



(51) International Patent Classification:

F01N 3/20 (2006.01)

F02M 63/00 (2006.01)

(21) International Application Number:

PCT/US2019/043580

(22) International Filing Date:

26 July 2019 (26.07.2019)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

16/106,891

21 August 2018 (21.08.2018)

US

(71) Applicant: TENNECO AUTOMOTIVE OPERATING COMPANY INC. [US/US]; 500 North Field Drive, Lake Forest, Illinois 60045 (US).

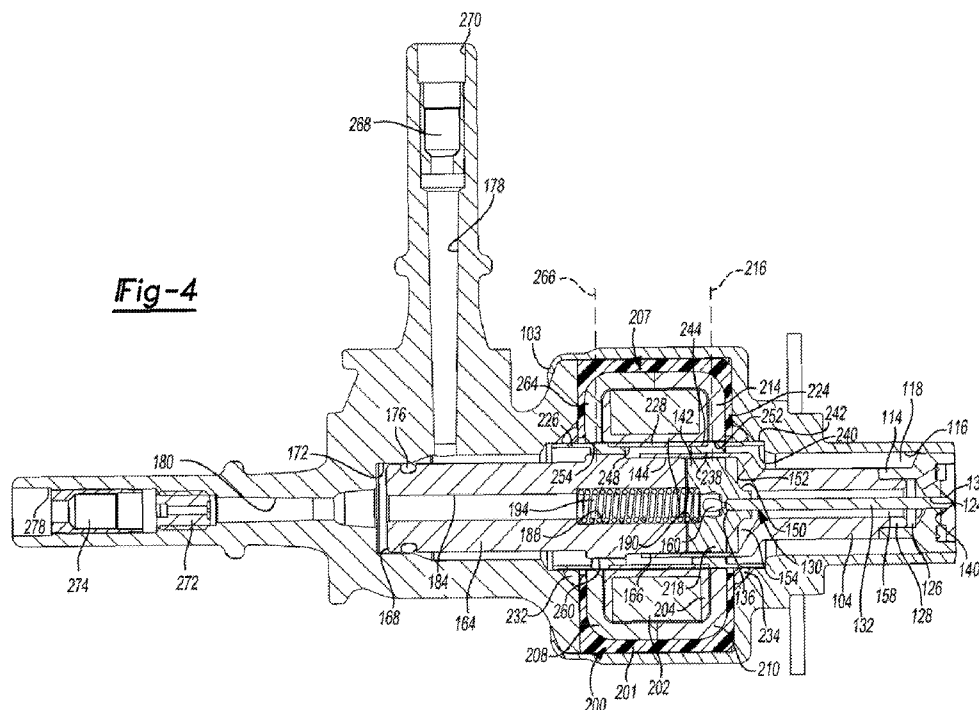
(72) Inventor: ENKE, Olaf; Tenneco Automotive, c/o IP Department, 3901 Willis Road, Grass Lake, Michigan 49240 (US).

(74) Agent: WALKER, Donald G.; HARNESS, DICKEY & PIERCE, P.L.C., P.O. Box 828, Bloomfield Hills, Michigan 48303 (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, DJ, DK, DM, DO, 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.

(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, ST, 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,

(54) Title: INJECTOR FLUID FILTER WITH UPPER AND LOWER LIP SEAL



(57) Abstract: An injector for injecting a reagent includes an axially translatable valve member positioned within a housing. A flux sleeve is surrounded by a coil of an electromagnet. A pole piece defines a return passageway for reagent to flow. A filter surrounds the pole piece and includes a cage and a mesh fixed to the cage. The cage includes a deformable first seal biasedly engaging an outer surface of the pole piece. The cage includes a second seal biasedly engaging the housing. The first and second seals define a closed volume such that all of the reagent flowing through the injector passes through the mesh.

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).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

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

INJECTOR FLUID FILTER WITH UPPER AND LOWER LIP SEAL

FIELD

[0001] The present disclosure relates to injector systems and, more particularly, relates to an injector system for injecting reagent, such as an aqueous urea solution, into an exhaust stream to reduce oxides of nitrogen (NO_x) emissions from diesel engine exhaust.

BACKGROUND

[0002] This section provides background information related to the present disclosure which is not necessarily prior art. Lean burn engines provide improved fuel efficiency by operating with an excess of oxygen, that is, a quantity of oxygen that is greater than the amount necessary for complete combustion of the available fuel. Such engines are said to run "lean" or on a "lean mixture." However, this improved or increase in fuel economy, as opposed to non-lean burn combustion, is offset by undesired pollution emissions, specifically in the form of oxides of nitrogen (NO_x).

[0003] One method used to reduce NO_x emissions from lean burn internal combustion engines is known as selective catalytic reduction (SCR). SCR, when used, for example, to reduce NO_x emissions from a diesel engine, involves injecting an atomized reagent into the exhaust stream of the engine in relation to one or more selected engine operational parameters, such as exhaust gas temperature, engine rpm or engine load as measured by engine fuel flow, turbo boost pressure or exhaust NO_x mass flow. The reagent/exhaust gas mixture is passed through a reactor containing a catalyst, such as, for example, activated carbon, or metals, such as platinum, vanadium or tungsten, which are capable of reducing the NO_x concentration in the presence of the reagent.

[0004] An aqueous urea solution is known to be an effective reagent in SCR systems for diesel engines. However, use of such an aqueous urea solution involves many disadvantages. Urea is highly corrosive and may adversely affect mechanical components of the SCR system, such as the injectors used to inject the urea mixture into the exhaust gas stream. Urea also may solidify upon prolonged exposure to high temperatures, such as temperatures encountered in diesel exhaust systems. Solidified urea will accumulate in the narrow passageways and exit orifice openings typically found in injectors. Solidified urea may also cause fouling of moving parts of the injector

and clog any openings or urea flow passageways, thereby rendering the injector unusable.

[0005] In addition, if the urea mixture is not finely atomized, urea deposits will form in the catalytic reactor, inhibiting the action of the catalyst and thereby reducing the SCR system effectiveness. High injection pressures are one way of minimizing the problem of insufficient atomization of the urea mixture. However, high injection pressures often result in over-penetration of the injector spray plume into the exhaust stream, causing the plume to impinge on the inner surface of the exhaust pipe opposite the injector. Over-penetration also leads to inefficient use of the urea mixture and reduces the range over which the vehicle can operate with reduced NO_x emissions. Only a finite amount of aqueous urea can be carried on a vehicle, and what is carried should be used efficiently to maximize vehicle range and reduce the need for frequent replenishment of the reagent.

[0006] Several known reagent injectors include a solenoid valve for metering the supply of reagent into the exhaust stream. Typically, a magnetic moveable member of the valve is urged to translate between open and closed positions as an electromagnet is selectively energized and deenergized. The electromagnets of many prior injectors include multiple flux leakage areas resulting in a poorly defined magnetic circuit. Control of the reagent valve may not be optimized using these types of magnetic circuits. The amount of reagent actually dispensed within the exhaust system may vary from a target rate of reagent injection resulting in inefficient use of the onboard reagent. The time required for the valve to cycle from a closed condition, to an opened condition, and back to a closed condition, may be larger than desired due to the magnetic circuit arrangement.

[0007] Further, aqueous urea is a poor lubricant. This characteristic adversely affects moving parts within the injector and requires that relatively tight or small fits, clearances and tolerances be employed between adjacent or relatively moving parts within an injector. Aqueous urea also has a high propensity for leakage. This characteristic adversely affects mating surfaces requiring enhanced sealing resources in many locations.

[0008] It may be advantageous to provide an improved electromagnetically controlled injector having a well-defined magnetic circuit to improve reagent injection control.

[0009] Methods and apparatus of the present disclosure provide the foregoing and other advantages.

SUMMARY

5 **[0010]** This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0011] An injector for injecting a reagent includes an axially translatable valve member positioned within a housing. A flux sleeve is surrounded by a coil of an electromagnet. A pole piece defines a return passageway for reagent to flow. A filter
10 surrounds the pole piece and includes a cage and a mesh fixed to the cage. The cage includes a deformable first seal biasedly engaging an outer surface of the pole piece. The cage includes a second seal biasedly engaging the housing. The first and second seals define a closed volume such that all of the reagent flowing through the injector passes through the mesh.

