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[Continued on next page]

(54) Title: IGNITION DISCONNECT

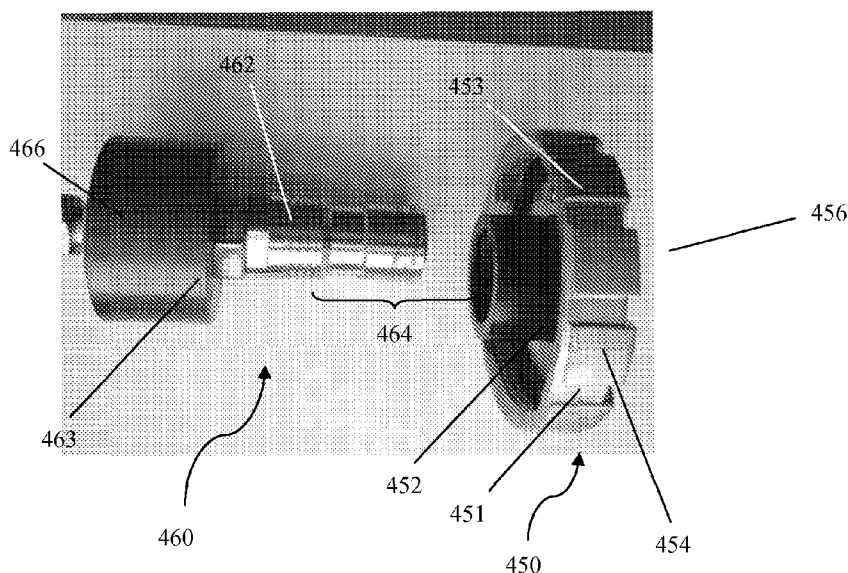


FIG. 4A

(57) Abstract: The invention provides devices, systems and methods for filling, capping and electronically monitoring the closure of a fuel tank. In some embodiments, the invention provides devices, systems and methods for filling, capping and providing an ignition disconnect mechanism upon uncapping of a natural gas fuel tank.

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IGNITION DISCONNECT

CROSS-REFERENCE

[0001] This application claims the benefit of U.S. Provisional Patent Application Serial No. 61/612,902, filed March 19, 2012, and U.S. Patent Application Serial No. 13/843,041, filed March 15, 2013, each of which is incorporated herein by reference in its entirety.

BACKGROUND OF INVENTION

[0002] Safety and reliability requirements for alternative fuel systems for vehicles include considerations for filling, storage and delivery of on-board fuel supply. Handling of different fuels may impose different requirements on each fuel system. Challenges remain concerning safety and reliability of filler assemblies on natural gas and other alternative fuel tanks.

SUMMARY OF INVENTION

[0003] Recognized herein is the need for improved fuel tank fill systems.

[0004] The invention provides devices, systems and methods for filling, capping and electronically monitoring the closure of a fuel tank. Some embodiments provide systems and methods for filling, capping and providing an ignition disconnect mechanism upon uncapping of a natural gas fuel tank.

[0005] An aspect of the invention relates to a vehicle fuel tank fill cap comprising an electric wire embedded in the fill cap, and a mating feature on the fill cap, wherein the mating feature on the fill cap is configured to be connected and separated in a controlled manner, by a vehicle operator, with a complementary mating feature on a fill neck of a fill receptacle at a vehicle, and wherein the electric wire embedded in the fill cap completes, when the fill cap is connected with the fill neck of the fill receptacle, a control circuit, and wherein the control circuit is capable of disconnecting a vehicle engine ignition system when an open circuit condition exists at the control circuit. The mating feature on the fill cap may be a female threaded connection and the complementary mating feature on the fill neck of the fill receptacle may be a male threaded connection. The mating feature on the fill cap and the complementary mating feature on the fill neck of the fill receptacle may include one or more of the following: flange, ledge, button, pin, bracket, latch, pin,

receiving indent, lock, slot, snap, collar, clip, clasp, or flip handle. The fill cap and the fill receptacle may be configured to provide a press-fit connection.

[0006] Another aspect of the invention related to a vehicle fuel tank fill cap comprising an indicator provided on the fill cap and a mating feature on the fill cap, wherein the mating feature on the fill cap is configured to be connected and separated in a controlled manner, by a vehicle operator, with a complementary mating feature on a fill neck of a fill receptacle at a vehicle, wherein the indicator provided on the fill cap completes, when the fill cap is connected with the fill neck of the fill receptacle, a control circuit, and wherein the control circuit is capable of disconnecting a vehicle engine ignition system when an open circuit condition exists at the control circuit. The mating feature on the fill cap may be a female threaded connection and the complementary mating feature on the fill neck of the fill receptacle may be a male threaded connection. The mating feature on the fill cap and the complementary mating feature on the fill neck of the fill receptacle may form a twist-lock connection. The mating feature on the fill cap and the complementary mating feature on the fill neck of the fill receptacle may include one or more of the following: flange, ledge, button, pin, bracket, latch, pin, receiving indent, lock, slot, snap, collar, clip, a cam lock, a pin, a clasp, or flip handle. The fill cap and the fill receptacle may be configured to provide a press-fit connection. The indicator may be an electric wire. The indicator may be an actuator. The indicator may be a trigger. The indicator may be a magnet. The indicator may be embedded in the fill cap. The indicator may be secured to the fill cap.

[0007] A further aspect of the invention relates to a vehicle fuel tank fill cap comprising an indicator provided on the fill cap, wherein the indicator provided on the fill cap completes and/or activates, when the fill cap is in proximity of an indicator receiver provided on the vehicle, a control circuit, and wherein the control circuit is capable of affecting a response of a vehicle system upon a change in circuit condition at the control circuit. The vehicle fuel tank fill cap may further comprise a mating feature on the fill cap, wherein the mating feature on the fill cap is configured to be connected and separated in a controlled manner, by a vehicle operator, with a complementary mating feature on a fill neck of a fill receptacle at a vehicle. The fill cap may be in proximity of the indicator receiver when the fill cap is connected with the fill neck of the fill receptacle. The response may be disconnecting a vehicle engine ignition system. The change in circuit condition may be a change from a closed circuit condition to an open circuit condition.

The indicator receiver may be provided on the fill neck, a cover, a fill manifold, a faceplate, or a combination thereof. The indicator receiver may be embedded in the fill neck, a cover, a fill manifold, a faceplate, or a combination thereof. The indicator receiver may be a read sensor. The indicator may be an actuator, a trigger, a magnet, or a combination thereof.

[0008] Other goals and advantages of the invention will be further appreciated and understood when considered in conjunction with the following description and accompanying drawings. While the following description may contain specific details describing particular embodiments of the invention, this should not be construed as limitations to the scope of the invention but rather as an exemplification of preferable embodiments. For each aspect of the invention, many variations are possible as suggested herein that are known to those of ordinary skill in the art. A variety of changes and modifications can be made within the scope of the invention without departing from the spirit thereof.

INCORPORATION BY REFERENCE

[0009] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference.

BRIEF DESCRIPTION OF DRAWINGS

[0010] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings of which:

[0011] FIG. 1A is a schematic of a fuel system carried on board a vehicle.

[0012] FIG. 1B is a schematic of a fuel system.

[0013] FIG. 2A is a photograph of an ignition disconnect rubber cap.

[0014] FIG. 2B is a photograph of an ignition disconnect rubber cap with embedded wire.

[0015] FIG. 3 is a photograph of a fuel tank cover with a fill receptacle in accordance with an embodiment of the present invention.

[0016] FIG. 4A shows an ignition disconnect fill cap and fill receptacle in accordance with an embodiment of the present invention.

[0017] FIG. 4B shows positive placement of an ignition disconnect fill cap onto a fill receptacle.

[0018] FIG. 4C is a side view of an ignition disconnect fill cap connected to a fill receptacle.

[0019] FIG. 5A shows an ignition disconnect fill cap, fill receptacle with fill neck and fill manifold in accordance with an embodiment of the present invention.

[0020] FIG. 5B is an exploded view of an assembly of an ignition fill cap, fill receptacle, fill neck and fill manifold.

[0021] FIG. 5C shows an assembly of a fill receptacle, fill neck and fill manifold.

[0022] FIG. 5D shows positive placement of an ignition disconnect fill cap onto a fill receptacle with fill neck and fill manifold.

[0023] FIG. 6 are sectional and perspective views of an ignition disconnect fill cap connected with a fill neck with a read sensor.

[0024] FIG. 7A is a photograph of a fuel tank cover with in accordance with an embodiment of the present invention.

[0025] FIG. 7B is a perspective view of a fuel tank cover in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF INVENTION

[0026] The invention provides devices, systems and methods for filling, capping and electronically monitoring the closure of a fuel tank. In some embodiments, the invention provides devices, systems and methods for filling, capping and providing an ignition disconnect mechanism upon uncapping of a natural gas fuel tank. Various aspects of the invention described herein may be applied to any of the particular applications set forth below or in any other type of fuel storage/delivery setting. The invention may be applied as a standalone method or system, or as part of an integrated fuel storage/delivery system. It shall be understood that different aspects of the invention can be appreciated individually, collectively, or in combination with each other.

[0027] FIG. 1A is a schematic of a vehicle **100** with a fuel system **110** mounted thereon. A vehicle **100** may be any type of vehicle known in the art. A vehicle may be a truck, such as a light duty truck (e.g., class 1, class 2 or class 3), medium duty truck (e.g., class 4, class 5 or class 6), or heavy-duty truck (e.g., class 7 or class 8). In some embodiments,

the vehicles may be cars, wagons, vans, buses, high-occupancy vehicles, dump trucks, tractor trailer trucks, transit, refuse or heavy-duty vehicles, or any other vehicles. The vehicle may have any weight. For example, the vehicle may weigh more than or equal to about 5000 lbs, 7,500 lbs, 10,000 lbs, 12,500 lbs, 15,000 lbs, 17,500 lbs, 20,000 lbs, 22,500 lbs, 25,000 lbs, 30,000 lbs, or 35,000 lbs.

[0028] The fuel system **110** may be mounted to the vehicle in various configurations. For example, in a side mount configuration, a fuel system **110** may be installed on the side of the vehicle frame rail (not shown). Fuel systems may be installed on one or both sides of the vehicle, providing, for example, standard fuel capacities, measured in diesel gallon equivalents (DGE), of 40 DGE, 60 DGE or 80 DGE. In another example, in a behind-the-cab configuration, a fuel system **110** may be installed behind the cab on the vehicle frame rail, providing, for example, standard fuel capacities of 45 DGE, 60 DGE, 75 DGE or 100 DGE. In a further example, in a roof mount configuration, a fuel system **110** may be installed on the roof of the vehicle body or in a custom integration, providing a wide range of customizable fuel capacities. In an additional example, in a front-of-the-body configuration, a fuel system **110** may be installed in front of the vehicle body, providing, for example, standard fuel capacities of 60-75 DGE.

