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[Continued on next page]

(54) Title: COMBUSTION ENGINE BREATHING SYSTEM VALVE MODULE

(57) Abstract: A combustion engine breathing system valve module, and products and systems using the same.

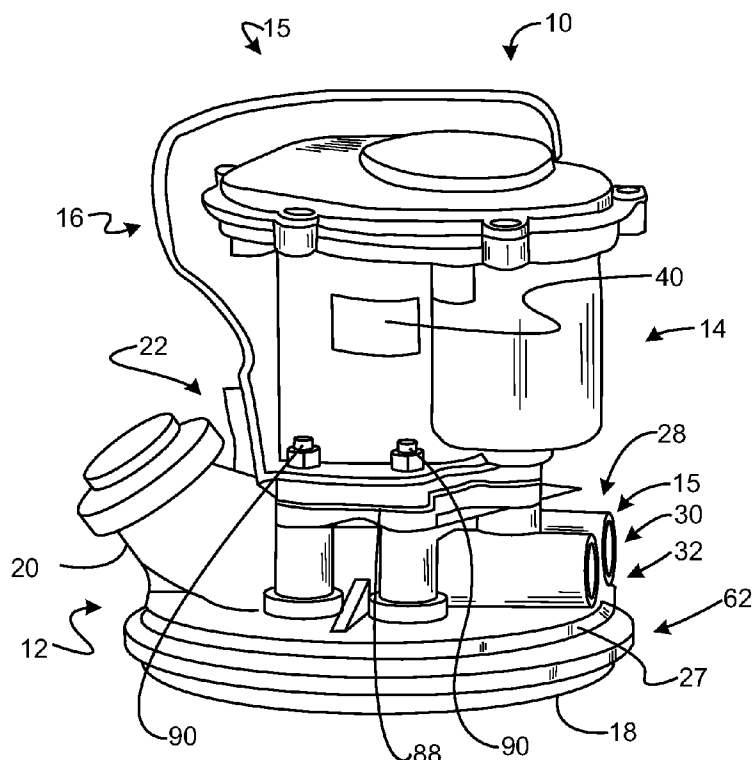


FIG. 1



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NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG,
CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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COMBUSTION ENGINE BREATHING SYSTEM VALVE MODULE

[0001] This application claims the benefit of United States Provisional Application No. 60/895,980 filed March 20, 2007.

TECHNICAL FIELD

[0002] The field to which the disclosure generally relates includes combustion engine breathing system valves, and systems including the same.

BACKGROUND

[0003] Combustion engine breathing systems may include an air intake side connected to deliver air to a combustion engine and an exhaust side connected to the combustion engine to exhaust combustion gases therefrom. Such combustion engine breathing systems may also include a high pressure exhaust gas recirculation line extending from the exhaust side to the air intake side, and where a turbocharger is present, a low pressure exhaust gas recirculation line may also extend from the exhaust side, connected at a location downstream of a turbine, to the air intake side. A variety of valves may be utilized in such combustion air breathing systems to control the flow of exhaust gas and air in the exhaust side, air intake side, exhaust gas recirculation lines or bypass lines for any of the above.

SUMMARY OF EXEMPLARY EMBODIMENTS OF THE INVENTION

[0004] One embodiment of the invention includes a valve module including a valve assembly and an actuator assembly and a heat barrier means to protect the actuator assembly.

[0005] Another embodiment of the invention includes a valve module including a valve assembly, an actuator assembly and a heat shield to protect the actuator assembly.

[0006] Another embodiment of the invention includes a valve module including a valve assembly and an actuator assembly, and a water cooling system in the valve assembly.

[0007] Another embodiment of the invention includes a valve module including a valve assembly and an actuator assembly, and wherein the valve assembly includes a rotatable disc and a slide means constructed and arranged to limit the wear on the disc.

[0008] Other exemplary embodiments of the invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while disclosing exemplary embodiments 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

- [0009]** Exemplary embodiments of the present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:
- [0010]** FIGS. 1-35 illustrate various embodiments of the invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

- [0011]** The following description of the embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.
- [0012]** FIG. 1 illustrates one embodiment of the invention including a valve module 10 including a valve assembly 12 and an actuator assembly 14. The valve module 10 may also include a heat barrier means 15 such as a heat shield 16 constructed and arranged to protect the actuator module from components of the valve assembly 12. The valve assembly 12 may include a plurality of openings or ports for the flow of gas therethrough. For example, the valve assembly 12 may include at least three openings such as, two inlets and one outlet or two outlets and one inlet. In the embodiment shown in FIG. 1, the valve assembly 12 includes an exhaust gas inlet (port) 18, an exhaust gas recirculation outlet (port) 20 and an exhaust gas outlet (port) 22. In the embodiment shown in FIG. 1, the exhaust gas inlet 18 may be constructed and arranged to be connected directly to a diesel particulate filter assembly as will be described hereafter. The valve assembly 12 may also include an alternative heat barrier means 15 such as a cooling system 28 having a channel defined therein and

constructed and arranged to flow a cooling fluid therethrough as will be described in greater detail hereafter. The cooling system 28 may include a cooling fluid inlet 30 and a cooling fluid outlet 32. The valve assembly 12 may also include a valve disc, shown generally at 62, received in a valve housing 13 and constructed and arranged to be moved by the actuator to open all of the openings, completely close all of the openings, partially close all of the openings or any combination thereof, for example, as will be described in greater detail herein.

[0013] Referring now to FIGS. 2-3, in one embodiment of the invention, the valve module 10 may be connected directly to a diesel particulate filter assembly 24 which may include a filter (monolith or otherwise) contained in a housing. In the embodiment shown in FIG. 2, the valve disc (generally shown by numeral 62), is positioned at an angle to the direction of flow of the exhaust gas through the diesel particulate filter 24. In this arrangement the axis of the diesel particulate filter 24, and ports 20, 22 are generally parallel and thus abrupt turns of air or exhaust are avoided. Alternatively conduit or sheet metal may be provided to guide or direct the flow of gas toward the opening formed in the valve house for positioning arrangements and to reduce back pressure and the like. During regeneration of the diesel particulate filter 24 wherein particulate matter is burned off, the diesel particulate monolith or other filter can reach temperatures of up to 1200°C and the exhaust gas can reach temperatures ranging from about 850-900°C. In order to protect a variety of components in the actuator assembly 14 including, but not limited to, the actuator motor and electronics, a heat shield

16 may be provided which shields the actuator assembly 14 from components of the valve assembly 12 including, for example, the EGR outlet 20 and the exhaust outlet 22. The heat shield 16 may include a portion 88 interposed between the valve assembly 12 and the actuator assembly 14, preferably at a location near the cooling system 28. The heat shield 16 may be made from any of a variety of materials including single or multiple layers, including sheet metal, composite materials. Preferably, the shield 16 includes at least one layer having a relatively low heat transfer coefficient. For example, the heat shield 16 may include a low heat transfer coefficient material sandwiched between two layers of sheet metal.

[0014] Referring now to FIG. 3, the actuator assembly 14 may include an actuator housing 34 including a first portion 36 which may be constructed and arranged to receive a motor and a second portion 38 constructed and arranged to receive a shaft for driving the valve disc 62. The actuator assembly 14 may also include a cover 42 which may be connected to the valve housing 34 in any of a variety of manners, including crimping, bolting, screwing, by an adhesive or other suitable means. An electrical connector 40 may be provided and made a part of the actuator assembly 14 to provide power and electrical signals to components of the actuator assembly 14 including the motor and electronic components as will be described hereafter. The valve assembly 12 may be connected to the actuator assembly 14, for example, by bolts extending through portions of the valve housing 13 and through a through hole in a portion of the actuator housing 34. A nut or a shoe horse 50 having a plurality of threaded orifice therein may be used to secure the bolt. Other means of attaching the

valve assembly 12 to the actuator assembly 14 are within the scope of the invention, including welding, clamping, and adhering the same together. Optionally, a spacer 52 may be interposed between the valve assembly 12 and the actuator assembly 14. Shown also in FIG. 3 is a portion of an exhaust gas side component, which may be a diesel particulate filter assembly 24 connected to the valve assembly 12 by a fastening means 48. The fastening means 48 may include, but is not limited to, a v-band clamp, or other means of fastening the components together, such as crimping, welding or adhering the components together. Shown also is a portion of an exhaust gas recirculation conduit 44 connected to the exhaust gas recirculation outlet 20 of the valve housing 13. Also shown is a portion of exhaust conduit connected to the exhaust outlet 22 of the valve housing 13. The exhaust conduit 46 may have an open end to exhaust combustion gases to the atmosphere.

[0015] Referring now to FIG. 4, the valve assembly 12 may include a bushing 54 pressed into the valve housing 13 and constructed and arranged to receive a valve shaft 56. The valve housing 13 may be made from any of a variety of materials, including cast iron, cast steel, stainless steel, high grade stainless steel or corrosion resistant alloys or composites. An insert 58 may be provided and constructed and arranged to protect portions of the valve housing 13 from corrosive constituents present in the exhaust gas in the event that the valve housing 13 is constructed from a less corrosive resistant material, such as cast iron. The insert 58 may be connected to the valve housing 13 by way of one or more bolts 60. A rotating valve disc 62 is provided and may slide on the insert

58 (if present) or in the case where no insert is present, a gap may be provided between the valve disc 62 and the valve housing 13 wherein a portion of the valve disc 62 may rotate on another component as will be described herein.

[0016] In another embodiment of the invention, the portion of the valve housing 13 exposed to the exhaust gas may be coated with a layer of relatively high corrosion resistant material such as, but not limited to, stainless steel grade 904L or other alloy such as 254 SMO, C-276 or Carp-20 alloy. The coating may be applied by sputtering, thermal spraying, kinetic/cold spraying of metal powder or other similar means. The material utilized to make or coat the valve housing 13, insert 58, or valve disc 62 may vary, depending upon the application and desirability to control temperature, friction, wear, corrosion, heat expansion and heat deformation.

[0017] The valve disc 62 is mounted on a valve shaft 56. The valve shaft 56 heat treated or may be made out of or coated with a material that matches that of the bushing 54 to minimize friction and wear. In one embodiment, to mount the valve disc 62 on the valve shaft 56, a nut 64 may be threaded onto the valve shaft 56. The valve disc 62 may also be attached to the valve shaft 56 by any of a variety of other means including, but not limited to, crimping, staking, welding, soldering, riveting, by an adhesive or any other suitable means. For positioning the valve disc 62 on the valve shaft 56, a portion of the valve shaft 56 has a d-shape. That is, a portion of the valve shaft 56 includes a flat surface 66, best seen in FIG. 6. The valve disc 62 includes a complementary d-shaped through hole formed therein for receiving the valve shaft 56 and engaging the flat

portion 66. In embodiments of the invention that do not include the insert 58, the valve disc 62 may slide directly on the bushing 54 or a truss bearing built out of up to 3 washers or a plurality of ball bearings as will be described herein. The bushing, truss bearing, washers and ball bearings may be made out of any suitable material and may be coated to reduce friction and wear.

[0018] A lever 70 (best seen in FIG. 8) may be provided on one end of the shaft 56 to hold a fail-safe mechanism 72 which may be a coil spring. The coil spring 72 may be guided by a hub 74 which may include two separate pieces, each piece having a cap 76 (shown in FIG. 20) with a through hole formed therein and a plurality of spaced apart fingers 78 extending downwardly from the cap 76. The two pieces of the hub 74 may be arranged so that the fingers of each are positioned in an interdigitated fashion as shown in FIG. 20.

[0019] Referring again to FIG. 4, the valve assembly 12 may include a cooling system 28 which in addition to the inlet opening 30 and outlet opening 32 includes an opening 80 (best seen in FIGS. 27-28 as will be described hereafter) for ease of manufacturing. The opening 80 communicates with a channel of the cooling system. In such case, a spacer plate 82 may be provided along with a gasket 84 to seal the opening 80 in the valve housing 13 defining the cooling channel 83 of the cooling system 28. The function of the spacer plate 82 and the gasket 84 may be combined and integrated into one piece. In another embodiment of the invention, the cooling system 28 including the cooling channel 196, may be manufactured using a lost core process so that the cooling channel is completely closed and does not include the opening 80. This may be

accomplished using foam, sand, salt, plaster or other suitable material which may be removed after the valve housing 13 has been cast around such a core. In such case, the spacer plate 82 and the gasket 84 may not be necessary.

[0020] A heat shield 16 may be provided as an alternative to or as a second heat barrier (in addition to the heat barrier provided by the cooling system 28) to prevent or limit heat transferred to the actuator assembly 14 to prevent heat from damaging the actuator motor 86 or the electronics (to be described hereafter). A portion 88 of the heat shield may be interposed between valve assembly 12 and the actuator assembly 14 and may be held in position by dowels 136 and clamped together by bolts 90 as shown in FIG. 1. A small bracket 92 may be connected to the heat shield 16 and the actuator housing 34 to provide additional support for the upper end of the heat shield 16 and to hold the upper portion of the heat shield 16 away from the valve assembly 14. The heat shield 16 may be constructed and arranged to shield the sensor element 94 housed in the actuator assembly 14.