15 **[0012]** Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

20 DRAWINGS

[0013] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0014] FIG. 1 is a schematic depicting an exemplary exhaust aftertreatment
25 system including an electromagnetically controlled reagent injector having a flux bridge and flux break in accordance with the teachings of the present disclosure;

[0015] FIG. 2 is a perspective view of the electromagnetically controlled reagent injector;

[0016] FIG. 3 is an exploded perspective view of the reagent injector;

30 **[0017]** FIG. 4 is a cross-sectional view taken through the injector depicted in FIGS. 2 and 3;

[0018] FIG. 5 is an enlarged cross-sectional view illustrating the magnetic flux density of an embodiment having a single-piece magnetic portion extending between the two magnetic portions of the flux sleeve;

[0019] FIG. 6 is a cross-sectional view of an injector including a cage filter;

[0020] FIG. 7 is a perspective view of the cage filter shown in FIG. 6;

[0021] FIG. 8 is a fragmentary cross-sectional view of a portion of the injector including the cage filter; and

5 **[0022]** FIG. 9 is a fragmentary cross-sectional view of another portion of the injector including the cage filter.

[0023] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

10 **DETAILED DESCRIPTION**

[0024] Example embodiments will now be described more fully with reference to the accompanying drawings.

[0025] It should be understood that although the present teachings may be described in connection with diesel engines and the reduction of NO_x emissions, the present teachings may be used in connection with any one of a number of exhaust streams, such as, by way of non-limiting example, those from diesel, gasoline, turbine, fuel cell, jet or any other power source outputting a discharge stream. Moreover, the present teachings may be used in connection with the reduction of any one of a number of undesired emissions. For example, injection of hydrocarbons for the regeneration of diesel particulate filters is also within the scope of the present disclosure. For additional description, attention should be directed to commonly-assigned U.S. Patent No. 8,047,452, entitled "Method And Apparatus For Injecting Atomized Fluids", which is incorporated herein by reference.

20 **[0026]** With reference to the FIGS., a pollution control system 8 for reducing NO_x emissions from the exhaust of a diesel engine 21 is provided. In FIG. 1, solid lines between the elements of the system denote fluid lines for reagent and dashed lines denote electrical connections. The system of the present teachings may include a reagent tank 10 for holding the reagent and a delivery module 12 for delivering the reagent from the tank 10. The reagent may be a urea solution, a hydrocarbon, an alkyl ester, alcohol, an organic compound, water, or the like and can be a blend or combination thereof. It should also be appreciated that one or more reagents can be available in the system and can be used singly or in combination. The tank 10 and delivery module 12 may form an integrated reagent tank/delivery module. Also provided as part of system 8 is an electronic injection controller 14, a reagent injector 16, and an

30

exhaust system 18. Exhaust system 18 includes an exhaust conduit 19 providing an exhaust stream to at least one catalyst bed 17.

[0027] The delivery module 12 may comprise a pump that supplies reagent from the tank 10 via a supply line 9. The reagent tank 10 may be polypropylene, epoxy
5 coated carbon steel, PVC, or stainless steel and sized according to the application (e.g., vehicle size, intended use of the vehicle, and the like). A pressure regulator (not shown) may be provided to maintain the system at predetermined pressure setpoint (e.g., relatively low pressures of approximately 60-80 psi, or in some embodiments a pressure of approximately 60-150 psi) and may be located in the return line 35 from the
10 reagent injector 16. A pressure sensor may be provided in the supply line 9 leading to the reagent injector 16. The system may also incorporate various freeze protection strategies to thaw frozen reagent or to prevent the reagent from freezing. During system operation, regardless of whether or not the injector is releasing reagent into the exhaust gases, reagent may be circulated continuously between the tank 10 and the
15 reagent injector 16 to cool the injector and minimize the dwell time of the reagent in the injector so that the reagent remains cool. Continuous reagent circulation may be necessary for temperature-sensitive reagents, such as aqueous urea, which tend to solidify upon exposure to elevated temperatures of 300°C to 650°C as would be experienced in an engine exhaust system.

[0028] Furthermore, it may be desirable to keep the reagent mixture below
20 140°C and preferably in a lower operating range between 5°C and 95°C to ensure that solidification of the reagent is prevented. Solidified reagent, if allowed to form, may foul the moving parts and openings of the injector.

[0029] The amount of reagent required may vary with load, exhaust gas
25 temperature, exhaust gas flow, engine fuel injection timing, desired NO_x reduction, barometric pressure, relative humidity, EGR rate and engine coolant temperature. A NO_x sensor or meter 25 is positioned downstream from catalyst bed 17. NO_x sensor 25 is operable to output a signal indicative of the exhaust NO_x content to an engine control unit 27. All or some of the engine operating parameters may be supplied from engine
30 control unit 27 via the engine/vehicle databus to the reagent electronic injection controller 14. The reagent electronic injection controller 14 could also be included as part of the engine control unit 27. Exhaust gas temperature, exhaust gas flow and exhaust back pressure and other vehicle operating parameters may be measured by respective sensors.

[0030] With reference now to FIGS. 2-4, reagent injector 100 will be further described. Reagent injector 100 includes an outer injector body 102 having an outer body upper section 102a and an outer body lower section 102b. Outer body lower section 102b may include a deformable portion 103 that is crimped to outer body upper section 102a. An elongated inner lower body 104 may be received within at least one of outer body upper section 102a and outer body lower section 102b. Elongated inner lower body 104 defines a cylindrical central bore 106 in fluid communication with an orifice plate 108 to define at least one exit orifice 110 that passes completely through the orifice plate 108.

[0031] Orifice plate 108 may be coupled to and retained within outer body lower section 102b using an orifice plate holder 112. Orifice plate holder 112 may be integrally formed with inner lower body 104, if desired. Alternately, orifice plate holder 112 is formed separately, as shown in the FIGS., to include a reduced diameter portion 114 spaced apart from an inner wall 116 of outer body lower section 102b. A supply fluid passageway 118 is formed therebetween. Reduced diameter portion 114 is hollow and receives a reduced diameter end portion 120 of inner lower body 104. Plate holder 112 may be fixed to inner lower body 104 and outer body lower section 102b via a process such as electron beam welding. Orifice plate holder 112 also includes a central bore 124 coaxially aligned with central bore 106 and having a smaller inner diameter than central bore 106. A plurality of passageways 125 extend through plate holder 112 to fluidly interconnect passageway 118 with a cavity 126 formed between reduced diameter end portion 120 and central bore 124.

[0032] A valve member 130 is slidably mounted within central bore 106. Valve member 130 includes an elongated pintle 132 having a conically shaped first end 134 and an opposite second end 136. Conical end 134 is selectively engageable with valve seat 140 to define a sealed and closed position of valve member 130 when seated. An unsealed, opened position exists when pintle 132 is unseated from valve seat 140. Valve seat 140 surrounds exit orifice 110. The valve seat may be conically or cone-shaped as shown to complement the shape of conical end 134 of pintle 132 to restrict the flow of reagent through orifice 110. Depending on the application and operating environment, pintle 132 and orifice plate 108 may be made from a carbide material, which may provide desired performance characteristics and may be more easily and cost-effectively manufactured. In addition, limitations or disadvantages associated with other materials may be avoided, such as those associated with

manufacturing complex part shapes. Carbide may provide additional advantages, such as insensitivity to brazing temperatures that may range from 870-980°C, as opposed to carbon steels and tool steels, which may distemper. Carbide may also provide an increased surface hardness when compared to the hardness achievable with most other steels. Carbide may also be advantageous with regard to overall wear resistance.

[0033] A pintle head 142 is fixed to end 136 of pintle 132. Pintle head 142 is slidably positioned within an enlarged bore 144 of inner lower body 104. A running-class slip fit between pintle head 142 and bore 144 provides an upper guide for valve member 130. A lower valve member guide is formed at the sliding interface between central bore 124 and pintle 132. Based on this arrangement, valve member 130 is accurately aligned with valve seat 140 and exit orifice 110.

[0034] A bottom surface 150 of pintle head 142 is spaced apart from a surface 152 of inner lower body 104 to define a cavity 154 in fluid communication with cavity 126 via a passageway 158 defined as a portion of central bore 106 that is not occupied by pintle 132. A passageway 160 extends through pintle head 142 to define a portion of a reagent return passageway.

