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(54) FUELING SYSTEM

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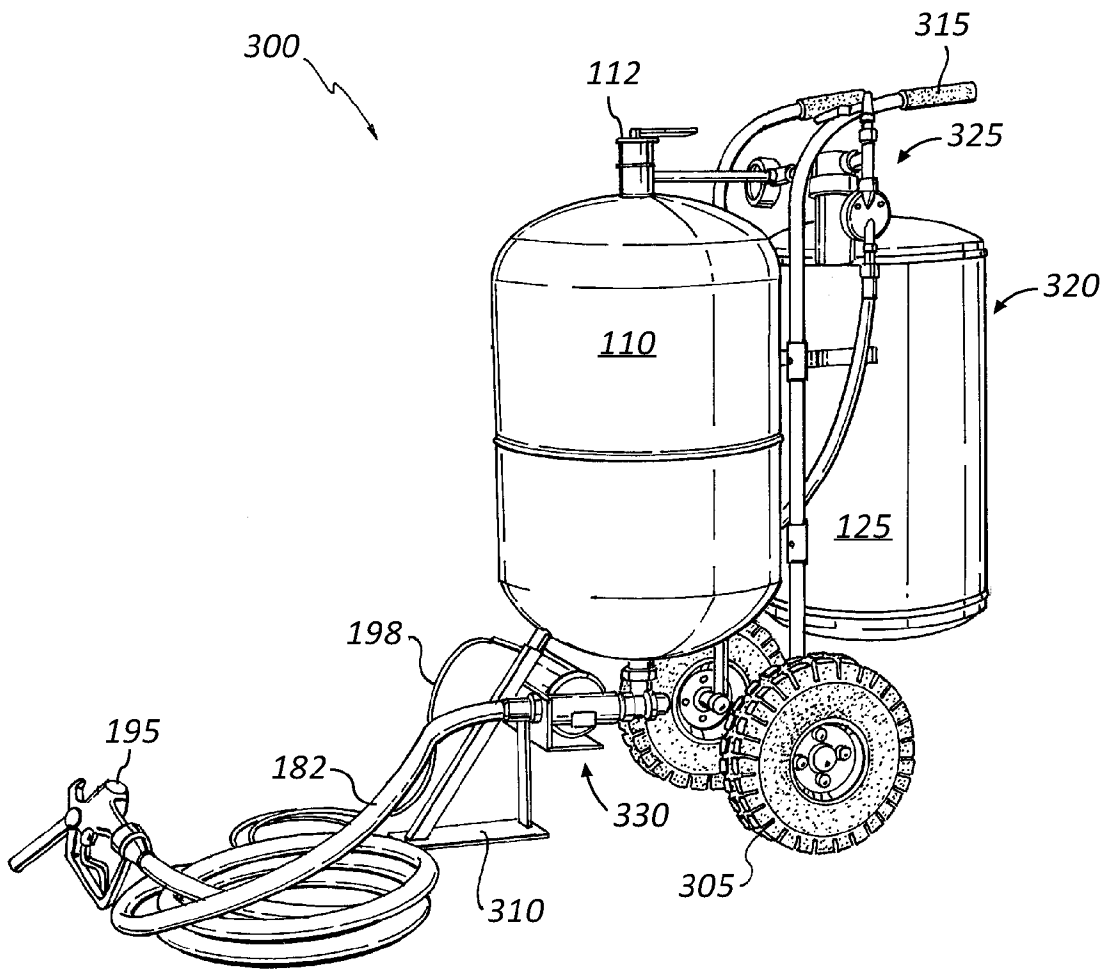
(57) **ABSTRACT**

An apparatus for providing fuel comprises a fuel handling portion and an air handling portion. The fuel handling portion comprises a fuel tank adapted to store fuel as well as a fuel nozzle in fluid communication with the fuel tank and adapted to dispense fuel from the fuel tank. The air handling portion comprises an air tank adapted to be filled with pressurized gas from a pressurized gas source. After the pressurized gas source is removed, the air handling portion is operative to apply the pressurized gas from the air tank to the fuel in the fuel tank so as to provide a motive force for dispensing fuel through the fuel nozzle.



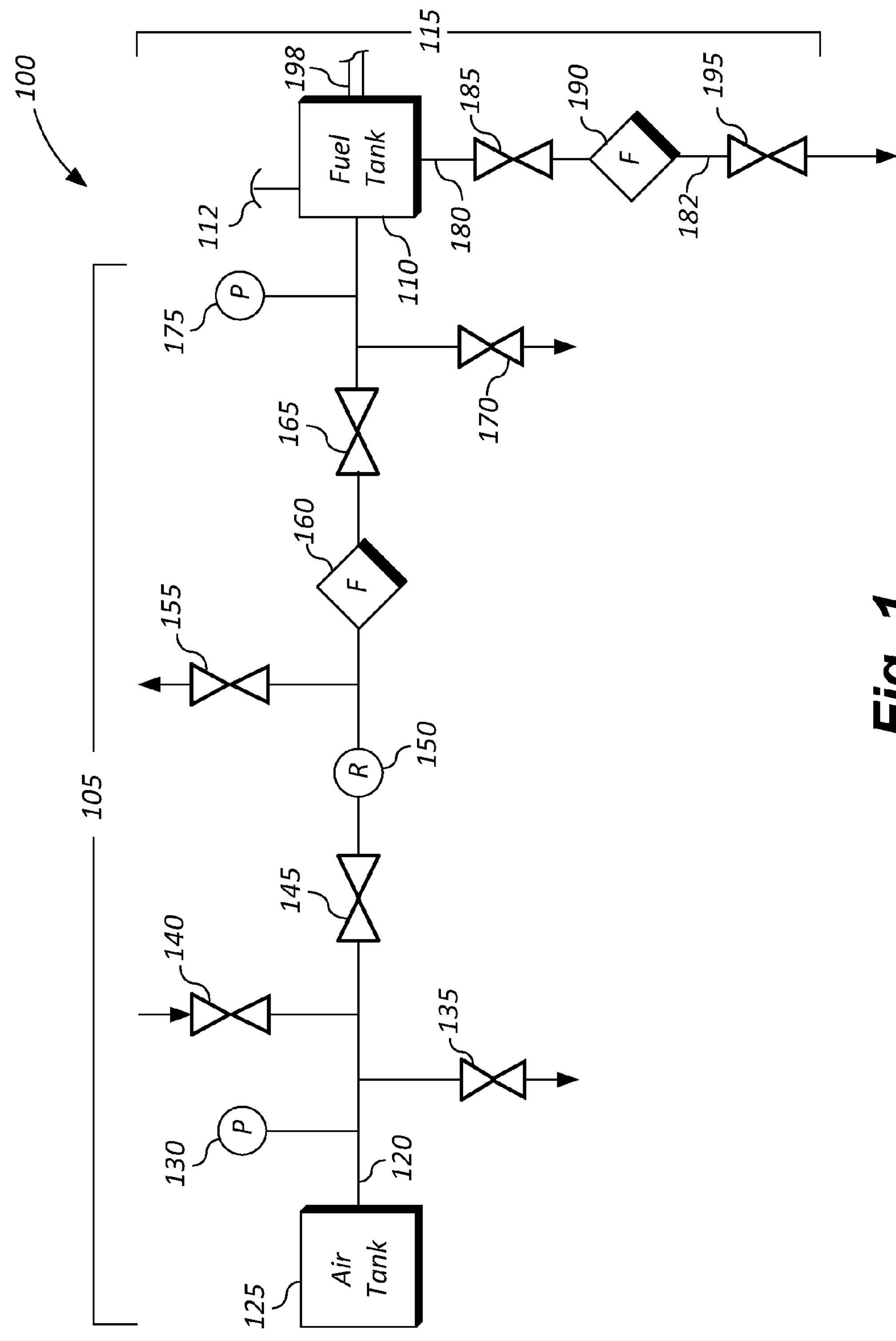

100
115
105
Fuel Tank
Air Tank
F
F
P
P
R
198
112
110
180
185
190
182
195
175
170
165
160
155
150
145
140
135
130
120
125

