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(54) PRECIPITATION COVER FOR AN EXHAUST SYSTEM

(71) Applicant: **Deere & Company**, Moline, IL (US)

(72) Inventors: **Dharani BABU**, Chennai (IN); **Santosh S. MANGADE**, Pune (IN); **Daniel J. DEBOER**, Waucom, IA (US)

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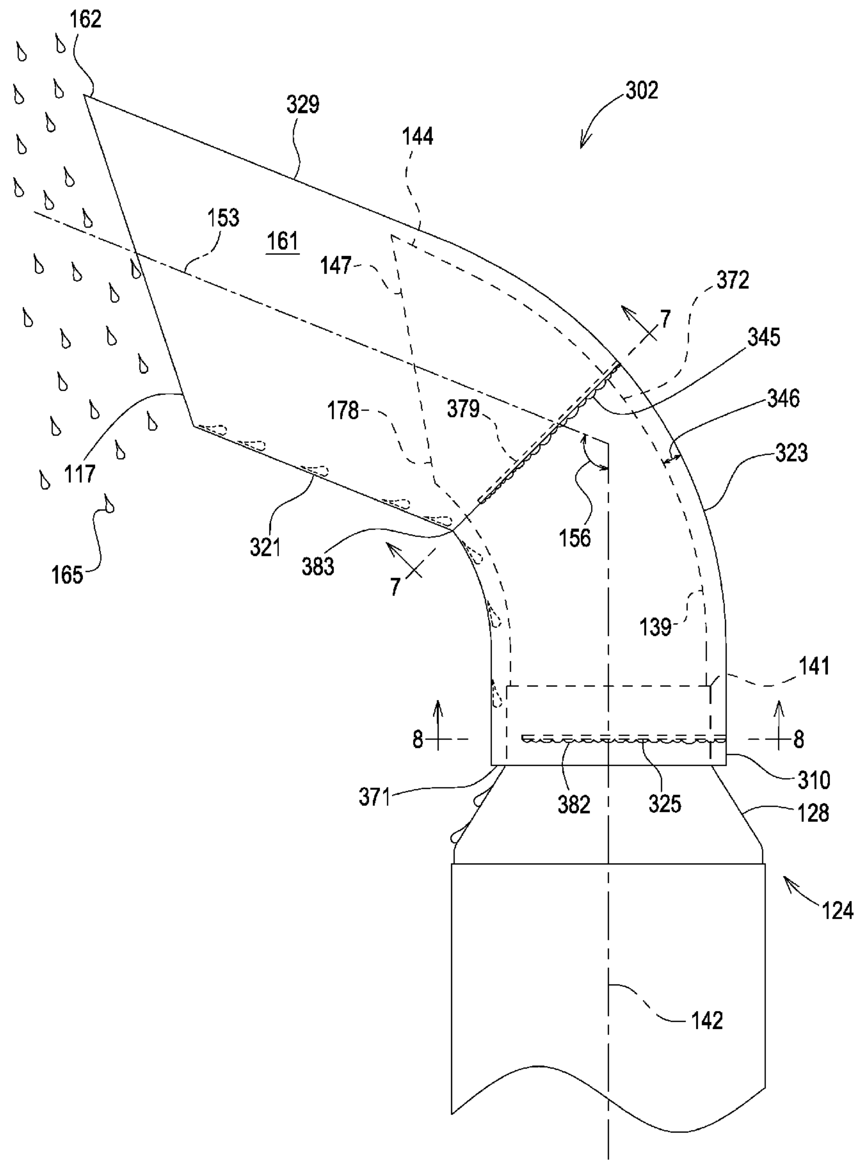
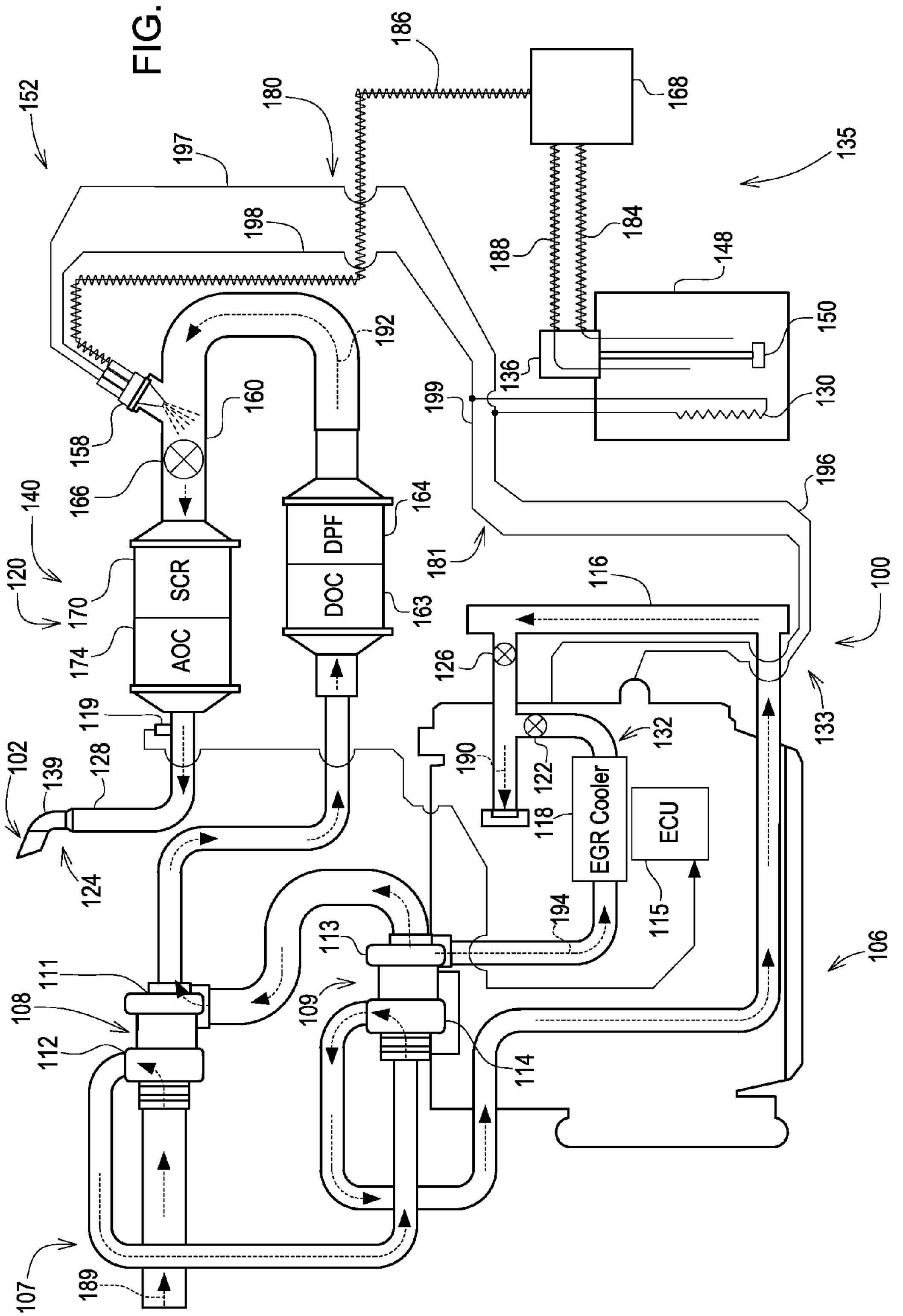
(57) **ABSTRACT**

