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(54) Apparatus for an exhaust system

(57) An apparatus (102) for an exhaust system (140) comprises a precipitation cover (129) adapted to be positioned at least partially downstream of a tailpipe (124) relative to a direction of an exhaust gas flow. The precipitation cover (129) comprises a first cover end (110) and a second cover end (117). The first cover end (110) is configured as a precipitation outlet, the second cover end (117) is configured as an exhaust gas outlet and a precipitation inlet, wherein when the first cover end (110) and the tailpipe (124) are coupled together, the first cover end (110) and the tailpipe (124) cooperate so as to form a precipitation exit opening (171).

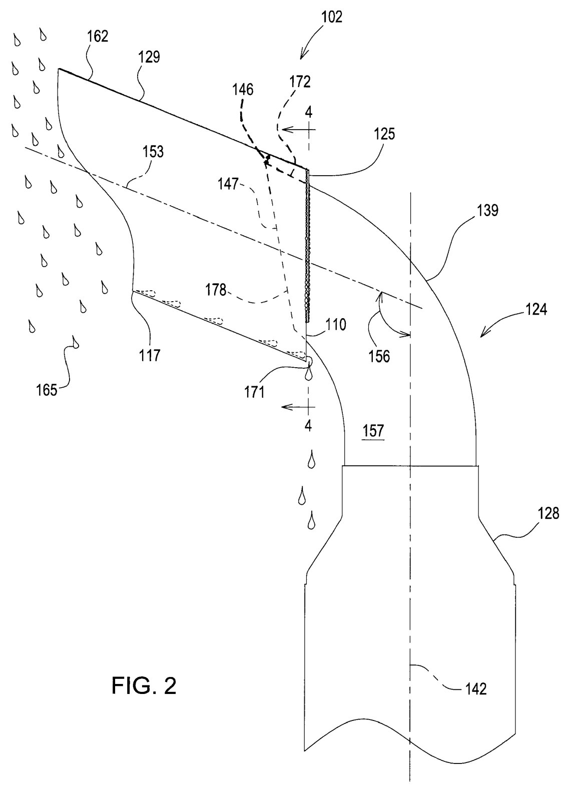

FIG. 2

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Description

[0001] The present invention relates to an apparatus for an exhaust system.

[0002] All engines - diesel, gasoline, propane, and natural gas - produce exhaust gas containing carbon monoxide, hydrocarbons, and nitrogen oxides. These emissions are the result of incomplete combustion. Diesel engines also produce particulate matter. As more government focus is being placed on health and environmental issues, agencies around the world are enacting more stringent emission's laws.

[0003] Because so many diesel engines are used in trucks, the U.S. Environmental Protection Agency and its counterparts in Europe and Japan first focused on setting emissions regulations for the on-road market. While the worldwide regulation of off-road diesel engines came later, the pace of cleanup and rate of improvement has been more aggressive for off-road engines than for on-road engines.

[0004] Manufacturers of off-road diesel engines are expected to meet set emissions regulations. For example, Tier 3 emissions regulations required an approximate 65 percent reduction in particulate matter (PM) and a 60 percent reduction in NO_x from 1996 levels. As a further example, Interim Tier 4 regulations required a 90 percent reduction in PM along with a 50 percent drop in NO_x. Still further, Final Tier 4 regulations, which will be fully implemented by 2015, will take PM and NO_x emissions to near-zero levels.

[0005] To meet such emissions levels, at least a portion of the exhaust gas being emitted from many engines must pass through an aftertreatment system. The aftertreatment system is configured to remove various chemical compounds and particulate emissions, such as PM and NO_x. The aftertreatment system may comprise a NO_x sensor, which is configured to produce a NO_x signal indicative of a NO_x content of exhaust gas flowing thereby. An ECU may use the NO_x signal to control, for example, a combustion temperature of the engine and/or to control the amount of a reductant injected into the exhaust gas, so as to minimize the level of NO_x entering the atmosphere.

[0006] However, a problem associated with NO_x sensors is that, if they come into contact with precipitation - such as rain, melted snow, or melted ice - they may be prone to sending inaccurate NO_x signals, and they may even be prone to complete failure. Complete failure may occur if precipitation contacts a sensor element of the NO_x sensor, causing the sensor element to crack, especially if the exhaust gas superheats the precipitation (e.g., 800° C and above). Such failures may lead to the engine being derated, customer dissatisfaction, and expensive repairs.

[0007] Therefore, what is needed in the art is an apparatus for minimizing the amount of precipitation that comes into contact with the NO_x sensor, while at the same time, minimizing the effect on the normal exhaust function (i.e., minimizing any back pressure). What is additionally needed in the art is such apparatus that is cost effective, easy to implement, does not require moving parts, and is visually appealing.

[0008] These and other objects are achieved by the present invention, wherein an apparatus for an exhaust system is provided. The apparatus comprises a precipitation cover adapted to be positioned at least partially downstream of a tailpipe relative to a direction of an exhaust gas flow. The precipitation cover comprises a first cover end and a second cover end. The first cover end is configured as a precipitation outlet, the second cover end is configured as an exhaust gas outlet and a precipitation inlet, wherein when the first cover end and the tailpipe are coupled together, the first cover end and the tailpipe cooperate so as to form a precipitation exit opening.

[0009] The disclosed apparatus minimizes the amount of precipitation that enters the tailpipe and, thus, the amount that comes into contact with the NO_x sensor. At the same time, the disclosed apparatus only minimally interferes with the normal exhaust function of the engine (i.e., it minimizes any back pressure). And, further yet, it is cost effective, easy to implement, does not require moving parts, and is visually appealing.

[0010] For a complete understanding of the objects, techniques, and structure of the invention reference should be made to the following detailed description and accompanying drawings, wherein similar components are designated by identical reference numerals:

Fig. 1 is a schematic illustration of a power system comprising an apparatus for an exhaust system according to the present invention,

Fig. 2 is an elevational view of a tailpipe and an apparatus in accordance with a first embodiment of the invention, the apparatus comprising a precipitation cover and a spacer,

Fig. 3 is a partially exploded, perspective view of the tailpipe of Fig. 2 as well as of the precipitation cover and the spacer,

Fig. 4 is a sectional view taken along line 4-4 of Fig. 2 illustrating the precipitation cover and the spacer,

Fig. 5 is a view of an apparatus in accordance with a second embodiment of the invention taken from a view similar to that shown in Fig. 4,

Fig. 6 is an elevational view of a tailpipe and an apparatus in accordance with a third embodiment of the invention taken from a view similar to that shown in Fig. 2,

Fig. 7 is a sectional view taken along line 6-6 of Fig.

6 illustrating a supplemental spacer, and

Fig. 8 is a sectional view taken along line 7-7 of Fig. 6 illustrating the supplemental spacer.

[0011] Referring to Fig. 1, there is shown a schematic illustration of a power system 100 comprising an apparatus 102 for an exhaust system 140 having an aftertreatment system 120. The apparatus 102 works particularly well in combination with, for example, a NO_x sensor 119, but it would work just as well with any power system 100 having an internal combustion engine 106, regardless of whether it has an aftertreatment system 120, a NO_x sensor 119, etc.

[0012] The power system 100 may be used for providing power to a variety of machines, including on-highway trucks, construction vehicles, marine vessels, stationary generators, automobiles, agricultural vehicles, and recreation vehicles.

[0013] Internal combustion engine 106 may be any kind of engine that produces an exhaust gas, the exhaust gas being indicated by directional arrow 192. For example, internal combustion engine 106 may be a gasoline engine, a diesel engine, a gaseous fuel burning engine (e.g., natural gas) or any other exhaust gas producing engine. The internal combustion engine 106 may be of any size, with any number of cylinders (not shown), and in any configuration (e.g., "V," inline, and radial). Although not shown, the internal combustion engine 106 may include various sensors, such as temperature sensors, pressure sensors, and mass flow sensors.

[0014] The power system 100 comprises an intake system 107. The intake system 107 comprises components configured to introduce a fresh intake gas, indicated by directional arrow 189, into the internal combustion engine 106. For example, the intake system 107 comprises an exhaust intake manifold (not shown) in fluid communication with the cylinders of the internal combustion engine 106, a compressor 112, a charge air cooler 116, and an air throttle actuator 126.