[0029] A vehicle **100** may be propelled by a fuel, including, but not limited to, compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), dimethyl ether (DME), methanol, ethanol, butanol, Fischer-Tropsch (FT) fuels, hydrogen or hydrogen-based gas, hythane, HCNG, syngas and/or other alternative fuels or fuel blends. For example, natural gas in the form of CNG or LNG may be an alternative fuel of choice for transit, refuse, and many other heavy-duty vehicles.

[0030] The fuel may be stored as a compressed gas, as a liquefied gas or as a liquid under its own vapor pressure. The fuel may be stored in an on-board fuel system **110**, comprising a fuel tank, vessel, or any other type of device capable of containing a fuel in compressed gas, liquefied gas or liquid form. Any description of a fuel tank herein may also be applied to other types of fuel containing devices.

[0031] The fuel tank may be configured in accordance with the chosen fuel storage mode. For example, compressed gases, such as CNG, may require that the fuel tank be outfitted with adequate high pressure components (e.g., high pressure seals, relief valves, compression devices), wherein high-strength and lightweight materials may allow CNG pressures up to, for example, 3,600 psig. In another example, liquefied gases, such as

LNG, may require that the fuel tank be outfitted with adequate liquefaction components (e.g., coolers, liquid-vapor separators, insulation). LNG systems may operate at pressures of, for example, 0 psig, 50 psig, 100 psig, 150 psig, 200 psig, 250 psig, 300 psig, or 350 psig and temperatures of, for example, -259°F, -223°F, -200°F, -186°F, -175°F, -167°F, -158°F, or -150°F, requiring the use of cryogenic (about -260°F) piping systems and vacuum-insulated storage tanks.

[0032] In some embodiments, a vehicle **100** may contain a single fuel tank. In other embodiments, the vehicle may contain a plurality of fuel tanks. The tanks may or may not have the same characteristics. The tanks may be mounted to any portion of the vehicle. In some embodiments, the tanks may be mounted to a side of the vehicle. One, two, or more tanks may be mounted on a single side of the vehicle, or on each side of the vehicle. The side-mounted tanks may at least partially protrude from a side surface of the vehicle.

[0033] The one or more fuel tanks may provide storage for a predetermined amount, or capacity, of fuel. For example, for natural gas measured in diesel/gasoline gallon equivalents (where 1 gasoline gallon equivalent (GGE) = standard cubic feet (SCF) of natural gas divided by 123, and 1 diesel gallon equivalent (DGE) = standard cubic feet (SCF) of natural gas divided by 139), the amount of fuel provided on board the vehicle may be, for example, up to about 28 DGE, 45 DGE, 52 DGE, 60 DGE, 63 DGE, 70 DGE, 75 DGE, 80 DGE, 88 DGE, 92 DGE, 140 DGE, 100 DGE, 105 DGE, 176 DGE, more than 176 DGE.

[0034] The fuel tank may have any size, shape and/or weight. For example, the fuel tank may be larger than, smaller than, or about the same size as a 5 gallon tank, 7 gallon tank, 10 gallon tank, 15 gallon tank, 20 gallon tank, 25 gallon tank, 30 gallon tank, 40 gallon tank, 50 gallon tank, or 70 gallon tank. The fuel tank may weigh more than, less than, or equal to about 0.01 tons, 0.03 tons, 0.05 tons, 0.07 tons, 0.1 tons, 0.2 tons, 0.3 tons, 0.5 tons, 0.7 tons, or 1.0 tons. For example, the fuel tanks may be of cylindrical form with dimensions (radius in inches x length in inches) of, for example, 25" x 61", 25" x 80", 25" x 90", 26" x 80", 26" x 90", 26" x 120", 26" x 76", 16" x 80", 21" x 86", 16" x 120", 21" x 70", 21" x 86", and one or more cylinders may be combined to achieve a predetermined total fuel capacity.

[0035] The fuel system **110** may be capable of containing a fuel at a predetermined pressure. For example, the fuel system **110** may be capable of containing a fuel having a pressure of less than or equal to about 10000 psig, 8000 psig, 7000 psig, 6500 psig, 6000

psig, 5500 psig, 5000 psig, 4750 psig, 4500 psig, 4250 psig, 4000 psig, 3750 psig, 3500 psig, 3250 psig, 3000 psig, 2750 psig, 2500 psig, 2000 psig, 1500 psig, 1000 psig, 500 psig, 300 psig, 100 psig, or less.

[0036] The fuel system **110** may have one or more fuel outputs. The fuel output may transfer the fuel to another part of the vehicle **100**, such as an engine. In one example, the fuel may be output to mix with air in the cylinder of an engine. The fuel may be used in the process of propelling the vehicle. Further, the fuel system **110** may have one or more fuel inputs. The fuel inputs may transfer the fuel from an external fuel supply to another part of the vehicle **100**, such as the one or more on-board fuel tanks.

[0037] FIG. **1B** is a schematic of the fuel system **110**. The fuel system **110** may comprise a fuel tank **120** into which fuel from an external fuel supply **130** is supplied through a fuel tank fill system **140**. The fuel fill system may comprise a fill cap **150** removably connected to a fill receptacle **160**. In some embodiments, the fill receptacle **160** may be in communication with the fuel tank **120** via a fuel distribution system **170**. The fuel system may further be in electronic communication with a control unit **180** via an indicator (e.g. a wire) **190**. The fuel system may be housed in a cover (not shown), which may be mounted to the vehicle, and may serve to contain and protect the fuel tank **120** and other fuel system components. The cover may be made of a variety of materials, including, but not limited to, metal or metal alloys (e.g., steel, iron, aluminum, titanium, copper, brass, nickel, silver, or any alloys or combinations thereof, composite materials (e.g., carbon fiber, fiberglass), or polymer materials. The cover may be made of a single material or may comprise multiple pieces made of different materials.

[0038] One or more fuel systems **110** may be provided on board the vehicle. For example, a vehicle having multiple fuel tanks **120** may have multiple fuel tank fill systems provided at each fill location on the vehicle. For example, a vehicle may have one or more fill locations, such as near the driver-side vehicle door, in the rear of the vehicle, on the roof of the vehicle etc. In another configuration, each fuel tank **120** may be accessed via multiple fuel tank fill systems **140**, i.e., each fuel tank may have multiple inlets. Further, each fuel tank fill system **140** may or may not comprise a fuel distribution system **170**. Thus, one or more fill locations may include a fill cap **150** removably connected to a fill receptacle, wherein the fill receptacle may be connected directly to the fuel tank **120**.

[0039] The fuel system **110** may be used to provide fuel to the fuel tank **120**. The fuel system **110** may also be used to provide fuel from the fuel tank **120** to, for example, the

vehicle engine. Fuel to and/or from the fuel tank may be transferred using a fuel distribution system **170**. The fuel distribution system **170** may comprise one or more flow transfer components, one or more flow conditioning components and/or one or more flow control components. For example, a flow distribution system **110** for CNG may comprise one, two, or more check valves at and/or downstream of the fill receptacle **160** along a gas flow path from the fill receptacle **170** to the fuel tank **120**. The one or more check valves may ensure that gaseous fuel is transferred in one direction only (toward the fuel tank).

[0040] The fuel distribution system **170** may be rated at a predetermined pressure (e.g., 3600 psig) and may be required by law to include the one or more check valves. The gas may be transferred via standard gas flow components known in the art (e.g., standard stainless steel, brass or other suitable tubing, check valves, shutoff valves, solenoid valves, bleed valves, relief valves, pressure regulating valves, filters). Further, the fuel distribution system may or may not comprise a pressure manifold. The pressure manifold may include one or more gas inlets and/or outlets (e.g., from multiple fill receptacles, to multiple fuel tanks and/or engine manifold inlets), one or more bleed valves, one or more pressure transducers and/or additional flow components. In some embodiments, a fuel distribution system may comprise a fuel transfer line from the fill receptacle **160** to the fuel tank **120**, and a fuel transfer line from the fuel tank **120** to the vehicle engine. The paths may or may not partially coincide, for example, by providing a single transfer flow path to the fuel tank and a tee connector or a 3-way valve to enable multiple transfer lines to feed fuel to and/or from the fuel tank.

[0041] The fuel distribution system **170** may further comprise a $\frac{1}{4}$ turn shutoff valve and/or other flow regulating device on one or more outlets from the pressure manifold and/or any transfer line regardless of the presence or absence of a pressure manifold. For example, a (manual) $\frac{1}{4}$ turn shutoff valve may be provided on the transfer line from the pressure manifold to the gas tank. In some embodiments, the fuel transfer line to the fuel tank may be bidirectional, i.e., the $\frac{1}{4}$ turn shutoff valve may allow flow in both directions. Alternatively, 3-way, 4-way or other valve types may be used.

[0042] One or more electronically-controlled shutoff valves, such as solenoid valves, may also be provided, for example, on the transfer line from the pressure manifold to the vehicle engine. Solenoid valves may be combined with other gas regulating valves, such as, for example, a pressure regulator downstream of the solenoid valve. For example, the

transfer line to the vehicle engine (e.g., via the engine distribution manifold) may include a solenoid valve in series with a downstream pressure regulator.

[0043] The one or more solenoid valves may or may not be in electronic communication with the control unit **180**. In some embodiments, the one or more solenoid valves may be in electronic communication with one or more other control units provided on the vehicle. The control unit **180** or another control unit may provide an electronic signal to the solenoid valve. For example, the solenoid valve may remain in a closed position until power is provided by a control unit to activate (i.e., open) the solenoid valve. In some cases, a flow measurement device may be provided that may close the solenoid valve if the fuel flow rate exceeds a predetermined value. Such closure of the solenoid valve may be further communicated to one or more control units.

[0044] Any control unit provided on the vehicle may have capability to send an audible or visual control signal (e.g., an alarm sound, or alarm symbol on the vehicle drive board) to the operator of the vehicle. Furthermore, any control unit provided on the vehicle may have capability of automatically providing one or more control signals to one or more other vehicle systems. Control unit signals and/or system actuation may be automatic. In some cases, control unit signals may prompt the vehicle operator (i.e., driver) to provide an input. The vehicle may be configured to allow automatic control, manual user control and/or a combination thereof.

[0045] The fuel tank fill system **110** may include one or more filters. The filters may be provided on a fuel transfer line from the fill receptacle to the pressure manifold, on a fuel transfer line from the pressure manifold to the fuel tank, on a fuel transfer line from the pressure manifold to the engine, on a fuel transfer line from the fill receptacle directly to the fuel tank, on a fuel transfer line from the fuel tank to the engine, etc. Any filter known in the art, including sieves, chemical adsorption and other inline filters, may be used.

[0046] In embodiments requiring cooling and/or insulation, such as in LNG fuel systems, the fuel system components may be appropriately outfitted with insulation, chillers and/or other components known in the art. For example, the fuel transfer lines and the fuel tank may be wound with insulation.