[0021] As stated earlier, the actuator housing 34 includes a first portion 36 constructed and arranged to receive an electric motor 86 which is pressed into place with the aid of a tolerance ring 96 which may be received in a lower cup 98 formed in the first portion 36. A tolerance ring 96 compensates for dimensional and positioning errors. The actuator motor 86 may be of any type DC-motor, torque or step motor available and which is suitable for the needs of the application. A motor bracket 100 may be provided to physically connect the actuator motor 86 to the actuator housing 34. A pinion gear 102 may be

provided on the shaft of the motor 86 to drive an intermediate gear 104 on a gear shaft 106 that that may be pressed, glued into the actuator housing 34 or otherwise attached thereto. An output gear 108 may be provided and connected to an output shaft 110. The gear train ratios may be changed to provide greater or lesser force or quicker or slower response as desired by change the intermediate gear 104 and the output gear 108. A sensor rotor 112 may also be connected to the output gear 108. The output gear 108 is also pressed into a ball bearing 114 and is additionally guided by a bushing 116 so that the output gear 108 transfers torque provided by the actuator motor 86 to a decoupling mechanism 118 of the output shaft 110 and the valve shaft 56. The decoupling mechanism 118 of the valve shaft 56 and the output shaft 110 prevents or limits heat transfer into the upper area of the actuator assembly 14 to prevent damage to the actuator motor 86 and electronics such as the sensor 94. The decoupling mechanism 118 of the valve shaft 56 and the output shaft 110 is constructed and arranged so that there is minimum contact between the two shafts. One embodiment of a decoupling mechanism 118 is shown in FIG. 9 wherein the output shaft 110 includes a slot 120 constructed and arranged to receive a blade portion 122 of the valve shaft 56.

[0022] Referring again to FIG. 4, the output shaft 110 may be sealed with a lip seal 124 which is pressed into the actuator housing 34. The ball bearing 114 and bushing 116 are also pressed into the actuator housing 34.

[0023] A rotor sensor 112 may be provided on the top of the output shaft 110 which cooperates with a sensor control board 94 to provide shaft position

feedback for closed loop control of the valve module 10. The rotor sensor 112 and the sensor board 94 may be contact or contactless, depending upon the application and may use any type of position detecting. The sensor control board 94, the connector 40, and all electrical connections necessary to drive the actuator motor 86 and provide position signaling to the connector 40, which operates as an interface to an engine electronic control unit, may be provided in one moldover lead frame assembly 182 to be described hereafter. The moldover lead frame assembly 182 may be bolted to the actuator housing 34.

[0024] A cover 126 may be provided on top of the actuator housing 34 with a sealing member (not shown) to close and protect the parts of the actuator assembly 14. The cover 126 may be made out of any suitable material including, but not limited to, metal, plastic or a composite. In the case of a plastic material or a composite, the lead frame assembly may be integrated into the cover 126. The cover 126 may be bolted, crimped, clamped, welded, bolted or otherwise attached to the actuator housing 34.

[0025] Referring now to FIG. 5, the spacer plate 82 may include a plurality of dowels 136 extending upwardly therefrom wherein each dowel may be received in a through hole formed in a portion 88 of the heat shield 16 which is interposed between the valve housing 13 and the actuator housing 34. A plurality of bolts 128 which extend through openings in the valve housing 13, gasket 84, spacer plate 82, the portion 88 of the heat shield 16 and the actuator housing 34. A nut or threaded horseshoe 50 may receive a bolt 128 to secure the components together. The lever 70 secured to the upper portion of the valve

shaft 56 may include a downwardly extending finger 130 which may be engaged by and biased by a first tang 132 at a first end of the fail safe mechanism in the form of a coil spring 72. The downwardly extending finger 130 of the lever 70 engages a stop 134 of the actuator housing 34. A second end of the coil spring 72 includes a second tang 138 which is constructed and arranged to engage a second stop 140 of the actuator housing 34 as best seen in FIG. 7. This allows for two-way fail safe biasing of the valve disc 62 so that regardless of which way the valve disc 62 had been previously rotated, if the actuator fails, the fail-safe mechanism biases the valve disc 62 to a position wherein the exhaust gas recirculation outlet port 20 is fully closed and the exhaust gas outlet port 22 is less than 100% closed. The coil spring 72 also biases the disc plate 62 to a position to eliminate or reduce any slop due to tolerances and to prevent the disc 62 from rattling during normal operation of the vehicle. The coil spring 72 also places an axially load on the valve shaft 56.

[0026] The upper portion of the valve shaft 56 at a location adjacent the blade portion 122 may include a first flat portion 142 and a second flat portion 144 to provide a double d-shape which may be received in a complementary through hole formed in the lever 70 as best seen in FIG. 24.

[0027] Referring now to FIG. 11, in one embodiment of the invention the valve disc 62 may be attached to the valve shaft 56 in a manner which allows the valve disc 62 to rotate with a gap 152 between the valve disc 62 and surfaces of the valve housing 13. In one embodiment, the valve disc 62 rides or slides on a bushing 54 surrounding the valve shaft 56. The valve housing 13 may be

constructed and arranged to define an exhaust inlet 18 in a manner which includes a planar face portion 146. A first opening 150 may be provided through the planar face 146 so that the first opening 150 communicates with the exhaust outlet port 22. A second opening (shown in FIG. 33) may also be provided in the planar face 146 and so that the second opening communicates with the exhaust gas recirculation outlet port 20. A raised land 148 may extend upwardly from the planar face portion 146 immediately around each of the first opening 150 and second opening and/or around the periphery of the planar face portion 146. The function of the raised land portion 148 is to provide a longer sealing gap.

[0028] Referring now to FIGS. 12-13, a friction wear reduction means may be a first washer 154 and may be provided on the valve shaft 56 over the bushing 54 to reduce wear on the valve disc 62 and the bushing 54. As shown in FIG. 13, the first washer 154 may be locked to the valve shaft 56 by a flat portion 158 formed in the upper end of the valve shaft 56 and wherein the washer 154 has a complementary through hole formed therein.

[0029] Referring now to FIGS. 14-15, in another embodiment of the invention, a second washer 160 may be provided and is locked to the valve housing 13 or is prevented from rotation with respect to the valve housing 13, and a third washer 162 is interposed between the first washer 154 and the second washer 160. The washers 154, 160 and 162 may be made from relatively expensive materials having less friction, and improved wear resistance. Therefore, the valve disc 62 may be made of less expensive materials.

[0030] Referring now to FIGS. 16-17, in another embodiment of the invention, a plurality of ball bearings 164 may be provided at a first end 166 of the bushing 54 to facilitate movement of the valve disc 62 or other options. Alternatively, the washers 154,160,162 or the ball bearings 164 may be located at a position spaced from the valve disc 62 where less heat would be encountered. For example, the washers 154,160,162 or ball bearings 164 may be located at a second end 168 of the bushing 54.

[0031] Referring now to FIG. 32, one embodiment of the invention may include a valve module 10 having an actuator assembly 14 and a valve assembly 12. The valve assembly 12 includes an exhaust inlet port 18, exhaust gas recirculation outlet port 20 and an exhaust gas outlet port 22.

[0032] FIG. 33 is a sectional view taken along line 33-33 of FIG. 32 and illustrates the valve disc 62 which may be in one form be a semi-disc as shown in FIG. 33. Again, the housing may include a planar face portion 146 havin a first opening 150 formed therein communicating with the exhaust gas outlet port 22 and a second opening 152 also formed therein communicating with the EGR exhaust gas port 20. The disc valve 62 to may be moved to a varied of positions to open, close, partially open or completely close the ports 20 and 22. FIG. 34 shows the disc valve moved to a position blocking the first opening 150 and the second opening 152 and thus closing the ports 20 and 22.

[0033] Referring now to FIG. 18, the actuator assembly 14 may include a groove 178 formed in an upper portion of the actuator housing 34 and an O-ring 180 may be provided in the groove 178 to seal the actuator assembly 14 when

the cover 42 is placed on the actuator housing 34. In another embodiment the cover 42 may have a mold in place seal. The sensor board 94 may be received in a moldover assembly 182.

[0034] Referring now to FIG. 21, the moldover assembly 182 may package the sensor board 94. A microprocessor may be provided on the sensor board 94 or else wherein the actuator assembly to provide for a smart actuator which controls both power and signals to accomplish feedback control of the positioning of the valve disc 62. Otherwise, the actuator assembly 14 may be a dumb actuator in which feedback control processing may be conducted in an electronic control unit located elsewhere in the vehicle. The moldover assembly 182 may capture portions of a lead frame 184 extending from the electrical connector 40 which includes a plurality of connector terminals 186. The lead frame 184 also is designed to accommodate positional tolerances. Compression limiters 188 may be provided in the moldover assembly 182 to prevent screws or bolts from causing the plastic material used for the moldover assembly 182 to flow away over repeated insertion of fastening devices or through thermal expansion and contraction.

[0035] Referring now to FIG. 19, terminals 190 may be provided to make electrical connection to the actuator motor 86. As shown in FIGS. 19 and 22, the tolerance ring 96 may be received in a cup 192 formed in the actuator housing 34.

[0036] Referring now to FIGS. 25-26, the valve housing 13 includes a cooling system 28 including a cooling inlet 30 and a cooling outlet 32 (the order

of which may be reversed). The valve housing 13 includes a central bore 194 extending therethrough to receive the valve shaft 56 and bushing 54. In one embodiment of the invention, the flow of cooling fluid, such as water, circulates around the central bore 194 in the direction of arrow C (or in the reverse direction) to cool the valve shaft and bushing as well as other components in the housing. Cooling of the valve shaft 56 reduces the likelihood that heat will be transferred through the valve shaft 56 and into the actuator assembly 14 and damaging components therein. As shown in FIG. 25, the cooling system 28 is completely closed and may be manufactured utilizing a lost core technique.

[0037] Referring now to FIGS. 27-28, in another embodiment, the cooling system 28 may be manufactured so that an opening 80 is provided through the valve housing 13 and communicates with the channel 196. The opening 80 allows for the valve housing 13 to be more easily cast.

[0038] Referring now to FIG. 29, one embodiment of the invention includes a mesh 198 positioned in the exhaust gas recirculation port 20 to catch debris that may be flowing through the system before the debris reaches a turbocharger compressor (if present), the combustion engine, or the turbocharger turbine (if present) to prevent damage to the same.

[0039] Referring now to FIGS. 30-31, in one embodiment of the invention, the cover 42 may include the electrical connector 40, other electronic components such as the sensor board 94 and any microprocessor, if present, as well as electrical leads and terminals 200, for making contact to the actuator motor terminals which may be M or F slot type or other suitable type. The cover

42 may be made from any of a variety of materials including, but not limited to, metals, plastics or composites.

[0040] Referring now to FIG. 35, one embodiment of the invention includes a system 210 including a valve module 10. The system 210 may include a combustion engine 212, such as but not limited to, a gasoline or a diesel combustion engine. An air intake side 214 may be provided, including a manifold 218 connected to the combustion engine 212 to feed air into the cylinders of the combustion engine 212. A primary air intake conduit 220 may be provided and connected at one end 222 to the air intake manifold 218 (or made a part thereof), and may include an open end 224 for drawing air therethrough. An air filter 226 may be located at or near the open end of the air intake conduit 220.

[0041] A combustion gas exhaust side 216 may be provided and constructed and arranged to discharge combustion exhaust from the combustion engine 212. The combustion exhaust side 216 may include an exhaust manifold 228 connected to the combustion engine 212 to exhaust combustion gases therefrom. The exhaust side 216 may further include a primary exhaust conduit 230 having a first end 232 connected to the exhaust manifold 228 (or made a part thereof), and may have an open end 234 for discharging exhaust gases to the atmosphere.

[0042] The system 210 may further include a first exhaust gas recirculation (EGR) assembly 240 extending from the combustion exhaust side 216 to the air intake side 214. A first EGR valve 246 may be provided in fluid communication with the primary exhaust gas conduit 230 or may be in a primary EGR line 242

and constructed and arranged to control the flow of the exhaust gas through the primary EGR line 242 into the air intake side 214 and into the combustion engine 212. A cooler 244 may be provided in fluid communication with the first primary EGR line 242 for cooling exhaust gases flowing through the same.

[0043] The system may further include a turbocharger 248 having a turbine 250 in fluid communication with the primary exhaust conduit 230 and having a compressor 252 in fluid communication with the primary air intake conduit 220 to compress gases flowing therethrough. In one embodiment of the invention, the turbine 250 may have a variable turbine geometry with turbine vanes movable from at least a first position to a second position to vary the geometry of the turbine and thus vary the speed of the rotation of the turbine for a given flow rate therethrough.