[0035] A pole piece 164 having a first end 166 is sized to be received within bore 144. First end 166 of pole piece 164 is fixed to inner lower body 104 using a process such as electron beam welding. An opposite second end 168 of pole piece 164 is sealingly fitted within a bore 172 formed in outer body upper section 102a. A seal 176 separates an inlet passageway 178 from an outlet passageway 180 within outer body upper section 102a. Elongated pole piece 164 includes a central bore 184 extending therethrough. Central bore 184 is coaxially aligned with central bore 106. A counterbore 188 inwardly extends from second end 168 of pole piece 164 that is coaxially aligned with a counterbore 190 extending into pintle head 142. A compression spring 194 is positioned within counterbores 188, 190 to urge valve member 130 into engagement with seat 140.

[0036] An electromagnet assembly 200 is positioned within outer body upper section 102a as depicted in the FIGS. Electromagnet assembly 200 may include a plastic material 201 overmolded to encapsulate the other components of electromagnet assembly 200 therein. Electromagnet assembly 200 includes a coil of wire 202 wrapped around a bobbin 204. A two-piece flux frame 207 includes a first frame half 208 fixed to a second flux frame half 210 positioned to circumferentially surround wire 202 and bobbin 204. Pintle head 142 is constructed from a magnetic material such as 430

stainless steel such that electrical energization of coil 202 produces a magnetic field urging pintle head 142 toward pole piece 164. End 134 of pintle 132 becomes disengaged from seat 140 to allow reagent to flow through exit orifice 110. Coil 202 may be energized via access to a receptacle 211, for example, in response to a signal
5 from electronic injection controller 14. Electronic injection controller 14 receives sensor input signals and determines when reagent is to be injected into the exhaust stream to provide selective catalytic reduction of NO_x emissions.

[0037] Controller 14 also defines the reagent injection duration and reagent injection rate. Depending on the engine operating condition, load, ambient air
10 temperature, exhaust temperature, and other factors, it may be desirable to control injector 100 to deliver a relatively wide range of reagent injection rates. To achieve this goal, it may be desirable to minimize the total time associated with moving pintle 132 from a seated position, to an open position, and returned to the seated position. Accurate control of the position of pintle head 142 may be achieved by providing a well
15 defined magnetic circuit.

[0038] Flux frame half 210 includes a radially extending portion 214 generally extending along transverse line 216. Pintle head 142 includes an enlarged diameter portion 218 intersected by line 216. Both flux frame half 210 and pintle head 142 are made from a magnetic material. To further define the magnetic circuit, inner lower body
20 104 is constructed from a non-magnetic material such as 304 stainless steel. A portion of inner lower body 104 through which line 216 crosses includes a minimum cross-sectional thickness to minimize any interruption in magnetic flux.

[0039] A fluid sleeve assembly 220 is depicted as a three-piece assembly having a first flux bridge collar 224 and a second flux bridge collar 226 interconnected
25 by a flux break 228, in some embodiments, or a flux bridge 228', in some embodiments. Fluid sleeve assembly 220 is shaped as an elongated hollow cylindrical member sized and positioned to define a portion of inlet passage 178. First and second seals 232, 234 assure that pressurized reagent continues to travel through inlet passage 178 and does not enter electromagnet assembly 200. Each of flux bridge collars 226 and 224 are
30 substantially the same including a counterbore including a first inner cylindrical surface 238 with a first reduced inner diameter and a second inner cylindrical surface 240 defining a second larger inner diameter. The external surface of each flux collar is also stepped including a cylindrical surface 242 having a larger outer diameter than a second cylindrical surface 244. Flux break or bridge 228 is a substantially right circular

cylinder having an inner surface 248 engaged and fixed to each reduced diameter outer surface 244. Outer surface 242 engages or is very minimally spaced apart from walls 252 and 254 that define circular apertures extending through flux frame halves 210, 208. First inner cylindrical surface 238 of flux bridge collar 224 is sized to closely fit
5 inner lower body 104 and minimize any air gap through which line 216 intersects.

[0040] First inner cylindrical surface 238 of flux bridge collar 226 is sized to cooperate with an enlarged diameter portion 260 of pole piece 164. Flux frame half 208 includes a radially inwardly extending portion 264 extending along a line 266. Enlarged diameter portion 260 and flux bridge collar 226 are axially positioned to be aligned with
10 line 266 and provide a magnet circuit pathway across injector 100. Flux frame halves 208 and 210 are constructed from a magnetic material such as 1018 low carbon steel. Flux bridge collars 224 and 226 are constructed from ferritic 430 stainless steel. Pole piece 164 is made from ferritic 430 stainless steel or a similar magnetic material. Pintle head 142 may be made from ferritic 430 stainless steel. In some embodiments, flux
15 break 228 is made from non-ferritic and non-magnetic 304 stainless steel as is inner lower body 104. Constructing the previously described components from magnetic and non-magnetic materials as well as closely positioning the magnetic materials adjacent to one another along lines 216 and 266 greatly improves the magnetic circuit performance associated with electromagnet assembly 200. Benefits may include the
20 use of a smaller coil wire, a lesser number of turns of wire, and a reduced quantity of electric current to provide an improved electromagnetic actuator having lower cost, reduced size and mass. Increased control regarding the position of valve member 130 is also realized. It should also be appreciated that the transverse planes defined by the ends of cylindrical wire coil 202 may be interpreted as part of the magnetic circuit as
25 well as the planes containing lines 216 and 266. At least one of these transverse planes cuts through pintle head 142, flux bridge collars 224, 226 and enlarged diameter pole piece portion 260.

[0041] In some embodiments, flux bridge 228' is made of a magnetic material, such as ferritic 430 stainless steel. In this embodiment, flux bridge 228' is
30 similarly magnetic as flux bridge collars 224, 226. Constructing the previously described components from magnetic and non-magnetic materials as well as closely positioning the magnetic materials adjacent to one another along lines 216 and 266 greatly improves the magnetic circuit performance associated with electromagnet assembly 200 as illustrated in FIG. 5. Benefits may include the use of a smaller coil

wire, a lesser number of turns of wire, and a reduced quantity of electric current to provide an improved electromagnetic actuator having lower cost, reduced size and mass. Increased control regarding the position of valve member 130 is also realized. It should also be appreciated that the transverse planes defined by the ends of cylindrical wire coil 202 may be interpreted as part of the magnetic circuit as well as the planes containing lines 216 and 266. At least one of these transverse planes cuts through pintle head 142, flux bridge collars 224, 226, flux bridge 228', and enlarged diameter pole piece portion 260.

[0042] As illustrated in FIG. 5, in some embodiments, flux bridge collars 224, 226 and flux bridge 228' can be a single unitary member. In this way, flux bridge collars 224, 226 and flux bridge 228' constitute portions or regions of a continuous member. In some embodiments, flux bridge collars 224, 226 and flux bridge 228' can comprise a plurality of discrete members similarly configured and oriented as flux bridge collars 224, 226 and flux bridge 228. Embodiments employing flux bridge 228' extending between flux bridge collars 224 can define an enhanced and/or increased flux density extending along flux bridge 228'. To further enhance and/or increase the flux density, in some embodiments, the length of enlarged bore 144 of inner lower body 104 can be shortened, as illustrated in FIG. 5 in comparison with FIG. 4.

[0043] A reagent fluid path is defined within injector 100 when pintle 132 is in the closed position. The fluid path provides for circulation of fluid through injector 100. More particularly, the reagent fluid path extends from an inlet 270 of outer body upper section 102a through an inlet filter 268 and inlet passageway 178 including a gap between an outer surface of pole piece 164 and outer body upper section 102a, through fluid sleeve assembly 220, fluid passageway 118, the paths formed in plate holder 112 through cavity 126, passageway 158, passageway 160, central bore 184, outlet passageway 180, a restrictor orifice 272, an outlet filter 274, to exit outlet 278. Typically, reagent entering inlet 270 is at a first relatively cool temperature compared to the exhaust passing through exhaust system 18 in close proximity to orifice 110. The recirculation of reagent through injector 100 transfers heat from orifice plate 108 and orifice plate holder 112. The recirculation of reagent also assists in transferring heat from coil 202 because bobbin 204 is placed in close contact with fluid sleeve assembly 220 through which reagent flows.