[0047] The control unit **180** may comprise one or more electronic control circuits, such as the control circuit including the wire **190**. In some embodiments, one or more indicators (e.g., an actuators, a trigger, a magnet) and one or more indicator receivers (e.g., a read sensor) may be used instead or in addition to a wire control circuit. Thus, any description

herein of control circuits having one or more wires may also be applied to control circuits having other types of indicator(s) and indicator receiver(s), and vice versa. Further, any description of components of the wire control circuit provided on the fill cap and/or in region(s) for receiving the fill cap, or functionality thereof, may also be applied to control circuits having other indicator(s) and/or indicator receiver(s), and vice versa. The control circuit **190** may electronically connect the fill cap **150** to the control unit **180** when the fill cap **150** is connected to the fill receptacle **160** (closed circuit). When the fill cap **150** is disconnected may correspond to an open circuit condition. The control unit **180** may actuate, electronically communicate with or otherwise control other systems on board the vehicle, such as, for example, a vehicle ignition system. In some embodiments, the control unit **180** may provide one or more control signals to the other vehicle systems based on the status of the control circuit **180**. For example, the control unit **180** may disconnect the engine ignition system when a change in circuit condition exists at the control circuit **190** due to the fill cap **150** being disconnected from the fill receptacle **160**. In one example, a change in a circuit condition may be a change from a closed circuit condition to an open circuit condition. Examples of responses to various circuit conditions include, for example, starting (e.g., connecting) one or more systems on board the vehicle, stopping (e.g., disconnecting) one or more systems on board the vehicle, controlling or actuating (e.g., continuously) one or more systems on board the vehicle in accordance with changes in circuit condition etc. In some cases, the open circuit condition may correspond to a stop or disconnect response, while in other cases, the open circuit condition may correspond to a start or connect response. Similarly, in some cases, the closed circuit condition may correspond to a start or connect response, while in other cases, the closed circuit condition may correspond to a stop or disconnect response. Further, start/connect and/or stop/disconnect responses may be triggered with a delay or upon a predetermined extent of change in circuit condition.

[0048] FIG. **2A** is a photograph of an ignition disconnect rubber cap **255**. The ignition disconnect rubber cap **255** is connected to a fill receptacle (not shown). In some cases, the ignition disconnect rubber cap **255** comprises a wire contact **290**. The ignition disconnect rubber cap **255** can be pressed onto the fill receptacle (e.g., any fill receptacle **160**, such as, for example, fill receptacle **464** in FIGs. **4A-C**) in order to cap a fuel tank, and pulled off the fill receptacle to open access to a fuel tank. Connection between the ignition disconnect rubber cap **255** and the fill receptacle may easily be disrupted through

mechanical means. Alternatively, air trapped between the rubber and the receptacle may expand due to heat absorbed at the rubber cap and cause the rubber cap to pop off the fill receptacle.

[0049] FIG. 2B is a photograph of an ignition disconnect rubber cap with an embedded wire 290 used to complete an ignition circuit. When the rubber cap 255 is connected to the fill receptacle (e.g., any fill receptacle 160, such as, for example, fill receptacle 464 in FIGs. 4A-C), the vehicle ignition is active and the vehicle engine can be started. If it is taken off, the vehicle ignition cannot be turned on. However, a need remains in providing an ignition disconnect cap that does not fall off when it is not supposed to. Improved systems and methods are needed in order to provide a secure connection to cover the fill receptacle.

[0050] With reference to FIG. 3, an aspect of the invention relates to an ignition disconnect fill cap 350 with a mating fill receptacle that are part of a fuel system on board a vehicle. The mating fill receptacle may have an outer receptacle or fill neck 361. The fuel system may be housed in a cover 312, such as a cover made from a composite material. Components of the fuel system, including, but not limited to, the fill cap 350, the fill neck 361, a ¼ turn shutoff valve 390 (only the location of which is shown) and a pressure gauge receptacle 391, may be accessed by a vehicle operator from the outside of the cover 312. Further, access to a tank valve and/or other components may be provided elsewhere on the cover 312, such as, for example, on a side surface of the cover 312.

[0051] The fuel system may be arranged inside the cover 312 in a variety of ways. For example, in a side mount configuration on a vehicle frame rail, a fuel tank may reside in a portion of the cover 312 closest to a front wheel of the vehicle, while a fuel tank fill system may reside in a portion of the cover 312 near a rear wheel of the vehicle. Such an arrangement may be beneficial from a safety standpoint in a collision of the vehicle. Alternative arrangements of fuel system components inside the cover may also be used. For example, the fuel tank fill system may reside in a portion of the cover 312 nearest to the vehicle body, while less sensitive or more impact tolerant components of the fuel system may reside in a portion of the cover farther away from the vehicle body.

[0052] The fill neck 361 may be threaded into, molded together with, welded to, or integrated during composite forming of the cover 312. For example, the fill neck can be wound into the composite cover during forming. In some cases, the fill neck may be attached to a faceplate (e.g., faceplate 796 in FIGs. 7A-B), a fill manifold (e.g., fill

manifold **463** in FIGs. **4A-C** or fill manifold **563** in FIGs **5A-D**). The fill neck may have a fill cap receiving region. The fill cap receiving region may be a threaded connection on the fill neck **361**, such as that shown in FIG. **3**. In other embodiments, the fill cap receiving region may be separately formed, and permanently or removably mounted/attached to the fill neck **361** and/or the cover **312**. Permanent attachment may be achieved by using screws, glue or adhesive, welded connections, solder, heat stakes or other permanent fastening approaches known in the art. Removable attachment may be achieved with suitable mating fasteners, including hooks, latches, grooves, snap fit features (e.g., mechanical or magnetic snap fit features), buttons, twist lock connections or other protrusions and features. In some cases, a compression fit may be achieved between components through suitable mechanical coupling means. In some embodiments, the fill cap receiving region and/or the fill neck **361** may be integrally formed with the cover **312**.

[0053] Attachment of the fill cap may be accomplished by forming complementary mating features on the fill cap and on the fill cap receiving region. For example, grooves on a mating component may be female fittings complementary to one or more male fittings on a receiving component, and protrusions on a mating part may be male fittings meant to twist, slide, retractably click or otherwise connect to female receptacles on the receiving component. Complementary mating features may include, but are not limited to, extruded features (e.g., flanges, ledges, buttons, pins, brackets, latches, pins or other fasteners), receiving indents, locks, slots, snaps, brackets, collars, clips, clasps, flip handles and/or other features. The complementary mating features may enable secure attachment of the fill cap to the fill neck **361**.

[0054] The fill cap **350** may be formed in a shape that is complementary to the fill neck **361**. For example, the fill cap may be formed with a round cross-section with internal threads **351** that mate with external threads on the fill neck **361**. The fill cap **350** may be formed in a shape that is complementary to other portions of the fill receptacle in addition to the fill neck **361**. Further, the fill cap may be formed of a single piece or of one or more separate pieces joined together. For example, the fill cap **350** may comprise an outer cap **356**, an inner cap **352**, an o-ring or other type of seal **353** and a support plate **354**. As described elsewhere herein (see, for example, FIGs. **5A-D**), the fill cap may further comprise pins, latches, protrusions or other mating members for connecting to the fill neck **361**. One or more fastening members, such as the screws **355**, any type of bonding

(e.g., adhesives, welded connections, solder, heat stakes), press-fits, snap fits, pins, or any other connecting means known in the art may be used to attach separate pieces together.

[0055] The fill cap **350** may be formed as concentric tubular pieces of round, square, rectangular, irregular or other cross-sections. The fill cap **350** may be formed of one, two, or more concentric tubular sections, which may be integrally or separately formed. The tubular assembly may be open on one end in the direction of connection with the fill neck **361**. On its other end, the tubular assembly may be closed, thereby forming a cap. Alternatively, as described elsewhere herein, the fill cap **350** and the mating fill receptacle with the fill neck **361** may be formed in a substantially non-twist, non-tubular fashion, such as, for example, as a clip, a cam lock, a pin or a clasp.

[0056] FIG. 4A shows an ignition disconnect fill cap **450** and fill receptacle **460** without a fill neck attached (also referred to herein as an “inner receptacle”) in accordance with the present invention. The fill neck may be provided separately. The fill cap **450** may or may not comprise an inner cap **452** made from, for example, a hard plastic material such as acetal, acetate, celluloid, resin, polystyrene or other plastic. The inner cap **452** may be suspended to an outer cap **456**, made from the same materials as the inner cap **452** or, for example, a metallic material such as aluminum, stainless steel, brass or other metal. In some cases, the fill cap **450** may not include the inner cap **452**. One or more actuators, triggers and/or magnets (collectively referred to herein as “indicators”), including, for example, portions of electric wire (not shown), may be provided on (e.g., embedded in or secured to) the outer cap **456**. Alternatively, the one or more actuators/triggers/magnets (e.g., portions of electric wire) may be embedded in or secured to (e.g., fastened, screwed, bolted, glued, welded, soldered, or otherwise engaged with) the inner cap **452**. In some cases, the one or more actuators/triggers/magnets (e.g., portions of electric wire) may be embedded in or secured to one or more of the following: the inner cap **452**, to the outer cap **456**, a support plate **454** or a seal **453**. The one or more actuators/triggers/magnets (e.g., portions of electric wire) may be molded into, or attached on the fill cap **450** using screws, glue or adhesive, welded connections, solder, heat stakes or other fastening approaches known in the art. The actuators/triggers/magnets (e.g., electric wire) may or may not be exposed on the body of the fill cap **450**. For example, the actuators/triggers/magnets (e.g., electric wire) may be fully contained within the fill cap **450** with electrical contacts accessible in one, two or more locations. The electrical

contacts may be surface contacts, or may be provided as, for example, indents, buttons or jacks. When connected to the fill receptacle **460** and/or a fill neck (e.g., fill neck **361** in FIG. **3**), the actuators/triggers/magnets (e.g., electric wire) embedded in or secured to the fill cap **450** may complete a control circuit or activate a read sensor or other system component capable of disconnecting a vehicle engine ignition system. The vehicle engine ignition system may be disconnected when an open circuit condition exists at the control circuit. For example, the electric wire may connect the control circuit with an engine starter motor directly, via a relay and/or via a signal from a controller. In such a configuration, upon interruption of the control circuit, the starter motor may not engage. The fill cap **450** may be formed of one, two or more parts. The parts may be formed of different materials, including, but not limited to, metals or metal alloys (e.g., steel, iron, aluminum, titanium, copper, brass, nickel, silver, or any alloys or combinations thereof), hard or soft plastics (e.g., acetal, acetate, celluloid, resin, polystyrene, rubber, all types of polymers, vinyls), or composite materials (e.g., carbon fiber, fiberglass). Alternatively, the fill cap may be formed as a single piece formed from any of these materials. For example, the fill cap **450** may be a single piece formed from metal (e.g., all brass), a single piece formed from acetate, a single piece formed from plastic etc.