[0044] A second EGR assembly 270 may be provided for low pressure exhaust gas recirculation. The second EGR assembly 270 may be identically constructed as the first EGR assembly 240, if desired. In one embodiment, the second EGR assembly includes a second EGR line 271 having a first end 272 connected to the primary exhaust conduit 230 and a second end 274 connected to the primary air intake conduit 220. In one embodiment, the valve module 10 may be connected at the juncture of the primary exhaust conduit 230 and the second EGR line 271. In one embodiment, the valve module 10 is directly connected to a diesel particulate filter assembly 24 in a manner for example, but not limited to, the configurations shown in FIG. 2. The primary exhaust gas conduit 230 may further include a throttle valve 320 to control the amount of

exhaust gas being exhausted through the open end 234 and to force exhaust gas to flow through the second EGR line 271.

[0045] The valve module 10 may be used anywhere in the combustion breathing system where three conduit section come together.

[0046] Additional components may be included in the primary exhaust conduit, including a catalytic converter 236 which may be located upstream of the particulate filter 24 and a muffler 238 which may be located downstream of the particulate filter 24.

[0047] A charge air cooler 256 may be located upstream of the compressor 252 and a air throttle valve 258 may be provided to control the amount of air being delivered to the combustion engine 212.

[0048] The above description of embodiments of the invention is merely exemplary in nature and, thus, variations thereof are not to be regarded as a departure from the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. A product comprising:
a combustion engine breathing system valve module comprising a valve assembly, an actuator assembly and a heat barrier means constructed and arranged to limit the transfer of heat from the valve assembly to the actuator assembly.
2. A product as set forth in claim 1 wherein the heat barrier means comprises a heat shield attached to at least one of the valve assembly or actuator assembly.
3. A product as set forth in claim 2 wherein the heat shield comprises at least one sheet of material.
4. A product as set forth in claim 2 wherein the heat shield comprises a plurality of sheets of material.
5. A product as set forth in claim 2 wherein the heat shield comprises at least one layer of a material having a lower heat transfer coefficient than the material of the valve assembly.

6. A product as set forth in claim 2 wherein the heat shield comprises a first layer of material having a lower heat transfer coefficient than the material of the valve assembly and wherein the first layer of material is sandwiched between layers of metal.

7. A product as set forth in claim 2 wherein the heat shield includes a portion interposed between the valve assembly and the actuator assembly.

8. A product as set forth in claim 7 wherein the heat shield includes a portion extending outwardly from the portion interposed between the valve assembly and actuator assembly so that a first end of the heat shield is spaced a distance from the actuator assembly and further comprising a bracket connecting the first end of the heat shield to the actuator assembly.

9. A product as set forth in claim 1 wherein the valve assembly includes at least three gas flow openings.

10. A product as set forth in claim 1 wherein the valve assembly includes an exhaust gas inlet port, an exhaust gas outlet port, and an exhaust gas recirculation port.

11. A product as set forth in claim 1 wherein the valve assembly includes two inlet ports and one outlet port.

12. A product as set forth in claim 2 wherein the valve assembly includes an exhaust gas inlet port, an exhaust gas outlet port, and an exhaust gas recirculation outlet port, and wherein the heat shield is positioned to be interposed between the actuator assembly and the exhaust gas outlet port and the exhaust gas recirculation outlet port to limit heat from being radiated or transferred from the exhaust gas outlet port or exhaust gas recirculation outlet port to the actuator assembly and damaging components in the actuator assembly.

13. A product as set forth in claim 12 further comprising a diesel particulate filter assembly attached to the valve module to allow exhaust from the diesel particulate filter assembly to enter the exhaust inlet port of the valve assembly.

14. A product as set forth in claim 1 wherein the heat barrier means comprises a cooling system, and wherein the cooling system is formed in a housing of the valve assembly, the cooling system including a cooling fluid inlet opening and a cooling fluid outlet opening formed in the valve housing and a cooling channel communicating with the cooling fluid inlet and the cooling fluid outlet.

15. A product as set forth in claim 14 wherein the cooling system is completely closed so that the cooling channel communicates only with the cooling fluid inlet opening and the cooling fluid outlet opening.

16. A product as set forth in claim 14 wherein the cooling system is open, and wherein an opening is provided in the valve housing communicating with the channel of the cooling system.

17. A product as set forth in claim 16 further comprising a gasket seal overlying the opening communicating with the channel of the cooling system.

18. A product as set forth in claim 17 wherein the gasket seal is interposed between the valve assembly and the actuator assembly.

19. A product as set forth in claim 18 further comprising a spacer plate overlying the gasket and interposed between the valve assembly and the actuator assembly.

20. A product as set forth in claim 1 further comprising a spacer plate interposed between the valve assembly and the actuator assembly.

21. A product as set forth in claim 14 wherein the valve housing includes a central bore extending therethrough, and the actuator assembly

including a valve shaft having a bushing surrounding a portion thereof, and wherein the valve shaft and the bushing are received in the central bore formed in the valve housing, and wherein the cooling channel is constructed and arranged to cool the valve shaft and bushing.

22. A product as set forth in claim 21 further comprising a valve disc connected to the valve shaft and wherein the cooling channel is constructed and arranged to cool the valve disc.

23. A product as set forth in claim 22 wherein the valve disc has a semi-disc shape.

24. A product as set forth in claim 21 wherein the cooling channel is constructed and arranged to flow a cooling fluid around the central bore formed in the valve housing.

25. A product comprising:
a valve module comprising a valve assembly, and an actuator assembly, the actuator assembly including a valve shaft and an actuator motor constructed and arranged to drive the valve shaft, and the valve assembly including a valve disc connected to the valve shaft to be rotated thereby, and wherein the valve assembly includes at least three openings comprising two inlets or two outlets, and wherein the valve disc may be moved to completely

close, partially close, partially open, or fully open the two inlets or two outlets, and wherein the valve disc is positioned in the valve housing constructed and arranged to rotate in a spaced apart relationship from a planar face of the valve housing, the planar face having a first opening and second opening formed therein each communicating respectively with one of the two inlets or two outlets.

26. A product as set forth in claim 25 further comprising a friction wear deduction means positioned so that the valve disc may move thereon.

27. A product as set forth in claim 26 wherein the friction wear reduction means comprises a bushing surrounding the valve shaft and constructed and arranged so that the valve disc may rotate thereon.

28. A product as set forth in claim 27 wherein the friction wear reduction means comprises a bushing surrounding a portion of the valve shaft and at least one washer interposed between the valve disc and the bushing.

29. A product as set forth in claim 28 further comprising a second washer interposed between the bushing and the valve disc.

30. A product as set forth in claim 29 further comprising a second washer and a third washer interposed between the valve disc and the bushing

and wherein the first washer is locked to one of the valve shaft or the bushing and wherein the first washer is locked to the valve housing.

31. A method as set forth in claim 29 wherein the friction wear reduction means comprises a plurality of bearings interposed between a bushing surrounding a portion of the shaft and the valve disc.

32. A product as set forth in claim 26 wherein the friction wear reduction means comprises at least one of a washer, or a plurality of ball bearings interposed between a bushing surrounding the valve shaft and the valve housing at a location spaced from the valve disc.

33. A product as set forth in claim 25 wherein the valve disc is spaced a distance sufficient to allow for movement of the disc and to accommodate fluctuations in the location of the disc due to changes in temperature or gas flow pressure but sufficiently narrow to provide adequate sealing.

34. A product as set forth in claim 25 wherein the valve housing includes a planar face adjacent to the valve disc, and at least one raised land extending outwardly from the planar face toward the valve disc.

35. A product as set forth in claim 34 wherein the planar face has a first opening formed therethrough communicating with a first gas flow port formed in

the valve housing, and a second opening formed through the planar face communicating with a second gas flow opening formed in the valve housing, and wherein a raised land is provided immediately adjacent each of the first and second openings formed in the planar face.

36. A product as set forth in claim 34 wherein the raised land is provided along the periphery of the planar face.

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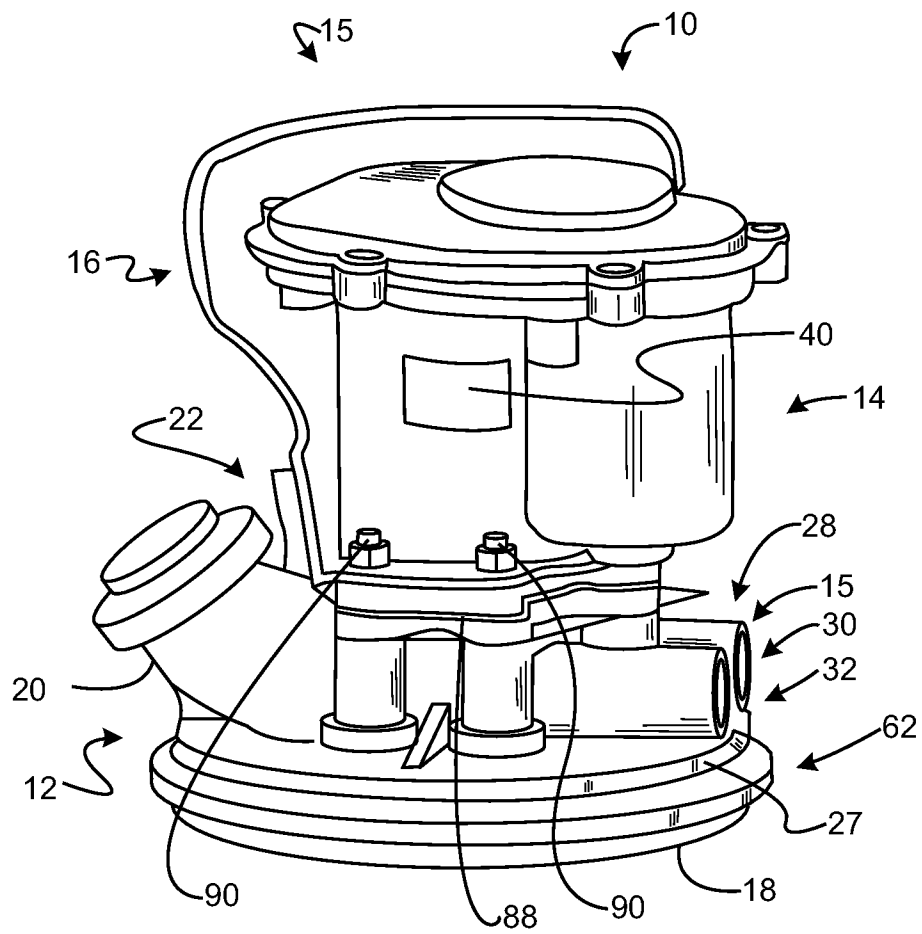


