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

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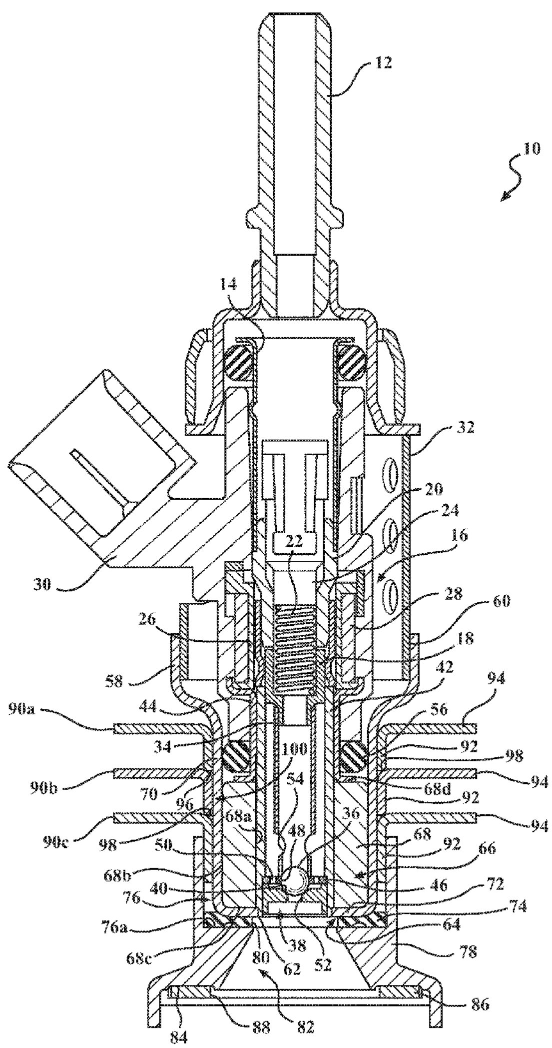
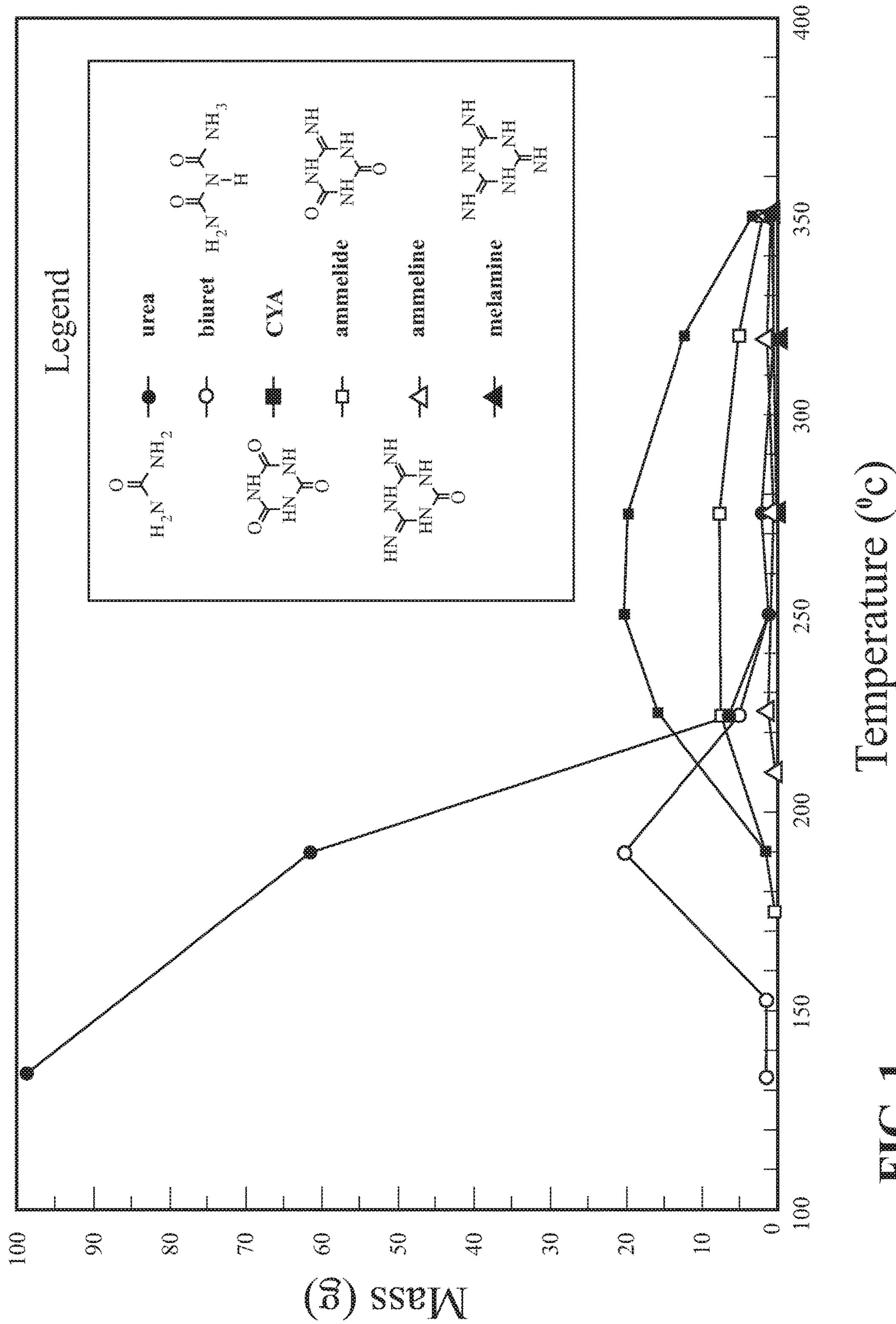
(57) **ABSTRACT**