[0044] When coil 202 is electrically energized, a magnetic field is generated and pintle head 142 is urged against the biasing force of spring 194 to unseat pintle end

134. Pressurized reagent located within cavity 126 passes between pintle 132 and seat 140 and through exit orifice 110 to inject reagent into an exhaust stream flowing through exhaust system 18. Electromagnet assembly 200 may be controlled by any number of methods including pulse width modulation to open and close exit orifice 110 at a predetermined frequency.

[0045] In an alternate embodiment depicted in Figures 6-9, an injector 300 is constructed substantially similarly to the previously defined injector 100. To avoid reiteration, only the differences in the embodiments will be described in detail. It should be appreciated that the description of similar components shown in Figures 1-5 applies to injector 300.

[0046] Injector 300 includes a cage filter 302 that may be provided in addition to or in lieu of one or both inlet filter 268 and outlet filter 274. Cage filter 302 includes a porous filter 304 fixed to a cage 306. Filter 304 is a substantially hollow cylindrically-shaped member configured to allow injected urea to freely flow therethrough but restrict contaminants from further flowing through injector 300. Cage 306 includes a substantially cylindrically-shaped hollow body 308 having a first end 310 and an opposite second end 312. Cage 306 includes an end wall 316 positioned at first end 310. An aperture 318 extends through end wall 316. End wall 316 includes an integrally formed first lip seal 320 depicted in Figure 8. When viewed in cross-section, end wall 316 reduces in thickness from an outer cylindrical surface 322 to an inner circumferential surface 324 that define aperture 318. First lip seal 320 is configured to deflect and/or slightly plastically and/or elastically deform when assembled to pole piece 164' to sealingly engage an outer cylindrical surface 328 of pole piece 164' in an interference fit.

[0047] Cage 306 includes a radially outwardly extending flange 330 integrally formed with body 308 and positioned at second end 312. Flange 330 extends radially outwardly and axially away from body 308 at an angle of approximately 45 degrees. An outer cylindrical surface 334 of flange 330 is sized to provide interference fit with an inner cylindrical surface 336 of a bore 338 of an injector housing 340 previously described as outer body upper section 102a. Flange 330 defines a second seal that acts as a lip seal. Flange 330 deforms plastically and/or elastically to form a tight fit with inner cylindrical surface 336.

[0048] Flange 330 includes a seat 342 positioned in engagement with fluid sleeve assembly 220'. Fluid sleeve assembly 220' is constructed substantially similar

to fluid sleeve assembly 220 in that it is three-piece assembly having flux bridge collars 224' and 226' on opposite ends constructed from ferritic 430 stainless steel or a similar ferritic material. Flux bridge collars 224' and 226' are interconnected by flux break 228", in some embodiments, or a flux bridge 228'" in other embodiments. Flux break
5 228" is constructed from a non-ferritic and non-magnetic 304 stainless steel or similar material. Flux bridge 228'" is similarly constructed to flux bridge collars 224', 226'.

[0049] Flux bridge collar 224' includes first and second radially extending flanges 346, 348, respectively. First flange 346 engages seat 342 of cage filter 302. First flange 346 is axially offset from an end of first flux bridge collar 224' such that an
10 axially extending portion 350 of first flux bridge collar 224' acts to guide and align cage 306.

[0050] It is contemplated that cage 306 is constructed from Nylon 6,6 having 30% glass reinforcement. The mesh may be constructed from a metal or a plastic. In the instant example, mesh 304 is constructed from Nylon 6,6 having apertures
15 extending therethrough and being sized at approximately 40 microns. Body 308 includes a plurality of windows 364 extending therethrough. Each window is covered by a portion of mesh 304. For fluid to pass through cage filter 302, fluid must pass through mesh 304.

[0051] Furthermore, the foregoing discussion discloses and describes merely
20 exemplary embodiments of the present disclosure. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims, that various changes, modifications and variations may be made therein without departing from the spirit and scope of the disclosure as defined in the following claims.

CLAIMS

What is claimed is:

1. An injector for injecting a reagent, the injector comprising:
5 a housing;
an axially translatable valve member positioned within the housing;
an electromagnet positioned within the housing and including a coil of wire
circumscribing at least a portion of the valve member, wherein the valve member
moves between a seated position and an unseated position in response to energizing
10 the electromagnet;

a flux frame surrounding the coil, the frame including first and second radially
extending portions axially spaced apart from one another, extending along substantially
parallel planes positioned on opposite sides of the coil;

a flux sleeve including two magnetic flux bridge collar portions interconnected by
15 one of a magnetic flux bridge portion and a non-magnetic flux break portion, each of the
two magnetic flux bridge collar portions being intersected by one of the planes in which
the radially extending flux frame portions lie to define flux bridges, the one of a flux
bridge portion and a flux break portion being surrounded by the coil and axially
positioned between the parallel planes;

20 a tubular pole piece disposed within the housing, wherein the pole piece defines
a return passageway for reagent to flow when the valve member is at at least one of the
seated position and the unseated position; and

a filter positioned within the housing and surrounding the pole piece, the filter
including a cage and a mesh fixed to the cage, the mesh covering windows extending
25 through the cage, the cage having a deformable first seal biasedly engaging an outer
surface of the pole piece, the cage including a second seal biasedly engaging the
housing, the first and second seals defining a closed volume between the housing and
the filter such that all of the reagent flowing through the injector passes through the
mesh.

30 2. The injector of claim 1, wherein the first and second seals are integrally
formed with the cage, wherein the cage, the first seal and the second seal define a one-
piece structure.

3. The injector of claim 2, wherein the cage is overmolded on the mesh.

4. The injector as in any one of claims 1-3, wherein the first seal radially inwardly extends from the mesh and the second seal radially outwardly extends from the mesh.

5. The injector as in any one of claims 1-3, wherein the mesh is shaped as a hollow right circular cylinder.

6. The injector as in any one of claims 1-3, wherein the cage includes a cup-shaped structure having the first seal positioned at an opposite end as the second seal.

7. The injector as in any one of claims 1-3, wherein the cage is constructed from Nylon 6,6 material.

8. The injector as in any one of claims 1-3, wherein the first seal and the second seal are deformable lip seals.

9. The injector as in any one of claims 1-3, wherein the second seal is shaped as a radially outwardly extending flange that forms a 45 degree angle with a longitudinal axis of the injector.

10. The injector as in any one of claims 1-3, wherein the pole piece extends through the entire filter and protrudes beyond the axial extent of the filter in each direction.

11. The injector as in any one of claims 1-3, wherein the flux sleeve includes three coaxially aligned tubes connected to each other.

12. The injector as in any one of claims 1-3, wherein the flux sleeve is a continuous member including the two magnetic flux bridge collar portions and the one of the magnetic flux bridge portion and non-magnetic flux break portion.

13. The injector as in any one of claims 1-3, wherein the reagent is directed to flow through the flux sleeve.

14. The injector as in any one of claims 1-3, wherein the valve member
5 includes a cylindrical pintle coupled to an enlarged pintle head, the pintle head being made from a magnetic material and positioned such that one of the planes intersects the pintle head when the valve member is at the seated position.