An apparatus for an exhaust system, the apparatus comprising 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, and the second cover end is configured as an exhaust gas outlet and a precipitation inlet. 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.




SCR
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EGR Cooler
ECU
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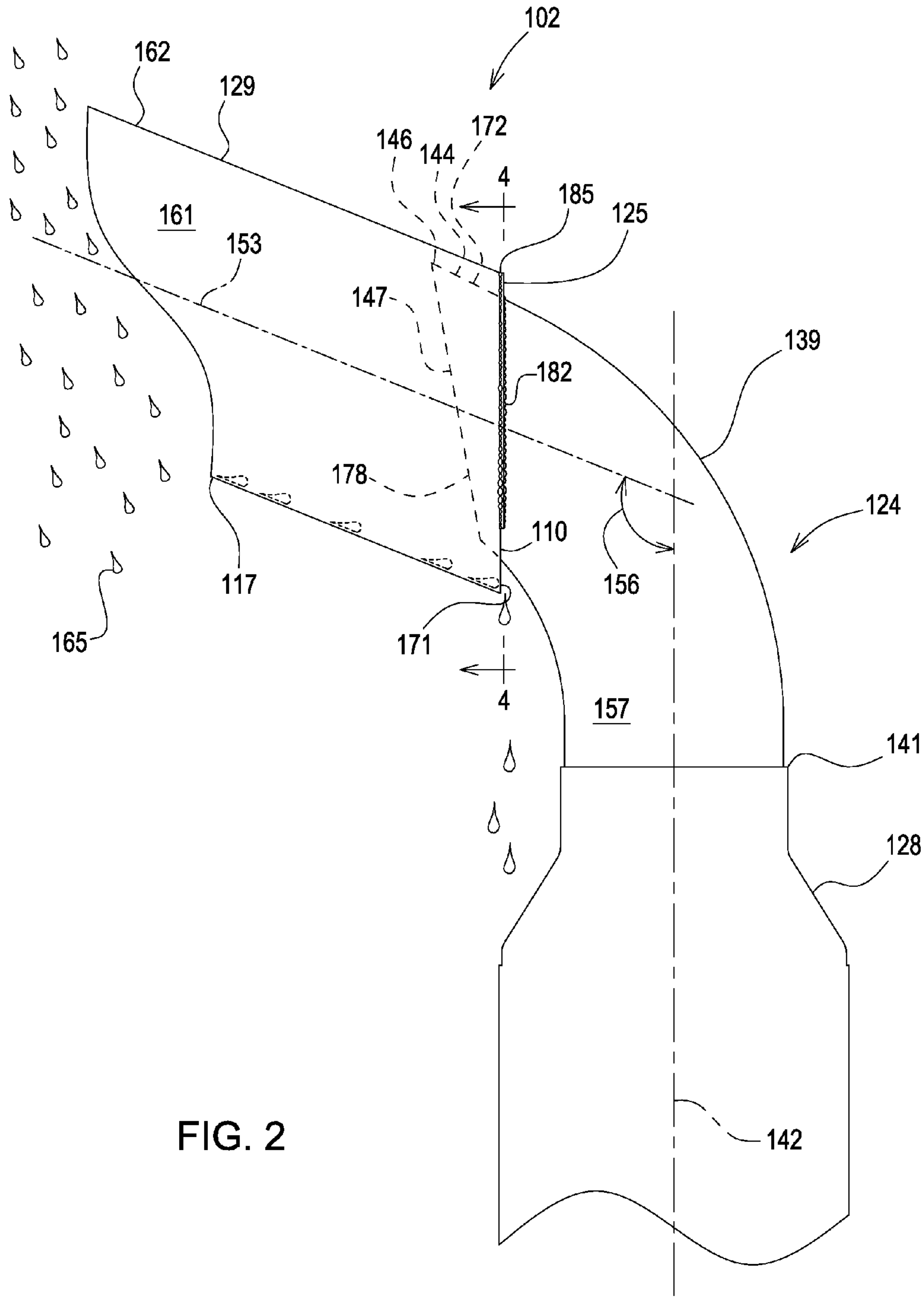
FIG. 1


102
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172
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FIG. 2