[0057] Similarly to the fill cap **450**, the fill neck (e.g., fill neck **361** in FIG. **3**) and/or the fill receptacle **460** may comprise one, two or more separate pieces, which may, for example, be arranged concentrically. For example, the fill receptacle **460** may comprise a heavy-duty diesel-type or gasoline-type inner receptacle **464**. Embodiments of the invention may include inner receptacles **464** with various diameters and corresponding fuel flow capacities, such as, for example, diameters (in inches) of more than, less than, or equal to about 1/8", 1/4", 1/2", 3/4", 5/6", 1", 1 1/2", 2", 2 1/2", 3", 4", 5", 6", 7" or more. Further, the fill receptacle **460** may comprise one or more fastening members, such as a bulkhead (through-hole) fitting **462** used to secure the fill receptacle to one or more walls, flanges or other structural components. Fastening members may also include other fittings, flanges, or connectors known in the art, one or more holding pieces, shells or fill manifolds **463** etc.

[0058] As described elsewhere herein, the fill receptacle **460** may also comprise an outer receptacle (also referred to herein as a "fill neck"). The fill neck may be separately formed. For example, the fill neck may be attached to a fuel tank cover, while the remainder of the fill receptacle **460**, including the inner receptacle **464** (e.g., as shown in

FIG. 4A), may be secured to the rest of the piping in a vehicle fuel tank fill system. The fill neck may or may not be attached to the inner receptacle and/or other pieces of the fill receptacle 460. For example, the fill receptacle of FIG. 4A may be supported by the rigidity its connection to the piping system, while the fill neck may surround the fill receptacle without mechanical contact between the two. Alternatively, the fill receptacle of FIG. 4A may be mechanically supported by and/or attached to the fill neck.

[0059] In some cases, a separate fill neck may not be used. Instead, the fill neck may be integrally formed with the inner receptacle 464 and/or other pieces of the fill receptacle 460. Thus, any description of features of the fill neck or the outer receptacle herein may also be applied to the inner receptacle and/or other pieces of the fill receptacle 460, and vice versa. A through hole or other transfer line/conduit may be provided at the fill receptacle 460 to allow fuel to be transferred from the fill receptacle to the fuel tank.

[0060] In some embodiments, the fill cap 450 may have one or more internal threads 451 that may mate with external threads of the fill receptacle, or a portion of the fuel tank cover. In one example, the inner cap 452 may mate with the inner receptacle 464 and the internal threads 451 may mate with an outer receptacle connector. In some embodiments, the inner cap and inner receptacle may form an inner connection via one or more threads, interlocking mechanisms, mating features, gaskets, seals, or other connection mechanisms. The inner cap and inner receptacle may press-fit with respect to one another. In some cases, as described in more detail elsewhere herein, the inner cap may not be used. Any of the connection mechanisms described herein with respect to the inner cap may also apply to connection mechanisms provided on the outer cap. Thus, the outer cap may, in some cases, replace at least a portion of the functionality of the inner cap. In some instances, the outer cap and outer receptacle may form an outer connection via one or more threads, interlocking mechanisms, gaskets, seals, or other connection mechanisms. The outer cap and outer receptacle may press-fit with respect to one another. The inner connection and the outer connection may be the same type of connection or different types of connections. In one example, an outer connection may have a screw-connection with mated threads while the inner connection may be a press-fit connection. As described elsewhere herein, various other connection types may be employed for the inner and/or outer connections, such as, for example, snap fits, quick connects, press-fits, magnetic connections, twist-locks, pins for locking in place, flip handles, collars, or any other secure mating connections.

[0061] FIG. 4B shows positive placement of the ignition disconnect fill cap 450 onto a fill receptacle 460. The inner receptacle 464 may be an off-the-shelf receptacle or a custom-made receptacle. For example, the receptacle may be specifically configured for handling a particular fuel, high pressure or other specific requirements. The inner receptacle 464 may also be designed to appropriately connect to a fuel supply nozzle and/or other fuel fill equipment. The fill cap 450 may easily be adapted to be received on any given type of inner receptacle 464. The inner cap 452 may be designed to receive and/or fit snugly onto a mating inner receptacle 464. As shown in FIGS. 4A-4B, the inner receptacle 464 may be outfitted with a threaded connection (or other connection type). A mating threaded connection may be provided on the inner cap 452 of the fill cap 450. Thus, a fill cap 450 may be attached to a fill receptacle 460 by multiple threaded or other connection mechanisms, such as the threaded connection between the inner cap 452 and the inner receptacle 464, and the outer cap 456 and an outer receptacle (not shown). As described elsewhere herein, one or more actuators/trigger/magnets, such as, for example, one or more portions of electric wire (not shown) may be provided in one or more locations on the fill cap 450. The control circuitry of the invention may require positive placement and secure connection to be sensed at multiple threaded (or other) connections in order not to trigger an ignition circuit disconnect condition. In some cases, the control circuitry may require an indicator (e.g., an actuator) to be within a given distance from an indicator receiver (e.g., a read sensor) in order not to trigger, for example, an ignition circuit disconnect condition, or a circuit change condition. For example, when the fill cap 450 is connected, the electric wire provided at the fill cap may be electrically connected to the control circuit via the fill neck. The fill neck may be outfitted with electric wire and/or may be made of an electrically conducting material. The fill neck may be in electronic communication with the control circuit. In another example, when the fill cap 450 is connected, the electric wire provided at the fill cap may be electrically connected to the control circuit at one or more other locations on the fill receptacle 460. Electrical connection of the fill receptacle 460 to the rest of the control circuit may be provided through any means of electrical connection known in the art.

[0062] The inner receptacle may be removably or permanently interconnected with one or more other parts of the fill receptacle 460. Any connection means known in the art and described in elsewhere herein may be used to assemble the fill receptacle 460. Further, the inner receptacle 464 may be connected to downstream components of a fuel tank fill

system via any connection means known in the art, such as, for example, through a metal (e.g., stainless steel, carbon steel, brass) tube fitting **466** connected to standard pipe tubing downstream of the fill receptacle **460**.

[0063] The fill receptacle **460** and/or its individual parts may be formed from a range of materials analogous to the fill cap **450**. Thus, any description of materials used to form the fill cap **450** may also be applied to the fill receptacle **460** and/or the fill neck (e.g., fill neck **361** in FIG. 3). The fill cap **450**, the fill receptacle **460** and/or the fill neck (e.g., fill neck **361** in FIG. 3) may each be assembled from multiple materials. The materials may be selected to allow interconnection between the fill cap and the fill receptacle, and between the fill receptacle and other parts of a vehicle fuel system (e.g., via the tube fitting **466**). In some cases, the fill cap, the fill receptacle, the fill neck or a combination thereof may be made of the same material throughout (e.g., all brass).

[0064] FIG. 4C is a side view of the ignition disconnect fill cap **450** partially connected to a fill receptacle **460**, with the threads on the inner cap **452** engaged with the threads on the inner receptacle **464**. Due to the positive placement provided herein, the fill cap may not fall off the fill receptacle because it may be screwed onto the fill neck of the fill receptacle attached to the vehicle's fuel system. Thus, a positive connection may be made and may ensure that the fill cap **450** may not fall off.

[0065] The fill receptacle **460** may be outfitted with an outer (threaded) receptacle or fill neck **461**. The fill neck **461** may be formed of any suitable material described herein, such as, for example, aluminum metal. The fill neck may be integrated with a fuel tank cover (e.g., wound into a composite fuel tank cover) in order to provide a secure connection of the fill fuel receptacle to the vehicle's fuel system. In some cases, the fill neck **461** may be formed with an extended body **467**, used to secure or fasten the fill neck **461** to the vehicle. Once the fill neck **461** is secured to the vehicle, as shown in FIG. 3, the threads on the outer cap **456** may be engaged with the threads on the fill neck **461**, and the electric circuit through the fill cap **450** may be completed.

[0066] A further aspect of the invention relates to an ignition disconnect fill cap with a mating fill receptacle that are part of a fuel system on board a vehicle. The fill cap may comprise an indicator, such as, for example, any indicator described herein (e.g., an actuator, a trigger, a magnet, a wired connection, a proximity switch, or a combination thereof). When the fill cap is in proximity of an indicator receiver provided on a vehicle (e.g. on the fill neck, fill manifold, cover, faceplate etc.), the indicator provided on the fill

cap may complete and/or activate a control circuit capable of affecting a response of a vehicle system. The response may be affected upon a change in circuit condition at the control circuit. For example, the response may be that of connecting, disconnecting, activating, sending a signal to, actuating and/or otherwise controlling a vehicle system (e.g., vehicle engine ignition system, one or more electronic control units and/or other systems on board the vehicle).

[0067] The fill cap may comprise one or more mating features. The mating features may be configured to be connected and separated with a complementary mating feature on a fill neck (also “outer receptacle” herein) of a fill receptacle. In some embodiments, the mating features may be configured to be connected and separated with a fill receptacle not having a fill neck, or having an integrated fill neck (e.g., an integrally formed fill neck, a non-separable fill neck etc.).

[0068] FIG. 5A shows an ignition disconnect fill cap 550, a fill receptacle 560 with fill neck 561 and a fill manifold 563. As described elsewhere herein, the fill cap may be made from, for example, a hard plastic material such as acetal, acetate, celluloid, resin, polystyrene or other plastic, a metallic material such as aluminum, stainless steel, brass or other metal. The fill cap may be integrally molded or formed from one or more separate pieces. In this embodiment, the fill cap may not comprise an inner and an outer portion inner cap portion; a single cap body may be used. The fill cap 550 may be formed with one or more mating features for attachment of the fill cap on a fill cap receiving region (e.g., the fill neck 561). The fill cap receiving region may have complementary mating features, such as, for example, any mating features described herein. For example, the fill cap 550 may have one or more pins 557 for mating with a complementary groove on the fill neck 561 (e.g., as shown in FIGs. 5A-5D). The fill cap and/or the fill cap receiving region may have one, two or more pins or latches (or other mating features) and one, two or more complementary slots (or other mating features). The mating features may be integral to the fill cap and/or the fill cap receiving region (e.g., the neck 561).

Alternatively, the mating features may be provided separately on the fill cap and/or the fill cap receiving region. For example, the fill cap may have two pins that may be formed of a different material (e.g., metal) than the fill cap itself (e.g., hard plastic). The pins, latches or other mating features may be used to connect the fill cap to the fill neck 561 or to one or more alternative fill cap receiving regions. The mating features may allow for a twist-lock connection (e.g., the pins may snap into position inside the groove). The pins

and/or the groove may be formed to facilitate engagement with complementary features and to allow a secure end position of the mating connection.