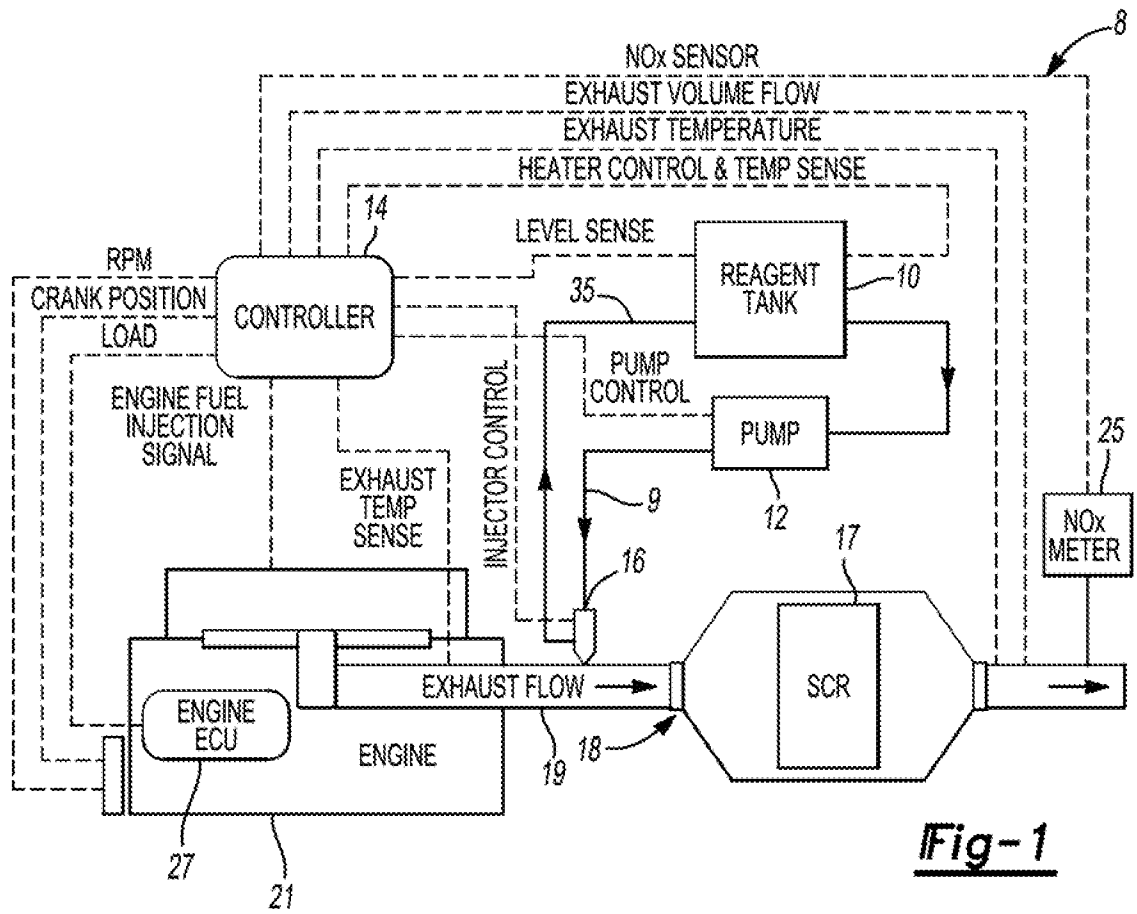
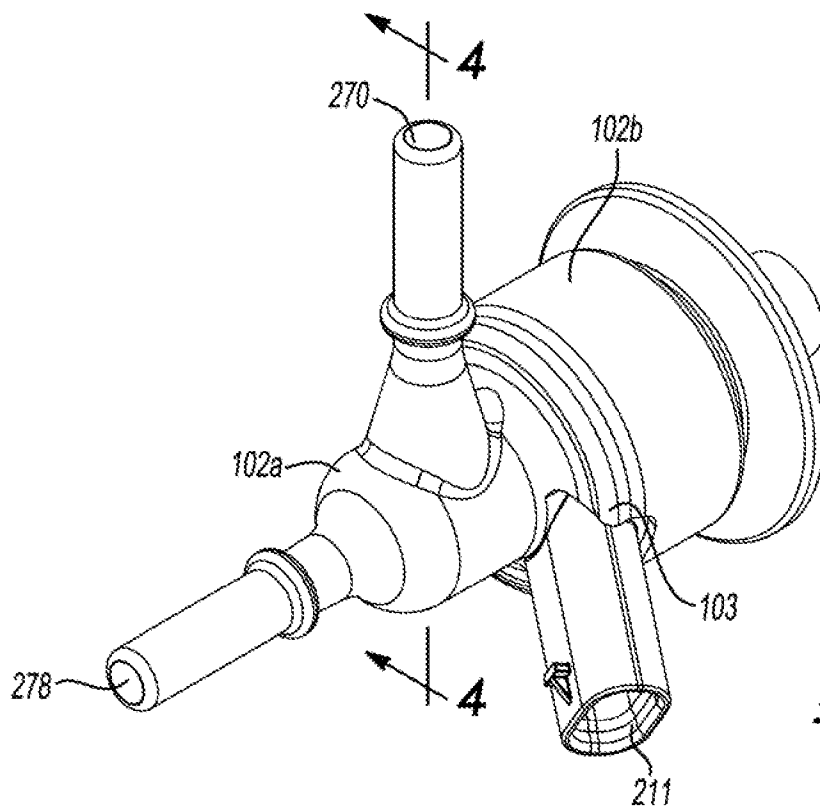
15. The injector as in any one of claims 1-3, wherein the tubular pole piece
10 forms an interference fit with the first seal, the second seal and the housing defining another interference fit.