Fig. 1

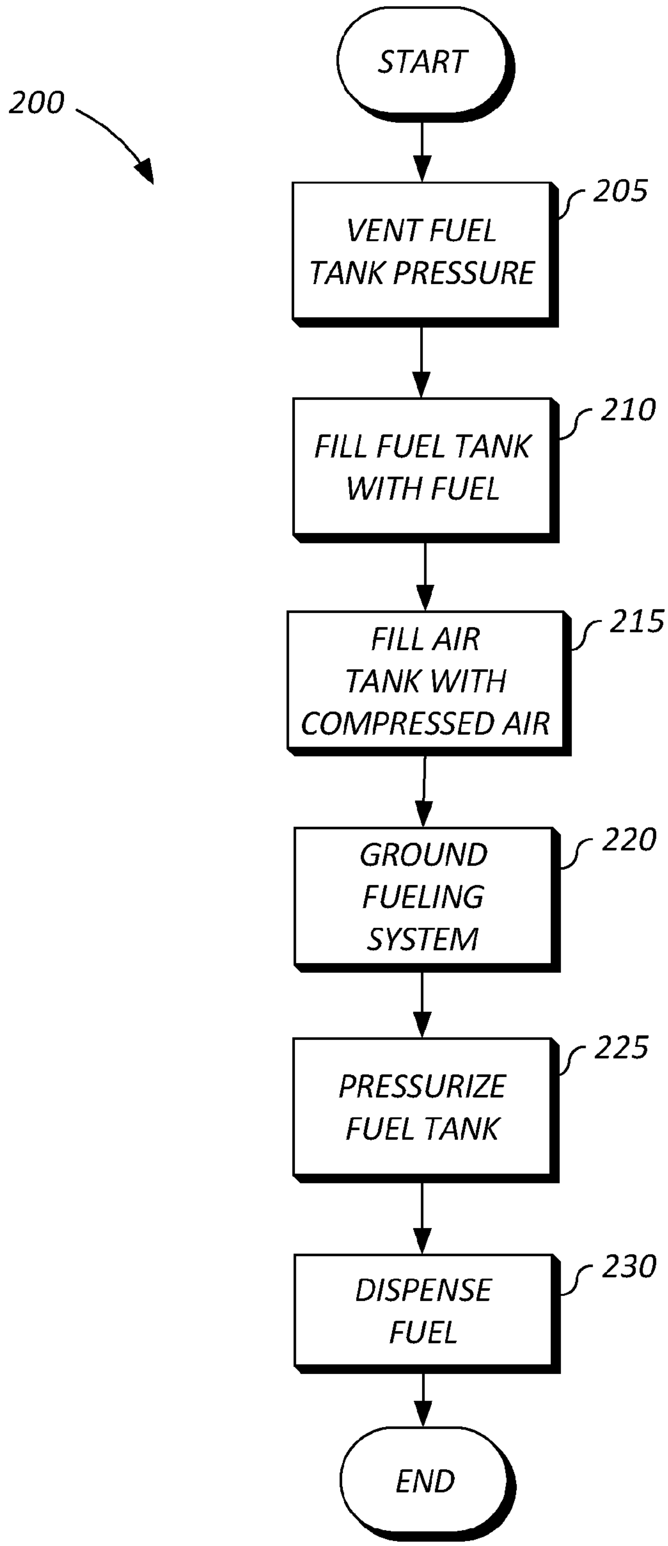

200
START
VENT FUEL TANK PRESSURE
205
FILL FUEL TANK WITH FUEL
210
FILL AIR TANK WITH COMPRESSED AIR
215
GROUND FUELING SYSTEM
220
PRESSURIZE FUEL TANK
225
DISPENSE FUEL
230
END