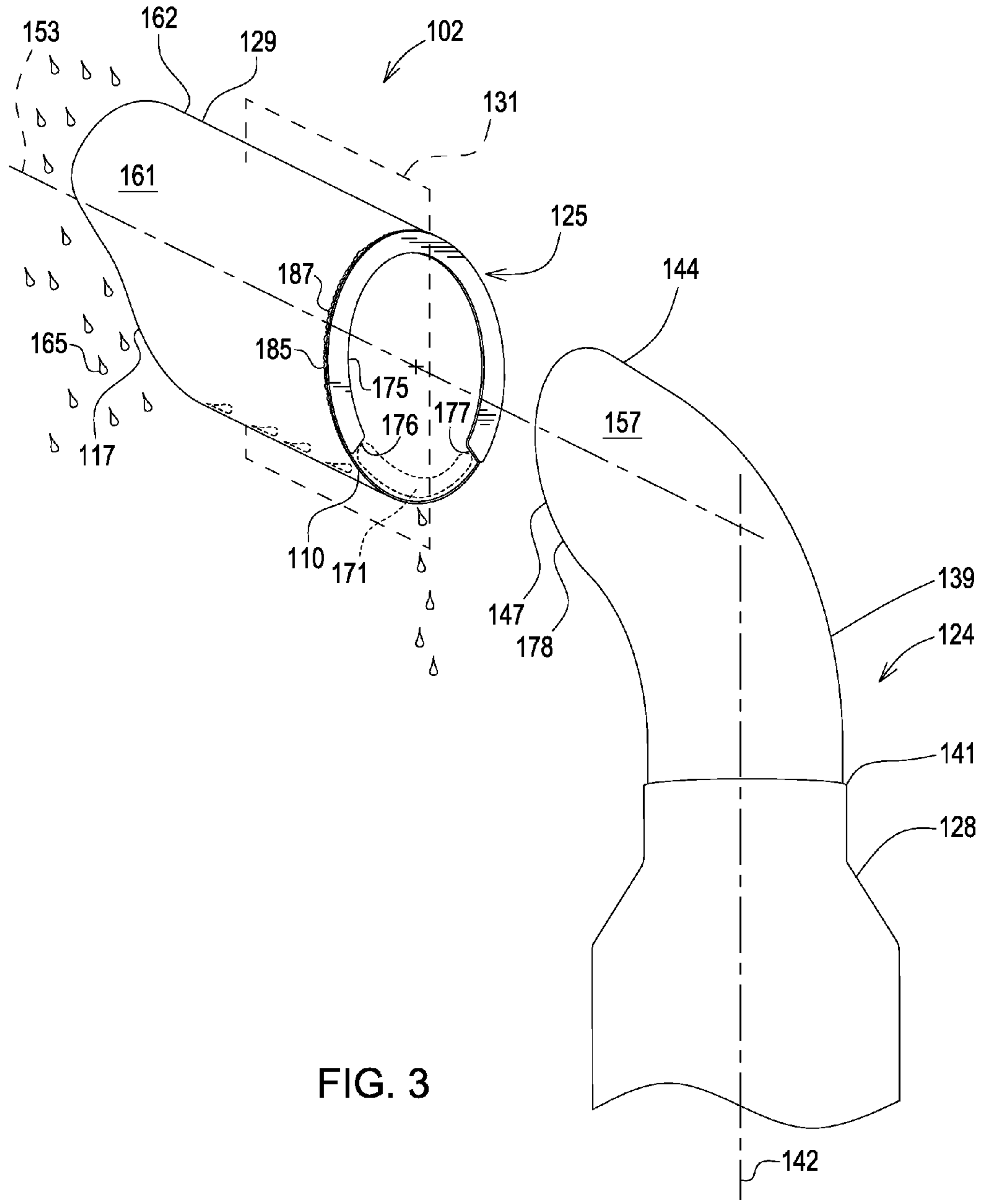
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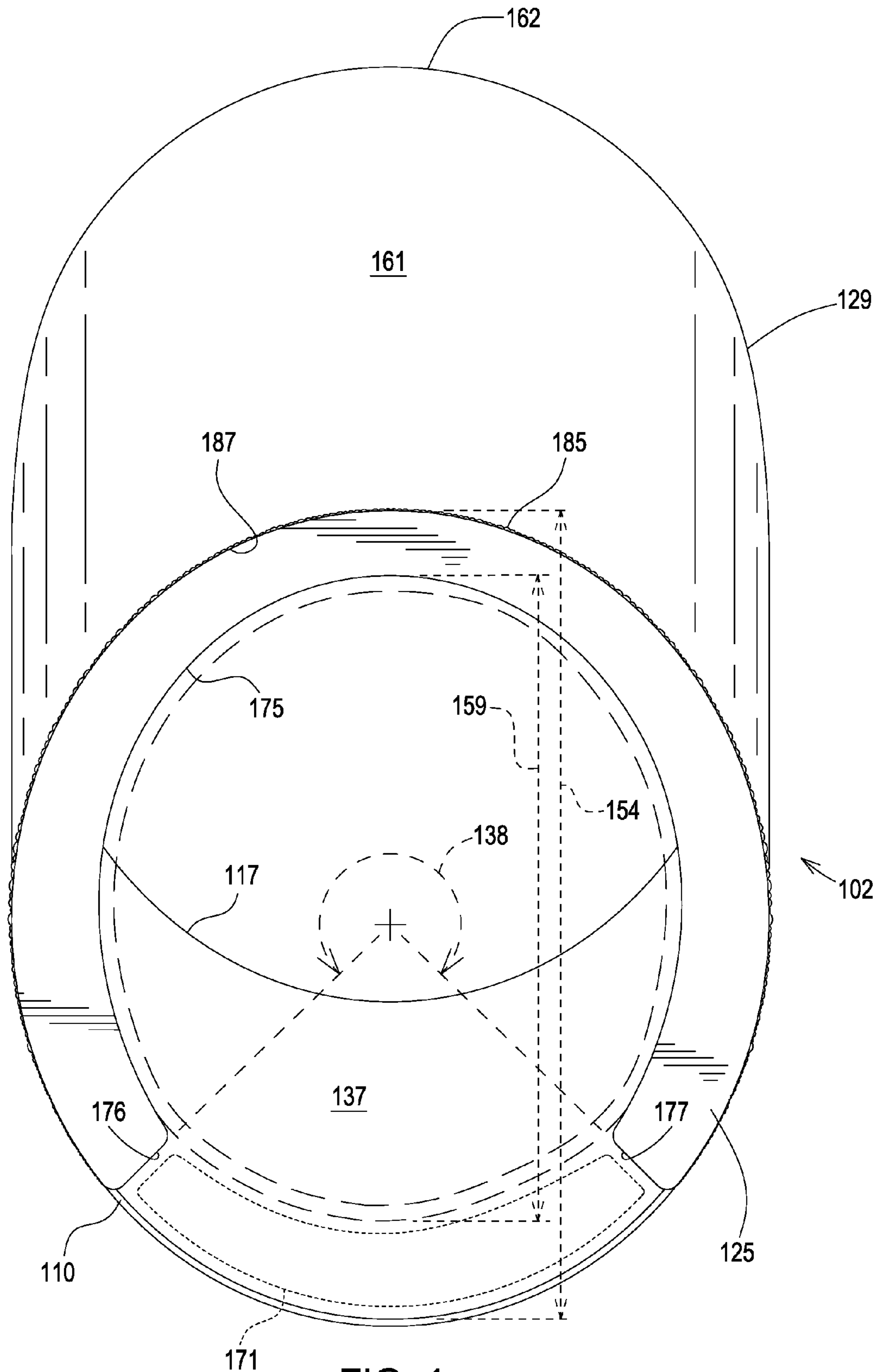