[0069] The fill receptacle may have an inner receptacle **564**. The inner receptacle may be of any of the types described elsewhere herein. The inner receptacle may be attached or supported by the fill manifold **563**. The inner receptacle may be in fluid communication with the fill manifold. The fill manifold may distribute one or more fuel flows from the receptacle to one or more locations in the fuel system. The fill manifold may have one or more outlets (not shown). The connection between the inner receptacle and the fill manifold may be provided by a fitting, such as, for example, a bulkhead (through-hole) fitting **562**, or any other mechanical and/or fluid connector known in the art.

[0070] The fill cap may comprise an indicator, such as, for example, an actuator, a trigger, a magnet, or a combination thereof. The indicator may interact with an indicator receiver provided, for example, on the fill neck, on a cover, on the fill manifold, on a faceplate on a cover, or a combination thereof. For example, the fill cap **550** may comprise an indicator (not shown) that interacts with an indicator receiver, such as, for example, a read sensor **592** in the fill neck **561**, as described in more detail elsewhere herein. The indicator receiver located in the fill neck may be part of one or more control circuits. For example, the indicator in the fill neck may be in electric communication with one or more control circuits one or more wired or wireless connections. The indicator receiver may be embedded in the fill neck, in the cover, in the fill manifold, in the faceplate, or a combination thereof.

[0071] FIG. **5B** is an exploded view of an assembly of the ignition fill cap **550**, the fill receptacle **560**, the fill neck **561** and the fill manifold **563**. The pins **557** on the fill cap **550** may be positioned such that they may engage with the grooves on the fill neck **561**. The fill neck may be positioned such that the inner receptacle with the fitting **562** may slide through it, and the fill neck may be held in position and supported by the fill manifold **563**. In some cases, the fill neck, the fill manifold and/or the fitting may have complementary mating shapes (e.g., a square or hexagonal inside/outside circumference). For example, the inside circumference of the fill neck may engage with the outside circumference of the fitting, thus preventing the fill neck from rotating in its position. Lateral motion of the fill neck may be prevented by the surface of the fill manifold. In some cases (see, for example, FIG. **6**), the inside circumference may be formed by a protruding portion of the fill cap. The protruding portion may be similarly shaped to be

complementary to one or more other components. The connections from the read sensor **592** may be positioned such that they do not interfere with positive placement of the fill cap **550**, fill neck **561** and fill receptacle **560**.

[0072] FIG. **5C** shows an assembly of the fill receptacle **560**, the fill neck **561** and the fill manifold **563**. The fill neck may be attached to fill manifold. In some cases, one or more fasteners or other interlocking mechanisms may be used to securely attach the fill neck on the fill manifold. In some cases, one or more mating features used for positive placement of the fill cap onto the fill neck of the fill receptacle may also be used for positive placement of the fill neck onto the fill manifold (e.g., a dual groove may be used, wherein a first portion of the groove is for connecting the fill neck to the fill manifold, and a second portion of the groove is for connecting the fill cap to the fill neck). The read sensor **592** may be connected to one or more electronic systems on the vehicle.

[0073] FIG. **5D** shows positive placement of the ignition disconnect fill cap **550** onto the fill neck **561** of the fill receptacle. The pin(s) **557** may engage and lock into position, as shown, inside the groove(s) on the fill neck and fill manifold. This locking mechanism may prevent both axial and radial motion of the fill cap with respect to the fill neck. The fill manifold **563** may support the fill cap/fill neck assembly. The fill manifold may be in fluid communication with a fuel distribution system and/or other fuel system components. The read sensor **592** may be in electronic communication with one or more electronic or electromechanical systems in the fuel system or elsewhere on the vehicle.

[0074] FIG. **6** are sectional and perspective views of an ignition disconnect fill cap **650** connected with a receptacle base attachment sleeve or fill neck **661**. The fill cap may comprise an indicator such as, for example, a read sensor trigger **693**. The fill neck may comprise an indicator receiver, such as, for example, a read sensor **692**. The indicator may be secured in a hole or cavity in the fill cap (e.g., a cavity along the circumference of the fill cap). Alternatively, depending on type of indicator (i.e., ruggedness/sensitivity), the indicator may molded into the fill cap, glued into the fill cap, press-fit into an opening in the fill cap, etc. The indicator receiver may be secured in one or more holes or cavities, for example, using silicone. The indicator receiver may contain sensitive electronic circuitry. Thus, in some cases, it may be secured in the holes with silicone. Alternatively, if a more rugged type or design of the indicator receiver is used, it may be press-fit, molded, or otherwise secured into the fill neck. A gasket **665** may be provided between a

portion of the fill cap that protrudes into the fill neck. The gasket may be placed between the fill cap and a support surface onto which the fill neck is seated (e.g., the fill manifold).

[0075] With continued reference to FIG. 6, the inside circumference formed by the protruding fill cap portion may be circular. In some cases, the inside circumference may have a given shape (e.g., hexagonal, irregular, etc.). Further, the fill cap and/or the fill neck may have a formed body. The body may have an irregular shape, a substantially circular circumference, a square/rectangular circumference etc. The shape of the fill cap and mating components may be shaped, grooved to facilitate operation of the fill assembly by a user.

[0076] In some embodiments, the indicator receiver may be activated or triggered only upon complete connection of the fill cap to the fill cap receiving region. In some embodiments, for example, when the indicator receiver is a read sensor, the read sensor may be activated or triggered when the fill cap with the indicator (e.g., an actuator, a trigger, a magnet, or a combination thereof) is placed within proximity of the read sensor. In some cases, the read sensor may be activated or triggered regardless of its location or mating engagement of the fill cap with the fill cap receiving region; i.e., the fill cap may or may not be at least partially connected to the fill cap receiving region (e.g., the fill neck). In some cases, sufficient proximity to activate or trigger the read sensor may not be achieved without at least partially engaging the fill cap with a mating portion on the fill cap receiving region. In some cases, the fill cap may need to be connected with the fill neck (or other fill cap receiving region, such as, for example, an alternative portion of the fill receptacle) in order to activate or trigger the read sensor.

[0077] The fill cap **650** may engage with the fill neck **661** to provide positive placement of the fill cap onto the fill neck of the fill receptacle, wherein mating feature(s) on the fill cap and complementary mating feature(s) on the fill neck of the fill receptacle form a secure connection. The connection may be a twist lock connection (e.g., using the pins and grooves), a press-fit connection (e.g., a quick-connect), a snap-fit connection, or any other type of connection. Thus, a positive connection may be made and may ensure that the fill cap does not fall off of the fill neck/fill receiver.

[0078] In some embodiments, the indicator(s) and indicator receiver(s) may not come in contact with the fuel being filled, thus eliminating risk of explosion. The ignition disconnect functionality provided by the devices, systems and methods herein thus offers safe monitoring of fuel fill processes.

[0079] FIG. 7A is a photograph of a fuel tank cover 712 in accordance with an embodiment of the present invention. The fuel tank cover may comprise a faceplate 796. One or more access points to a fuel system (e.g., the fuel system housed inside the cover) may be provided on the faceplate, including, for example, a ¼ turn (manual) shutoff valve 795, a pressure gauge 791, and one or more fill caps 750 removably connected to one or more mating fill necks 761 of one or more fill receptacles. The fill necks 761 may be attached to the faceplate 796 via, for example, a flanged connection and/or using one or more fasteners for connecting a fill manifold on a back side of the faceplate to a front side of the faceplate positioned on the surface of the cover, thereby squeezing the fill necks, which may be securely affixed to the fill manifolds, into place. Alternatively, any mating and/or other connecting means for connecting components described herein, or any other connecting or fastening means known in the art may be used to secure the fill necks to the faceplate.

[0080] FIG. 7B is a perspective view of the fuel tank cover 712 with the faceplate 796, the ¼ turn (manual) shutoff valve 795, the pressure gauge 791, and the one or more fill caps 750 removably connected to the one or more mating fill necks 761.

[0081] The invention may offer significant advantages with respect to existing options for fuel tank fill systems. The systems and methods herein may be advantageously applied to improve vehicle performance, functionality, reliability and safety.

[0082] While preferable embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

CLAIMS

WHAT IS CLAIMED IS:

1. A vehicle fuel tank fill cap comprising:
an electric wire embedded in the fill cap; and
a mating feature on the fill cap, wherein the mating feature on the fill cap is configured to be connected and separated in a controlled manner, by a vehicle operator, with a complementary mating feature on a fill neck of a fill receptacle at a vehicle, and
wherein the electric wire embedded in the fill cap completes, when the fill cap is connected with the fill neck of the fill receptacle, a control circuit, and
wherein the control circuit is capable of disconnecting a vehicle engine ignition system when an open circuit condition exists at the control circuit.
2. The vehicle fuel tank fill cap of claim 1, wherein the mating feature on the fill cap is a female threaded connection and the complementary mating feature on the fill neck of the fill receptacle is a male threaded connection.
3. The vehicle fuel tank fill cap of claim 1, wherein the mating feature on the fill cap and the complementary mating feature on the fill neck of the fill receptacle include one or more of the following: flange, ledge, button, pin, bracket, latch, pin, receiving indent, lock, slot, snap, collar, clip, clasp, or flip handle.
4. The vehicle fuel tank fill cap of claim 1, wherein the fill cap and the fill receptacle are configured to provide a press-fit connection.
5. The vehicle fuel tank fill cap of claim 1, wherein the mating feature on the fill cap and the complementary mating feature on the fill neck of the fill receptacle form a twist-lock connection.