Fig. 2

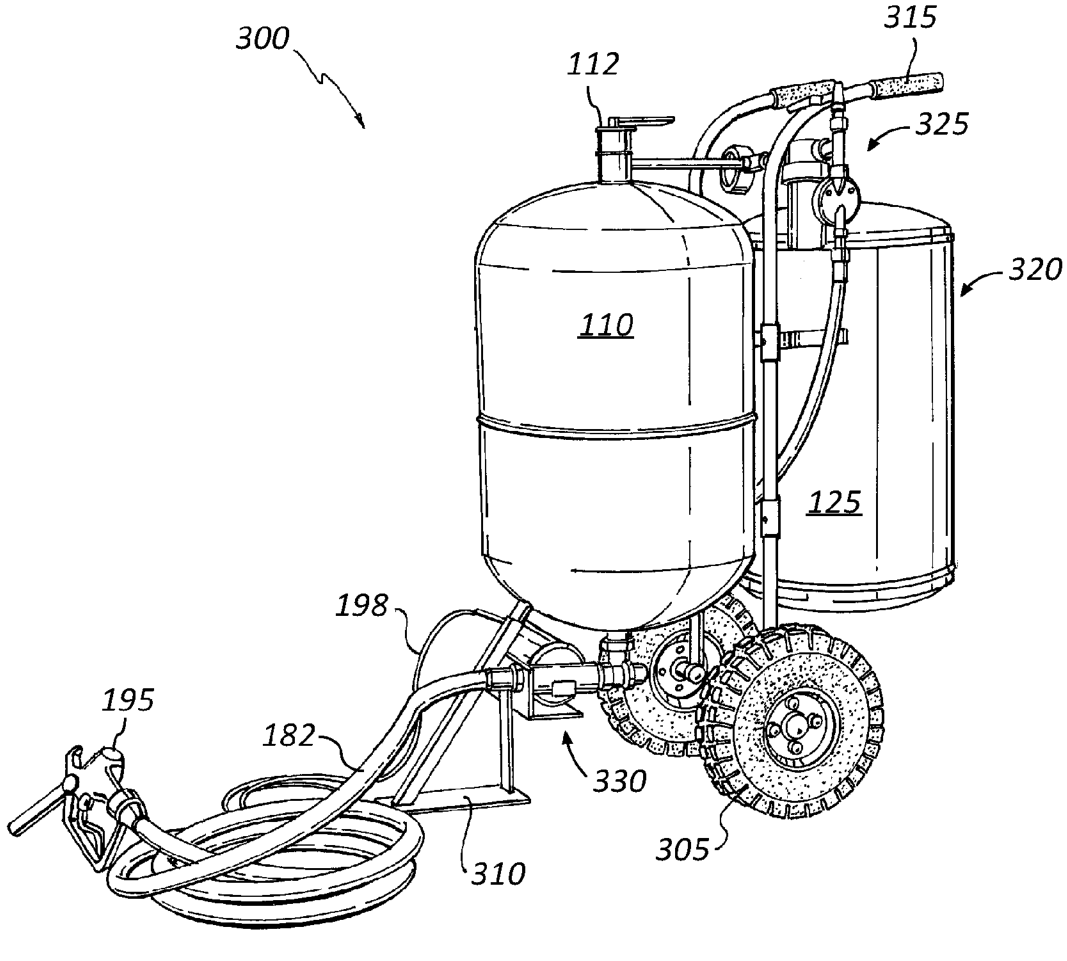


Fig. 3

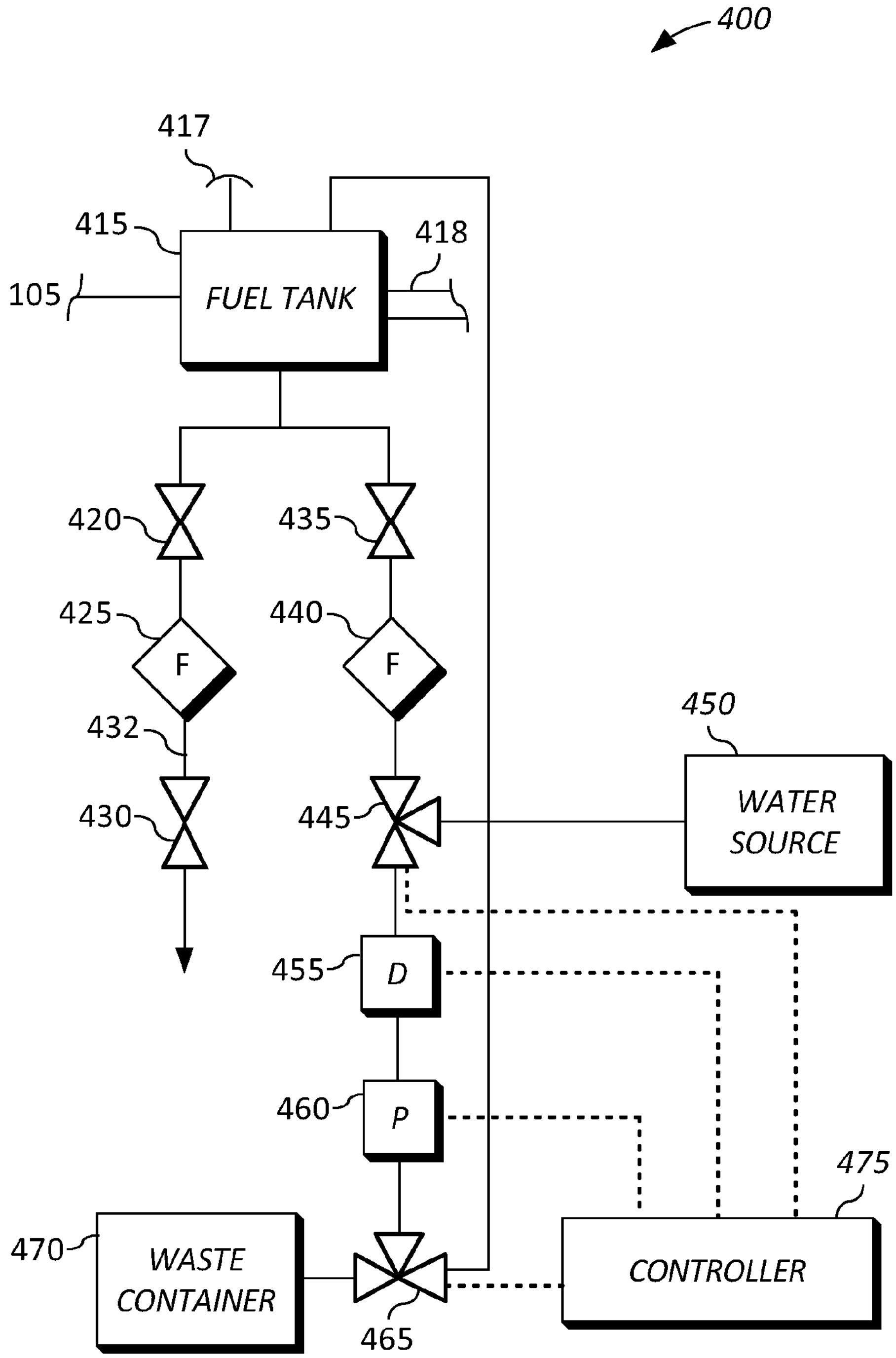

400
417
415
418
105
FUEL TANK
420
435
425
F
440
F
450
432
WATER SOURCE
430
445
455
D
460
P
475
470
WASTE CONTAINER
CONTROLLER
465

Fig. 4

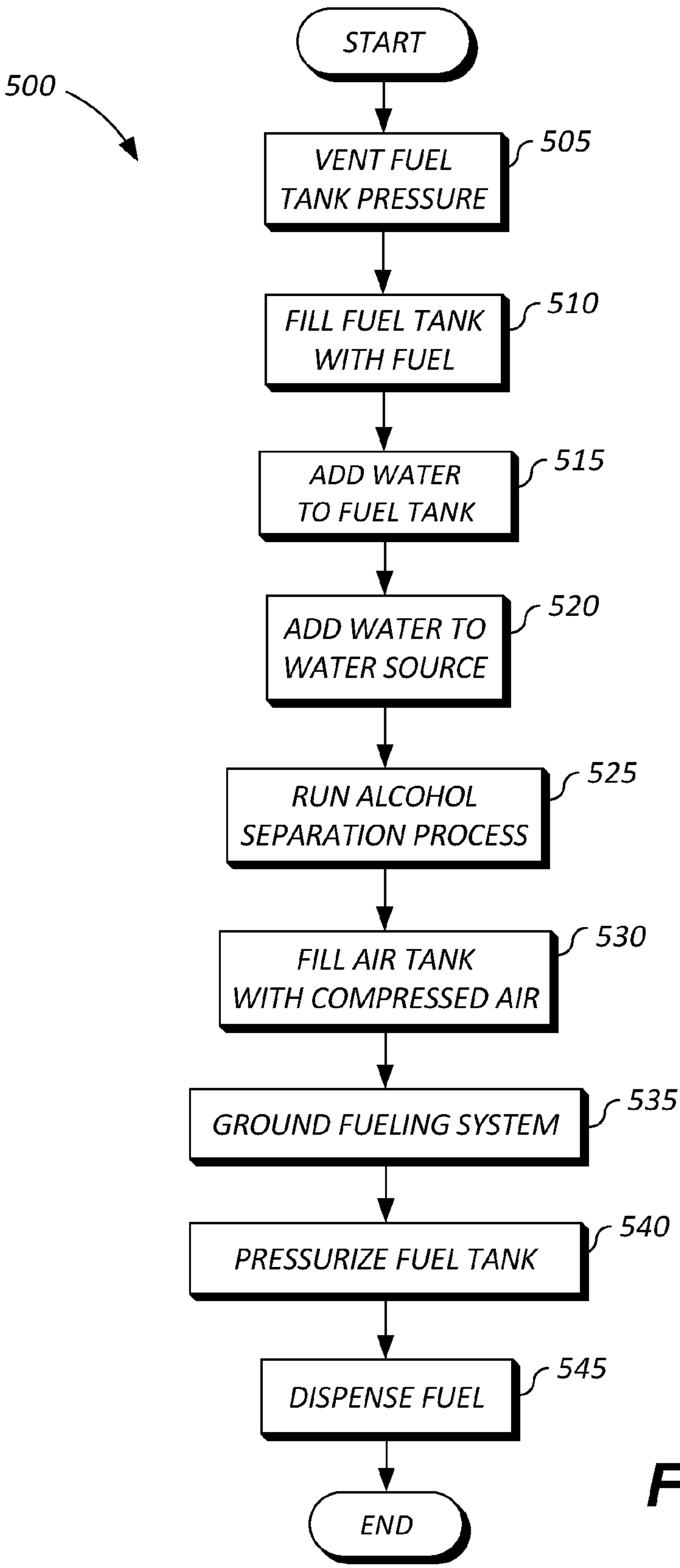

START
500
VENT FUEL TANK PRESSURE
505
FILL FUEL TANK WITH FUEL
510
ADD WATER TO FUEL TANK
515
ADD WATER TO WATER SOURCE
520
RUN ALCOHOL SEPARATION PROCESS
525
FILL AIR TANK WITH COMPRESSED AIR
530
GROUND FUELING SYSTEM
535
PRESSURIZE FUEL TANK
540
DISPENSE FUEL
545
END