FIG. 1

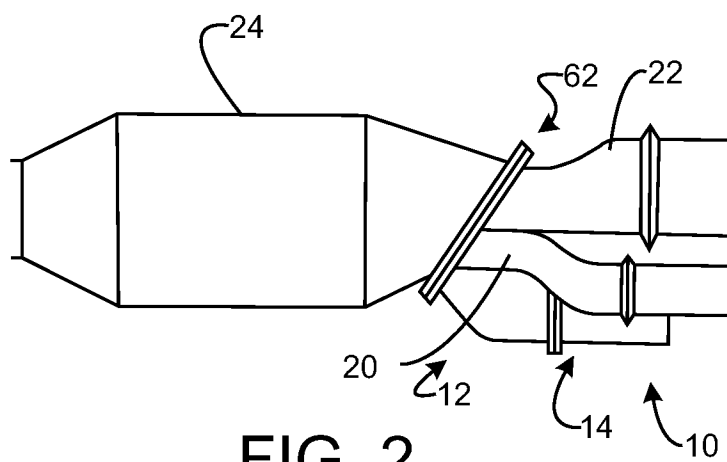
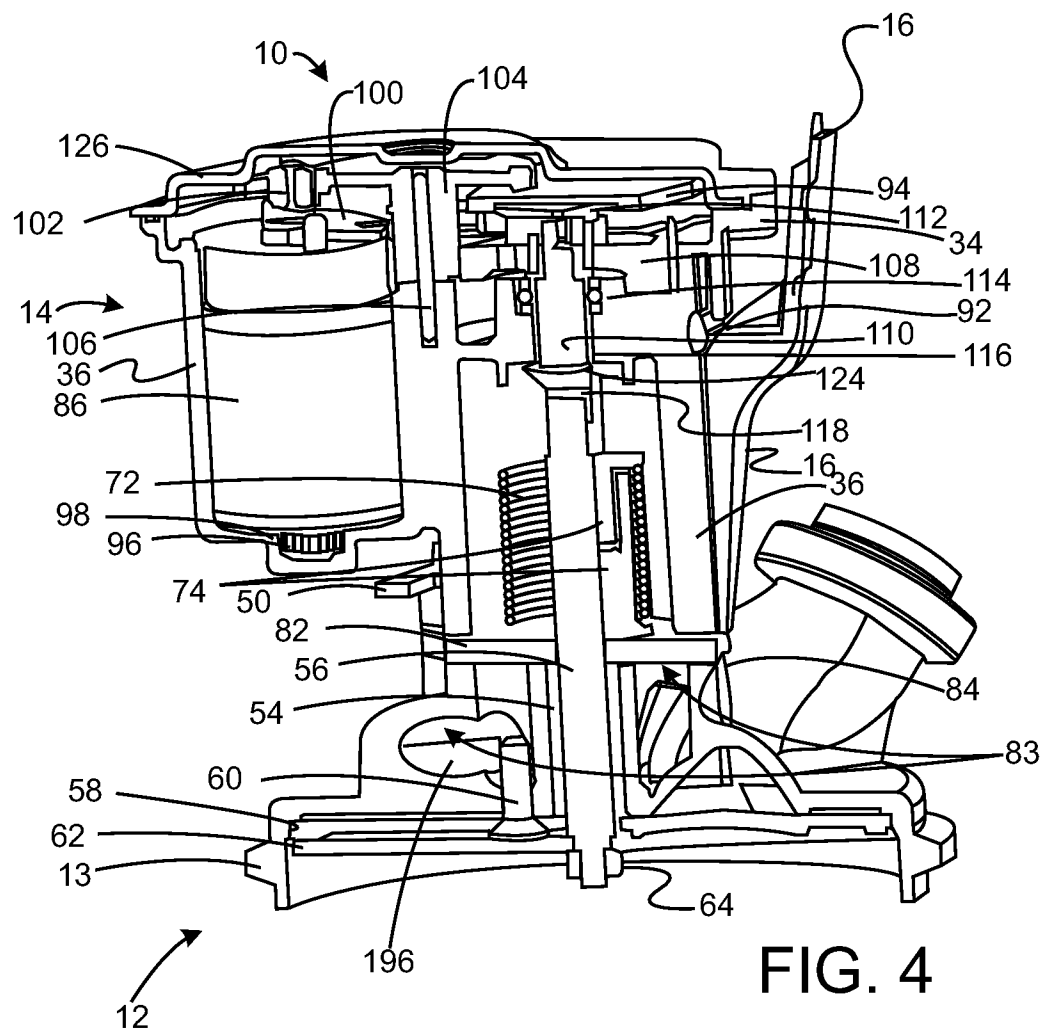
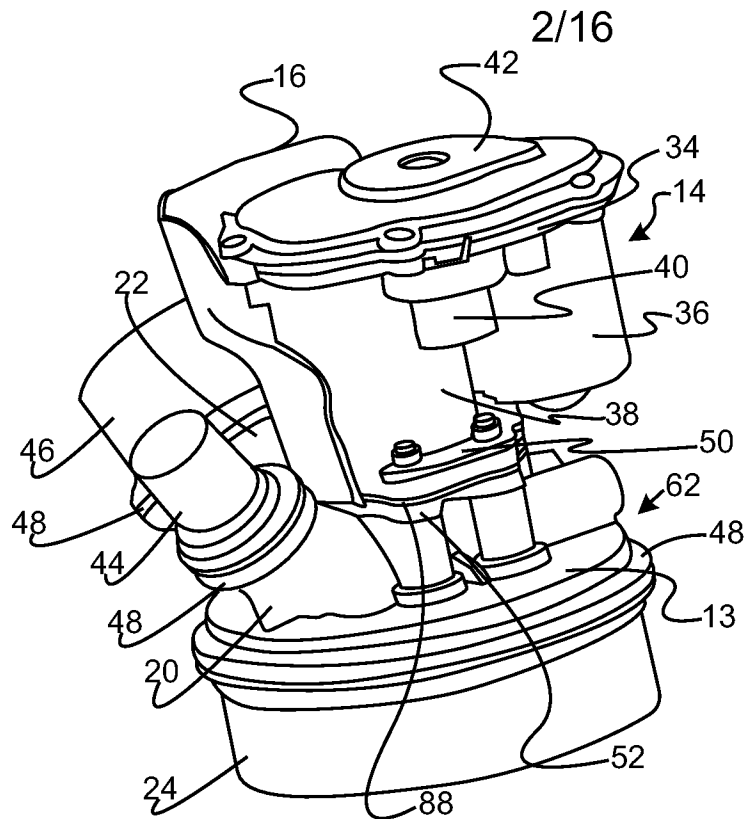


FIG. 2



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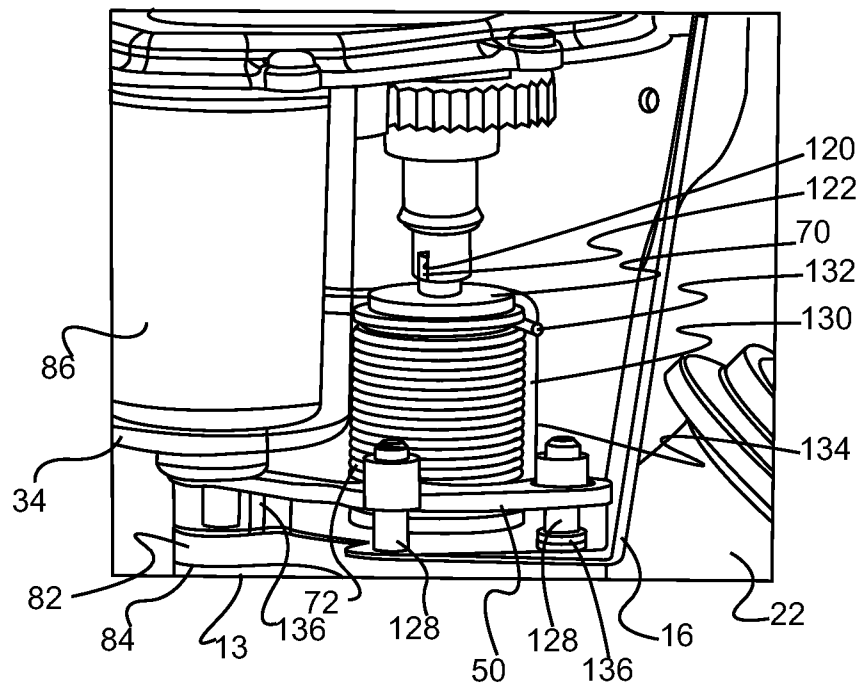


FIG. 5

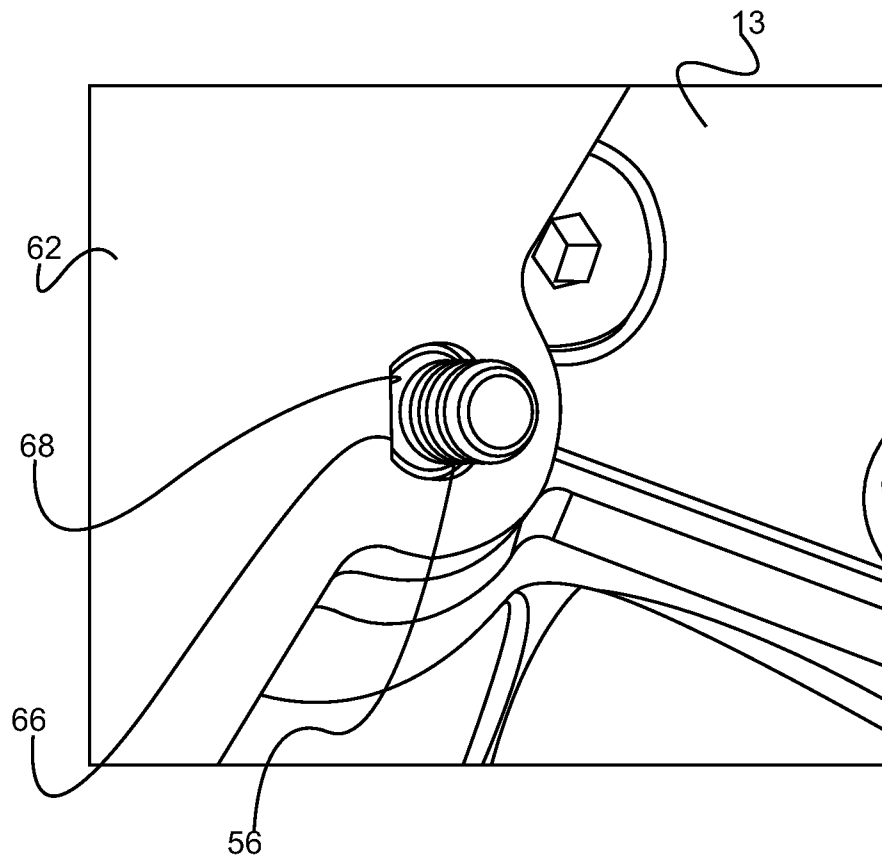


FIG. 6

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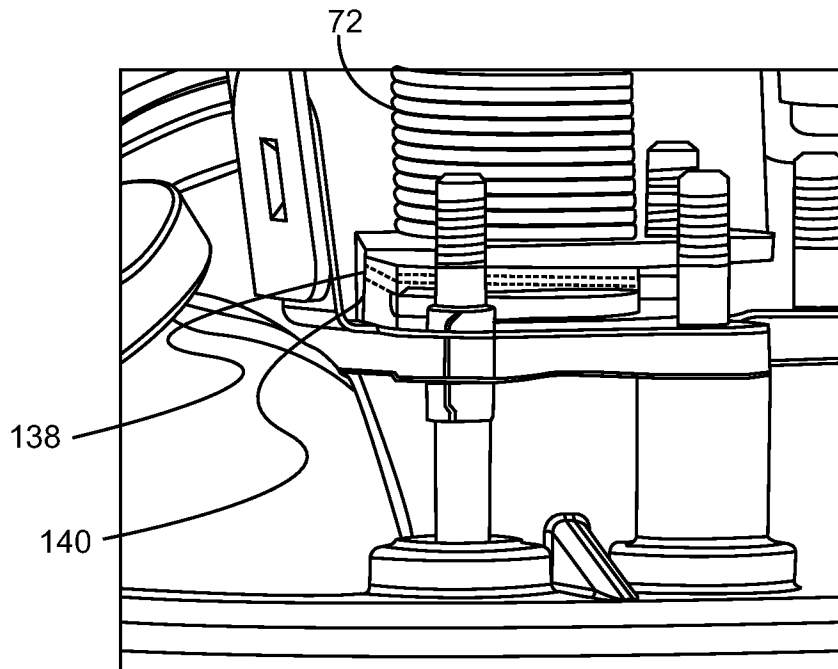


FIG. 7

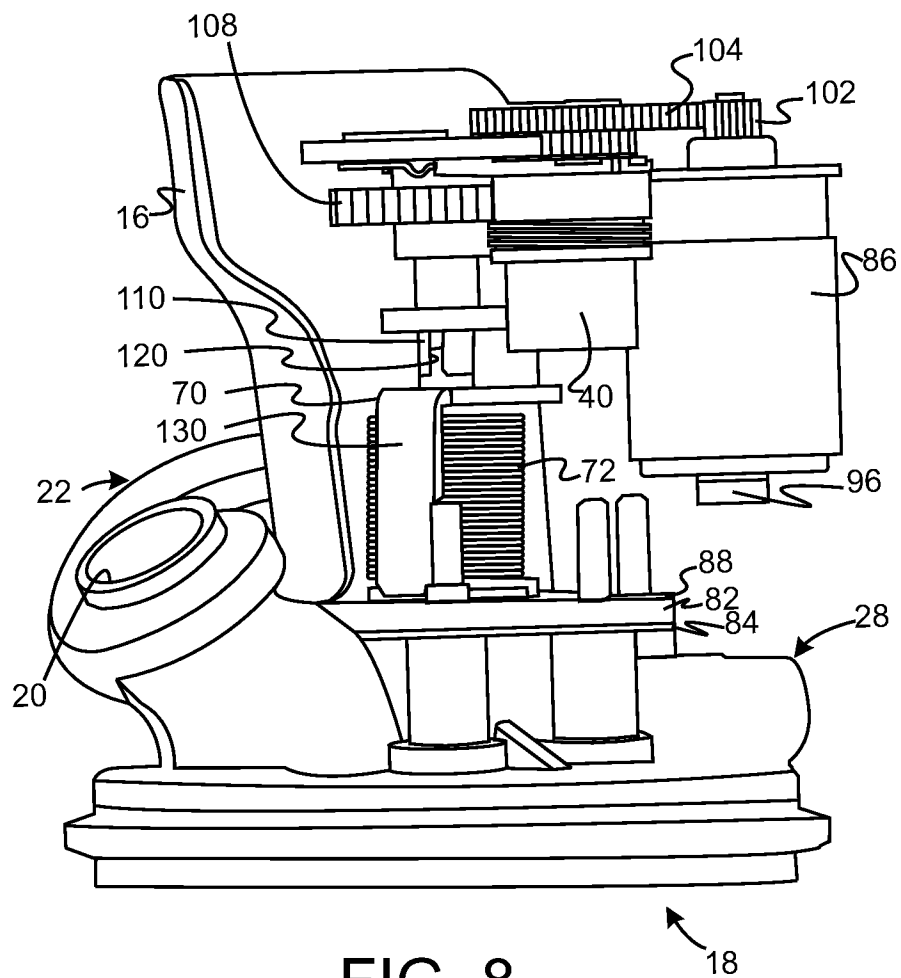


FIG. 8

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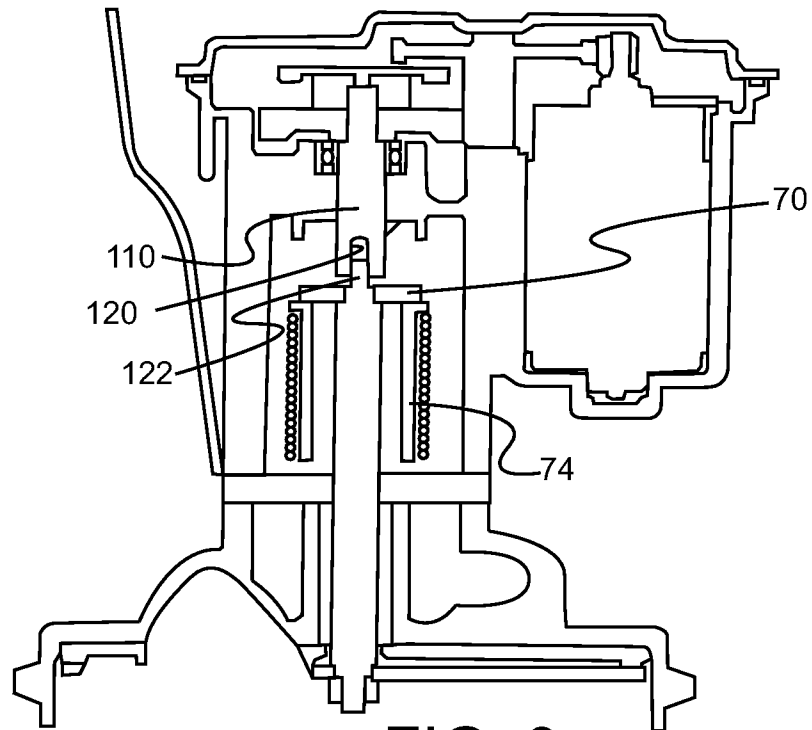