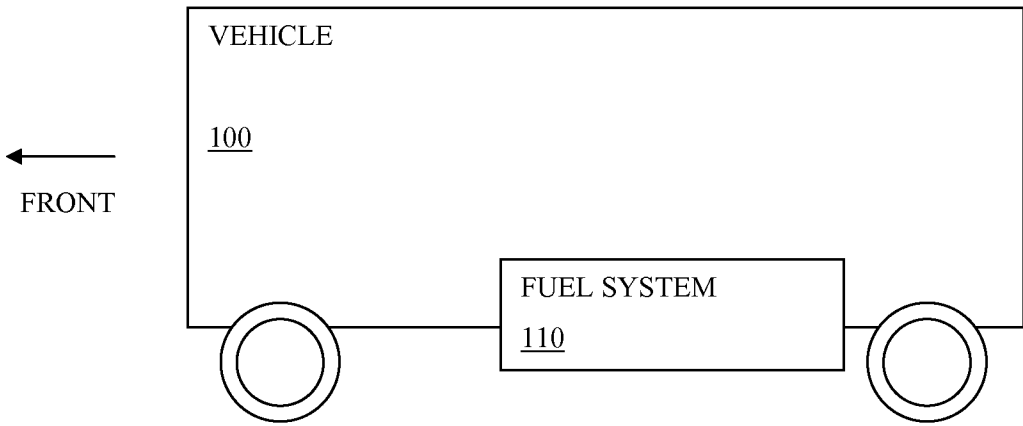


FIG. 1A

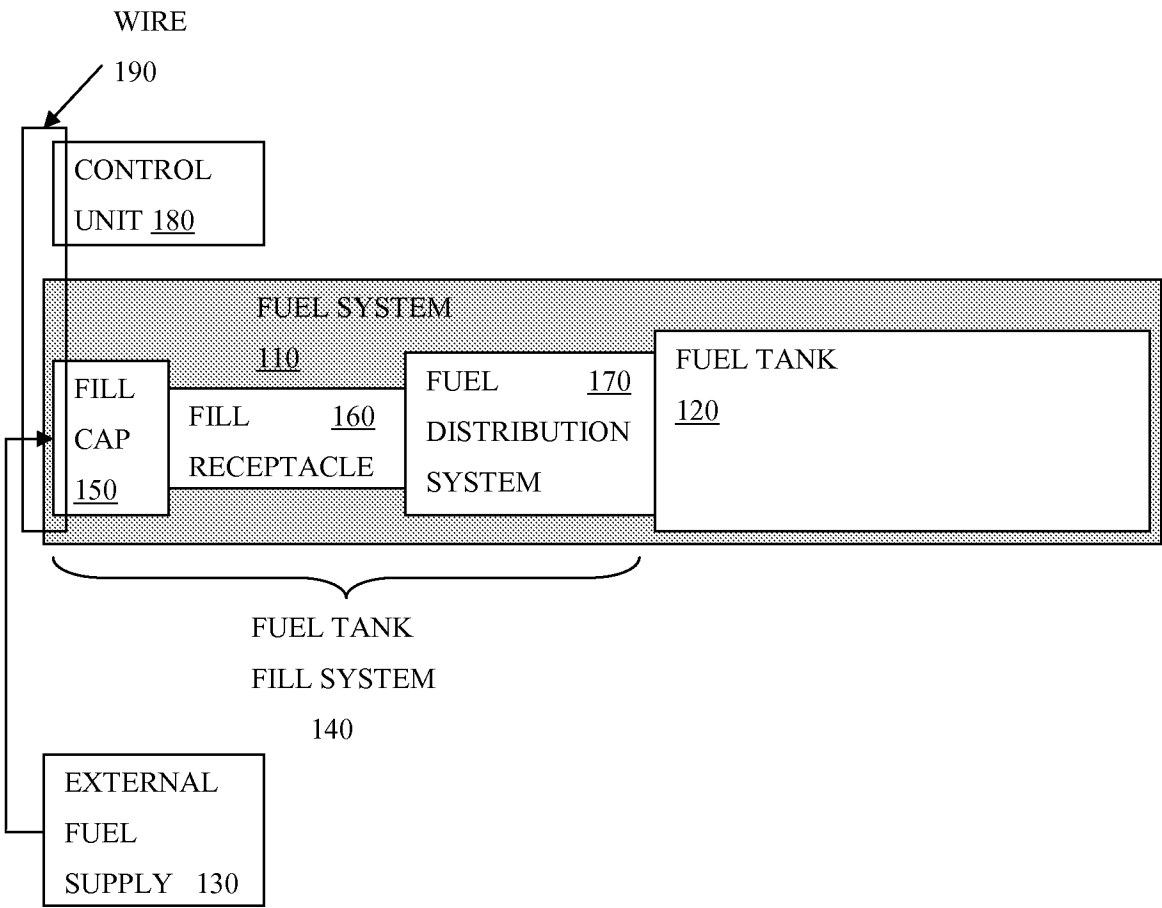


FIG. 1B

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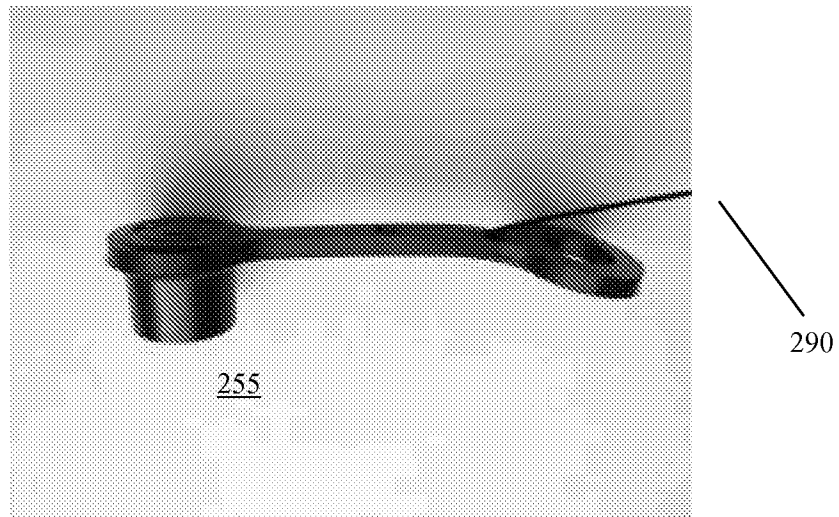


FIG. 2A (PRIOR ART)

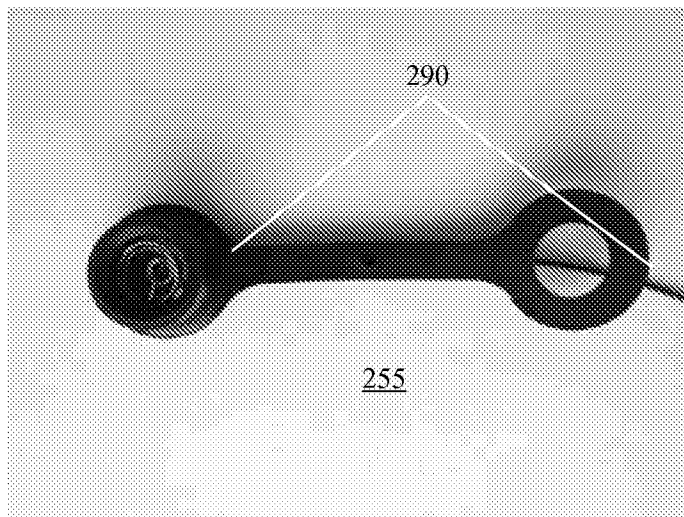


FIG. 2B (PRIOR ART)

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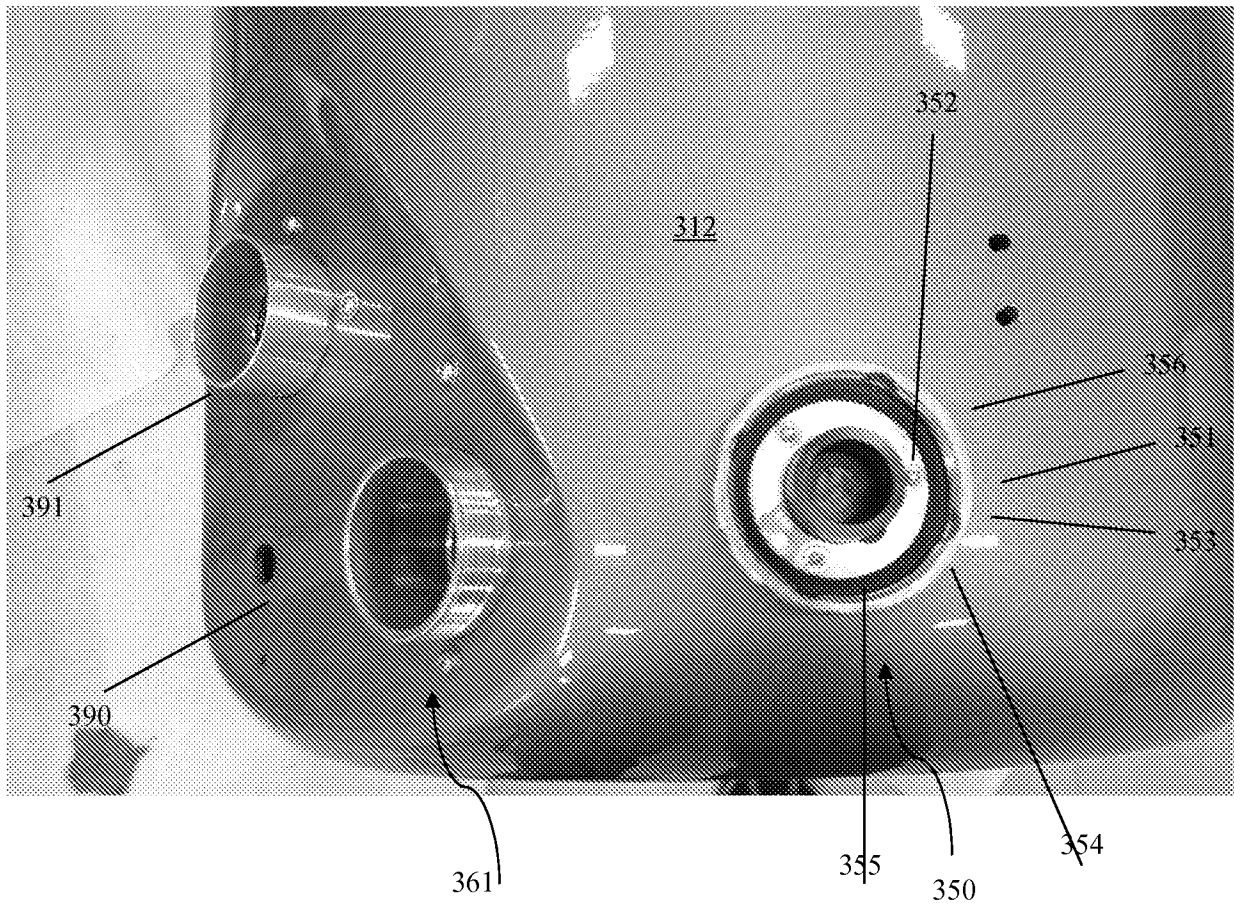


FIG. 3

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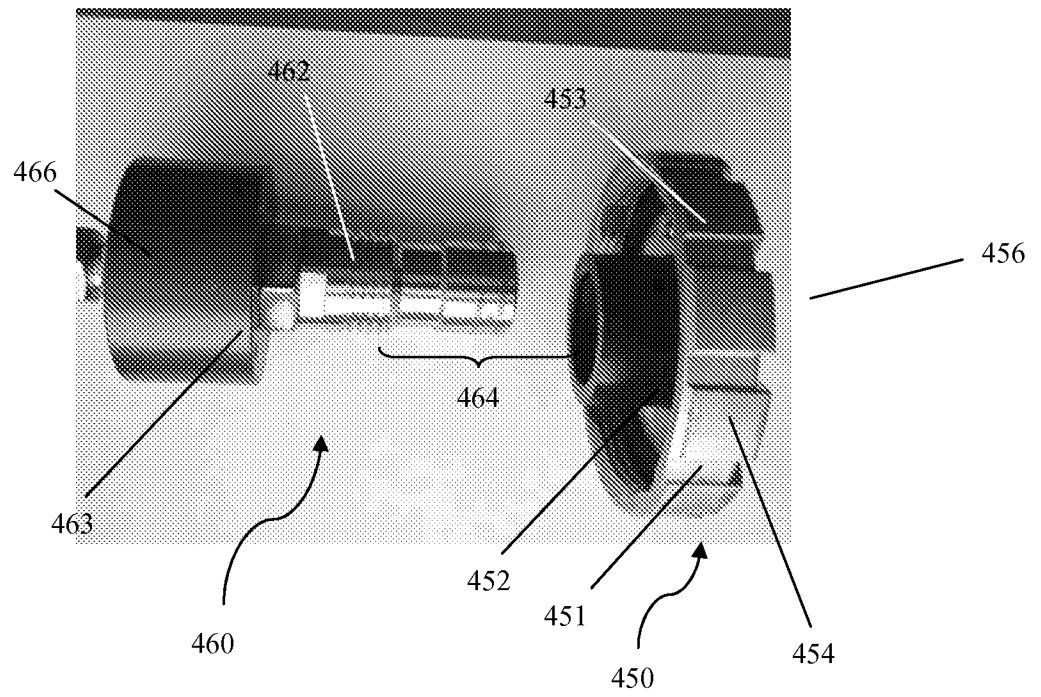