Fig. 5

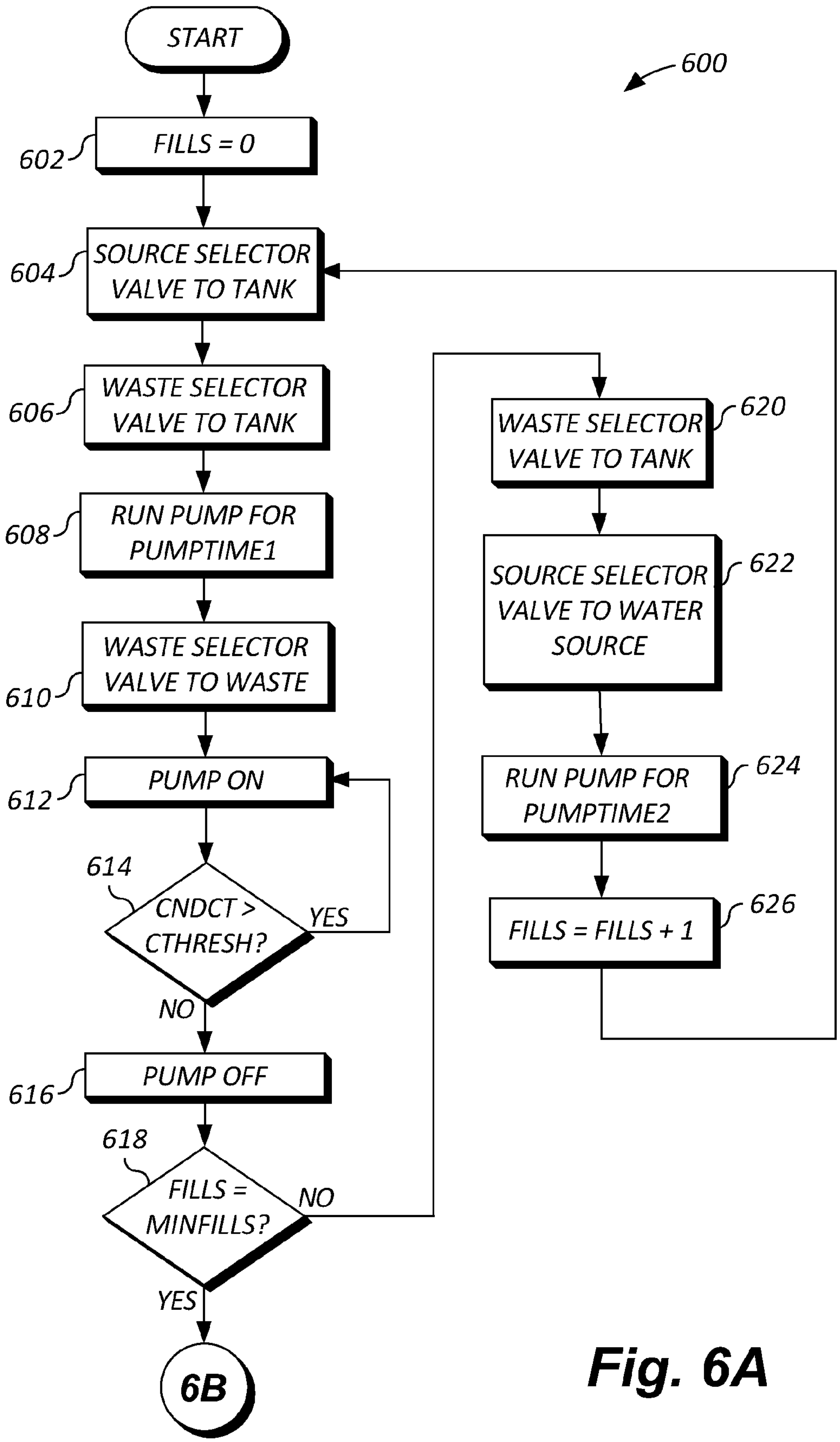

START
600
FILLS = 0
602
SOURCE SELECTOR VALVE TO TANK
604
WASTE SELECTOR VALVE TO TANK
606
RUN PUMP FOR PUMPTIME1
608
WASTE SELECTOR VALVE TO WASTE
610
PUMP ON
612
614
CNDCT > CTHRESH?
YES
NO
PUMP OFF
616
618
FILLS = MINFILLS?
NO
YES
6B
WASTE SELECTOR VALVE TO TANK
620
SOURCE SELECTOR VALVE TO WATER SOURCE
622
RUN PUMP FOR PUMPTIME2
624
FILLS = FILLS + 1
626

Fig. 6A

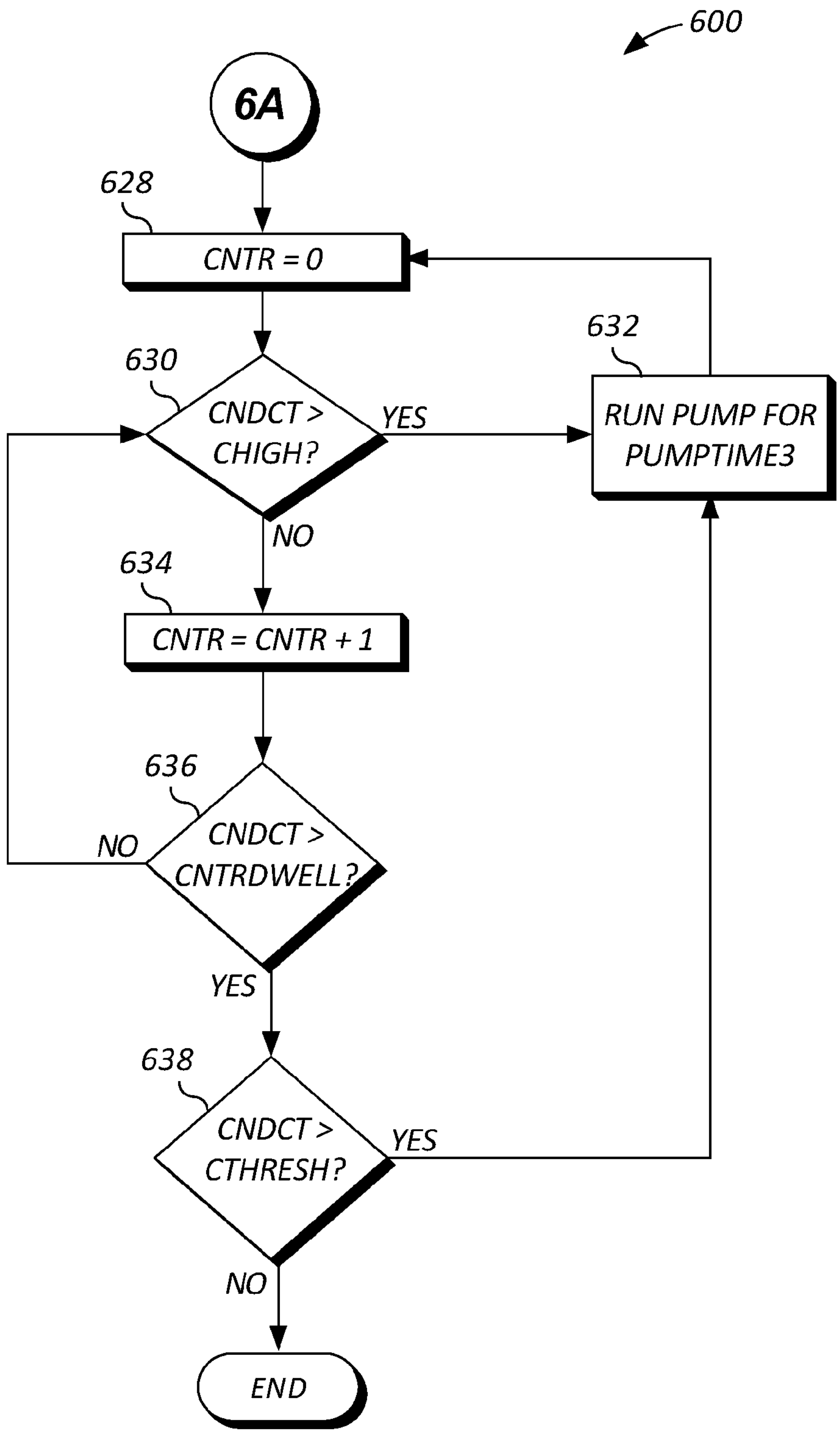

600
6A
628
CNTR = 0
630
CNDCT > CHIGH?
YES
632
RUN PUMP FOR PUMPTIME3
NO
634
CNTR = CNTR + 1
636
CNDCT > CNTRDWELL?
NO
YES
638
CNDCT > CTHRESH?
YES
NO
END