FIG. 9

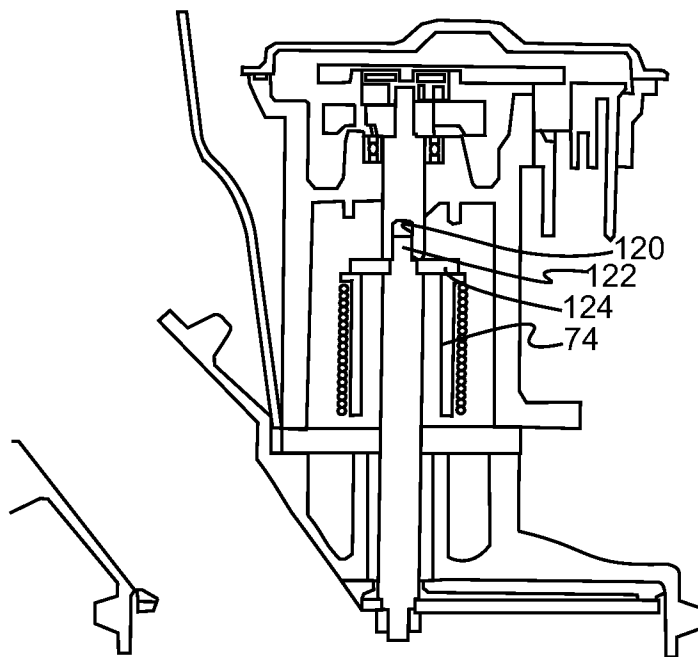
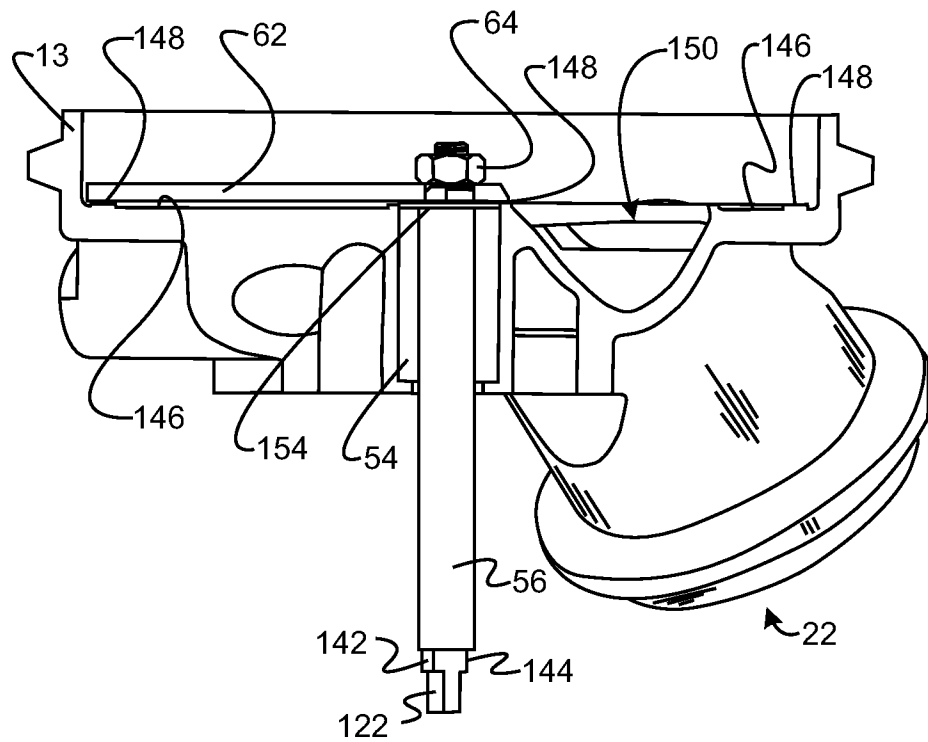
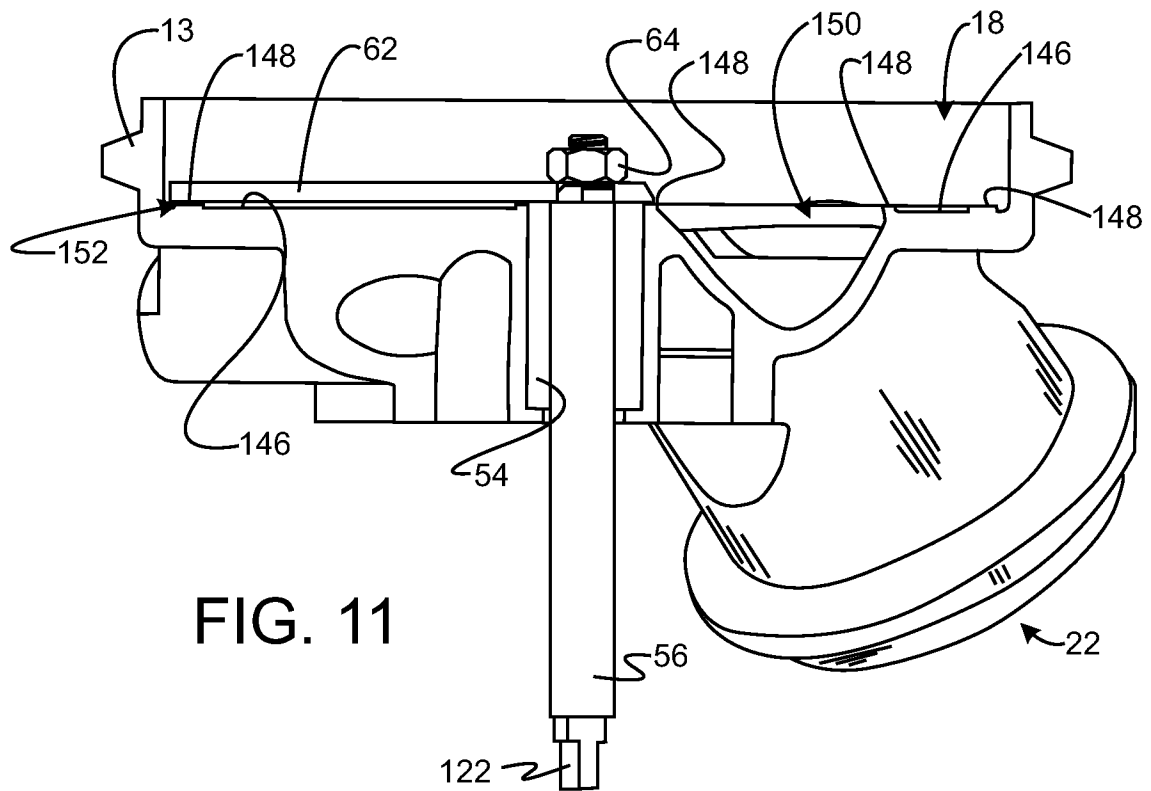


FIG. 10

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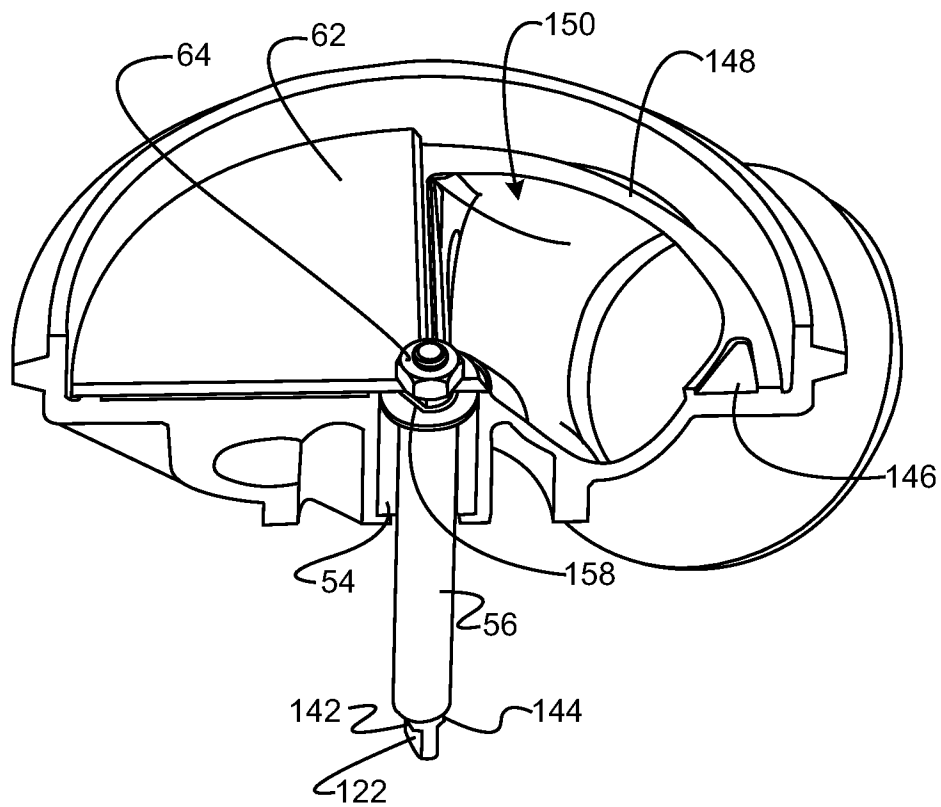