15

20

25

30

**Fig-1****Fig-2**

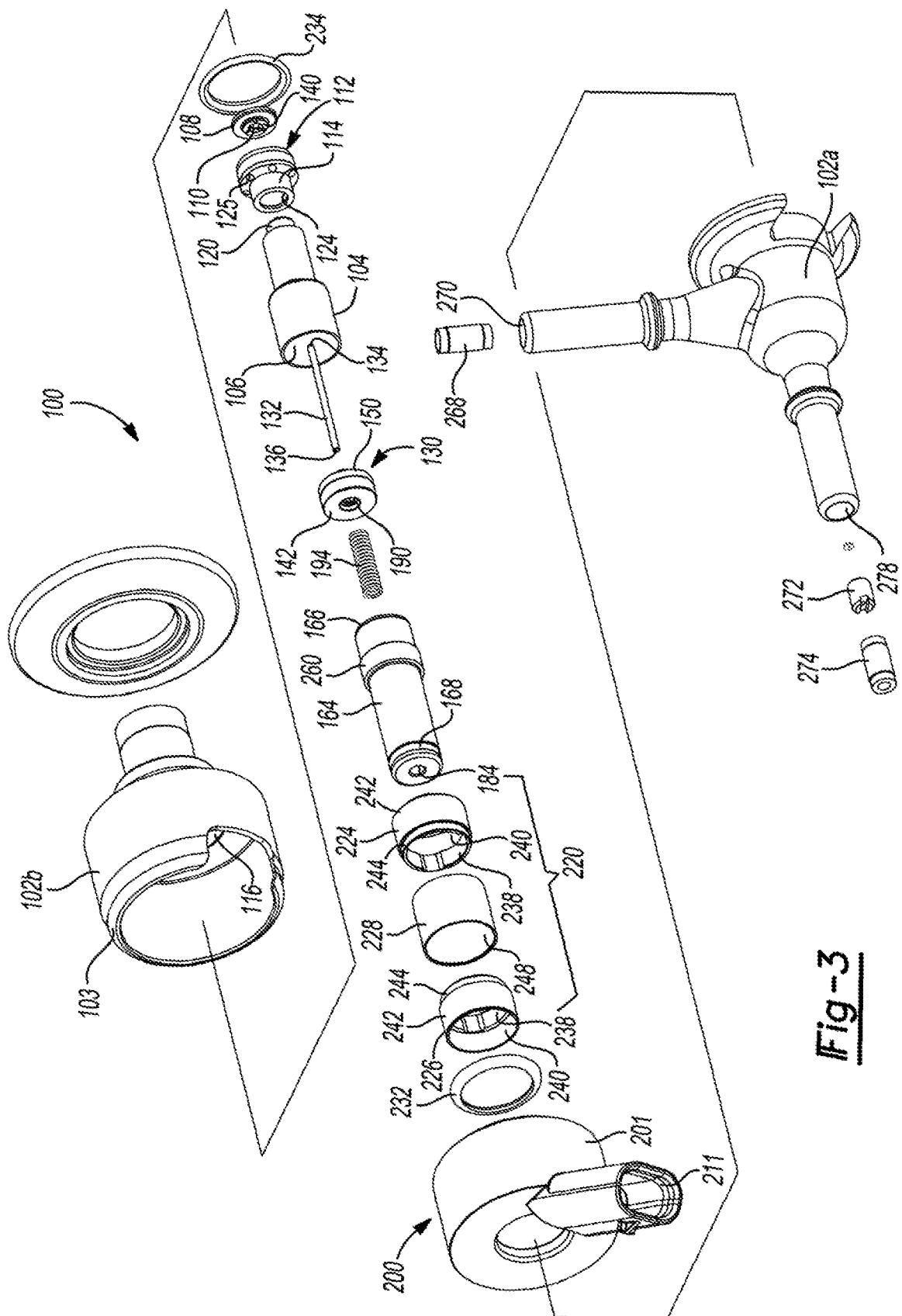


Fig-3

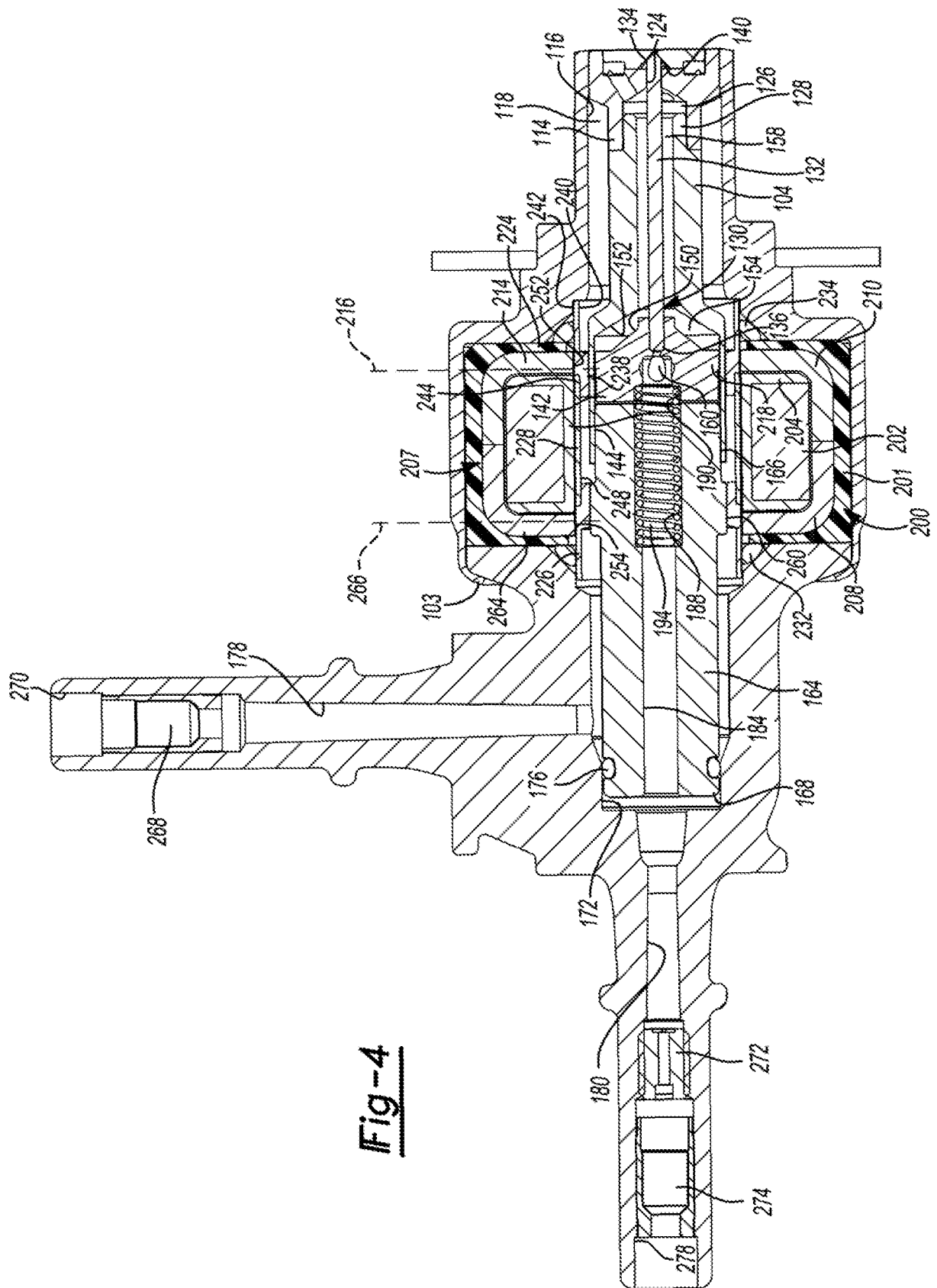