Fig. 6B

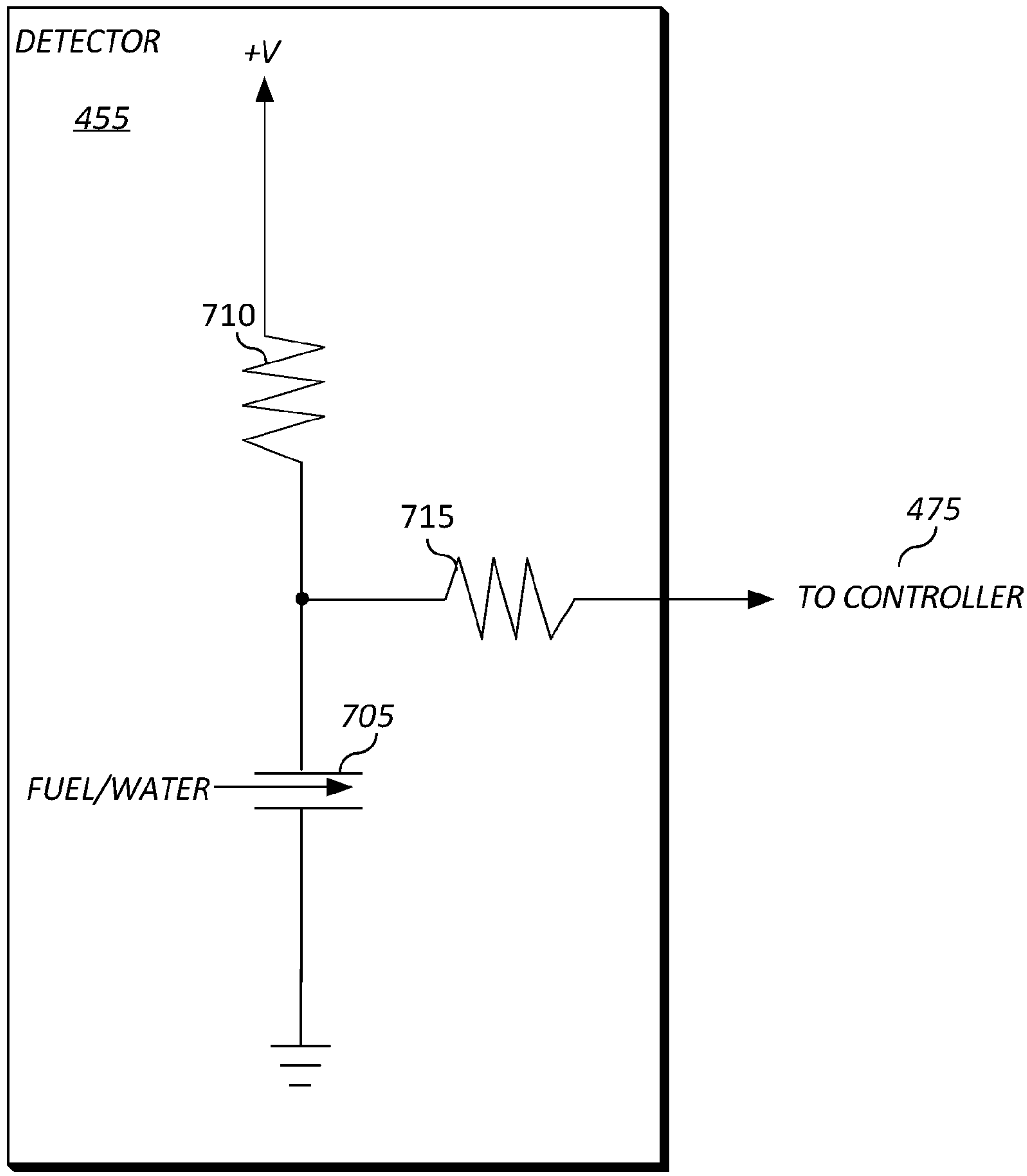


Fig. 7

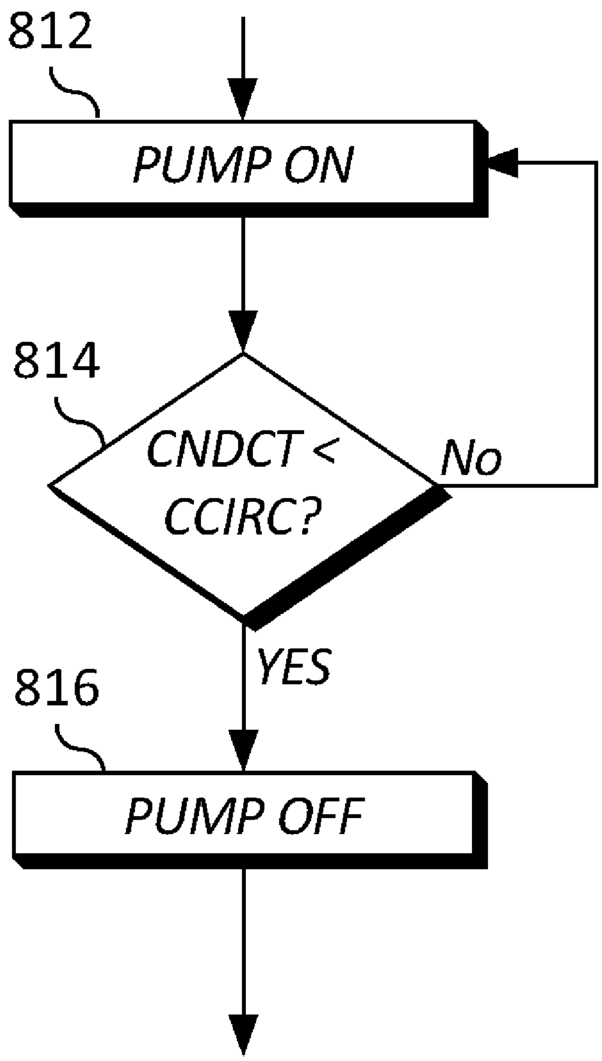


Fig. 8

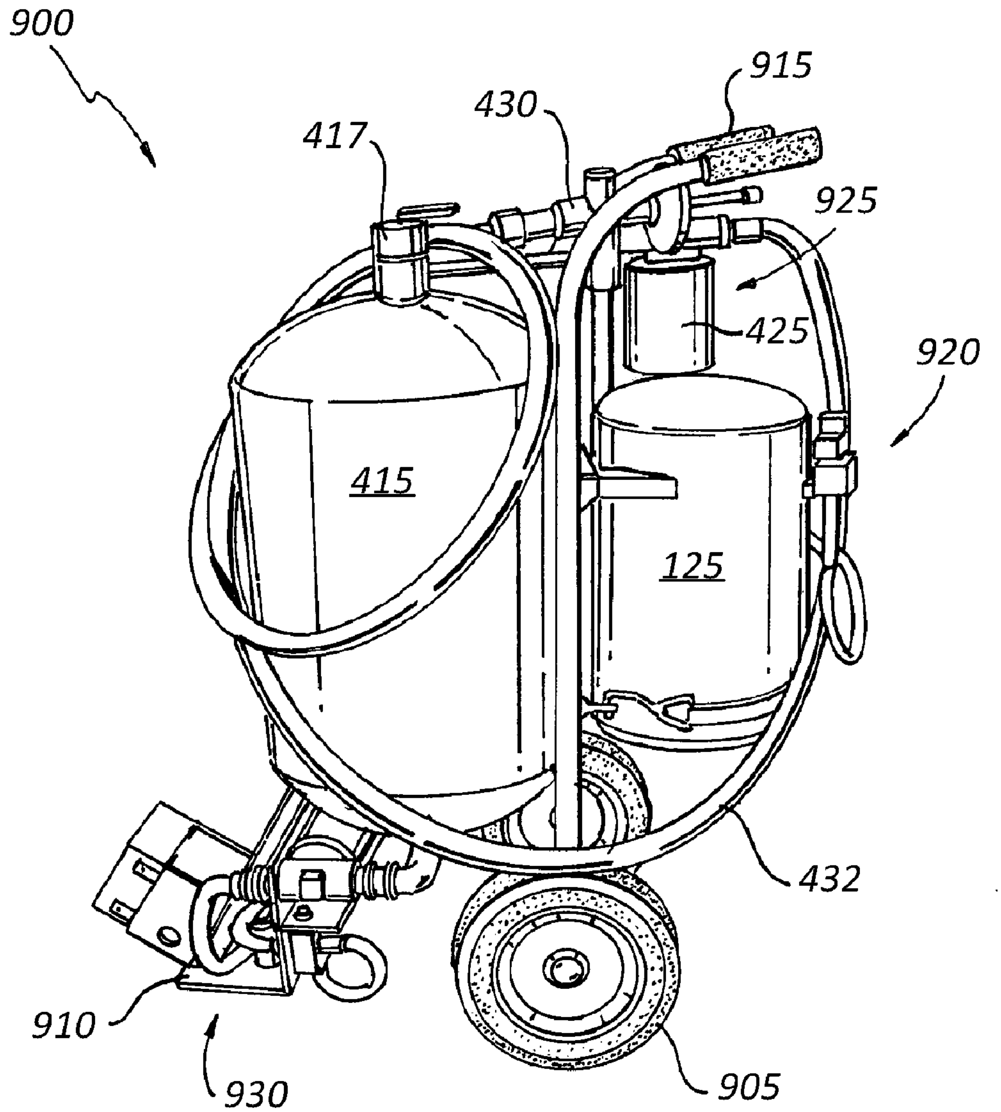


Fig. 9

FUELING SYSTEM

FIELD OF THE INVENTION

[0001] The present invention relates to apparatus and methods for obtaining, transporting, storing, and dispensing fuel. The present invention further relates to apparatus and methods for processing fuel.