FIG. 13

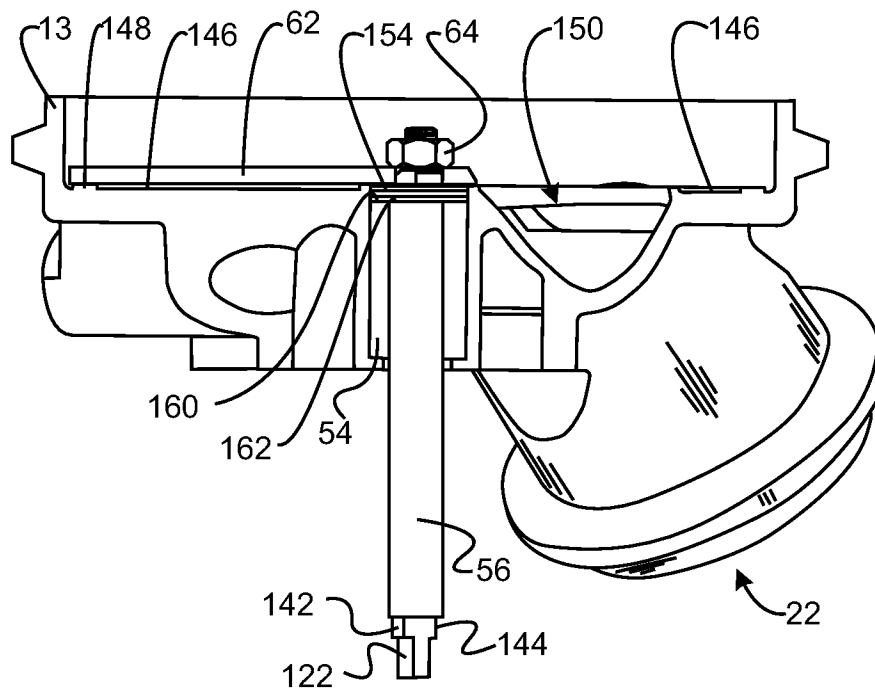
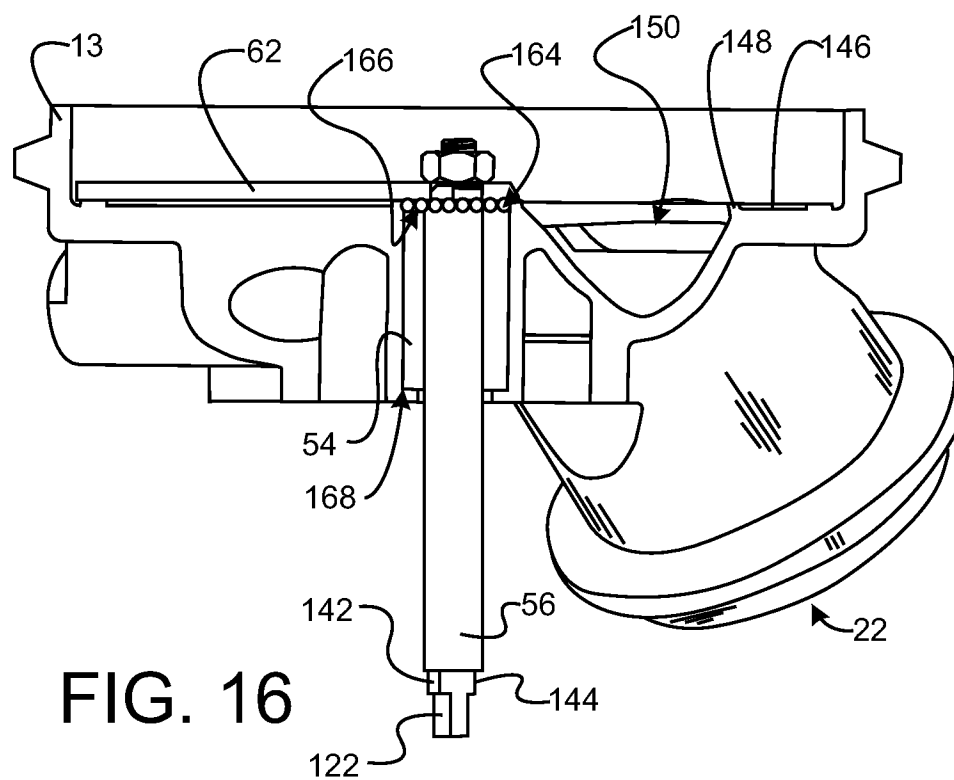
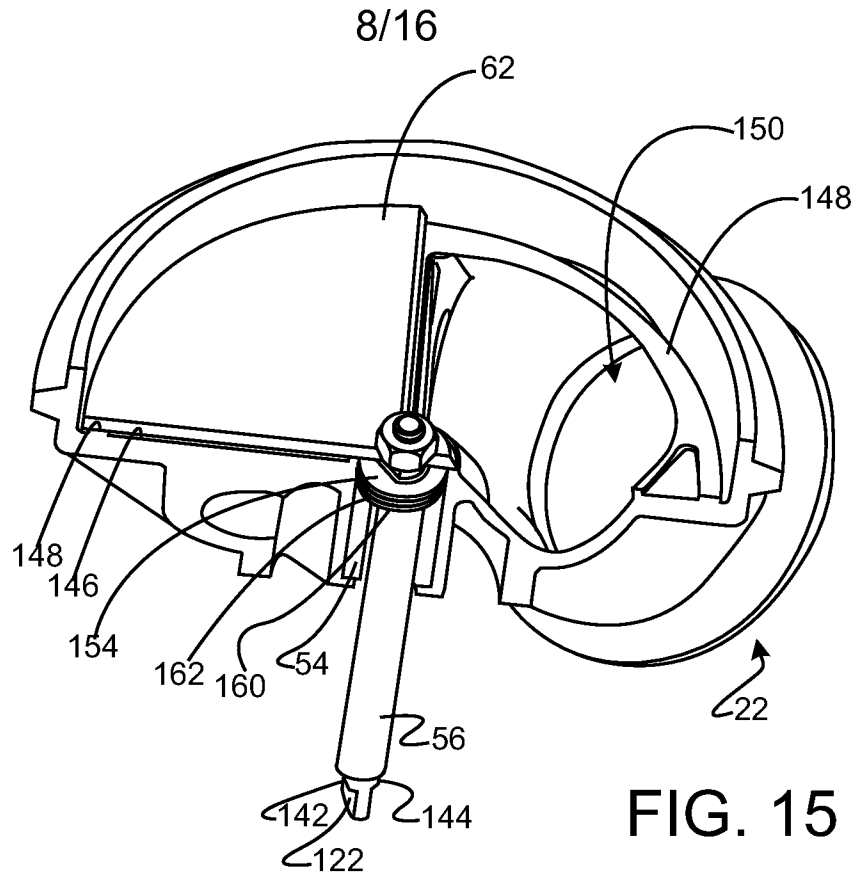


FIG. 14



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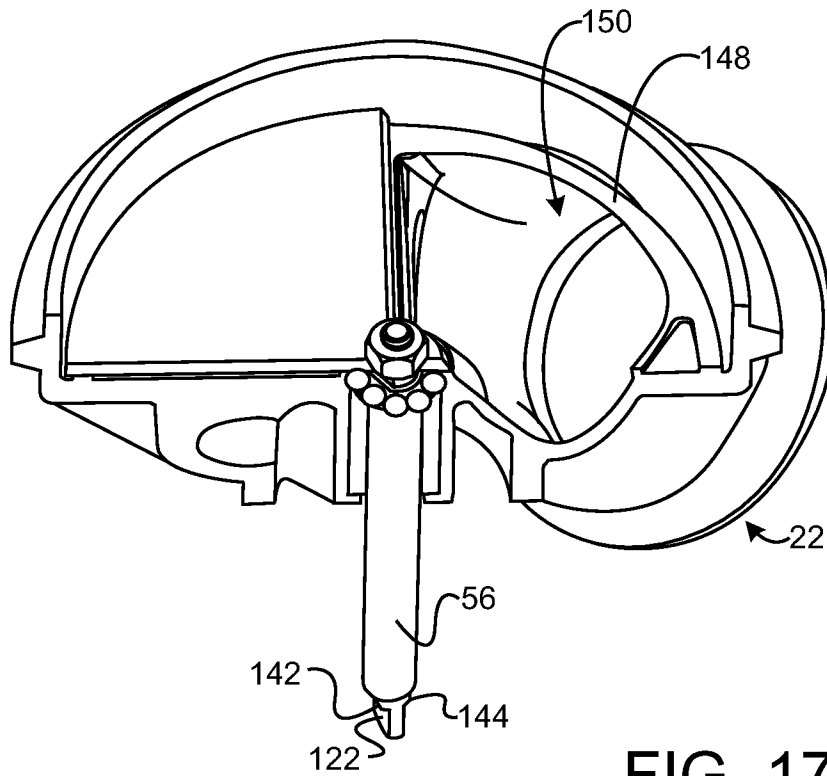