FIG. 4A

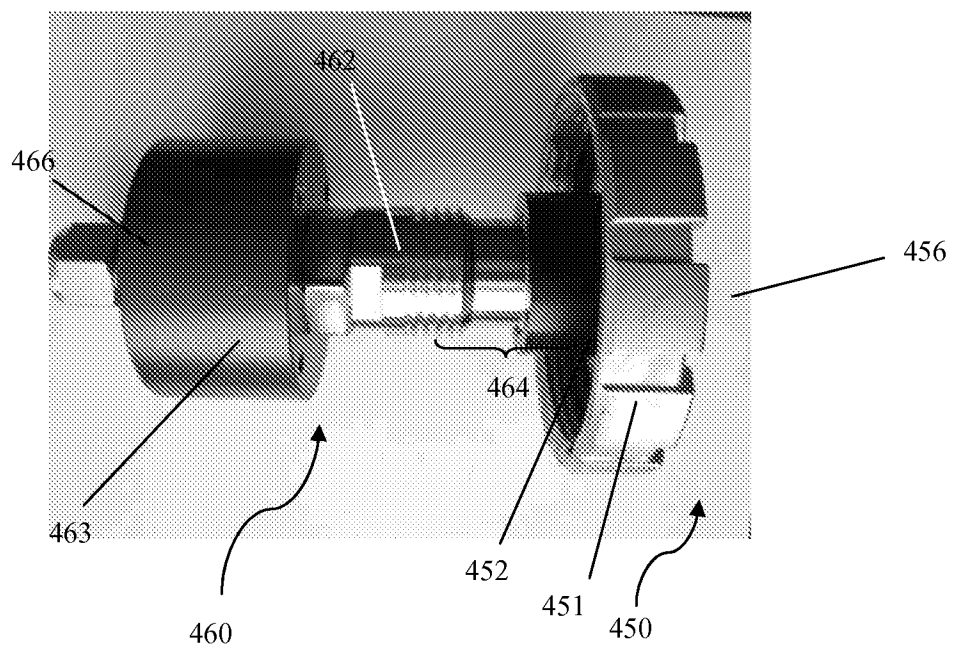


FIG. 4B

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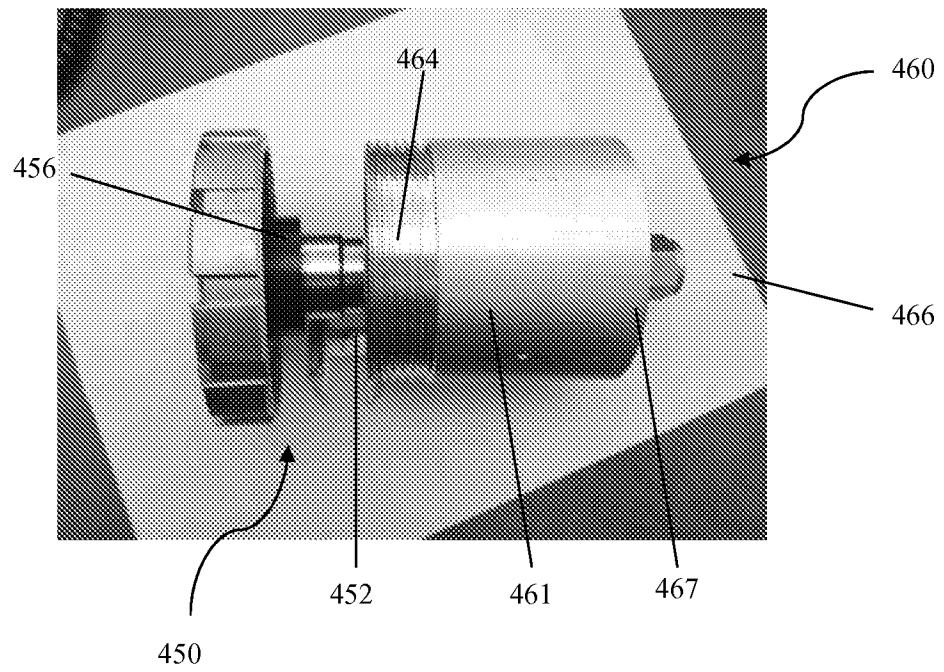