BACKGROUND OF THE INVENTION

[0002] Operators of motorized equipment such as auto enthusiasts, pilots, boaters, landscapers, and the like often find themselves requiring gasoline without having a convenient source of suitable fuel. To make matters worse, in many cases, a ready source of electrical power is also not available. During these situations, the only realistic fueling solution is frequently the ubiquitous five-gallon gas can. The user fills several of these gas cans at a remote gas station and then transports them to where they will be needed. The user then lifts the heavy gas cans above the vehicle's fuel tank and uses a spout or funnel to direct the fuel into the vehicle by gravity feed. In the case of large vehicles and high-wing airplanes, the user may even need to climb a stepstool or ladder with the cans in order to access the vehicle's fuel tank.

[0003] To make matters worse, in addition to being inconvenient and physically demanding, the use of gas cans in this manner is often dangerous from the perspective of explosion and fire, and also frequently results in fuel spillages that can damage a vehicle's paint. A user may even lose their grip on the gas can while fueling and allow the gas can to inadvertently drop onto the vehicle and cause damage. Finally, fueling with gas cans is slow because of a gas can's narrow opening and its dependence on gravity feed. Taking an inordinate amount of time to fuel a vehicle is especially inconvenient when the weather is cold or wet and the refueling is performed while the operator is exposed to the elements.

[0004] A further source of issues for the equipment operators mentioned above is the inclusion of alcohol in many fuels. Almost all regularly available automobile gasoline now contains 10% ethanol as a result of federal legislation. Nevertheless, ethanol can destroy critical fuel system and engine components if these components were not specifically designed for resistance to alcohol. Ethanol also has a tendency to phase separate from gasoline when exposed to water, creating a corrosive layer of water and ethanol at the bottom of a fuel tank. For these reasons, alcohol-containing fuels are not approved for many motorized vehicles. A large percentage of the piston-engine aircraft fleet, for example, is certified to run on automobile fuel so long as it is free of alcohol. Despite this, however, a pilot typically must use very expensive and highly polluting leaded aviation fuel instead of automobile fuel because the automobile fuel contains ethanol.

[0005] For the foregoing reasons, there is a need for improved fueling system designs that allow fuel to be obtained, transported, stored, and dispensed in a safe, efficient, and convenient manner. For those vehicles that cannot tolerate alcohol in the fuel, there is further a need for these new fueling systems to be capable of removing any ethanol from the fuel before the fuel is dispensed into the vehicle.

SUMMARY OF THE INVENTION

[0006] Embodiments of the present invention address the above-identified needs by providing fueling systems that allow fuel to be obtained, transported, stored, and dispensed in a safe, efficient, and convenient manner. Embodiments of the invention further provide fueling systems capable of removing any ethanol from the fuel before the fuel is dispensed into a vehicle.

[0007] In accordance with an aspect of the invention, an apparatus for providing fuel comprises a fuel handling portion and an air handling portion. The fuel handling portion comprises a fuel tank adapted to store fuel as well as a fuel nozzle in fluid communication with the fuel tank and adapted to dispense fuel from the fuel tank. The air handling portion comprises an air tank adapted to be filled with pressurized gas from a pressurized gas source. After the pressurized gas source is removed, the air handling portion is operative to apply the pressurized gas from the air tank to the fuel in the fuel tank so as to provide a motive force for dispensing fuel through the fuel nozzle.

[0008] In accordance with another aspect of the invention, a method of providing fuel comprises filling a fuel tank with fuel, the fuel tank in fluid communication with a fuel nozzle. Subsequently an air tank is pressurized with a gas from a pressurized gas source. With the pressurized gas source removed, fuel is dispensed from the fuel tank through the fuel nozzle while allowing pressurized gas from the air tank to provide a motive force for dispensing the fuel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description and accompanying drawings where:

[0010] FIG. **1** shows a schematic of at least a portion of a fueling system in accordance with a first illustrative embodiment of the invention;

[0011] FIG. **2** shows a flow diagram of an illustrative method for utilizing the FIG. **1** fueling system to dispense fuel;

[0012] FIG. **3** shows a perspective view of a working prototype of the FIG. **1** fueling system implemented in a cart;

[0013] FIG. **4** shows a schematic of at least a portion of a fueling system in accordance with a second illustrative embodiment of the invention;

[0014] FIG. **5** shows a flow diagram of a method for utilizing the FIG. **4** fueling system to remove alcohol and dispense fuel;

[0015] FIGS. **6**A and **6**B show flow diagrams of an automated separation process in the FIG. **4** fueling system;

[0016] FIG. **7** shows an electrical schematic of an illustrative detector in the FIG. **4** fueling system;

[0017] FIG. **8** shows a flow diagram of alternative steps for use in the FIGS. **6**A and **6**B process; and

[0018] FIG. **9** shows a perspective view of a working prototype of the FIG. **4** fueling system implemented in a cart.

DETAILED DESCRIPTION OF THE INVENTION

[0019] The present invention will be described with reference to illustrative embodiments. For this reason, numerous modifications can be made to these embodiments and the results will still come within the scope of the invention. No limitations with respect to the specific embodiments described herein are intended or should be inferred.

[0020] FIG. **1** shows a schematic of at least a portion of a fueling system **100** in accordance with a first illustrative embodiment of the invention. The fueling system **100** can be roughly broken into two portions. An air handling portion **105** allows the storage and transport of compressed air, and also provides a means for a fuel tank **110** to be pressurized with air. A fuel handling portion **115** allows the storage and transport of fuel, and also provides a means for the fuel to be dispensed.

[0021] Broken down even further, the air handling portion **105** comprises an air path **120** between an air tank **125** and the fuel tank **110**. Along a section of the air path **120** immediately after the air tank **125**, one finds an air tank pressure gauge **130**, an air tank safety relief valve **135**, an air tank fill valve **140**, an air tank valve **145**, and a pressure regulator **150**. Immediately after the pressure regulator **150**, one finds a fuel tank relief valve **155**, an air filter **160**, an air shutoff valve **165**, a fuel tank safety relief valve **170**, and a fuel tank pressure gauge **175**. In the fuel handling portion **115** of the fueling system **100**, one finds the fuel tank **110** with a fuel cap **112**, as well as a fuel path **180** that connects the bottom of the fuel tank **110** to a fuel shutoff valve **185**, a fuel filter **190**, and finally, a fuel nozzle **195**. The fuel path **180** from the fuel filter **190** to the fuel nozzle **195** comprises a fuel hose **182**.

[0022] For safety purposes, the fueling system **100** further comprises an electrical grounding system that allows all the components of the fueling system **100** to be electrically tied to the vehicle being fueled. This equalizes the electrical potential between the fueling system **100** and the vehicle, thereby reducing the chance of a spark forming during fueling. A bonding strap **198** is attached to the fuel tank **110** and is available to tie the fueling system **100** to the vehicle being fueled. The electrically conductive conduits and fixtures forming the fueling system **100**, in addition to a grounding wire integral to the fuel hose **182**, assure that all the parts of the fueling system **100** achieve the same electrical potential as the bonding strap **198**.

[0023] When the air handling portion **105**, the fuel handling portion **115**, and the grounding system are combined, one achieves a fueling system **100** that allows fuel to be obtained, transported, stored, and dispensed in a safe, efficient, and convenient manner. Pressurization provided by the air handling portion **105** allows the fuel tank **110** to be pressurized with air. Fuel flow from the fuel tank **110**, in turn, is driven by this air pressure (i.e., air pressure creates the motive force for the fuel flow) and does not depend solely on gravity. Ultimately, a user of the fueling system **100** receives a fueling experience similar to that of a conventional gas pump, but without the need for an immediate source of electrical power.