FIG. 17

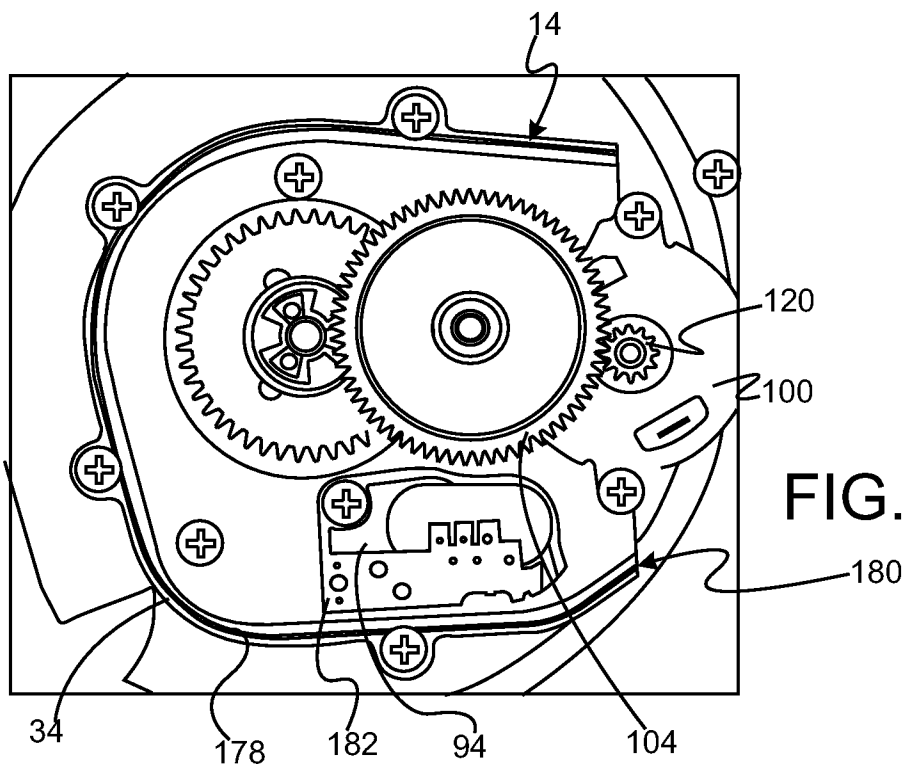


FIG. 18

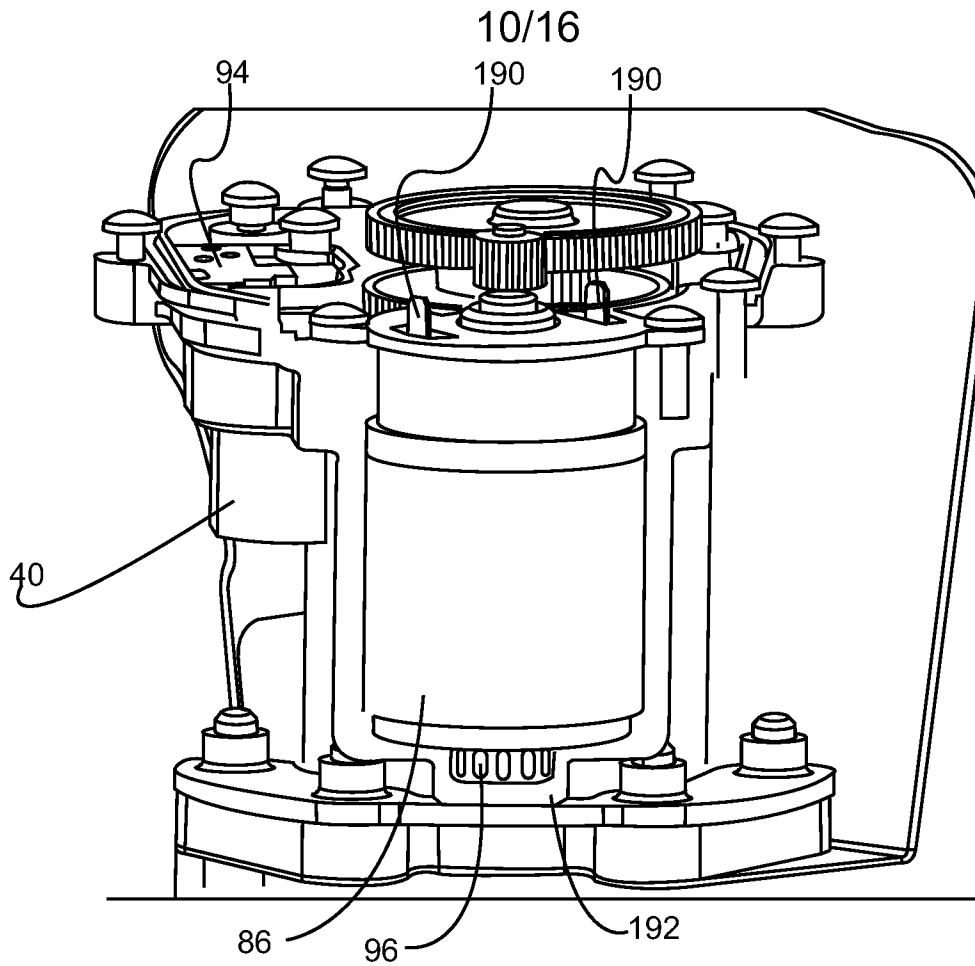


FIG. 19

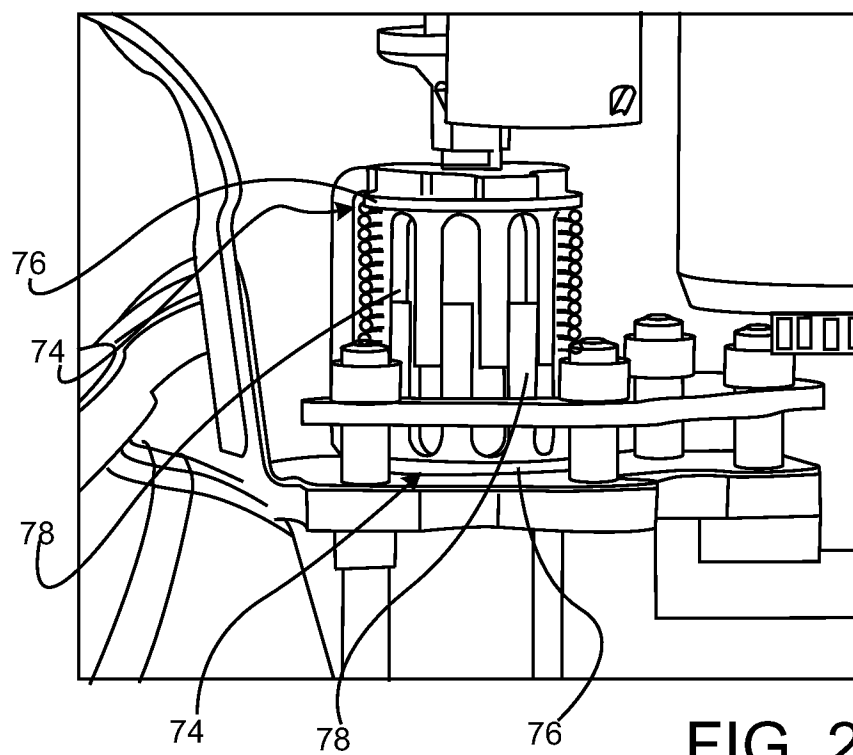


FIG. 20

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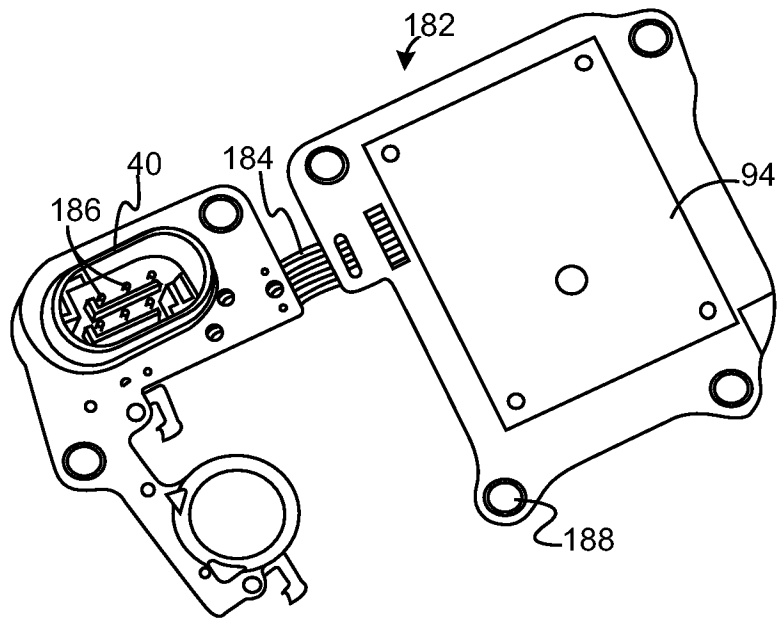


FIG. 21

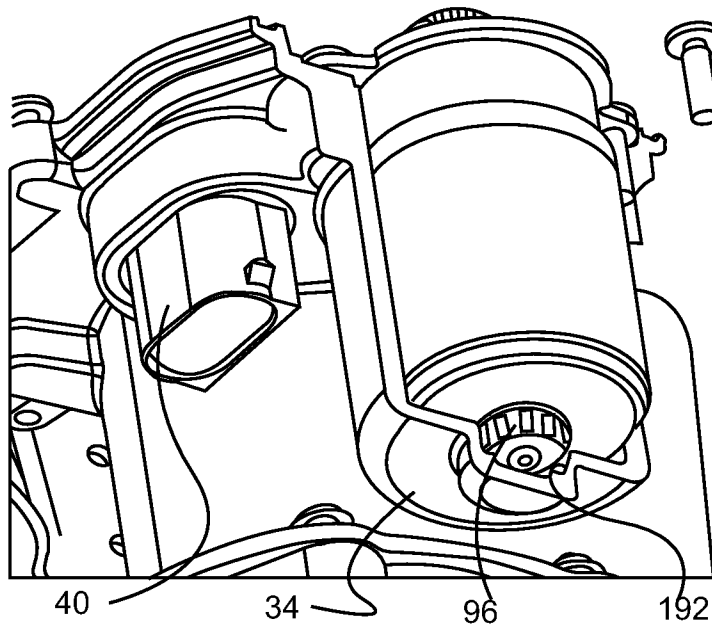


FIG. 22

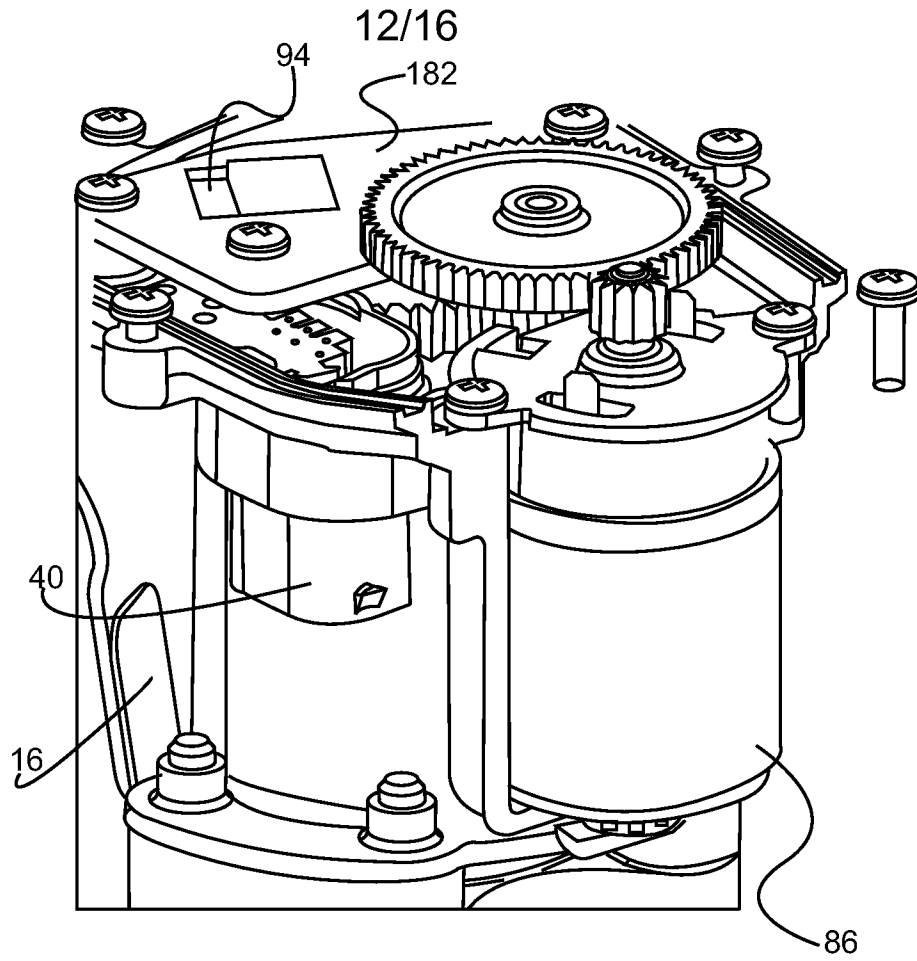


FIG. 23

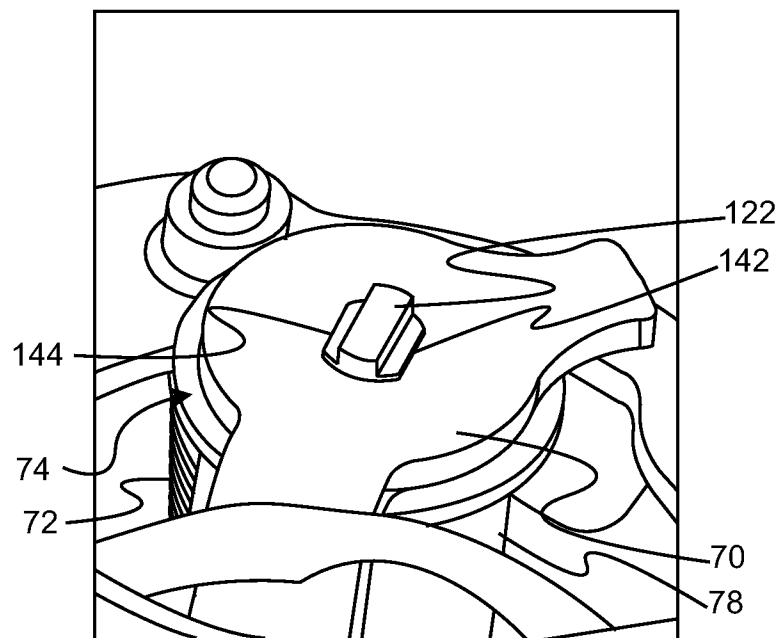
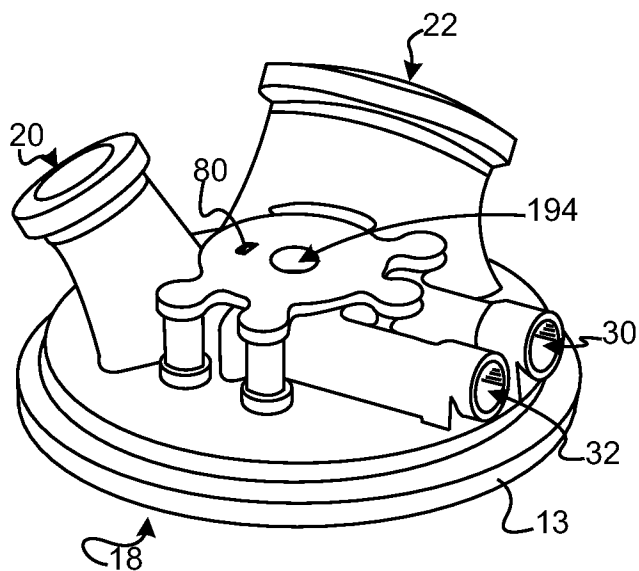
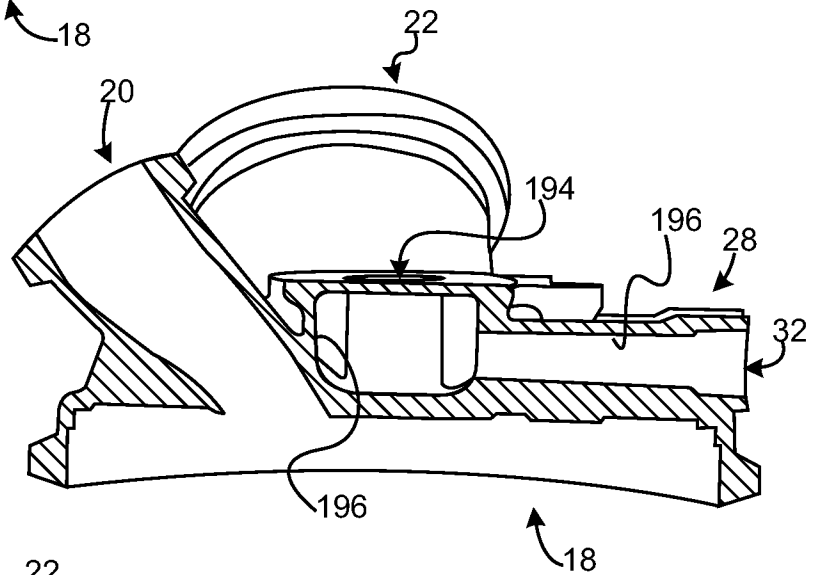
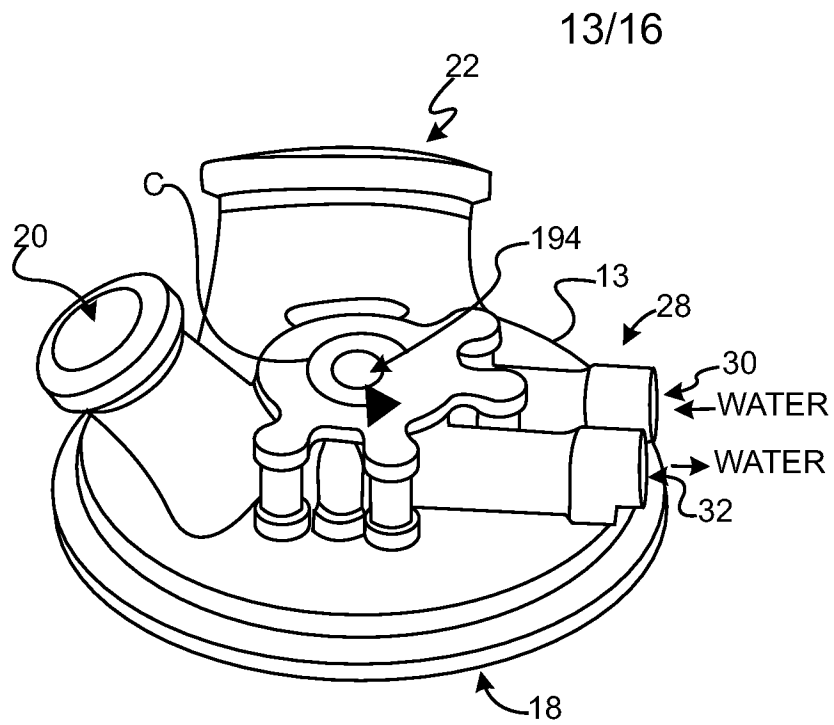