[0015] Exemplarily, the compressor 112 may be a fixed geometry compressor, a variable geometry compressor, or any other type of compressor configured to receive the fresh intake gas, from upstream of the compressor 112. The compressor 112 compresses the fresh intake gas to an elevated pressure level. As shown, the charge air cooler 116 is positioned downstream of the compressor 112, and it is configured to cool the fresh intake gas. The air throttle actuator 126 is positioned downstream of the charge air cooler 116, and it may be, for example, a flap type valve controlled by an electronic control unit (ECU) 115 to regulate the air-fuel ratio.

[0016] The exhaust system 140 comprises components configured to direct exhaust gas from the internal combustion engine 106 to the atmosphere. Specifically, the exhaust system 140 comprises the exhaust intake manifold in fluid communication with the cylinders of the internal combustion engine 106. During an exhaust stroke, at least one exhaust valve (not shown) opens, allowing the exhaust gas to flow through the exhaust intake manifold and a turbine 111. The pressure and volume of the exhaust gas drives the turbine 111, allowing it to drive the compressor 112 via a shaft (not shown). The combination of the compressor 112, the shaft, and the turbine 111 forms a turbocharger 108.

[0017] The power system 100 comprises a second turbocharger 109 that cooperates with the turbocharger 108 (i.e., series turbocharging). The second turbocharger 109 comprises a second compressor 114, a second shaft (not shown), and a second turbine 113. Exemplarily, the second compressor 114 may be a fixed geometry compressor, a variable geometry compressor, or any other type of compressor configured to receive the fresh intake flow, from upstream of the second compressor 114, and compresses the fresh intake flow to an elevated pressure level before it enters the internal combustion engine 106.

[0018] The power system 100 also comprises an exhaust gas recirculation (EGR) system 132 that is configured to receive a recirculated portion of the exhaust gas, as indicated by directional arrow 194. The intake gas is indicated by directional arrow 190, and it is a combination of the fresh intake gas and the recirculated portion of the exhaust gas. The EGR system 132 comprises an EGR valve 122, an EGR cooler 118, and an EGR mixer (not shown).

[0019] The EGR valve 122 may be a vacuum controlled valve, allowing a specific amount of the recirculated portion of the exhaust gas back into the exhaust intake manifold. The EGR cooler 118 is configured to cool the recirculated portion of the exhaust gas flowing therethrough. Although the EGR valve 122 is illustrated as being downstream of the EGR cooler 118, it could also be positioned upstream from the EGR cooler 118. The EGR mixer is configured to mix the recirculated portion of the exhaust gas and the fresh intake gas into, as noted above, the intake gas.

[0020] At least a portion of the exhaust gas passes through the aftertreatment system 120. The aftertreatment system 120 is configured to remove various chemical compounds and particulate emissions present in the exhaust gas received from the internal combustion engine 106. After being treated by the aftertreatment system 120, the exhaust gas is expelled into the atmosphere via a tailpipe outlet 178. The apparatus 102 comprises a precipitation cover 129 adapted to be positioned at least partially downstream of a tailpipe 124 relative to a direction of the exhaust gas flow, as indicated by directional arrow 192.

[0021] The NO_x sensor 119 is configured to produce and transmit a NO_x signal to the ECU 115 that is indicative of a NO_x content of exhaust gas flowing thereby. The NO_x sensor 119 may, for example, rely upon an electrochemical or catalytic reaction that generates a current, the magnitude of which is indicative of the NO_x concentration of the exhaust gas.

[0022] The ECU 115 performs four primary functions:

(1) converting analog sensor inputs to digital outputs; (2) performing mathematical computations for all fuel and other systems; (3) performing self diagnostics; and (4) storing information. Exemplarily, the ECU 115, in response to the NO_x signal, controls a combustion temperature of the internal combustion engine 106 and/or the amount of a reductant injected into the exhaust gas, so as to minimize the level of NO_x entering the atmosphere.

[0023] Referring back to Fig. 1, as shown, the aftertreatment system 120 comprises a diesel oxidation catalyst (DOC) 163, a diesel particulate filter (DPF) 164, and a selective catalytic reduction (SCR) system 152. The SCR system 152 comprises a reductant delivery system 135, an SCR catalyst 170, and an ammonia oxidation catalyst (AOC) 174. Exemplarily, the exhaust gas flows through the DOC 163, the DPF 164, the SCR catalyst 170, and the AOC 174, and is then, as just mentioned, expelled into the atmosphere via the tailpipe outlet 178.

[0024] In other words, in the embodiment shown, the DPF 164 is positioned downstream of the DOC 163, the SCR catalyst 170 downstream of the DPF 164, and the AOC 174 downstream of the SCR catalyst 170. The DOC 163, the DPF 164, the SCR catalyst 170, and the AOC 174 are coupled together. Exhaust gas treated, in the aftertreatment system 120, and released into the atmosphere contains significantly fewer pollutants - such as diesel particulate matter, NO_2, and hydrocarbons - than an untreated exhaust gas.

[0025] The DOC 163 may be configured in a variety of ways and contains catalyst materials useful in collecting, absorbing, adsorbing, and/or converting hydrocarbons, carbon monoxide, and/or oxides of nitrogen contained in the exhaust gas. Such catalyst materials may include, for example, aluminum, platinum, palladium, rhodium, barium, cerium, and/or alkali metals, alkaline-earth metals, rare-earth metals, or combinations thereof. The DOC 163 may include, for example, a ceramic substrate, a metallic mesh, foam, or any other porous material known in the art, and the catalyst materials may be located on, for example, a substrate of the DOC 163. The DOC 163 may also be configured to oxidize NO contained in the exhaust gas, thereby converting it to NO_2. Or, stated slightly differently, the DOC 163 may assist in achieving a desired ratio of NO to NO_2 upstream of the SCR catalyst 170.

[0026] The DPF 164 may be any of various particulate filters known in the art configured to reduce particulate matter concentrations, e.g., soot and ash, in the exhaust gas to meet requisite emission standards. Any structure capable of removing particulate matter from the exhaust gas of the internal combustion engine 106 may be used. For example, the DPF 164 may include a wall-flow ceramic substrate having a honeycomb cross-section constructed of cordierite, silicon carbide, or other suitable material to remove the particulate matter. The DPF 164 may be electrically coupled to a controller, such as the ECU 115, that controls various characteristics of the DPF 164.

[0027] If the DPF 164 were used alone, it would initially help in meeting the emission requirements, but would quickly fill up with soot and need to be replaced. Therefore, the DPF 164 is combined with the DOC 163, which helps extend the life of the DPF 164 through the process of regeneration. The ECU 115 may be configured to measure the PM build up, also known as filter loading, in the DPF 164, using a combination of algorithms and sensors. When filter loading occurs, the ECU 115 manages the initiation and duration of the regeneration process.

[0028] Moreover, the reductant delivery system 135 comprises a reductant tank 148 configured to store the reductant. One example of a reductant is a solution having 32.5% high purity urea and 67.5% deionized water (e.g., DEF), which decomposes as it travels through a decomposition tube 160 to produce ammonia. Such a reductant may begin to freeze at approximately 12 deg F (-11 deg C). If the reductant freezes when a machine is shut down, then the reductant may need to be thawed before the SCR system 152 can function.

[0029] The reductant delivery system 135 further comprises a reductant header 136 mounted to the reductant tank 148, the reductant header 136 further comprising a level sensor 150 configured to measure a quantity of the reductant in the reductant tank 148. The level sensor 150 may comprise a float configured to float at a liquid/air surface interface of reductant included within the reductant tank 148. Other implementations of the level sensor 150 are possible, and may include, exemplarily, one or more of the following: (a) using one or more ultrasonic sensors; (b) using one or more optical liquid-surface measurement sensors; (c) using one or more pressure sensors disposed within the reductant tank 148; and (d) using one or more capacitance sensors.

[0030] In the illustrated embodiment, the reductant header 136 comprises a tank heating element 130 that is configured to receive coolant from the internal combustion engine 106, and the power system 100 comprises a cooling system 133 that comprises a coolant supply passage 180 and a coolant return passage 181. A first segment 196 of the coolant supply passage 180 is positioned fluidly between the internal combustion engine 106 and the tank heating element 130 and is configured to supply coolant to the tank heating element 130. The coolant circulates, through the tank heating element 130, so as to warm the reductant in the reductant tank 148, therefore reducing the risk that the reductant freezes therein. In an alternative embodiment, the tank heating element 130 may, instead, be an electrically resistive heating element.