[0024] FIG. **2** shows a flow diagram of an illustrative method **200** for utilizing the fueling system **100** to dispense fuel. The first set of steps allows the fuel tank **110** to be pressurized with air from the air tank **125**. In step **205**, the fuel tank **110** is vented of any excess pressure by closing the air tank valve **145**, and then opening the air shutoff valve **165** and the fuel tank relief valve **155**. Once this venting is accomplished, the user then shuts the air shutoff valve **165** and the fuel tank relief valve **155** and moves onto step **210**, wherein the fuel tank **110** is filled with fuel. Here, the user merely removes the fuel cap **112** of the fuel tank **110** and dispenses fuel into the fuel tank **110** from a convenient source of fuel (e.g., an automobile gas station). After the fuel cap **112** is replaced, the air tank **125** is then filled with compressed air in step **215**. Filling the air tank **125** may be performed by coupling a source of compressed air (i.e., an air compressor) to the air tank fill valve **140** and filling the air tank **125** while the air tank valve **145** remains closed.

[0025] The fuel tank **110** is then ready to be pressurized. In step **220**, the fueling system **100** is grounded to the vehicle being fueled. In step **225**, the air tank valve **145** and the air shutoff valve **165** are opened causing compressed air to travel from the air tank **125** through the pressure regulator **150** and the air filter **160** into the fuel tank **110**. The pressure regulator **150** reduces the air pressure from the fill pressure in the air tank **125** (e.g., 120 pounds per square inch (psi)) to something substantially lower than that (e.g., 10 psi). The air filter **160**, in turn, removes any contaminants from the compressed air before the contaminants have a chance to enter the fuel tank **110**. Pressurized in this manner, the fuel tank **110** is ready to dispense fuel. In step **230**, the user opens the fuel shutoff valve **185** and positions the fuel nozzle **195** in a vehicle's fuel tank opening. Actuating the fuel nozzle **195** causes fuel to first travel through the fuel filter **190** and then into the vehicle.

[0026] Notably, during the entire method **200** described above, any potentially dangerous over-pressure events are avoided by the air tank safety relief valve **135** and the fuel tank safety relief valve **170**. The air tank safety relief valve **135** may be configured to vent when the pressure in the air tank **125** exceeds, for example, 145 psi. The fuel tank safety relief valve **170** may be configured to vent when the fuel tank **110** exceeds, as another example, 25 psi.

[0027] The fueling system **100** may be physically implemented in several different forms. FIG. **3**, for example, shows a perspective view of a working prototype of the fueling system **100** implemented in a cart **300** with two rear wheels **305**, a front base **310**, and two handles **315**. A region **320** of the working prototype comprised the air tank pressure gauge **130**, the air tank safety relief valve **135**, and the air tank fill valve **140**; while another region **325** comprised the air tank valve **145**, the pressure regulator **150**, the fuel tank relief valve **155**, the air filter **160**, the air shutoff valve **165**, the fuel tank safety relief valve **170**, and the fuel tank pressure gauge **175**. A region **330** near the bottom of the cart **300** comprised the fuel shutoff valve **185** and the fuel filter **190**. This prototype and others displayed excellent reliability and robustness. Fuel flow rates were often greater than those provided by gas pumps at automobile gas stations. For example, flow rates greater than eight gallons per minute were achieved with a ⅜-inch diameter fuel hose **182** even with a partially used fuel filter **190**.

[0028] Advantageously, the fueling system **100** can be constructed using conventional, off-the-shelf components, reducing the need to manufacture custom parts. In one configuration, for example, the air tank **125** and the fuel tank **110** may comprise conventional air-tight metallic tanks. Both tanks are preferably rated to about five times the normal maximum operating pressure to provide a wide margin of safety. The air tank valve **145**, the fuel tank relief valve **155**, the air shutoff valve **165**, and the fuel shutoff valve **185** may comprise conventional ball valves, while the air tank fill valve **140** may comprise a conventional Schrader valve. The air tank safety relief valve **135** and the fuel tank safety relief valve **170** may comprise conventional adjustable pressure relief valves. The pressure gauges **130**, **175**, the pressure regulator **150**, the air filter **160**, the fuel filter **190**, and the fuel nozzle **195** may just be conventional components readily sourced from a number of commercial vendors. Lastly, the air path **120** and the fuel path **180** that tie the various other components together may comprise conventional metallic fittings, metallic tubing, conventional rubber hoses, and a conventional grounded fuel hose **182**.

[0029] As described earlier, the inclusion of ethanol in a lot of fuels provides a barrier to the use of that fuel in many vehicles. FIG. **4** shows a schematic of at least a portion of fueling system **400** in accordance with a second illustrative embodiment of the invention that addresses that issue. The fueling system **400** includes an air handling portion **105** identical to the air handling portion **105** in the fueling system **100** (and therefore marked with the identical reference numeral). The fuel handling portion **410**, on the other hand, comprises a number of added elements that allow ethanol to be removed from the fuel using an automated separation process. The fuel handling portion **410** comprises a fuel tank **415** with a fuel cap **417**, and a bonding strap **418**. The fuel tank **415** has an output at its bottom that is split into two branches. On a first branch, the fuel flow is directed through a first fuel shutoff valve **420** into a first fuel filter **425** and ultimately to a fuel nozzle **430** via a fuel hose **432**. On a second branch, the fuel is directed to a second fuel shutoff valve **435**, to a second fuel filter **440**, and to a motorized source selector valve **445**. The source selector valve **445** is connected to a water source **450**. After the motorized source selector valve **445**, the fuel (or the water or ethanol-water, as the case may be) is directed to a detector **455**, to a pump **460**, and finally to a motorized waste selector valve **465**. The waste selector valve **465** determines whether the fluid in the fuel tank **415** is pumped to a waste container **470** or back to the top of the fuel tank **415**.

[0030] FIG. **5** goes on to show a flow diagram of a method **500** for utilizing the fueling system **400** to remove alcohol from fuel and ultimately dispense the alcohol-free fuel into a vehicle. In step **505**, the fuel tank **415** is vented in a manner similar to step **205** in the method **200**. Next, in step **510**, ethanol-containing fuel is added to the fuel tank **415** in a manner similar to step **210**. In the next step, however, the method **500** diverges from that described earlier. In step **515**, a quantity of water (e.g., about one gallon) is also added to the fuel tank **415**. Moreover, in step **520**, additional water is added to the water source **450**. In step **525**, the automated separation process **600** is initiated.

[0031] The automated separation process **600** in the fueling system **400** is controlled by a controller **475**. The controller **475** receives signals from the detector **455** and controls the states of the source selector valve **445**, the pump **460**, and the waste selector valve **465**. The automated separation process **600** leverages the fact that ethanol in fuel phase separates from that fuel when exposed to water, thereby forming an ethanol-water layer that is heavier than the remaining fuel and settles below that fuel. Causing the phase separation to occur and then removing the bottom layer of ethanol-water thereby becomes a means of removing the alcohol from the fuel.

[0032] FIGS. **6**A and **6**B show flow diagrams of the illustrative automated separation process **600** in the fueling system **400**. In step **602**, the controller **475** sets a variable FILLS to zero (i.e., FILLS=0). It then commands the source selector valve **445** to route fuel from the second fuel filter **440** to the detector **455** (step **604**), and also commands the waste selector valve **465** to route fluids from the pump **460** back to the top of the fuel tank **415** (step **606**). Subsequently, in step **608**, the controller **475** commands the pump **460** to turn on and run for a time PUMPTIME**1** (e.g., 10 minutes). This starts to circulate the fuel-ethanol-water from the bottom of the fuel tank **415** to its top, thereby thoroughly mixing the fuel-ethanol-water and starting the process of phase separation. After the pump **460** is stopped, the controller **475** in step **610** commands the waste selector valve **465** to start sending fluid to the waste container **470** instead of back to the top of the fuel tank **415**.