FIG. 24



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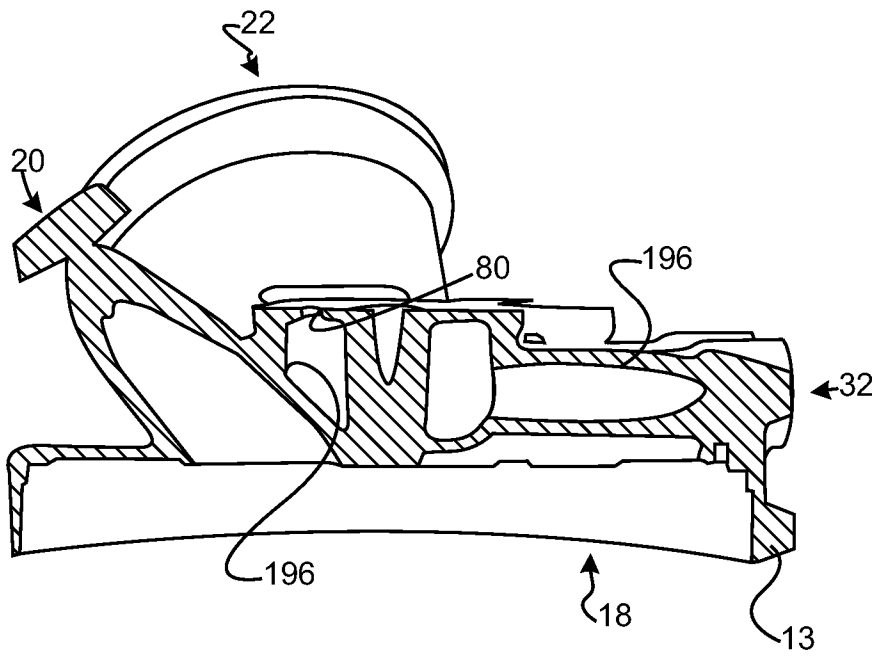


FIG. 28

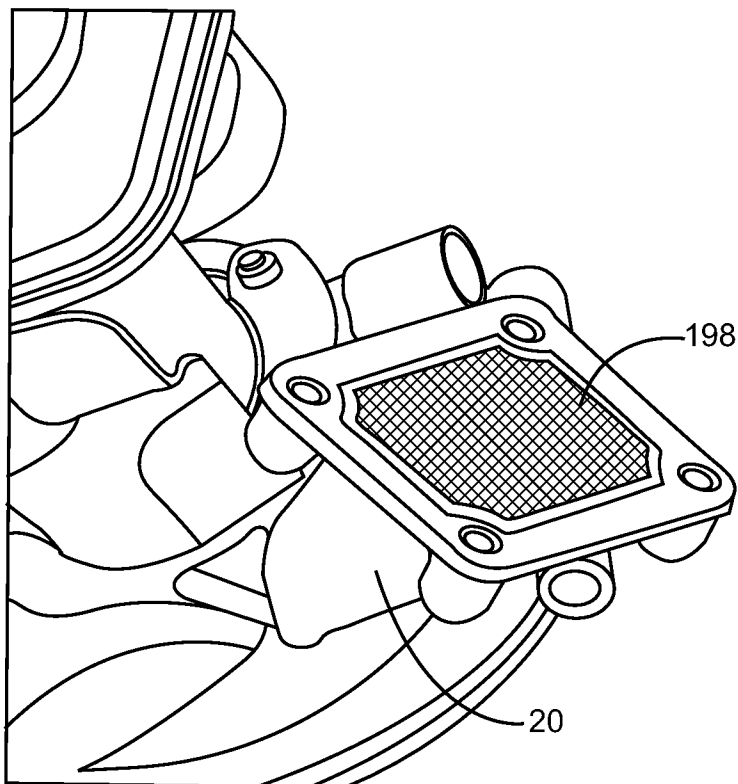


FIG. 29

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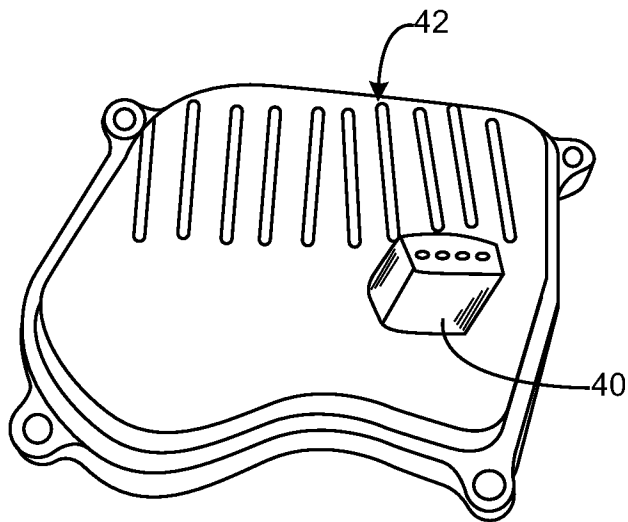


FIG. 30

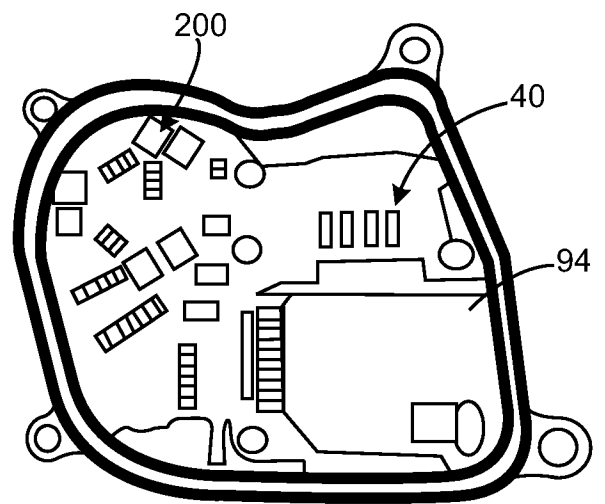


FIG. 31

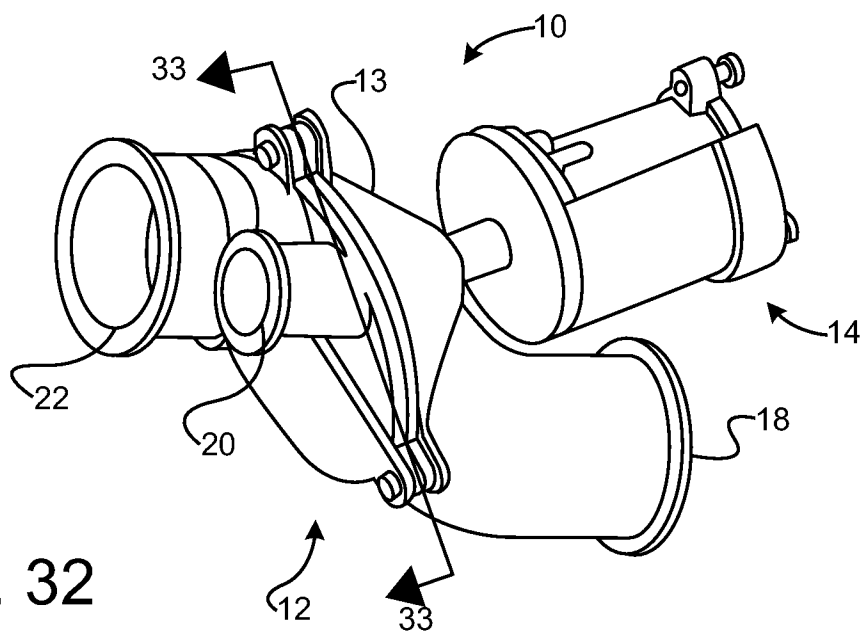


FIG. 32

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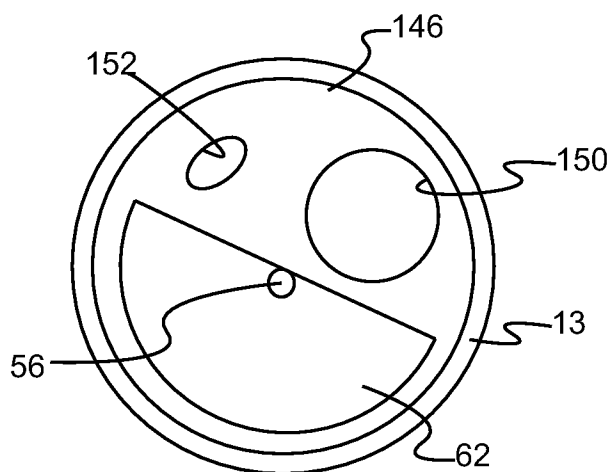


FIG. 33

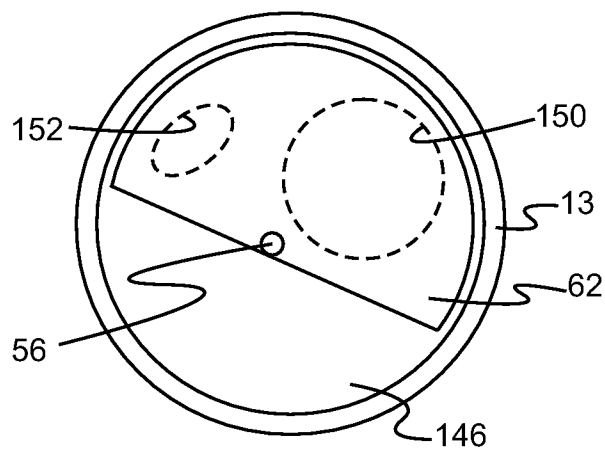


FIG. 34

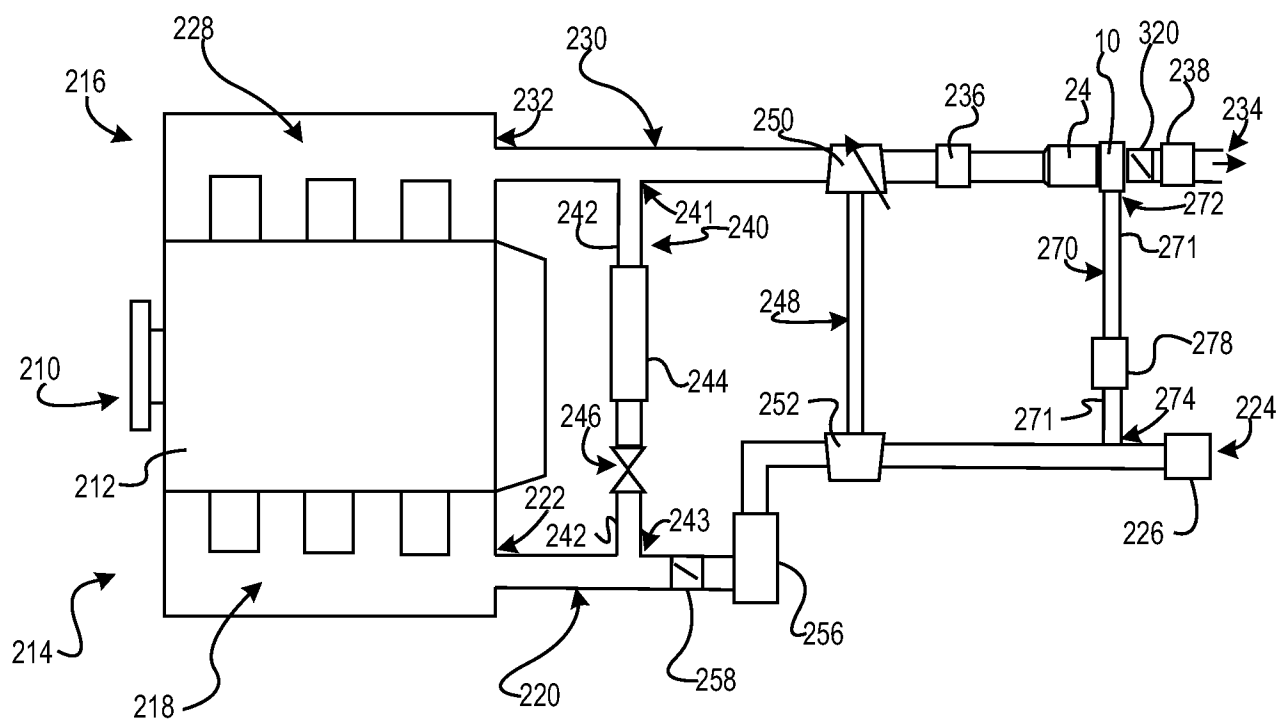


FIG. 35