FIG. 3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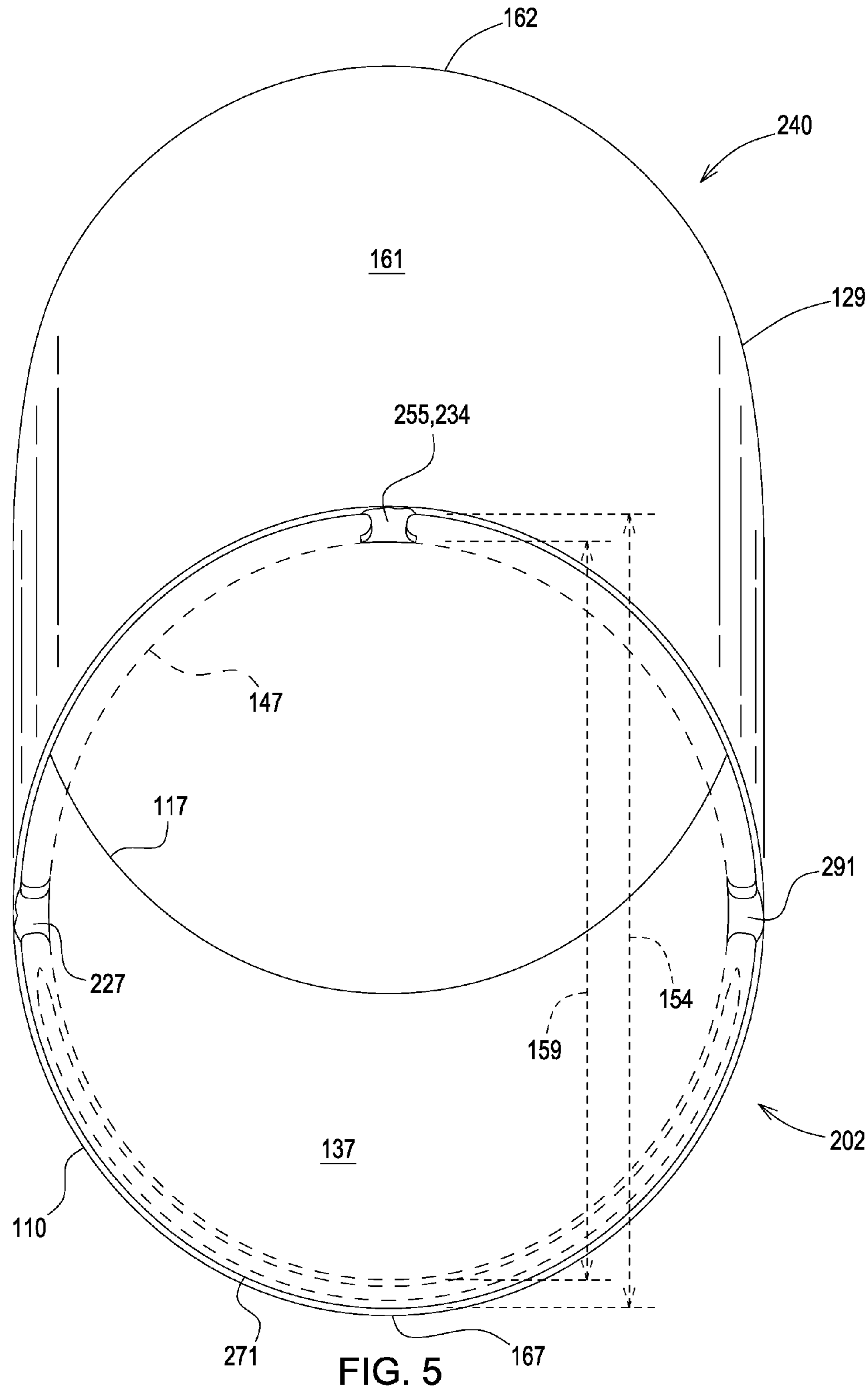
171

