with the lower wall 72 of the outer shield 58, but on the opposite side of

the lower wall 72 in comparison to the plug 68. The internal gasket 74 is located on a bottom surface 76a of a cavity, shown generally at 76, of a v-clamp flange 78. A portion of the outer shield 58 is also disposed in the cavity 76, as shown in Figure 3. The internal gasket 74 also includes an aperture 80, and after DEF flows out of the central aperture 52, the DEF flows through the aperture 80, and into a dispersion area, shown generally at 82, of the v-clamp flange 78. The v-clamp flange 78 also includes a notch portion 84, and disposed in the notch portion 84 is a main gasket 86. The main gasket 86 also has an aperture 88, through which the DEF passes after flowing through the dispersion area 82.

**[0031]** The injector 10 also includes a second heat dissipation element, which in this embodiment is a plurality of fins, shown generally at 90. More specifically, there are three fins 90a, 90b, 90c, and each fin 90 is substantially similar. Each fin 90 includes a circular mounting flange portion 92, and a circular projecting flange portion 94. The flange portions 92, 94 are integrally formed with one another, and are substantially perpendicular to one another. The circular mounting flange portion 92 of each fin 90 is welded to the outer wall 70 of the outer shield 58. The circular mounting flange portion 92 of the first fin 90a and the second fin 90b are substantially the same size. However, the circular mounting flange portion 92 of the third fin 90c is larger in comparison to the circular mounting flange portion 92 of the first two fins 90a, 90b, and is partially located in the cavity 76 of the v-clamp flange 78. The circular mounting flange portion 92 of the third fin 90c is also connected to the side wall of the v-clamp flange 78.

**[0032]** Each circular mounting flange portion 92 has a lower edge 96, and each fin 90 includes a bend portion 98, where the circular mounting flange portion 92 and the circular projecting flange portion 94 intersect with one another. When assembled, the lower edge 96 of the first fin 90a contacts the bend portion 98 of the second fin 90b, and the lower edge 96 of the second fin 90b contacts the bend portion 90 of the third fin 90c. Furthermore, as shown in Figure 3, the circular mounting flange portion 92 of each fin 90a,90b,90c are all in substantial alignment with one another, and adjacent one another. Each circular mounting flange portion 92 is positioned relative to one another so as to form a continuous wall, or an outer circumferential wall, shown generally at 100, which surrounds part of the outer wall 70 of the outer lower shield 58.

**[0033]** Since the injector 10 is designed for use in environments having temperatures ranging from -40°C to 160°C, the components of the injector 10 are exposed to high temperatures, and the heat must be dissipated in order to prevent damage to the components of the injector 10. As mentioned above, the DEF passes through the tube 34, and out the plurality of exit apertures 54, and then the fluid passes through the side apertures 50, and out the central aperture 52. When the DEF is at elevated temperatures, the heat from the DEF exposes these components to the elevated temperatures. The thermally conductive plug 68 transfers heat away from the lower valve body 42, and the areas around the tube 34, the guide 46, and the valve seat 40. The fins 90a,90b,90c also transfer heat away from these components. More specifically, the outer circumferential wall 100 absorbs heat, such that the heat is transferred to each of the circular

projecting flange portions 94. The flange portions 94 having a substantially circular shape, and being in the shape of a flange, increases the surface area available for heat dissipation, increasing efficiency.

**[0034]** Furthermore, each of the gaskets 74,86 also provides thermal isolation to control heat dissipation from the injector 10.

**[0035]** In this embodiment, the thermally conductive plug 68 is press-fit into the outer lower shield 58. However, it is within the scope of the invention that the plug 68 may be welded into the outer lower shield 58, or connected to the outer lower shield 58 in any other suitable manner. The plug 68 in this embodiment is made of copper. However, it is within the scope of the invention that other materials, such as steel, aluminum, nickel, or other suitable materials may be used. It is also within the scope of the invention that other materials, may be used, such as a thermally insulating material. This material may be used in the event that overtemperature conditions arise from hot soak ambient conditions, where the thermally insulating material serves to prevent the ambient heat from affecting the temperature of the injector fluid. It is also shown in the Figures that three fins 90a,90b,90c are used. However, it is within the scope of the invention that more or less fins may be used.