[0031] A second segment 197 of the coolant supply passage 180 is positioned fluidly between the tank heating element 130 and a reductant delivery mechanism 158 and is configured to supply coolant thereto. The coolant heats the reductant delivery mechanism 158, reducing the risk that reductant freezes therein.

[0032] A first segment 198 of the coolant return passage 181 is positioned between the reductant delivery mechanism 158 and the tank heating element 130, and a second segment 199 of the coolant return passage 181 is positioned between the internal combustion engine 106 and the tank heating element 130. The first segment 198 and the second segment 199 are configured to return the coolant to the internal combustion engine 106.

[0033] The decomposition tube 160 is positioned downstream of the reductant delivery mechanism 158 but upstream of the SCR catalyst 170. The reductant delivery mechanism 158 may be, for example, an injector that is selectively controllable to inject reductant directly into the exhaust gas. As shown, the SCR system 152 comprises a reductant mixer 166 that is positioned upstream of the SCR catalyst 170 and downstream of the reductant delivery mechanism 158.

[0034] The reductant delivery system 135 additionally comprises a reductant pressure source (not shown) and a reductant extraction passage 184. The reductant extraction passage 184 is coupled fluidly to the reductant tank 148 and the reductant pressure source therebetween. Exemplarily, the reductant extraction passage 184 is shown extending into the reductant tank 148, though in other embodiments the reductant extraction passage 184 may be coupled to an extraction tube via the reductant header 136. The reductant delivery system 135 further comprises a reductant supply module 168 comprising the reductant pressure source. Exemplarily, the reductant supply module 168 is similar to a Bosch reductant supply module, such as the one found in the "Bosch Denoxtronic 2.2 - Urea Dosing System for SCR Systems."

[0035] The reductant delivery system 135 also comprises a reductant dosing passage 186 and a reductant return passage 188. The reductant return passage 188 is shown extending into the reductant tank 148, though in some embodiments of the power system 100, the reductant return passage 188 may be coupled to a return tube via the reductant header 136.

[0036] The reductant delivery system 135 may comprise - among other things - valves, orifices, sensors, and pumps positioned in the reductant extraction passage 184, reductant dosing passage 186, and reductant return passage 188.

[0037] As mentioned above, one example of a reductant is a solution having 32.5% high purity urea and 67.5% deionized water (e.g., DEF), which decomposes as it travels through the decomposition tube 160 to produce ammonia. The ammonia reacts with NO_x in the presence of the SCR catalyst 170, and it reduces the NO_x to less harmful emissions, such as N_2 and H_2O. The SCR catalyst 170 may be any of various catalysts known in the art. For example, in some embodiments, the SCR catalyst 170 may be a vanadium-based catalyst. But in other embodiments, the SCR catalyst 170 may be a zeolite-based catalyst, such as a Cu-zeolite or a Fe-zeolite.

[0038] The AOC 174 may be any of various flow-through catalysts configured to react with ammonia to produce mainly nitrogen. Generally, the AOC 174 is utilized to remove ammonia that has slipped through or exited the SCR catalyst 170. As shown, the AOC 174 and the SCR catalyst 170 are positioned within the same housing. But in other embodiments, they may be separate from one another.

[0039] Referring to Figs. 2 and 3, the apparatus 102 in accordance with a first embodiment of the invention is shown in more detail. The precipitation cover 129 comprises a first cover end 110 and a second cover end 117. The first cover end 110 is configured as a precipitation outlet, and the second cover end 117 is configured as an exhaust gas outlet and a precipitation inlet. When the first cover end 110 and the tailpipe 124 are coupled together, the first cover end 110 and the tailpipe 124 cooperate so as to form a precipitation exit opening 171. In some embodiments, including the one illustrated in Figs. 2 to 4, the first cover end 110 and an end 147 of the tailpipe 124 cooperate, so as to form the precipitation exit opening 171. The precipitation cover 129 and the precipitation exit opening 171 are configured so as to minimize the amount of precipitation 165 that enters the tailpipe 124 and that, ultimately, comes into contact with the NO_x sensor 119.

[0040] At least a portion of the first cover end 110 is positioned radially outside of the end 147 of the tailpipe 124. For example, as illustrated, the precipitation cover 129 and the tailpipe 124 are both tubularly shaped, wherein an inner diameter 154 of the precipitation cover 129 is larger than an outer diameter 159 of the tailpipe 124. In other embodiments, the precipitation cover 129 and/or the tailpipe 124 may take other shapes, such as an extended square shapes, extended oblong shapes, and so forth.

[0041] Further, the precipitation cover 129 comprises a hood 162 extending axially away from the second cover end 117. The hood 162 is angularly aligned with a spacer 125 relative to an imaginary cover axis 153. The hood 162 minimizes the amount of precipitation 165 that enters the precipitation cover 129 and tailpipe 124, particularly if the precipitation 165 is falling in the direction shown in Fig. 2, for example. The hood 162 is illustrated as having a smooth, round contour, but other embodiments could take various different shapes, assuming that the hood 162 maintains its functionality (i.e., minimizing the amount of precipitation 165 that enters the precipitation cover 129 and tailpipe 124).

[0042] The tailpipe 124 further comprises a first tailpipe section 128 and a second tailpipe section 139. The second tailpipe section 139 may be substantially elbow shaped and may be positioned downstream of the first tailpipe section 128, relative to the direction of the exhaust gas flow. The first tailpipe section 128 defines an imaginary tailpipe axis 142, and the precipitation cover 129 defines imaginary cover axis 153. As shown in Fig. 2, the imaginary tailpipe axis 142 and the imaginary cover axis 153 define an angle 156 therebetween in a range of 90° and 150°, and in some embodiments, it may be between 110° and 130°. The angle 156 is such that it prevents precipitation 165 from entering the tailpipe 124, even when the precipitation 165 is falling at, for example, a 40° angle.

[0043] The precipitation cover 129 may be made of, for example, aluminized steel or stainless steel. Aluminized steel provides a surface that paints stick to, even when the aluminized steel is very hot, and the aluminized steel does not rust, even if the paint is scratched off thereof. Likewise, the first tailpipe section 128, the second tailpipe section 139, and the spacer 125 may also be made of, for example, either aluminized steel or stainless steel.

[0044] As shown in Fig. 2, the precipitation cover 129 overlaps the tailpipe 124 so as to form an overlapped region 172, and the precipitation cover 129 and the tailpipe 124 are spaced apart, along the overlapped region 172, so as to form an annular gap 146 therebetween.

[0045] The apparatus 102 further comprises the spacer 125 mounted to the tailpipe 124, and the precipitation cover 129 is mounted to the spacer 125. Or, more specifically, the spacer 125 is mounted to an outer surface 157 of the tailpipe 124, and the precipitation cover 129 is mounted to an outer surface 187 of the spacer 125. As illustrated in, for example, Fig. 3, the imaginary tailpipe axis 142 and the imaginary cover axis 153 define a plane 131, and the spacer 125 and the precipitation cover 129 are symmetric to one another relative to the plane 131.

[0046] As shown in Fig. 4, the spacer 125 is "horseshoe shaped" and partially extends around the outer surface 157 of the tailpipe 124. For example, the spacer 125 extends around approximately 270° about the tailpipe 124 (see angle 138), though in other embodiments, the spacer 125 extends around a smaller or larger angle. In other embodiments, the spacer 125 may comprise multiple pieces and take a number of different shapes, and it may comprise holes, slots, and the like.

[0047] A first end surface 176 of the spacer 125 connects an inner surface 175 and the outer surface 187 of the spacer 125. A second end surface 177 of the spacer 125 also connects the inner surface 175 and the outer surface 187. The first end surface 176, the second end surface 177, the inner surface 175, and the outer surface 187 cooperate so as to define the precipitation exit opening 171.