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.

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Temperature (°c)
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FIG. 1

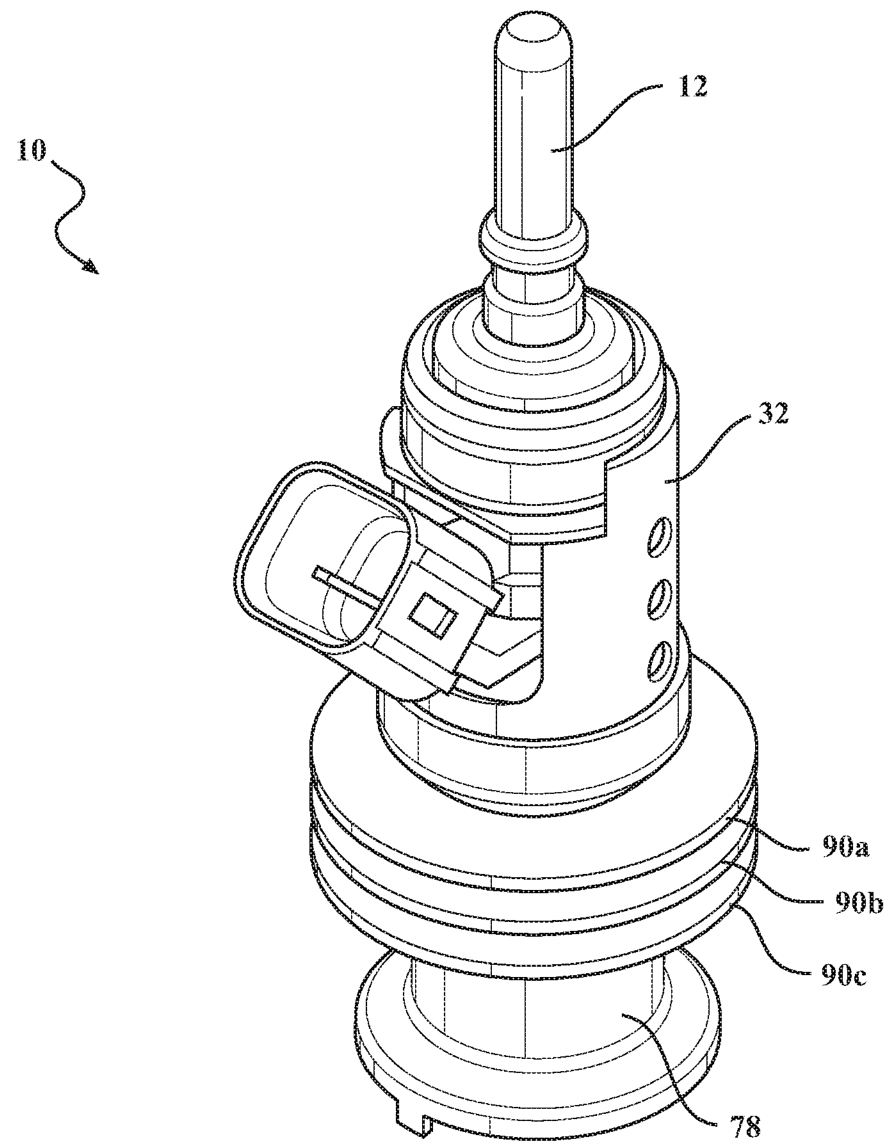
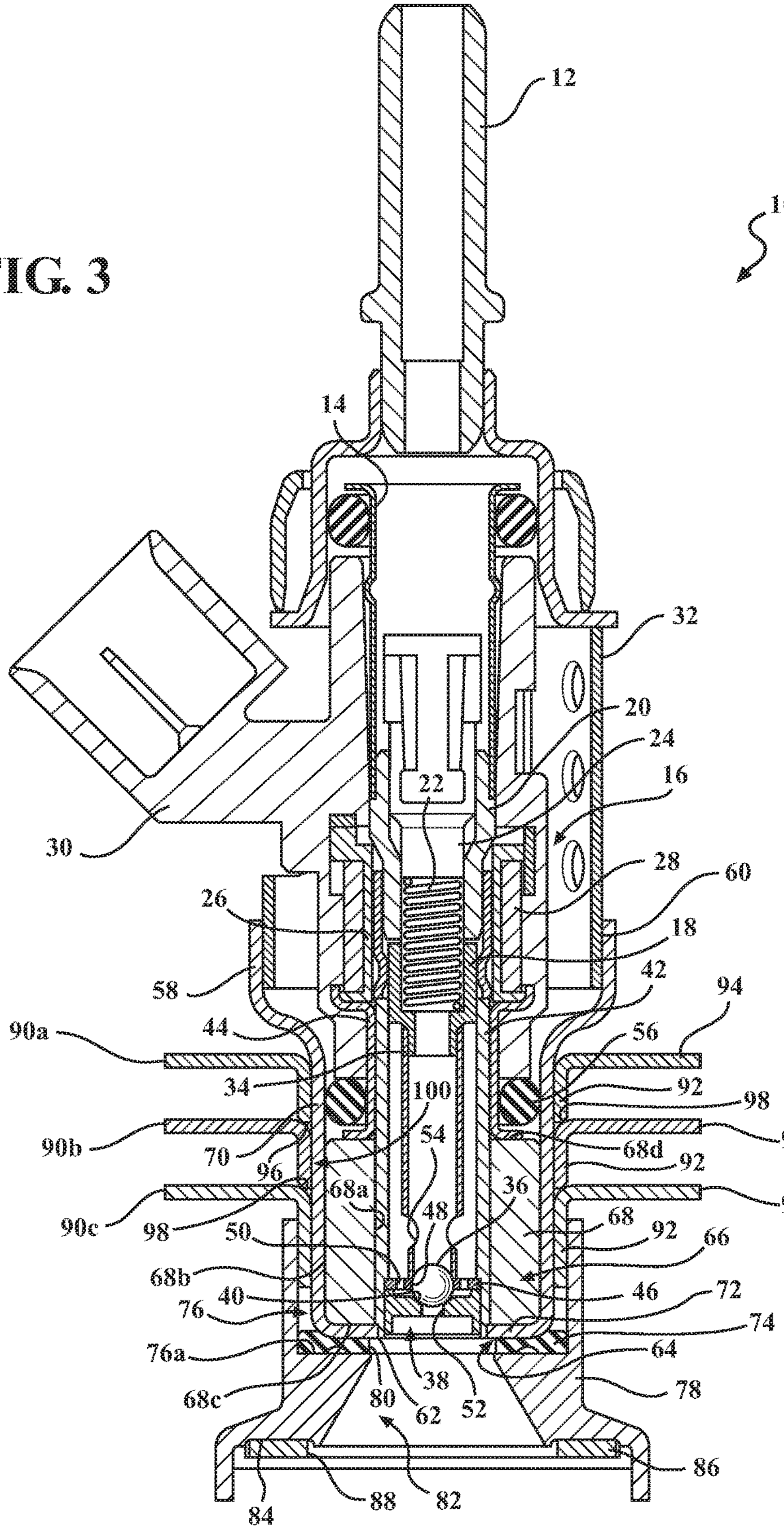