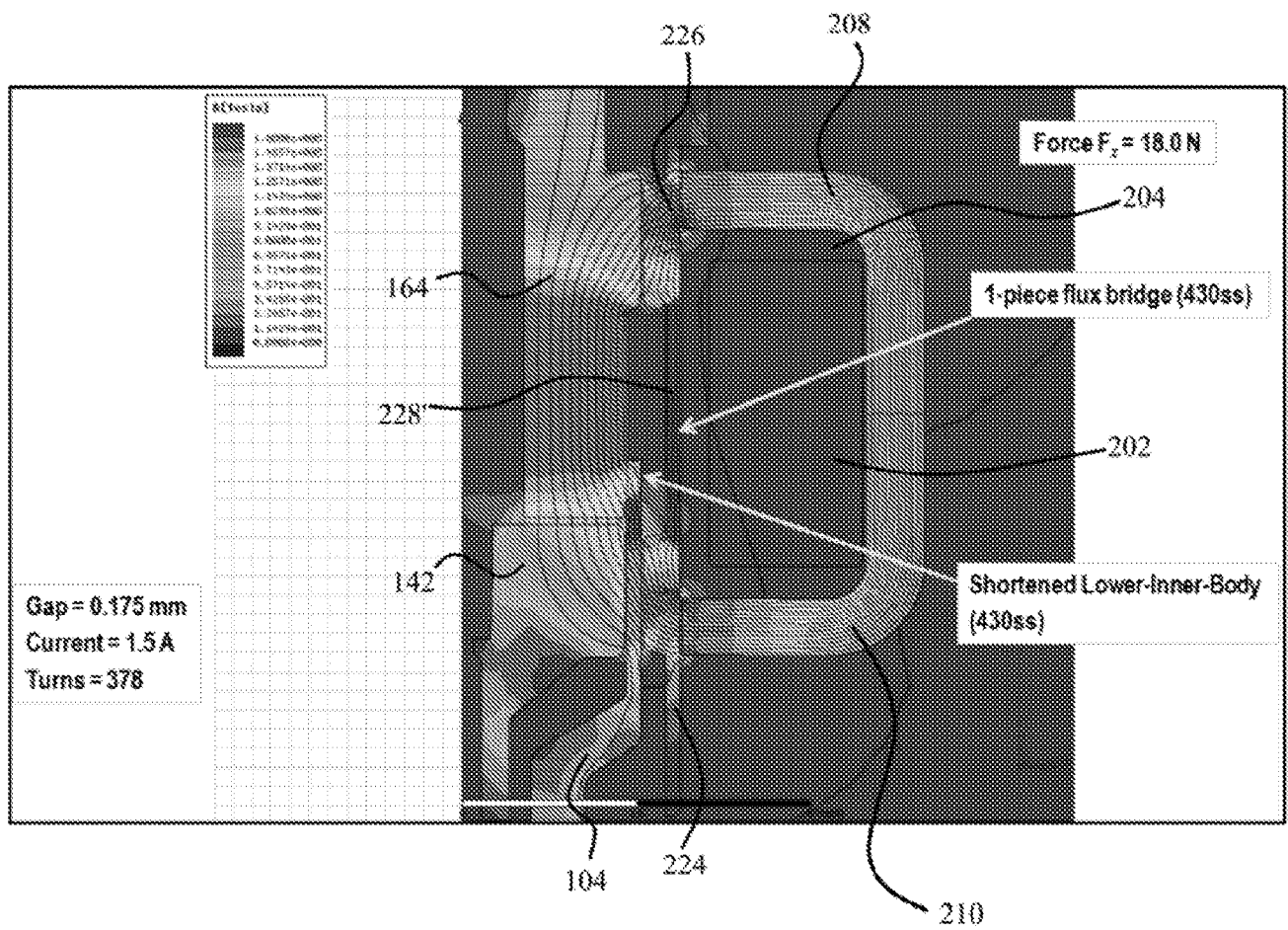
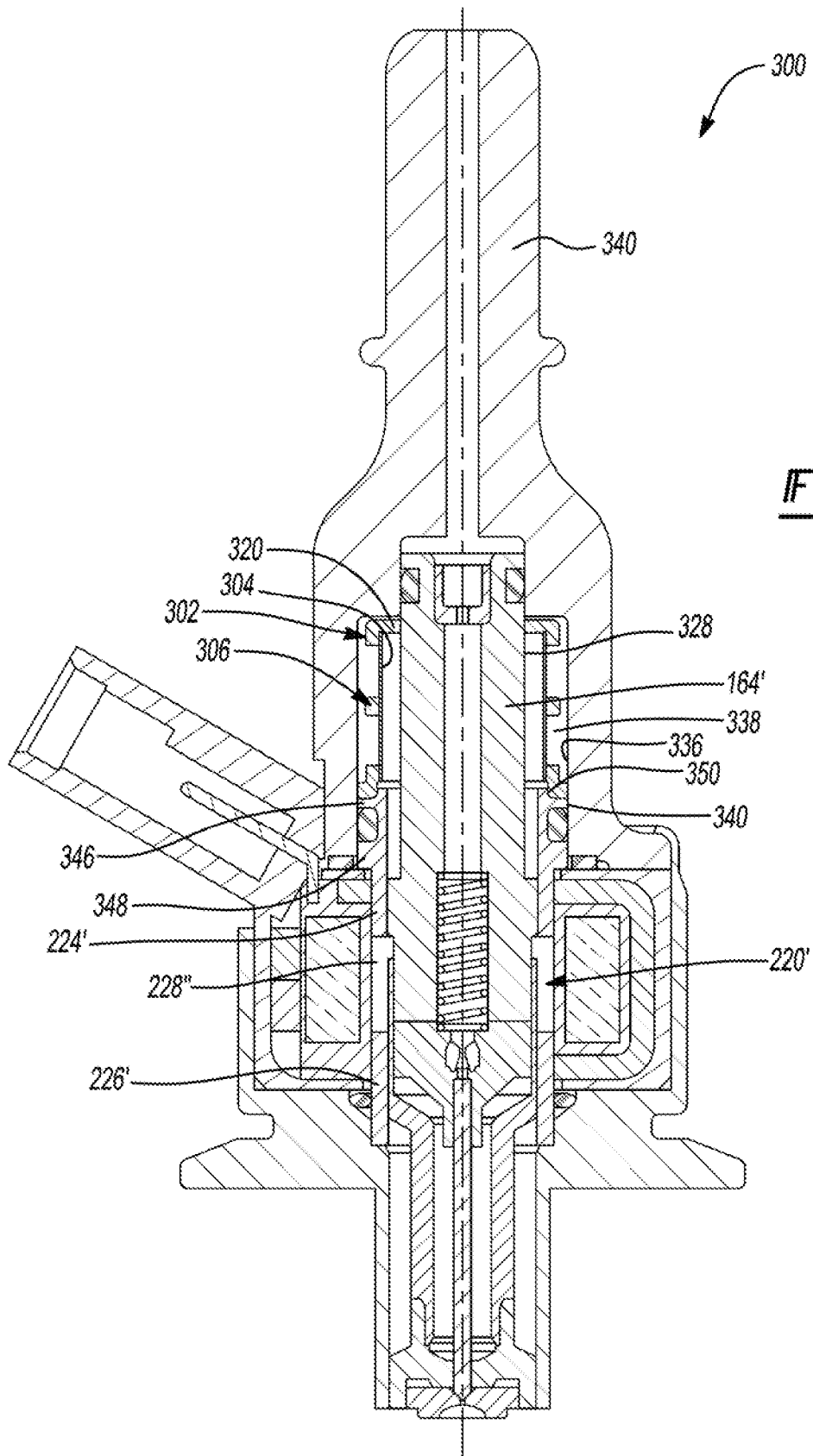
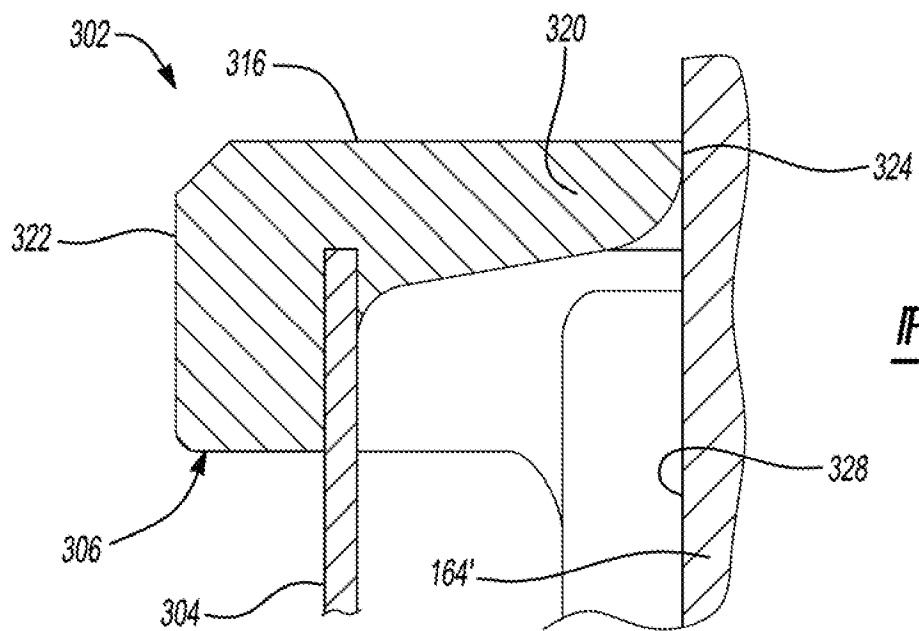
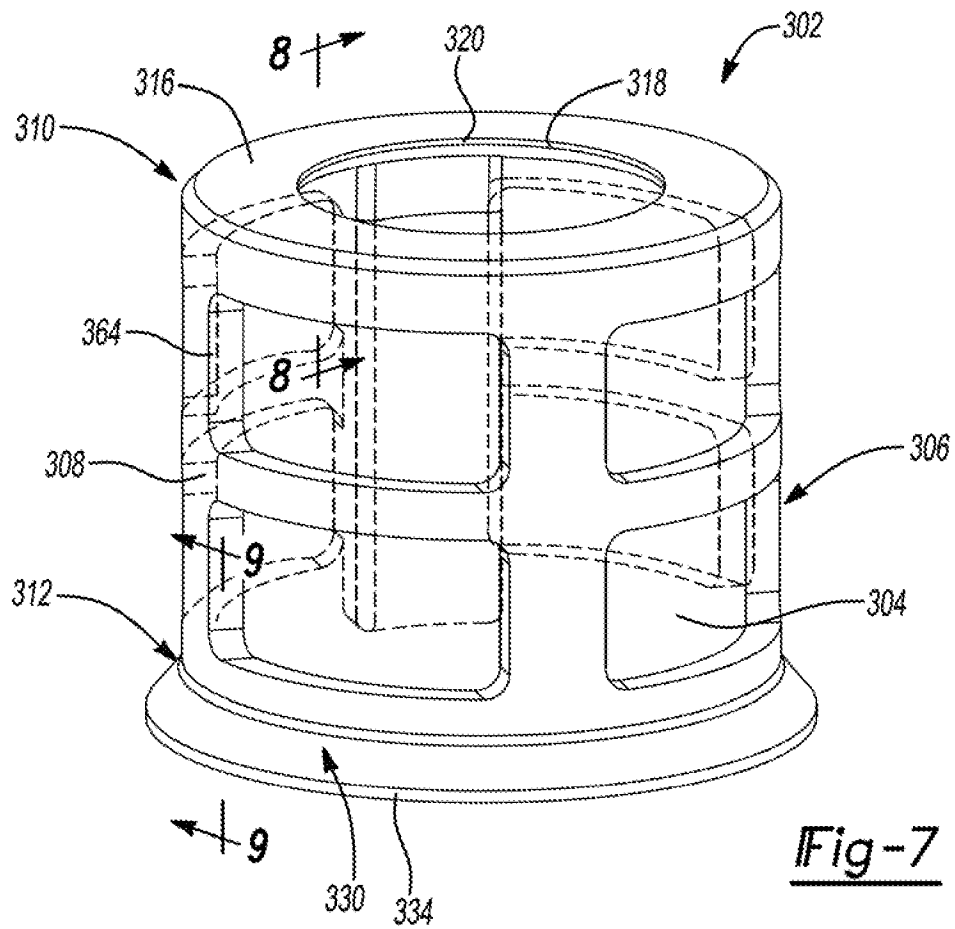