[0048] Referring to Fig. 5, there is shown a view of an apparatus 202 in accordance with a second embodiment of the invention taken from a view similar to that which is shown in Fig. 4. The apparatus 202 has many components similar in structure and function as apparatus 102, as indicated by the use of identical reference numerals where applicable. However, a difference between those is that spacer 225 of apparatus 202 is a bead of weld (see, for example, the bead of weld 234), rather than, for example, a plate. And as shown in the illustrated embodiment of apparatus 202, there is also a bead of weld 227 and a bead of weld 291. Such an embodiment may provide robust support of the precipitation cover 129, while simultaneously keeping assembly and manufacturing costs low. Other embodiments of the apparatus 202 may have a greater or lesser number of welds, and they may be oriented differently relative to one another.

[0049] Referring to Figs. 6 to 8, there is shown an apparatus 302 in accordance with a third embodiment of the invention. The third embodiment of the apparatus 302 has many components similar in structure and function as the first embodiment of apparatus 102 and the second embodiment of apparatus 202. However, in the third embodiment of apparatus 302, precipitation cover 329 comprises a base cover 321 and an extended cover 323. The base cover 321 is positioned substantially downstream of the end 147 of the tailpipe 124 relative to a direction of the exhaust gas flow, and the extended cover 323 is positioned substantially upstream of the end 147 of the tailpipe 124 relative to a direction of the exhaust gas flow. One potential advantage of the precipitation cover 329 is that operators of, for example, a work machine may find it more visually appealing.

[0050] As shown in Figs. 6 and 7, exemplarily, the apparatus 302 further comprises a supplemental spacer 379. The supplemental spacer 379 is mounted to the tailpipe 124, and the precipitation cover 329 is mounted to the supplemental spacer 379. Further, the supplemental spacer 379 is positioned downstream of spacer 325 relative to the direction of the exhaust gas flow. The precipitation cover 329 overlap the tailpipe 124 so as to form an overlapped region 372, and the precipitation cover 329 and the tailpipe 124 are spaced apart from one another, along the overlapped region 372, so as to form an annular gap 346 therebetween.

[0051] The supplemental spacer 379 is "horseshoe shaped" and partially extends around the outer surface 157 of the tailpipe 124. For example, the supplemental spacer 379 extends around approximately 270° of the tailpipe 124 (see angle 301). In other embodiments, the supplemental spacer 379 may comprise multiple pieces and take a number of different shapes, and it may comprise holes, slots, and the like.

[0052] In the embodiment illustrated in Fig. 7, a first end surface 303 of the supplemental spacer 379 connects an inner surface 304 and an outer surface 305 of the supple-mental spacer 379. A second end surface 395 of the supplemental spacer 379 connects the inner surface 304 and the outer surface 305 of the supplemental spacer 379. The first end surface 303, the second end surface 395, an inner surface 337 of the precipitation cover 329, and the outer surface 157 of the tailpipe 124 cooperate so as to define a supplemental precipitation exit opening 383.

[0053] Finally, in the embodiment illustrated in Fig. 8, a first end surface 376 of the spacer 325 connects an inner surface 375 and an outer surface 387 of the spacer 325. A second end surface 377 of the spacer 325 connects the inner surface 375 and the outer surface 387 of the spacer 325. As illustrated, the first end surface 376, the second end surface 377, the inner surface 375, and the outer surface 387 cooperate so as to define a precipitation exit opening 371.

[0054] Further, the spacer 325 is "horseshoe shaped" and partially extends around the outer surface 157 of the tailpipe 124. For example, the spacer 325 extends around approximately 270° of the tailpipe 124 (see angle 393), though the spacer 325 may extend around a smaller or a larger angle. In other embodiments, the spacer 325 may comprise multiple pieces and take a number of different shapes, and it may comprise holes, slots, and the likes.

Claims

1. An apparatus for an exhaust system, the apparatus (102, 202, 302) comprises a precipitation cover (129, 329) adapted to be positioned at least partially downstream of a tailpipe (124) relative to a direction of an exhaust gas flow, the precipitation cover (129, 329) comprises a first cover end (110) and a second cover end (117), the first cover end (110) is configured as a precipitation outlet, the second cover end (117) is configured as an exhaust gas outlet and a precipitation inlet, wherein when the first cover end (110) and the tailpipe (124) are coupled together, the first cover end (110) and the tailpipe (124) cooperate so as to form a precipitation exit opening (171, 371).

2. The apparatus according to claim 1, **characterized in that** the precipitation cover (129, 329) and the tailpipe (124) are both tubularly shaped, and an inner diameter (154) of the precipitation cover (129, 329) is larger than an outer diameter (159) of the tailpipe (124).

3. The apparatus according to claim 1 or 2, **characterized in that** the precipitation cover (129, 329) further comprises a hood (162) extending axially from the second cover end (117).

4. The apparatus according to claims 1 to 3, **characterized in that** the first cover end (110) and an end (147) of the tailpipe (124) cooperate so as to form the precipitation exit opening (171).

5. The apparatus according to claims 1 to 4, **characterized in that** at least a portion of the first cover end (110) is positioned radially outside of an end (147) of the tailpipe (124).

6. The apparatus according to claims 1 to 5, **characterized in that** the tailpipe (124) further comprises a first tailpipe section (128) and a second tailpipe section (139), the first tailpipe section (128) defining an imaginary tailpipe axis (142), the second tailpipe section (139) being substantially elbow shaped and is positioned downstream of the first tailpipe section (128) relative to the direction of the exhaust gas flow, the precipitation cover (129, 329) defining an imaginary cover axis (153), and the imaginary tailpipe axis (142) and the imaginary cover axis (153) defining an angle (156) therebetween in a range of 90° and 150°, in particular in a range of between 110° and 130°.

7. The apparatus according to claims 1 to 6, **characterized in that** the precipitation cover (129, 329) overlaps the tailpipe (124) so as to form an overlapped region (172, 372).

8. The apparatus according to claims 1 to 7, **characterized in that** the precipitation cover (129, 329) and the tailpipe (124) are spaced apart along the overlapped region (172, 372), so as to form an annular gap (146, 346) therebetween.

9. The apparatus according to claim 1 to 8, **characterized by** further comprising a spacer (125, 255, 325) mounted to the tailpipe (124), the precipitation cover (129, 329) being mounted to the spacer (125, 255, 325).

10. The apparatus according to claims 1 to 9, **characterized in that** the spacer (125, 325) partially extends around an outer surface (157) of the tailpipe (124), in particular the spacer (125, 325) being horseshoe shaped.

11. The apparatus according to claims 1 to 10, **characterized in that** the spacer (255) is a bead of weld (227, 234, 291).

12. The apparatus according to claims 1 to 11, **characterized in that** the tailpipe (124) further comprises a first tailpipe section (128) and a second tailpipe section (139), the first tailpipe section (128) defines an imaginary tailpipe axis (142), the second tailpipe section (139) is substantially elbow shaped and is positioned downstream of the first tailpipe section (128) relative to the direction of the exhaust gas flow, the precipitation cover (129, 329) defines an imaginary cover axis (153), the imaginary tailpipe axis (142) and the imaginary cover axis (153) define a plane (131), and the spacer (125, 255, 325) is symmetric relative to the plane (131).

13. The apparatus according to claims 1 to 12, **characterized in that** a first end surface (176, 376) of the spacer (125, 325) connects an inner surface (175, 375) of the spacer (125, 325) and an outer surface (187, 387) of the spacer (125, 325), a second end surface (177, 377) connects the inner surface (175, 375) of the spacer (125, 325) and the outer surface (187, 387) of the spacer (125, 325), wherein the first end surface (176, 376) of the spacer (125, 325), the second end surface (177, 377) of the spacer (125,

325), an inner surface (137, 337) of the precipitation cover (129, 329), and an outer surface (157) of the tailpipe (124) cooperate so as to define the precipitation exit opening (171, 371).

14. The apparatus according to claims 1 to 13, **characterized in that** the precipitation cover (329) comprises a base cover (321) and an extended cover (323), the base cover (321) being positioned substantially downstream of an end (147) of the tailpipe (124) relative to a direction of the exhaust gas flow, the extended cover (323) being positioned substantially upstream of the end (147) of the tailpipe (124) relative to a direction of the exhaust gas flow.

15. The apparatus according to claims 1 to 14, **characterized by** further comprising a supplemental spacer (379), the supplemental spacer (379) being mounted to the tailpipe (124), the precipitation cover (329) being mounted to the supplemental spacer (379), and the supplemental spacer (379) being positioned downstream of a spacer (325) relative to the direction of the exhaust gas flow.