**[0036]** 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:  
an injector, including:  
an actuator;  
a valve portion;  
an inlet tube for receiving diesel exhaust fluid; and  
at least one heat dissipation element for transferring heat away  
from the valve portion;  
wherein fluid flows through the inlet tube to the valve portion, and  
the actuator controls the movement of the valve portion to control the flow  
of fluid through the valve portion.
2. The apparatus of claim 1, the at least one heat dissipation element  
further comprising a thermally conductive plug.
3. The apparatus of claim 2, wherein the thermally conductive plug is  
made of a material selected from the group consisting of copper, steel, nickel,  
and aluminum.
4. The apparatus of claim 2, the thermally conductive plug being  
made of a thermally insulating material.

5. The apparatus of claim 2, further comprising:  
a lower valve body, the valve portion disposed in the lower valve body;  
and  
a through-aperture, the through-aperture formed as part of the thermally conductive plug;  
wherein, a portion of the lower valve body extends through the through-aperture of the thermally conductive plug.

6. The apparatus of claim 2, further comprising:  
an outer lower shield, the thermally conductive plug located in a cavity formed as part of the outer lower shield;  
an outer surface formed as part of the thermally conductive plug, the outer surface in contact with an outer wall of the outer lower shield; and  
a lower surface formed as part of the thermally conductive plug, the lower surface adjacent the outer surface and in contact with a lower wall of the outer lower shield.

7. The apparatus of claim 1, the at least one heat dissipation element further comprising at least one fin.

8. The apparatus of claim 7, the at least one fin further comprising:  
a circular mounting flange portion connected to an outer surface of the injector; and

a circular projecting flange portion integrally formed with the circular mounting flange portion;

wherein heat is transferred away from the injector through the circular mounting flange portion and the circular projecting flange portion.

9. The apparatus of claim 8, wherein the circular mounting flange portion is substantially perpendicular to the circular projecting flange portion.

10. The apparatus of claim 8, the at least one fin further comprising a plurality of fins, each of the plurality of fins having a circular mounting flange portion and a circular projecting flange portion.

11. The apparatus of claim 1, further comprising an outer circumferential wall formed by the circumferential mounting flange of each of the plurality of fins.

12. An injector, comprising:

an actuator;

a valve portion, the movement of the valve portion controlled by the actuator;

a lower valve body, the valve portion disposed in the valve body;

a thermally conductive plug substantially surrounding a portion of the valve body;

an outer lower shield, the thermally conductive plug located in a cavity formed as part of the outer lower shield; and

at least one fin attached to the outer lower shield;

wherein the thermally conductive plug and the at least one fin transfer heat away from the valve portion.

13. The injector of claim 12, the thermally conductive plug further comprising a through-aperture, a portion of the lower valve body extending through the through-aperture.

14. The injector of claim 12, the thermally conductive plug further comprising:

an outer surface in contact with an outer wall of the outer lower shield; and

a lower surface adjacent the outer surface, the lower surface in contact with a lower wall of the outer lower shield.

15. The injector of claim 12, the at least one fin further comprising:

a circular mounting flange portion attached to the outer lower shield; and

a circular projecting flange portion integrally formed with the circular mounting flange portion;

wherein heat is transferred away from the outer lower shield through the circular mounting flange portion.

16. The injector of claim 15, wherein the circular mounting flange portion is substantially perpendicular to the circular projecting flange portion.

17. The injector of claim 15, the at least one fin further comprising a first fin, a second fin, and a third fin, wherein the first fin, the second fin, and the third fin are attached to and circumscribe the outer lower shield.

18. The injector of claim 17, each of the first fin, the second fin, and the third fin further comprising a circular mounting flange portion and a circular projecting flange portion.

19. The injector of claim 18, wherein the circular mounting flange portion of the first fin is adjacent the circular mounting flange portion of the second fin, and the circular mounting flange portion of the second fin is adjacent the circular mounting flange portion of the third fin.

20. The injector of claim 19, further comprising an outer circumferential wall.

21. The injector of claim 20, the outer circumferential wall further comprising the circular mounting flange portion of the first fin, the circular mounting flange portion of the second fin, and the circular mounting flange portion of the third fin.

22. The injector of claim 12, wherein the thermally conductive plug is made of a material selected from the group consisting of copper, steel, nickel, and aluminum.