FIG. 4C

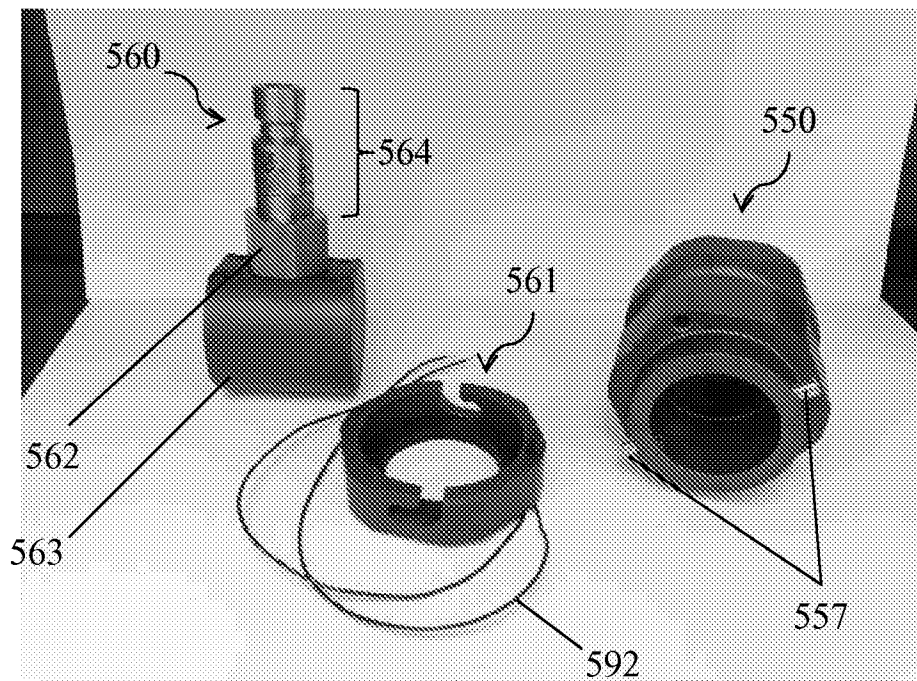


FIG. 5A

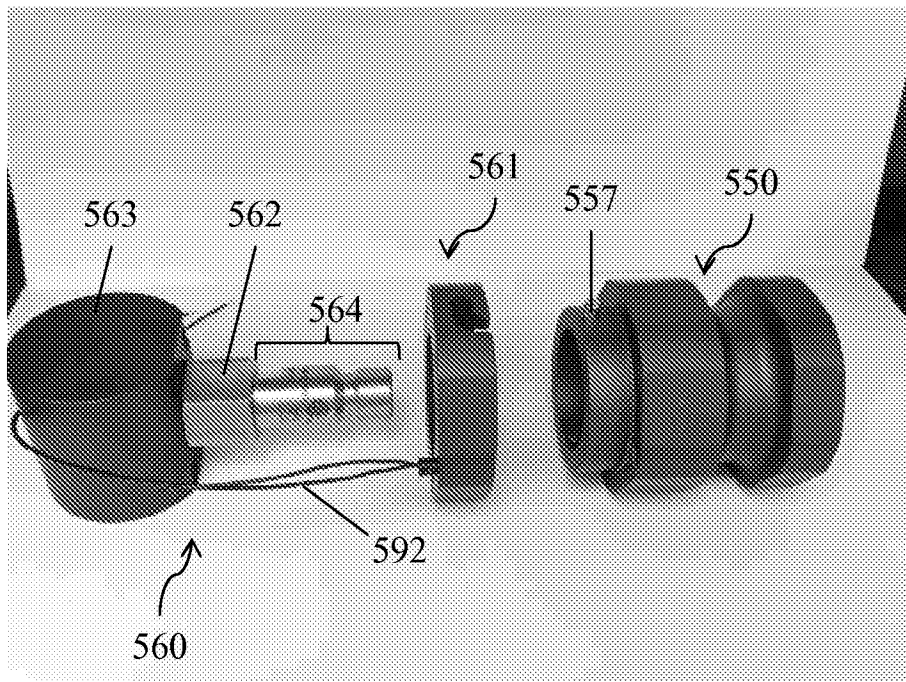


FIG. 5B

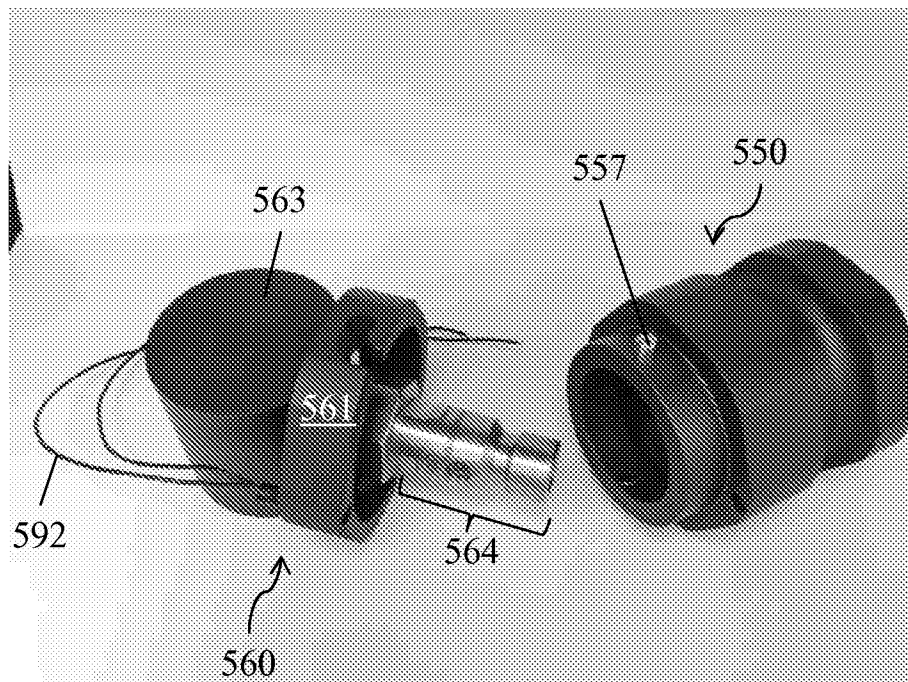


FIG. 5C

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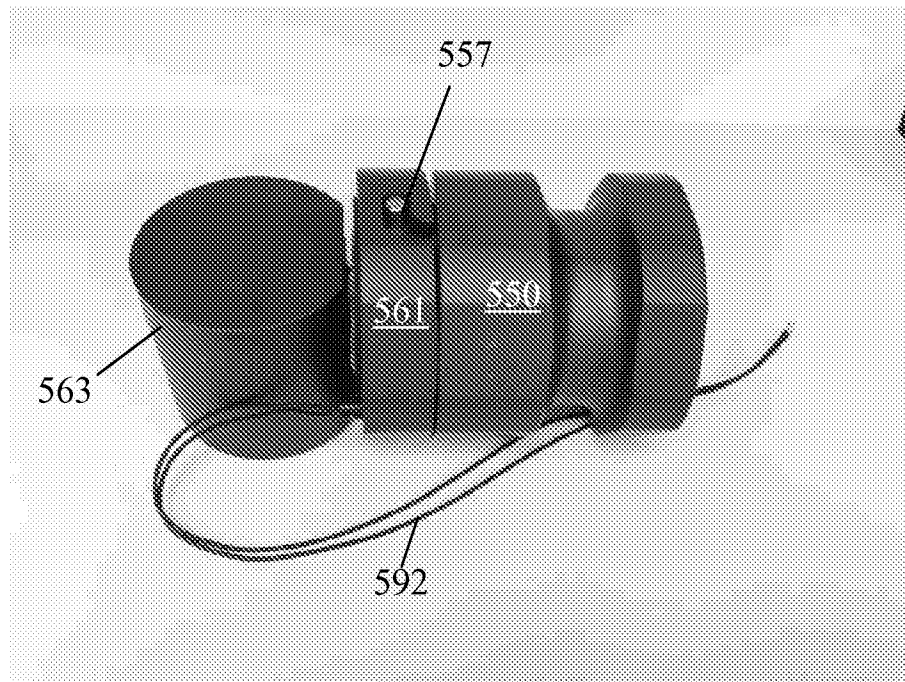


FIG. 5D

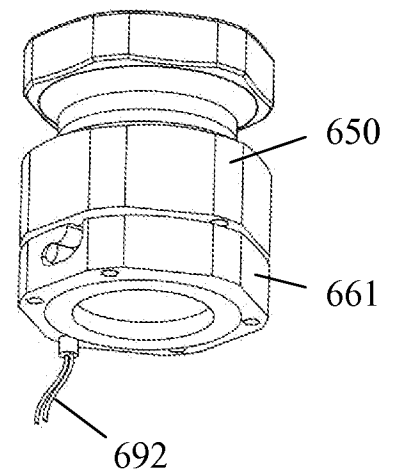
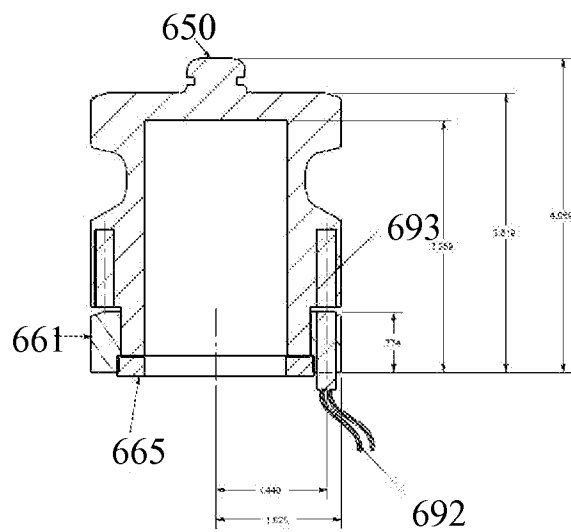


FIG. 6

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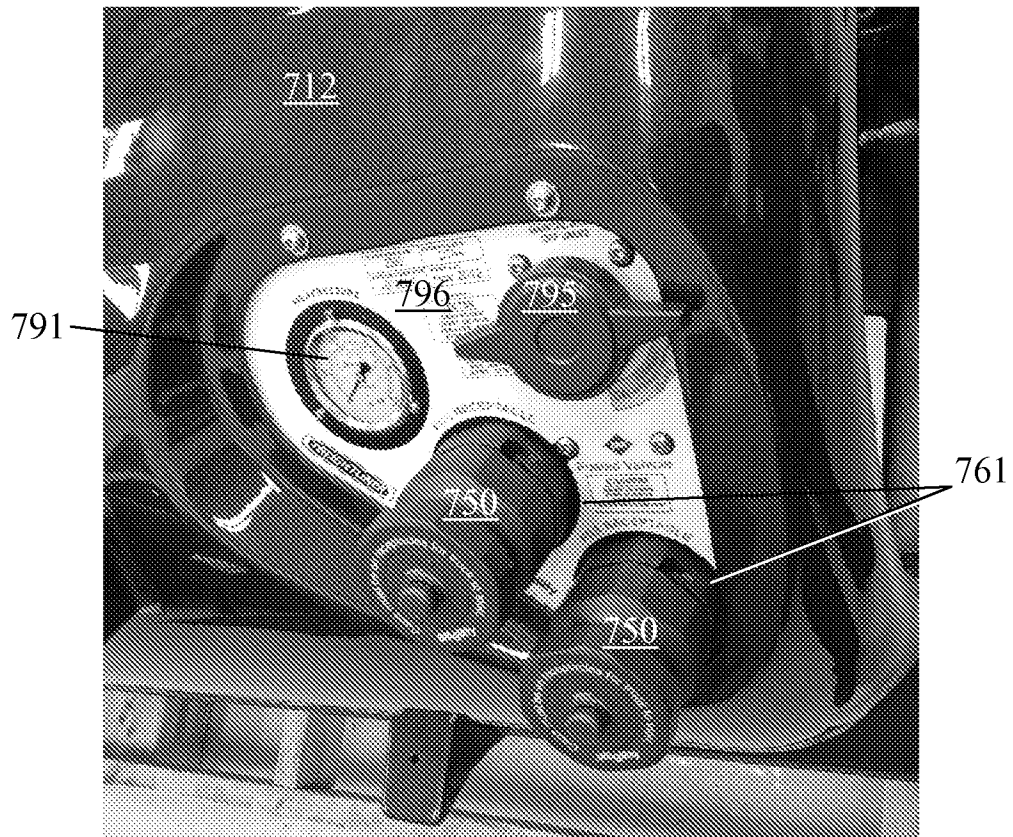


FIG. 7A

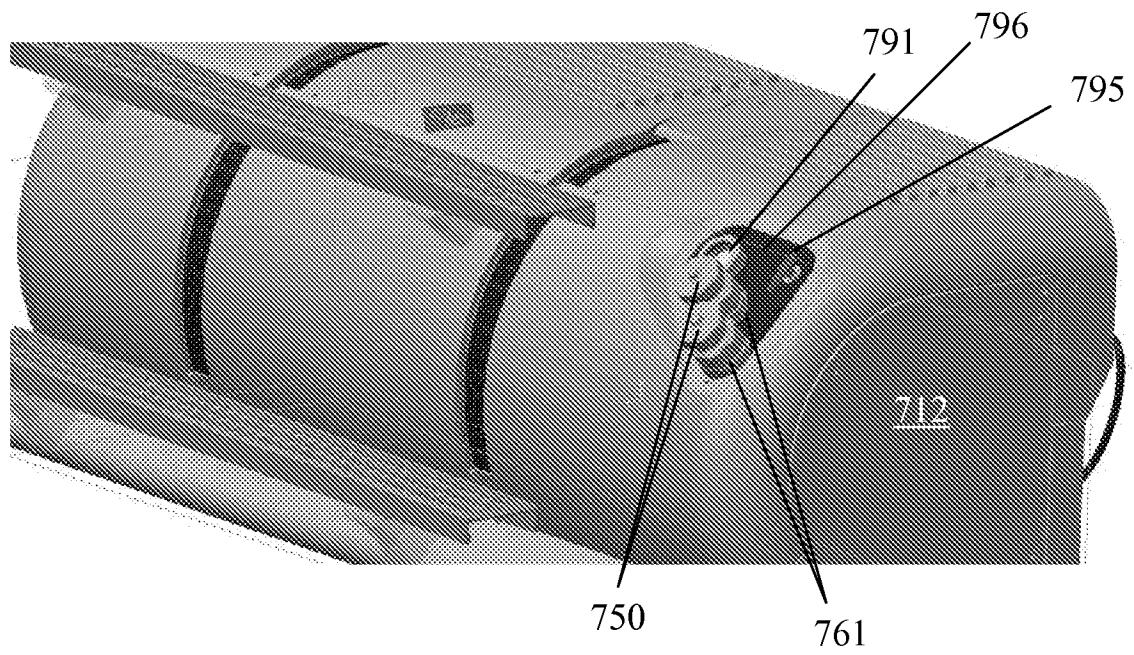


FIG. 7B

A. CLASSIFICATION OF SUBJECT MATTER**B60K 15/10(2006.01)i, B60K 15/00(2006.01)i, B60K 15/05(2006.01)i, F02D 41/22(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60K 15/10; B60K 15/04; F02B 77/00; B60K 15/05; B60K 15/00; F02D 41/22

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: ignition, start, thread, bolt, nut, screw, wire, cable, and line

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 01-40637 A1 (BRISTER, CHARLES) 07 June 2001 See page 7, lines 25-27; page 8, lines 4-6 and figures 2, 3A.	1-5
A	JP 2004-066901 A (FUJI HEAVY IND LTD) 04 March 2004 See paragraph 8 and figure 1.	1-5
A	WO 2005-084987 A1 (GUENDOUZ et al.) 15 September 2005 See claim 1 and figure 3.	1-5
A	US 3885547 A (DOEPKE et al.) 27 May 1975 See column 4, lines 21-43 and figure 5.	1-5
A	KR 20-0142865 Y1 (HYUNDAI MOTOR COMPANY) 01 June 1999 See abstract and figures 1-2.	1-5



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

26 June 2013 (26.06.2013)

Date of mailing of the international search report

01 July 2013 (01.07.2013)

Name and mailing address of the ISA/KR

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Telephone No. 82-42-481-8525



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/033029

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US 3885547 A	27.05.1975	None	
KR 20-0142865 Y1	01.06.1999	None	