16. The apparatus according to claims 1 to 15, **characterized in that** a first end surface (303) of the supplemental spacer (379) connects an inner surface (304) of the supplemental spacer (379) and an outer surface (305) of the supplemental spacer (379), a second end surface (395) of the supplemental spacer (379) connects the inner surface (304) of the supplemental spacer (379) and the outer surface (305) of the supplemental spacer (379), wherein the first end surface (303) of the supplemental spacer (379), the second end surface (395) of the supplemental spacer (379), an inner surface (337) of the precipitation cover (329) and an outer surface (157) of the tailpipe (124) cooperate so as to define a supplemental precipitation exit opening (383).

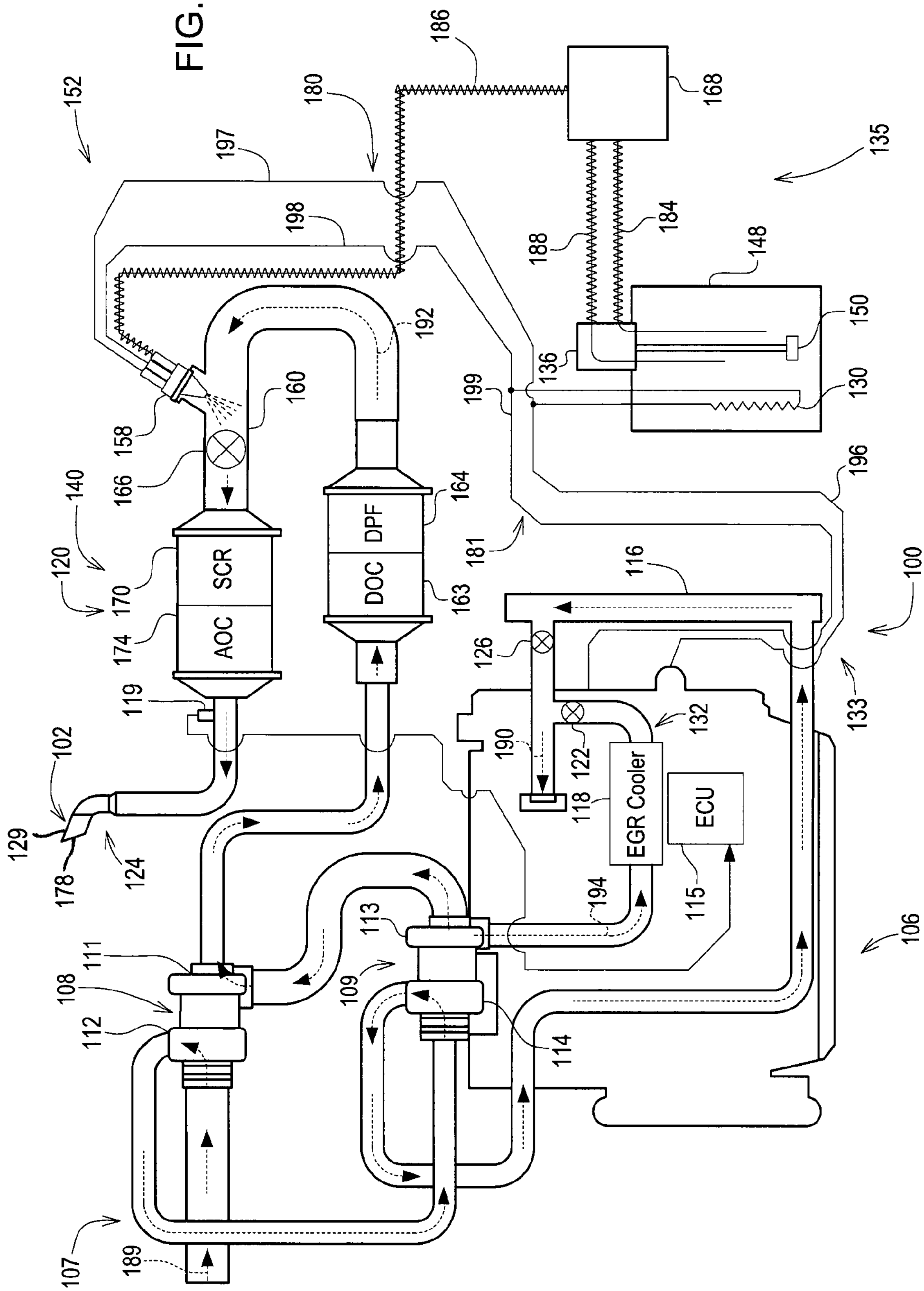


FIG. 1

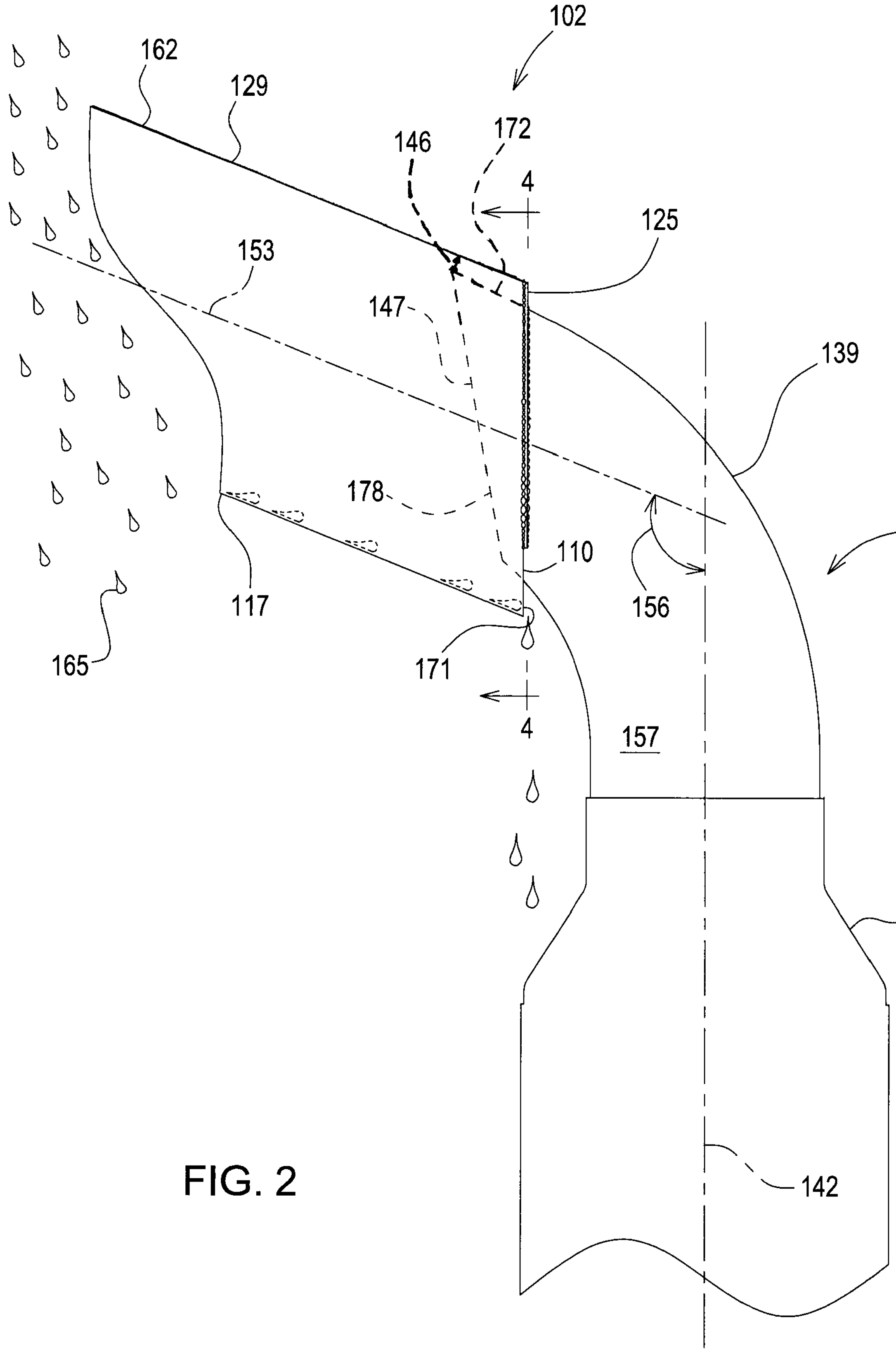
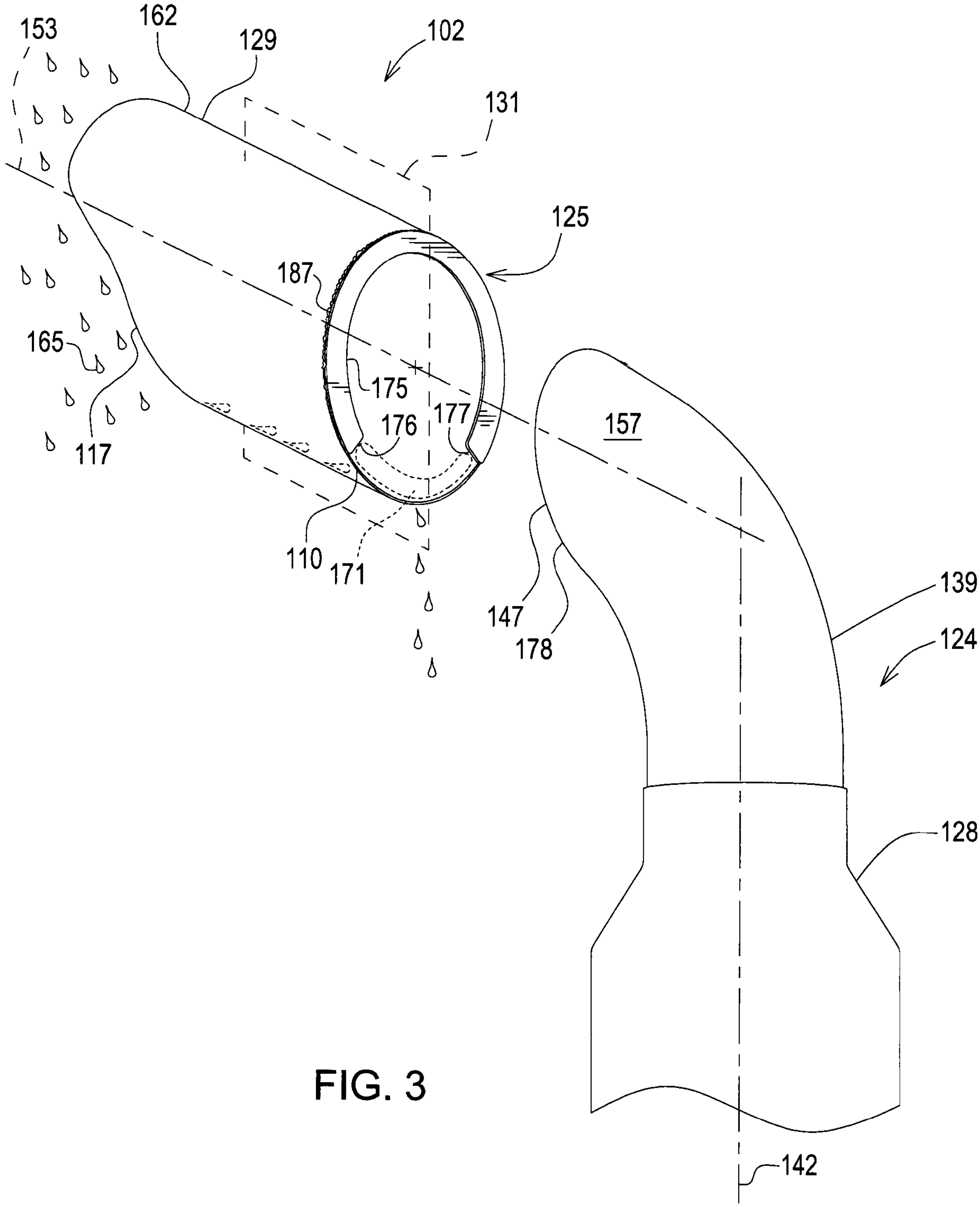

102
162
129
146
172
4
125
153
147
139
178
110
124
117
156
171
165
4
157
128
142

FIG. 2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171
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128
142