23. The injector of claim 12, wherein the thermally conductive plug is made of a thermally insulating material.

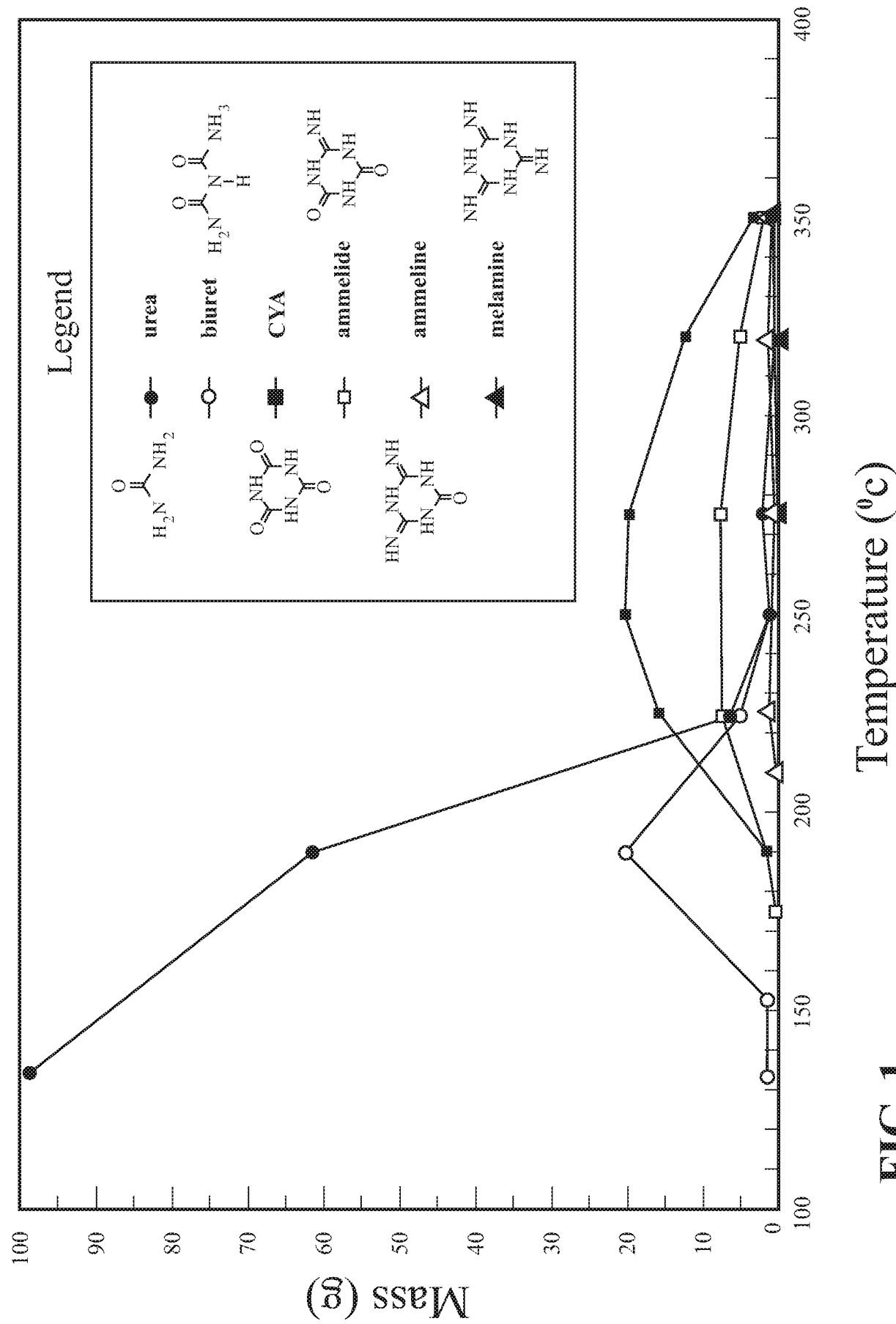


**FIG. 1**

2/3

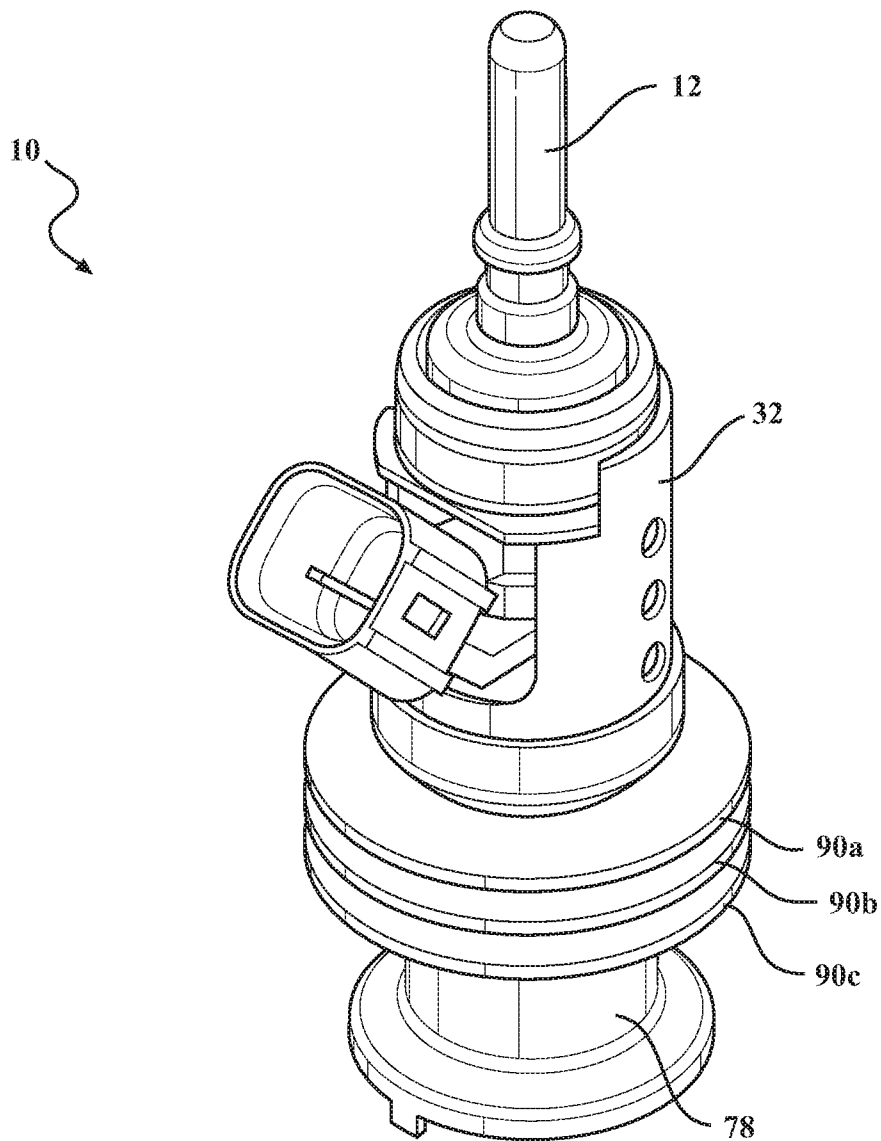
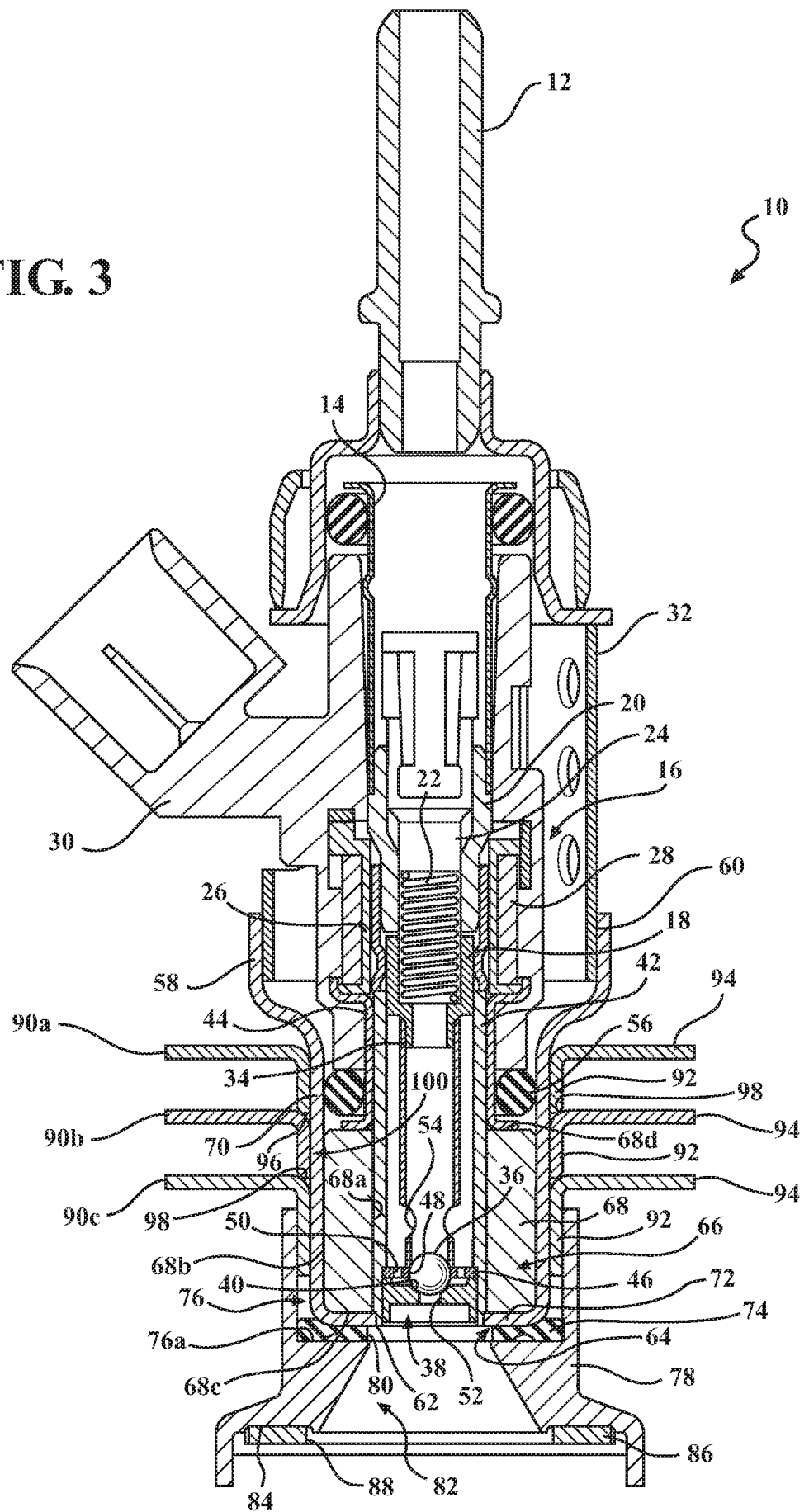