FIG. 2

FIG. 3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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 (NOx), 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 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, 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 (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 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 FIG. **1**.

[0006] Also shown in FIG. **1**, the formation of biuret begins in earnest at temperatures somewhere in excess of 150° C. At temperatures in excess of 190° 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 for 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] FIG. **1** is graph depicting the various changes in physical properties of diesel exhaust fluid when exposed to different temperatures;

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

[0021] FIG. **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 FIGS. **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 FIG. **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 **68***a*, through which a portion of the lower valve body **42** extends. An outer surface **68***b* of the plug **68** is also in contact with an outer wall **70** of the outer shield **58**, a lower surface **68***c* 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 **68***d* 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 **76***a* 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 FIG. **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 **90***a*,**90***b*,**90***c*, 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 **90***a* and the second fin **90***b* are substantially the same size. However, the circular mounting flange portion **92** of the third fin **90***c* is larger in comparison to the circular mounting flange portion **92** of the first two fins **90***a*,**90***b*, and is partially located in the cavity **76** of the v-clamp flange **78**. The circular mounting flange portion **92** of the third fin **90***c* 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 **90***a* contacts the bend portion **98** of the second fin **90***b*, and the lower edge **96** of the second fin **90***b* contacts the bend portion **90** of the third fin **90***c*. Furthermore, as shown in FIG. **3**, the circular mounting flange portion **92** of each fin **90***a*,**90***b*,**90***c* 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 **90***a*,**90***b*,**90***c* 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 **90***a*,**90***b*,**90***c* 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.

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 though-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 though-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.

* * * * *