FIG. 4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161
129
255,234
147
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154
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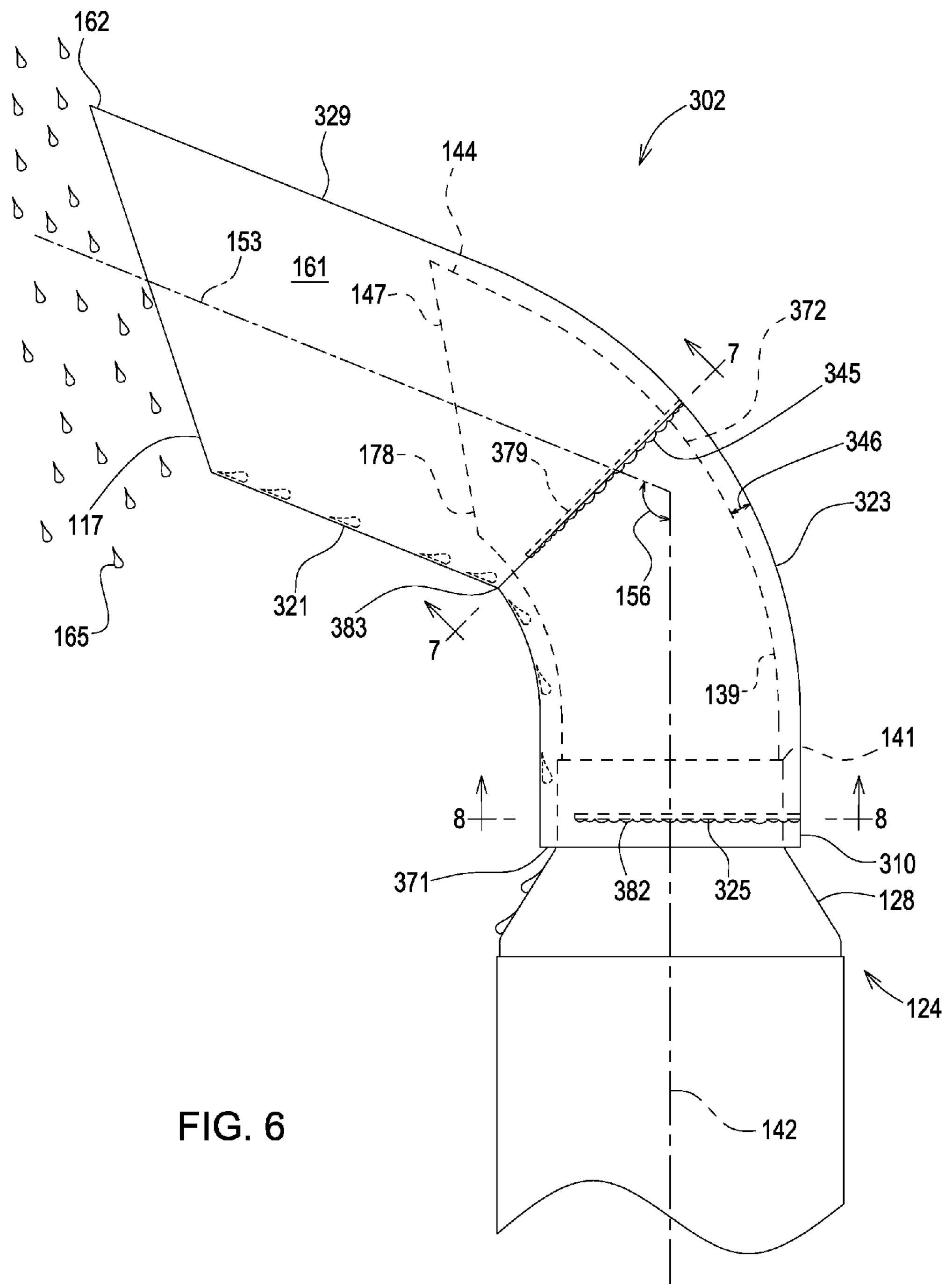
202
137
110
271
167