**FIG. 2**

3/3

FIG. 3



## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2017/047983

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, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                    | Relevant to claim No.                            |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|
| X<br>A    | DE 10 2010 030920 A1 (BOSCH GMBH ROBERT [DE]) 5 January 2012 (2012-01-05)<br>paragraphs [0001] - [0013], [0019] - [0024]<br>figure 3<br>-----         | 1,2,<br>4-21,23<br>3,22                          |
| X<br>A    | DE 10 2009 054654 A1 (BOSCH GMBH ROBERT [DE]) 16 June 2011 (2011-06-16)<br>paragraphs [0001] - [0026]<br>figure 1<br>-----                            | 1,2,<br>4-21,23<br>3,22                          |
| X<br>A    | DE 10 2012 209106 A1 (BOSCH GMBH ROBERT [DE]) 5 December 2013 (2013-12-05)<br>paragraphs [0001] - [0023], [0031] - [0059]<br>figure 1<br>-----<br>-/- | 1-3,5-7,<br>11-14,<br>20,22<br>8-10,<br>15-19,23 |



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

5 October 2017

Date of mailing of the international search report

18/10/2017

Name and mailing address of the ISA/

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Buecker, Christian

## INTERNATIONAL SEARCH REPORT

International application No  
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| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                            |                            |
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| A                                                    | paragraphs [0001] - [0011], [0013] -<br>[0035]<br>figure 2                                 | 8-11,<br>15-19,21          |
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