Fig-4

**Fig-5**

Fig-6



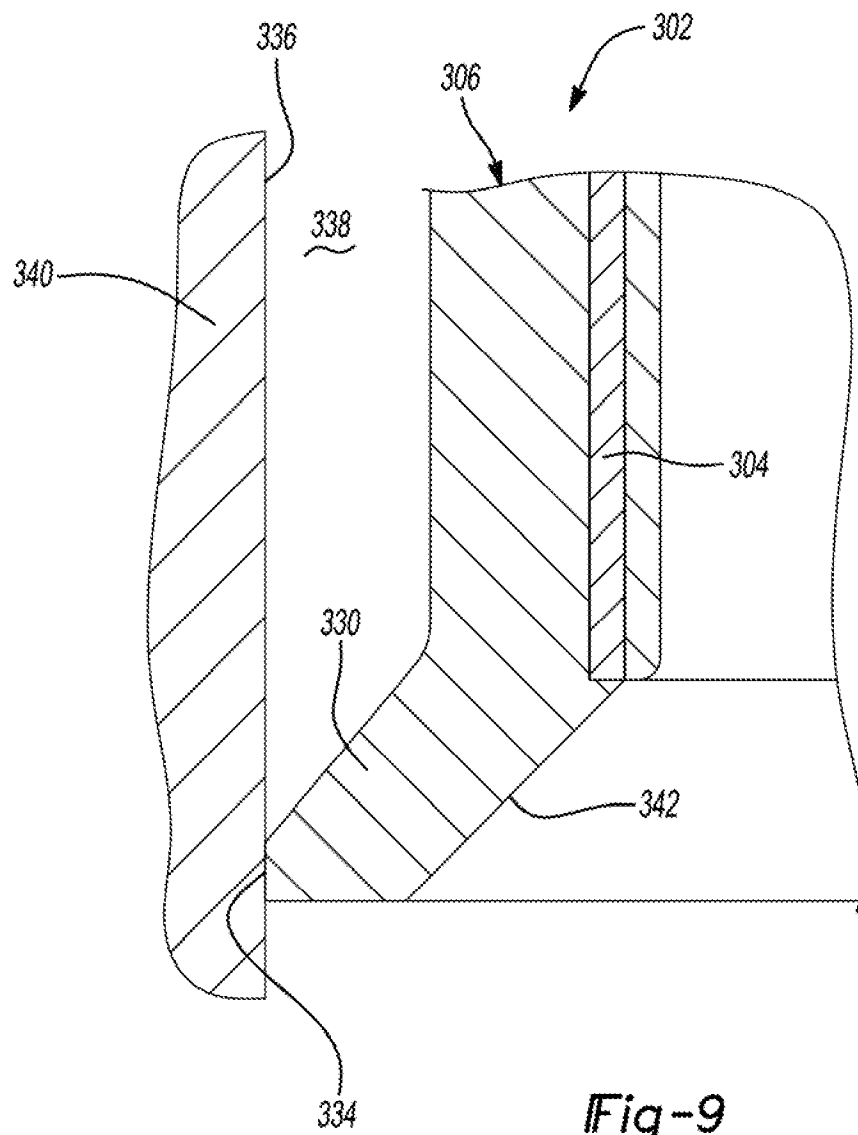


Fig-9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/043580**A. CLASSIFICATION OF SUBJECT MATTER****F01N 3/20(2006.01)i, F02M 63/00(2006.01)i**

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 3/20; F01N 1/00; F01N 3/00; F01N 3/025; F01N 3/36; F02M 47/02; F02M 51/08; F02M 61/16; F04B 17/04; F02M 63/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: injector, reagent, valve, electromagnet, flux frame, flux sleeve, pole, filter, cage, mesh, seal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 9683472 B2 (TENNECO AUTOMOTIVE OPERATING COMPANY INC.) 20 June 2017 See column 4, line 54 - column 7, line 55, claim 1 and figures 2-4.	1-15
A	JP 05-010221 A (NIPPONDENSO CO., LTD.) 19 January 1993 See paragraphs [0016]-[0017] and figures 3-6.	1-15
A	US 9759113 B2 (TENNECO AUTOMOTIVE OPERATING COMPANY INC.) 12 September 2017 See column 6, lines 9-24 and figures 3-4.	1-15
A	EP 1907689 B1 (L'ORANGE G.M.B.H.) 25 March 2009 See claims 1-4, 14, 17 and figures 1-3.	1-15
A	US 2015-0082775 A1 (ROBERT BOSCH G.M.B.H.) 26 March 2015 See paragraphs [0026]-[0041] and figure 2.	1-15



Further documents are listed in the continuation of Box C.



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

"D" document cited by the applicant in the international application

"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

14 November 2019 (14.11.2019)

Date of mailing of the international search report

14 November 2019 (14.11.2019)

Name and mailing address of the ISA/KR

International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

HWANG, Chan Yoon

Telephone No. +82-42-481-3347



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/043580

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 9683472 B2	20/06/2017	BR 112012019877 A2	26/04/2016
		BR 112013029195 A2	14/02/2017
		BR 112014004347 A2	21/03/2017
		CN 102834598 A	19/12/2012
		CN 102834598 B	18/03/2015
		CN 103502596 A	08/01/2014
		CN 103502596 B	15/02/2017
		CN 103764964 A	30/04/2014
		CN 103764964 B	17/08/2016
		CN 104791055 A	22/07/2015
		DE 112011100504 T5	11/04/2013
		DE 112011100504 T8	27/06/2013
		DE 112012002573 T5	18/06/2014
		DE 112012003626 T5	15/05/2014
		JP 2013-519822 A	30/05/2013
		JP 2014-517219 A	17/07/2014
		JP 2014-529706 A	13/11/2014
		JP 5748781 B2	15/07/2015
		JP 6097746 B2	15/03/2017
		KR 10-1767284 B1	23/08/2017
		KR 10-1900406 B1	08/11/2018
		KR 10-1947472 B1	22/04/2019
		KR 10-2012-0116503 A	22/10/2012
		KR 10-2014-0034247 A	19/03/2014
		KR 10-2014-0078636 A	25/06/2014
		SG 183207 A1	27/09/2012
		US 2011-0192140 A1	11/08/2011
		US 2011-0266370 A1	03/11/2011
		US 2011-0309166 A1	22/12/2011
		US 2015-0176461 A1	25/06/2015
		US 2015-0176463 A1	25/06/2015
		US 8740113 B2	03/06/2014
		US 8973895 B2	10/03/2015
		US 8998114 B2	07/04/2015
		WO 2011-100337 A2	18/08/2011
		WO 2011-100337 A3	22/12/2011
		WO 2012-177381 A2	27/12/2012
		WO 2012-177381 A3	10/05/2013
		WO 2013-033056 A2	07/03/2013
		WO 2013-033056 A3	25/04/2013
JP 05-010221 A	19/01/1993	None	
US 9759113 B2	12/09/2017	BR 112014027377 A2	27/06/2017
		CN 104271912 A	07/01/2015
		CN 107420165 A	01/12/2017
		DE 112013002372 B4	01/02/2018
		DE 112013002372 T5	22/01/2015
		JP 2015-517633 A	22/06/2015

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/043580

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1907689 B1	25/03/2009	JP 6085672 B2	22/02/2017
		KR 10-2014-0143396 A	16/12/2014
		US 2013-0299604 A1	14/11/2013
		US 2015-0090808 A1	02/04/2015
		US 8910884 B2	16/12/2014
		WO 2013-169481 A1	14/11/2013
		WO 2013-169481 A8	14/11/2013
US 2015-0082775 A1	26/03/2015	AT 426741 T	15/04/2009
		DE 102005035347 B3	10/08/2006
		EP 1907689 A1	09/04/2008
		JP 2009-503325 A	29/01/2009
		JP 4869345 B2	08/02/2012
		KR 10-1029214 B1	12/04/2011
		KR 10-2008-0034908 A	22/04/2008
		WO 2007-012433 A1	01/02/2007
		CN 104246220 A	24/12/2014
		CN 104246220 B	18/01/2017
		DE 102012206481 A1	24/10/2013
		EP 2839154 A1	25/02/2015
		EP 2839154 B1	10/08/2016
		US 9371824 B2	21/06/2016
		WO 2013-156178 A1	24/10/2013