FIG. 5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345
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8
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371
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124
142

FIG. 6

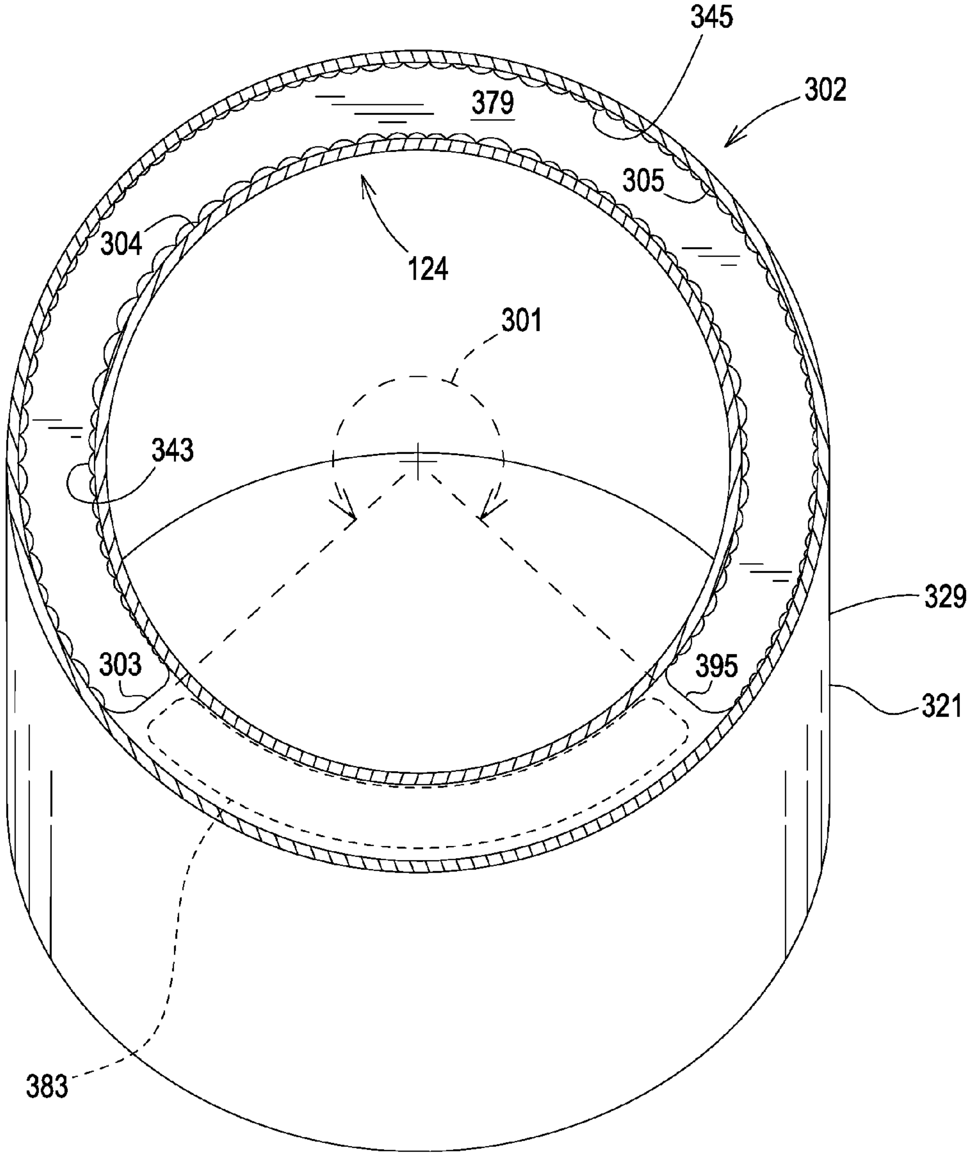

FIG. 7

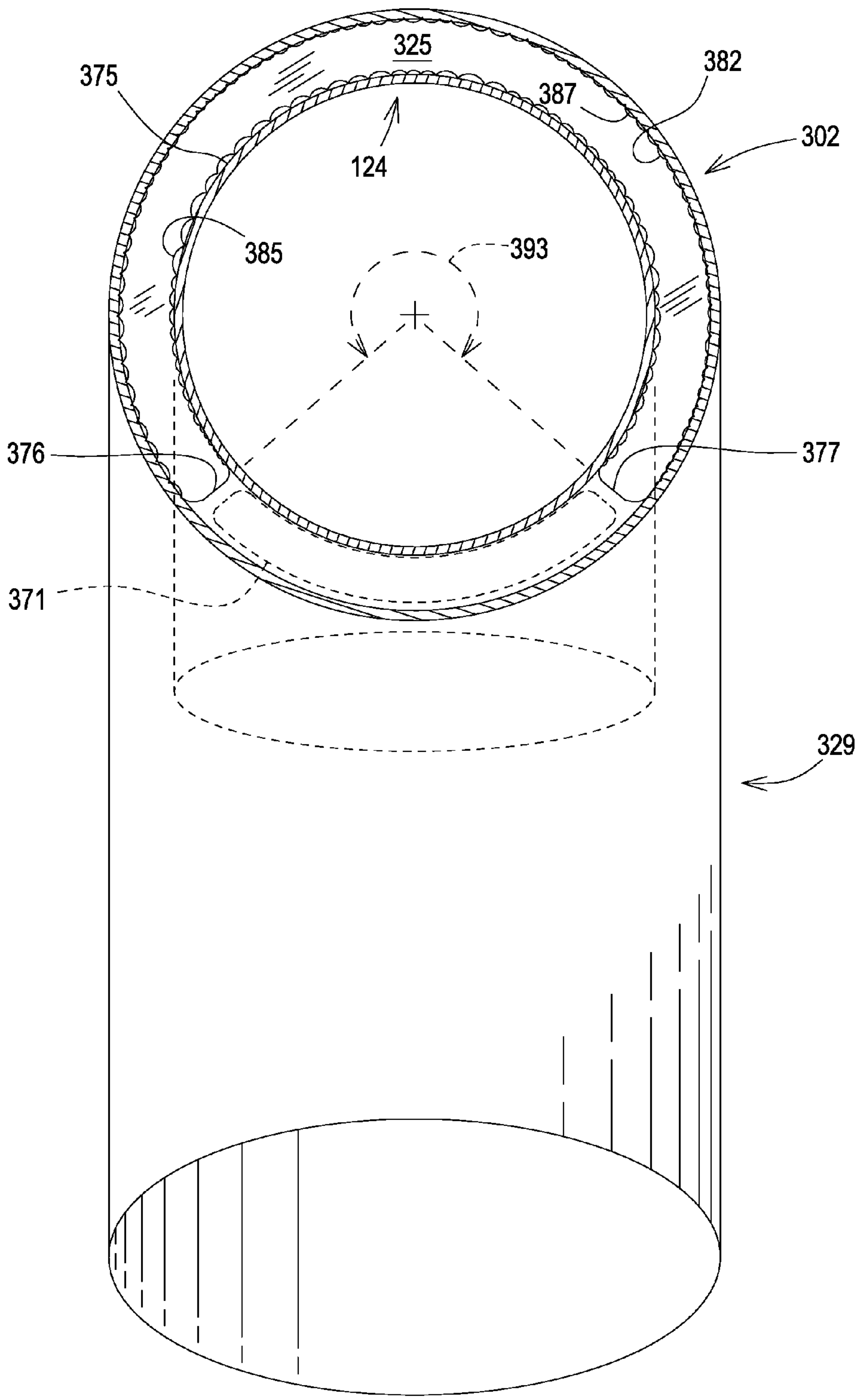

FIG. 8

PRECIPITATION COVER FOR AN EXHAUST SYSTEM

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates to an apparatus for an exhaust system. More specifically, the present disclosure relates to an apparatus comprising a precipitation cover for the exhaust system.

BACKGROUND OF THE DISCLOSURE

[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 nonroad diesel engines came later, the pace of cleanup and rate of improvement has been more aggressive for nonroad engines than for on-road engines.

[0004] Manufacturers of nonroad 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). And what is additionally needed in the art is an apparatus that is cost effective, easy to implement, does not require moving parts, and is visually appealing.

SUMMARY OF THE DISCLOSURE

[0008] Disclosed is an apparatus for an exhaust system, the apparatus comprising 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, and the second cover end is configured as an exhaust gas outlet and a precipitation inlet. 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.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The detailed description of the drawings refers to the accompanying figures in which:

[0011] FIG. **1** is a schematic illustration of a power system comprising an apparatus for an exhaust system;

[0012] FIG. **2** is an elevational view of a tailpipe and the apparatus, the apparatus comprising a precipitation cover and a spacer;

[0013] FIG. **3** is a partially exploded, perspective view of the tailpipe and the precipitation cover and the spacer;

[0014] FIG. **4** is a sectional view taken along lines **4-4** of FIG. **2**, and it illustrates the precipitation cover and the spacer;

[0015] FIG. **5** is a view of a second embodiment of the apparatus taken from a view similar to that shown in FIG. **4**;

[0016] FIG. **6** is an elevational view of a tailpipe and a third embodiment of the apparatus;

[0017] FIG. **7** is a sectional view taken along lines **6-6** of FIG. **6**, and it illustrates a supplemental spacer; and

[0018] FIG. **8** is a sectional view taken along line **7-7** of FIG. **6**, and it illustrates the spacer.

DETAILED DESCRIPTION OF THE DRAWINGS

[0019] Referring to FIG. **1**, there is shown a schematic illustration of a power system **100** comprising an apparatus **102** for an exhaust system **140**. The apparatus **102** may work particularly well in combination with, for example, a NO_x sensor **119**, but it would work just as well with any engine, regardless of whether it has an aftertreatment system **120**, a NO_x sensor **119**, etc.

[0020] 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.

[0021] The engine **106** may be any kind of engine **106** that produces an exhaust gas, the exhaust gas being indicated by directional arrow **192**. For example, engine **106** may be an internal combustion engine, such as a gasoline engine, a diesel engine, a gaseous fuel burning engine (e.g., natural gas) or any other exhaust gas producing engine. The engine **106** may be of any size, with any number cylinders (not shown), and in any configuration (e.g., "V," inline, and radial).

Although not shown, the engine **106** may include various sensors, such as temperature sensors, pressure sensors, and mass flow sensors.

[0022] The power system **100** may comprise an intake system **107**. The intake system **107** may comprise components configured to introduce a fresh intake gas, indicated by directional arrow **189**, into the engine **106**. For example, the intake system **107** may comprise an intake manifold (not shown) in communication with the cylinders, a compressor **112**, a charge air cooler **116**, and an air throttle actuator **126**.

[0023] 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** compress 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** may be 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.

[0024] Further, the power system **100** may comprise an exhaust system **140**. The exhaust system **140** may comprise components configured to direct exhaust gas from the engine **106** to the atmosphere. Specifically, the exhaust system **140** may comprise an exhaust manifold (not shown) in fluid communication with the cylinders. During an exhaust stroke, at least one exhaust valve (not shown) opens, allowing the exhaust gas to flow through the exhaust 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** is known as a turbocharger **108**.