FIG. 3

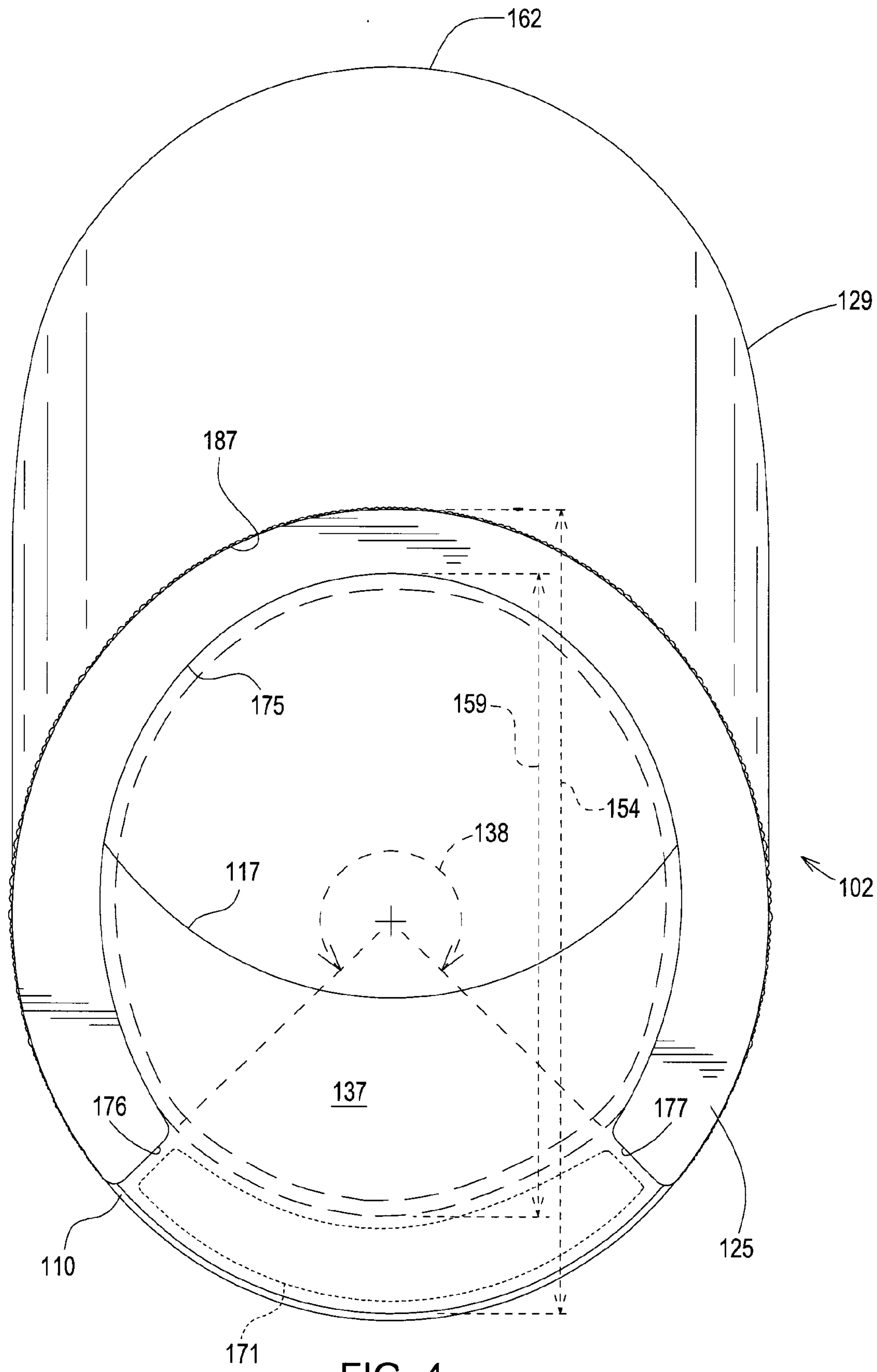


FIG. 4

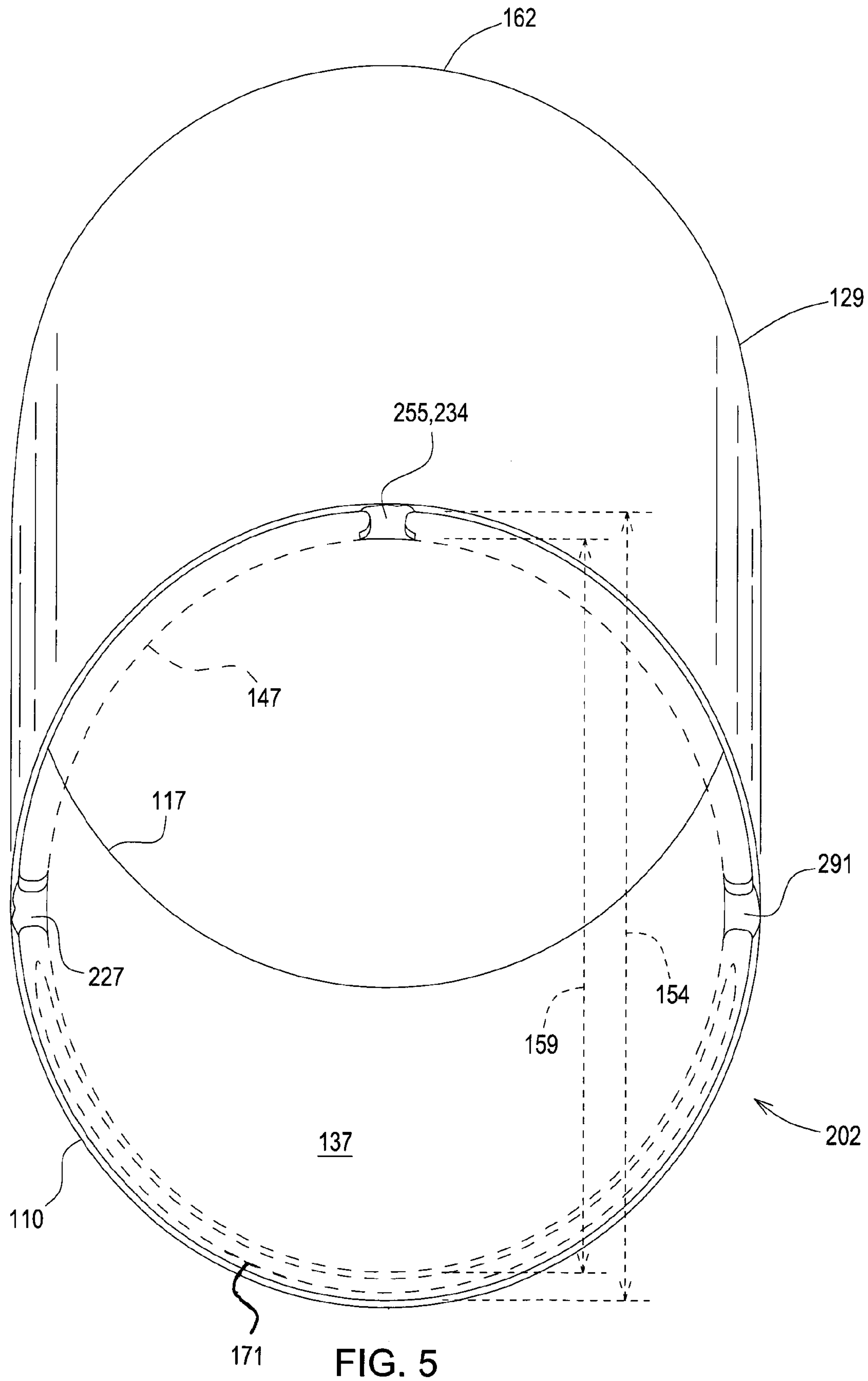
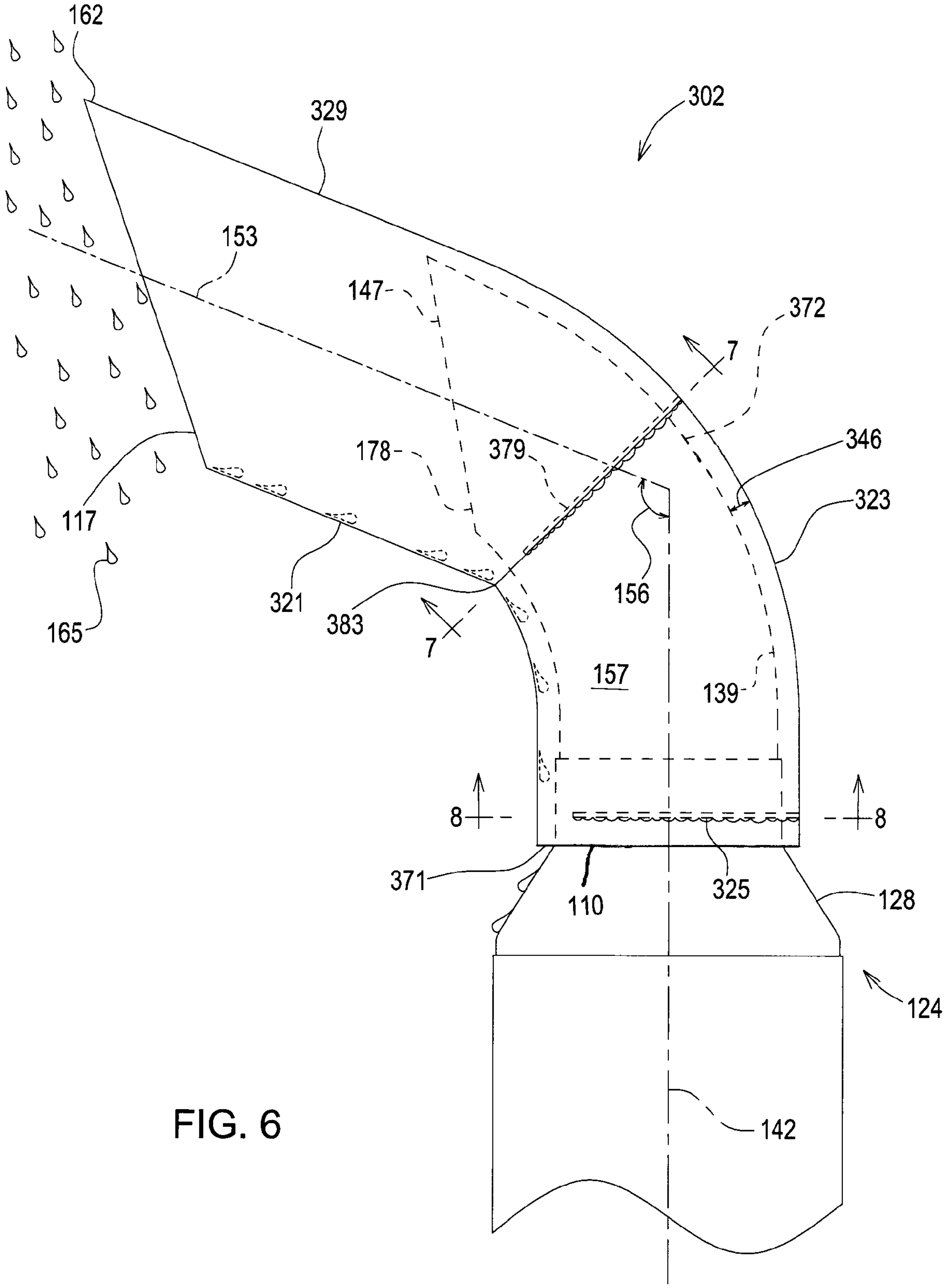


FIG. 5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147
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7
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157
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371
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325
128
124
142

FIG. 6

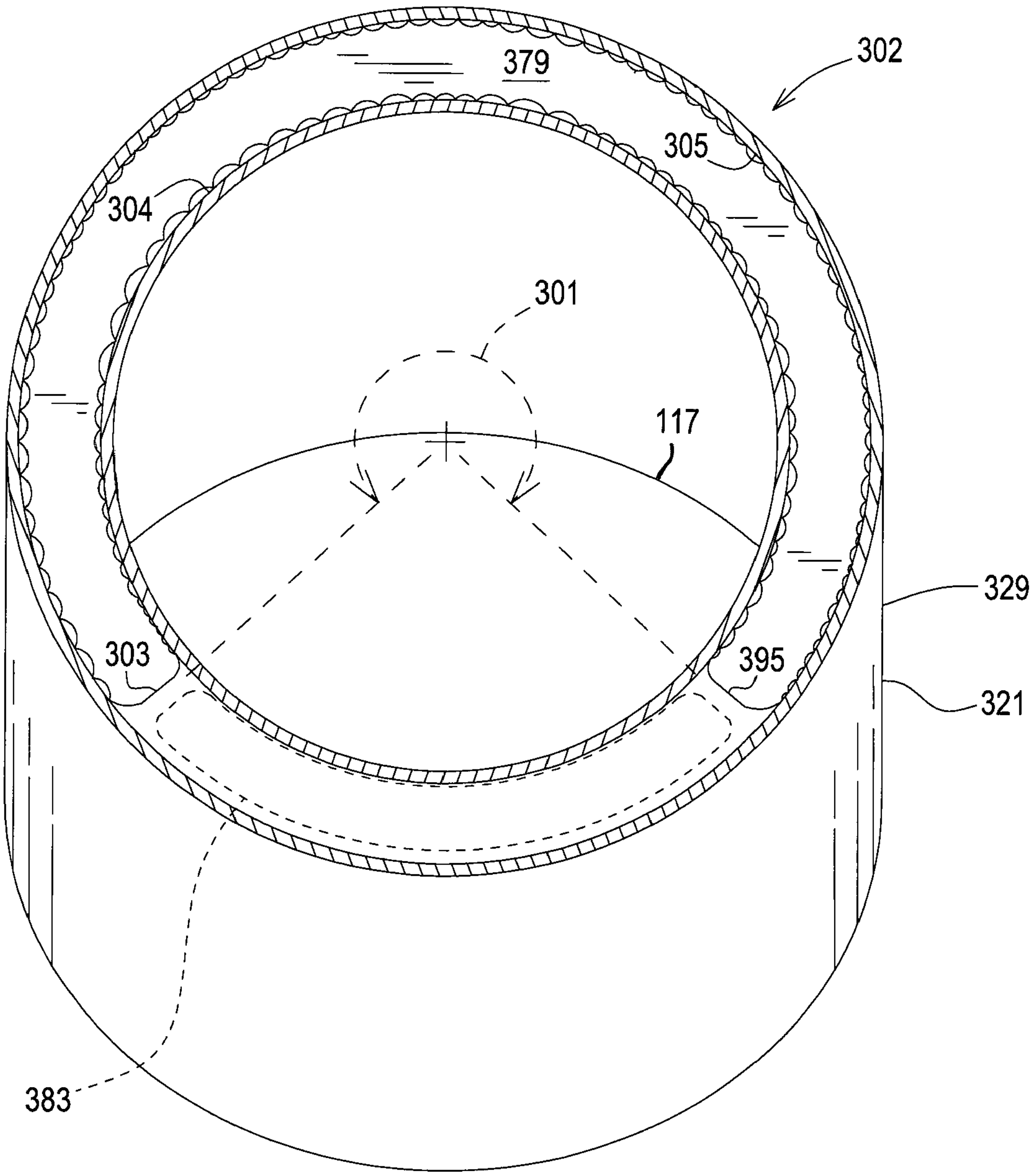

FIG. 7

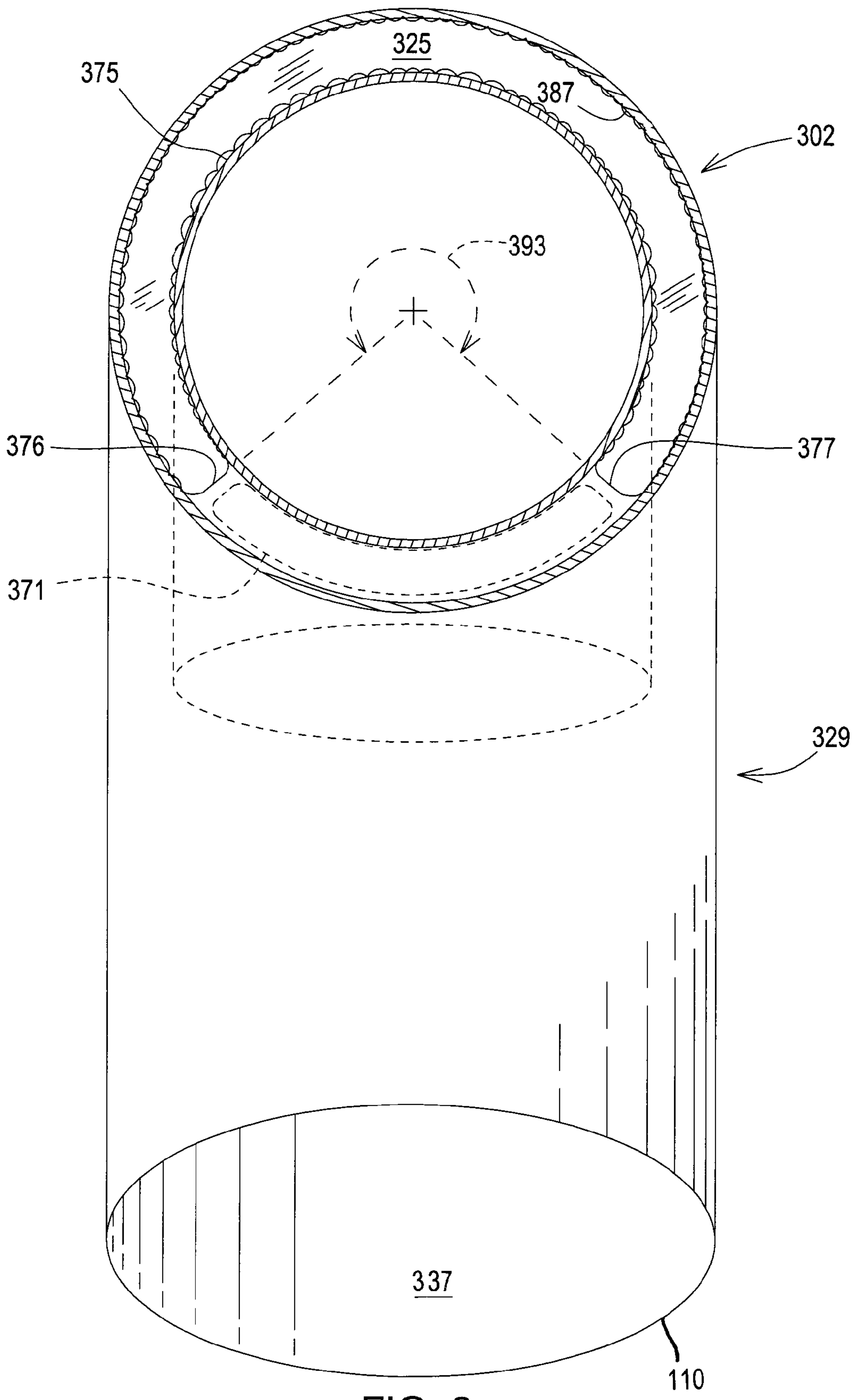

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 14 16 9794

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 3 954 290 A (CORBIN DEAN L) 4 May 1976 (1976-05-04) * figures 1-3 * * column 2, lines 3-12 * * column 2, lines 51-59 * * column 3, lines 1-10 * * claim 4 * -----	1,2,4,5, 7-10 3,6, 11-16	INV. F01N13/08
X A	US 3 792 722 A (HARMON M) 19 February 1974 (1974-02-19) * figures 1-3 * * column 1, lines 18-23 * * column 1, line 52 - column 2, line 21 * -----	1-5,7,8 9-16	
X A	US 2 468 961 A (CURPHY WILLIAM C) 3 May 1949 (1949-05-03) * figures 2,4 * * column 1, line 52 - column 2, line 5 * * column 3, lines 3-75 * -----	1,2,4,5, 7-9 3,6, 10-16	
A	US 5 170 020 A (KRUGER ALLAN J [US] ET AL) 8 December 1992 (1992-12-08) * figures 2-4 * * column 2, lines 3-22 * -----	1-16	TECHNICAL FIELDS SEARCHED (IPC) F01N

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	14 October 2014	Álvarez Goiburu, G

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The members are as contained in the European Patent Office EDP file on
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14-10-2014

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82