[0025] The power system **100** may also comprise, for example, 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 compress the fresh intake flow to an elevated pressure level before it enters the engine **106**.

[0026] The power system **100** may 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).

[0027] 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 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.

[0028] As further shown, the exhaust system **140** may comprise an aftertreatment system **120**, and at least a portion of the exhaust gas passes therethrough. The aftertreatment system **120** is configured to remove various chemical compounds and particulate emissions present in the exhaust gas received from the engine **106**. After being treated by the aftertreatment system **120**, the exhaust gas is expelled into the atmosphere via a tailpipe **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 (see directional arrow **192**).

[0029] The aftertreatment system **120** may comprise a NO_x sensor **119**, the NO_x sensor **119** being 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.

[0030] The ECU **115** may have 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** may, in response to the NO_x signal, control a combustion temperature of the 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.

[0031] 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 **178**.

[0032] 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** may be 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.

[0033] The DOC **163** may be configured in a variety of ways and contain 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(s) 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**.

[0034] 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 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**.

[0035] 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.

[0036] Moreover, the reductant delivery system **135** may comprise 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. (−11deg 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.

[0037] The reductant delivery system **135** may comprise a reductant header **136** mounted to the reductant tank **148**, the reductant header **136** further comprising, in some embodiments, 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.

[0038] In the illustrated embodiment, the reductant header **136** comprises a tank heating element **130** that is configured to receive coolant from the engine **106**, and the power system **100** may comprise 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 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.

[0039] 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.

[0040] 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 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 engine **106**.

[0041] The decomposition tube **160** may be 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** may comprise a reductant mixer **166** that is positioned upstream of the SCR catalyst **170** and downstream of the reductant delivery mechanism **158**.

[0042] The reductant delivery system **135** may additionally comprise a reductant pressure source (not shown) and a reductant extraction passage **184**. The reductant extraction passage **184** may be 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** may further comprise a reductant supply module **168**, and it may comprise the reductant pressure source. Exemplarily, the reductant supply module **168** may be, or be similar to, a Bosch reductant supply module, such as the one found in the "Bosch Denoxtronic 2.2—Urea Dosing System for SCR Systems."

[0043] The reductant delivery system **135** may also comprise 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**.

[0044] 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**.

[0045] 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 N2 and H2O. 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.

[0046] The AOC **174** may be any of various flowthrough 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** may be positioned within the same housing. But in other embodiments, they may be separate from one another.

[0047] 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. As shown, for example, in FIGS. **2-3**, 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. **2-4**, 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**.

[0048] At least a portion of the first cover end **110** may be positioned radially outside of an end **147** of the tailpipe **124**. For example, as illustrated, the precipitation cover **129** and the tailpipe **124** may both be tubularly shaped, wherein an inner diameter **154** of the precipitation cover **129** may be 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.

[0049] Further, the precipitation cover **129** may comprise a hood **162** extending axially away from the second cover end **117**. The hood **162** may be angularly aligned with a spacer **125** relative to the imaginary cover axis **153**. The hood **162** may minimize 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**).

[0050] The tailpipe **124** may further comprise 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** may define an imaginary tailpipe axis **142**, and the precipitation cover **129** may define an imaginary cover axis **153**. And as shown in FIG. **2**, the imaginary tailpipe axis **142** and the imaginary cover axis **153** may 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** may be such that it prevents precipitation **165** from entering the tailpipe **124**, even when the precipitation **165** is falling at, for example, a 40° angle.

[0051] 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.

[0052] As shown, in FIG. **2**, the precipitation cover **129** may overlap the tailpipe **124** so as to form an overlapped region **172**, and the precipitation cover **129** and the tailpipe **124** may be spaced apart, along the overlapped region **172**, so as to form an annular gap **146** therebetween.

[0053] The apparatus **102** may further comprise a spacer **125** mounted to the tailpipe **124**, and the precipitation cover **129** may be mounted to the spacer **125**. Or, more specifically, the spacer **125** may be mounted to an outer surface **157** of the tailpipe **124**, and the precipitation cover **129** may be mounted to an outer surface **157** of the spacer **125**. As illustrated in, for example, FIG. **3**, the imaginary tailpipe axis **142** and the imaginary cover axis **153** may define a plane **131**, and the spacer **125** and the precipitation cover **129** may be symmetric to one another relative to the plane **131**.

[0054] As shown, in FIG. **4**, the spacer **125** may be "horseshoe shaped" and may partially extend around the outer surface **157** of the tailpipe **124**. For example, the spacer **125** may extend around approximately 270° about the tailpipe **124** (see angle **138**), though in other embodiments, the spacer **125** may extend 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.

[0055] As shown in FIG. **4**, a first end surface **176** of the spacer **125** may connect an inner surface **175** and an outer surface **187** of the spacer **125**. A second end surface **177** of the spacer **125** may also connect the inner surface **175** and the outer surface **187**. The first end surface **176**, the second end surface **177**, the inner surface **175** of the precipitation cover **129**, and the outer surface **187** of the tailpipe **124** may cooperate so as to define the precipitation exit opening **171**.

[0056] Referring to FIG. **5**, there is shown a view of a second embodiment of the apparatus **202** taken from a view similar to that which is shown in FIG. **4** (though FIG. **4** is a view of the first embodiment of the apparatus **102**). The apparatus **202** has many components similar in structure and function as the apparatus **102**, as indicated by the use of identical reference numerals where applicable. However, a difference, between the apparatus **202** and the apparatus **102**, is that the spacer **225** of the 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 the 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.

[0057] Referring to FIGS. **6-8**, there is shown a third embodiment of an apparatus **302**. The third embodiment of the apparatus **302** has many components similar in structure and function as the first embodiment of the apparatus **102** and the second embodiment of the apparatus **202**. However, in the third embodiment of the apparatus **302**, the precipitation cover **329** may comprise a base cover **321** and an extended cover **323**. The base cover **321** may be positioned substantially downstream of an end **147** of the tailpipe **124** relative to a direction of the exhaust gas flow, and the extended cover **323** may be 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.

[0058] As shown in FIGS. **6-7**, exemplarily, the apparatus **302** may further comprise a supplemental spacer **379**. The supplemental spacer **379** may be mounted to the tailpipe **124**, and the precipitation cover **329** may be mounted to the supplemental spacer **379**. Further, the supplemental spacer **379** may be positioned downstream of the spacer **325** relative to the direction of the exhaust gas flow. The precipitation cover **329** may overlap the tailpipe **124** so as to form an overlapped region **372**, and the precipitation cover **329** and the tailpipe **124** may be spaced apart from one another, along the overlapped region **372**, so as to form an annular gap **346** therebetween.

[0059] As shown in FIG. **7**, the supplemental spacer **379** may be "horseshoe shaped" and may partially extend around the outer surface **157** of the tailpipe **124**. For example, the supplemental spacer **379** may extend around approximately 270° of the tailpipe **124** (see angle **393**). 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.

[0060] 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 supplemental spacer **379**. And 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**, the inner surface **304** 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**.

[0061] Finally, in the embodiment illustrated in FIG. **8**, a first end surface **376** of the spacer **325** may connect an inner surface **375** and an outer surface **387** of the spacer **325**. A first end surface **376** of the spacer **325** may connect an inner surface **375** and an outer surface **387** of the spacer **325**, and a second end surface **377** of the spacer **325** may also connect the inner surface **375** and the outer surface **387**. As illustrated, the first end surface **376**, the second end surface **377**, the inner surface **375**, and the outer surface **387** may cooperate so as to define the precipitation exit opening **371**.

[0062] Further, the spacer **325** may be "horseshoe shaped" and may partially extend around the outer surface **157** of the tailpipe **124**. For example, the spacer **325** may extend 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 like.

[0063] While the disclosure has been illustrated and described in detail in the drawings and foregoing description, such illustration and description is to be considered as exemplary and not restrictive in character, it being understood that illustrative embodiments have been shown and described and that all changes and modifications that come within the spirit of the disclosure are desired to be protected. It will be noted that alternative embodiments of the present disclosure may not include all of the features described yet still benefit from at least some of the advantages of such features. Those of ordinary skill in the art may readily devise their own implementations that incorporate one or more of the features of the present disclosure and fall within the spirit and scope of the present invention as defined by the appended claims.

1. An apparatus for an exhaust system, the apparatus comprising 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 comprising a first cover end and a second cover end, the first cover end configured as a precipitation outlet, the second cover end 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.

2. The apparatus of claim **1**, wherein the precipitation cover comprises a base cover and an extended cover, the base cover being positioned substantially downstream of an end of the tailpipe relative to a direction of the exhaust gas flow, the extended cover being positioned substantially upstream of the end of the tailpipe relative to a direction of the exhaust gas flow.

3. The apparatus of claim **1**, wherein the precipitation cover and the tailpipe are both tubularly shaped, and an inner diameter of the precipitation cover is larger than an outer diameter of the tailpipe.

4. The apparatus of claim **1**, wherein the precipitation cover further comprises a hood extending axially from the second cover end.

5. The apparatus of claim **1**, wherein the first cover end and an end of the tailpipe cooperate so as to form the precipitation exit opening.

6. The apparatus of claim **1**, wherein at least a portion of the first cover end is positioned radially outside of an end of the tailpipe.

7. The apparatus of claim **1**, wherein the tailpipe further comprises a first tailpipe section and a second tailpipe section, the first tailpipe section defining an imaginary tailpipe axis, the second tailpipe section being substantially elbow shaped and is positioned downstream of the first tailpipe section relative to the direction of the exhaust gas flow, the precipitation cover defining an imaginary cover axis, and the imaginary tailpipe axis and the imaginary cover axis defining an angle therebetween in a range of 90° and 150°.

8. The apparatus of claim **1**, wherein the angle therebetween is in a range of between 110° and 130°.

9. The apparatus of claim **1**, wherein the precipitation cover overlaps the tailpipe so as to form an overlapped region.

10. The apparatus of claim **9**, wherein the precipitation cover and the tailpipe are spaced apart, along the overlapped region, so as to form an annular gap therebetween.

11. The apparatus of claim **1**, further comprising a spacer mounted to the tailpipe, the precipitation cover being mounted to the spacer.

12. The apparatus of claim **11**, wherein the spacer is "horseshoe shaped."

13. The apparatus of claim **11**, wherein the spacer is a bead of weld.

14. The apparatus of claim **11**, wherein the tailpipe further comprises a first tailpipe section and a second tailpipe section, the first tailpipe section defines an imaginary tailpipe axis, the second tailpipe section is substantially elbow shaped and is positioned downstream of the first tailpipe section relative to the direction of the exhaust gas flow, the precipitation cover defines an imaginary cover axis, the imaginary tailpipe axis and the imaginary cover axis define a plane, and the spacer is symmetric relative to the plane.

15. The apparatus of claim **11**, wherein:

a first end surface of the spacer connects an inner surface of the spacer and an outer surface of the spacer;

a second end surface connects the inner surface of the spacer and the outer surface of the spacer; and

the first end surface of the spacer and the second end surface of the spacer and the inner surface of the precipitation cover and the outer surface of the tailpipe cooperate so as to define the precipitation exit opening.

16. The apparatus of claim **15**, wherein the spacer is mounted to an outer surface of the tailpipe, and the precipitation cover is mounted to an outer surface of the spacer.

17. The apparatus of claim **15**, wherein the spacer partially extends around the outer surface of the tailpipe.

18. The apparatus of claim **11**, further comprising a supplemental spacer, the supplemental spacer being mounted to the tailpipe, the precipitation cover being mounted to the supplemental spacer, and the supplemental spacer being positioned downstream of the spacer relative to the direction of the exhaust gas flow.

19. The apparatus of claim **18**, wherein:

a first end surface of the supplemental spacer connects an inner surface of the supplemental spacer and an outer surface of the supplemental spacer;

a second end surface of the supplemental spacer connects the inner surface of the supplemental spacer and the outer surface of the supplemental spacer; and

the first end surface of the supplemental spacer and the second end surface of the supplemental spacer and the inner surface of the precipitation cover and the outer surface of the tailpipe cooperate so as to define a supplemental precipitation exit opening.

20. An apparatus for an exhaust system, the apparatus comprising precipitation cover and a spacer, the 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 comprising a first cover end and a second cover end, the first cover end configured and a precipitation outlet, the second cover end configured as an exhaust gas outlet and a precipitation inlet, the spacer being mounted to the tailpipe, the precipitation cover being mounted to the spacer, 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;

the precipitation cover overlaps the tailpipe so as to form an overlapped region;

the precipitation cover and the tailpipe are spaced apart, along the overlapped region, so as to form an annular gap therebetween; and

the precipitation cover further comprises a hood extending axially from the second cover end.

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