[0033] In steps **612** and **614**, the controller **475** attempts to remove any ethanol-water that has collected at the bottom of the fuel tank **415**. This involves the use of the detector **455**. FIG. **7** shows an exemplary electrical schematic of the detector **455**. In the present embodiment, the detector **455** comprises two brass plugs **705** that are spaced apart and between which the fluids from the fuel tank **415** are allowed to flow. Ethanol-water creates a high conductivity between the brass plugs **705**, while fuel creates a low conductivity. The conductivity is detected through the use of a DC voltage source, a pull-up resistor **710**, and a series resistor **715**, as shown in the schematic. A high conductivity between the brass plugs **705** causes the voltage sent to the controller **475** to be low, and vice versa.

[0034] Again referring to FIGS. **6**A and **6**B, in step **612**, the pump **460** is turned back on, sending the fluid from the bottom of the fuel tank **415** to the waste container **470**. In step **614**, the controller **475** receives the conductivity, CNDCT, from the detector **455** and determines whether CNDCT is higher than a predetermined conductivity threshold, CTHRESH. If CNDCT>CTHRESH, meaning that the detector **455** is seeing ethanol-water, the pump **460** is allowed to keep on pumping. When CNDCT<CTHRESH, meaning that the detector **455** is seeing primarily ethanol-free fuel, the controller **475** turns off the pump **460** in step **616**.

[0035] In the present embodiment, additional water is incrementally added to the fuel in the fuel tank **110** and allowed to circulate for PUMPTIME**1** in a series of "water fills" in order to assure that the substantial majority of ethanol has been successfully removed. The additional water fills also aid in diluting the ethanol-water mixture in the waste container **470**, making its ultimate disposal less hazardous and easier from a regulatory standpoint. In step **618**, the controller **475** determines whether the fuel in the fuel tank **415** has been exposed to a predetermined number of water fills, MINFILLS. If not, the waste selector valve **465** in step **620** is set such that it again routes fluids to the top of the fuel tank **415** rather than to the waste container **470**. Subsequently, in step **622**, the controller **475** commands the source selector valve **445** such that it receives water from the water source **450** rather than from the second fuel filter **440**. The pump **460** is then allowed to run for a time PUMPTIME**2** in step **624**. The time PUMPTIME**2** is preferably set so that about one gallon of water is caused to be pumped from the water source **450** into the fuel tank **415**, although other water quantities may be chosen if desired. With the additional water added in this manner, the variable FILLS is incremented by one in step **626**. Steps **604**-**626** are repeated until the number of additional water fills is equal to MINFILLS. At that point, the process **600** progresses to step **628** in FIG. **6**B.

[0036] The remaining steps in the automated separation process **600** give any additional ethanol-water in the fuel tank **415** additional time to settle out without the fluid in the fuel tank **415** being circulated by the pump **460**. This additional time is called "dwell time." Dwell time is measured by having a counter, CNTR, in the controller **475** advance until it reaches a predetermined counter value, CNTRDWELL. In step **628**, CNTR is set to zero. In step **630**, the detector **455** determines whether CNDCT exceeds another predetermined conductivity value, CHIGH. CHIGH is a conductivity value greater than CTHRESH, and is used during the dwell time to avoid having the user wait through the entire dwell time when there is still a lot of ethanol-water collecting at the bottom of the fuel tank **415**. If CNDCT>CHIGH in step **630**, the controller **475** turns the pump **460** back on (step **632**) and runs the pump **460** for a time PUMPTIME3 (e.g., two seconds), thereby using the pump **460** to send more fluid to the waste container **470**. The pump **460** then turns back off, reinitiating the dwell time by reverting back to step **628**. If CNDCT<CHIGH in step **630**, the CNTR is advanced by one in step **634** and the controller **475** proceeds to step **636**.

[0037] Step **636** determines whether CNTR>CNTRDWELL has been achieved, meaning that the fueling system **400** has waited the predetermined dwell time in order to allow complete phase separation. If no, the controller **475** proceeds back to step **630**. If yes, the controller **475** moves to step **638**, where it again checks if CNDCT>CTHRESH. This is the final measurement to determine if all the ethanol-water has been removed from the fuel tank **415**. If the result is no, the controller **475** assumes that all the ethanol-fuel has been removed. If the answer is yes, the controller **475** assumes that ethanol-water still remains, and moves back to step **632**. The pump **460** is again run for PUMPTIME3 and the dwell time starts again in step **628**.

[0038] With the alcohol now removed from the fuel, the fuel can be dispensed in a manner similar to the fueling system **100**. Again referring to FIG. **5**, step **530** has the user fill the air tank **125** with compressed air in a manner similar to step **215**. In step **535**, the fueling system **400** is properly grounded to the vehicle. Lastly, in steps **540** and **545**, the fuel tank **110** is pressurized and the fuel is dispensed as was done in steps **225** and **230**, respectively.

[0039] The illustrative automated separation sequence can be modified and the results would still come within the scope of the invention. One such modification involves replacing step **608** in the automated separation process **600** shown in FIGS. **6**A and **6**B with the sequence of steps **802-806** shown in FIG. **8**. Step **608** in the process **600** causes the fuel-ethanol-water to be circulated through the fuel tank **110** for the time PUMPTIME1. Steps **802-806** in FIG. **8**, in contrast, use the detector **455** to determine the circulation time. More particularly, in step **806**, CNDCT is measured to see if it is below a predetermined conductivity, CCIRC. If yes, it is assumed that most, if not all, of the ethanol-water has phase separated from the fuel and is at the bottom of the fuel tank **415**. The circulation process may then be stopped. If no, it is assumed that more circulation is required and that process is allowed to continue.

[0040] Like the fueling system **100**, the fueling system **400** may also be manufactured using conventional, commercially available components. The fuel tank **415**, the first fuel shutoff valve **420**, the fuel hose **432**, and the fuel nozzle **430** may comprise the same components as their respective counterparts in the fueling system **100**. That said, it is preferred that the first fuel filter **425** be of the "water-block" variety to create a final barrier to dispensing any water into a vehicle. Suitable water-block fuel filters are conventional and are commercially available. Likewise, the second fuel shutoff valve **435** may comprise a conventional ball valve, while the second fuel filter **440** may comprise a conventional fuel filter (non water-block type). The pump **460** may be a conventional electric fuel pump and the selector valves **445**, **465** may be conventional electric fuel tank selector valves.

[0041] For logic functions, the controller **475** may include any suitable, commercially available microcontroller chip such as, but not limited to, a PIC-type microcontroller. Once its functions are understood, one of ordinary skill in the electronics arts would recognize how to program the microcontroller and how to configure any additional circuitry in the controller **475** needed to interface the microcontroller with the pump **460**, the detector **455**, and the selector valves **445**, **465**. Moreover, programming and interfacing microcontrollers are described in a number of books, including Valdes-Perez et al., *Controllers: Fundamentals and Applications with PIC*, CRC Press, 2009, which is hereby incorporated by reference herein. Power may be supplied to the controller **475** by battery (standard or rechargeable) or by line power. Displays may be added to the controller to indicate the various phases of the separation process such as draining, settling, and separating. Alarms and other features may also be programmed into the controller **475** to indicate fouled filters, inoperative pumps, out-of-range detector measurements, electrical faults, and the like.

[0042] FIG. **9** shows a perspective view of a working prototype of the fueling system **400** implemented in a cart **900** with two rear wheels **905**, a front base **910**, and two handles **915**. A region **920** of the working prototype comprised the air tank pressure gauge **130**, the air tank safety relief valve **135**, and the air tank fill valve **140**; while another region **925** comprised the air tank valve **145**, the pressure regulator **150**, the fuel tank relief valve **155**, the air filter **160**, the air shutoff valve **165**, the fuel tank safety relief valve **170**, the fuel tank pressure gauge **175**, the first fuel shutoff valve **420**, and the first fuel filter **425**. A region **930** near the bottom of the cart **900** comprised the second fuel shutoff valve **435**, the second fuel filter **440**, the motorized source selector valve **445**, the detector **455**, the pump **460**, the motorized waste selector valve **465**, and the controller **475**. Additional hoses were provided for connection to the water source **450** and the waste container **470** (not shown). In this prototype, it will be noted that the first fuel filter **425** (e.g., water-block type) was elevated on the cart **900** so that it was higher than the fuel tank **415**. Such a configuration is preferable; it helps to ensure that the first fuel filter **425** is not flooded with ethanol-water from the fuel tank **415**, and that the first fuel filter **425** provides the greatest effectiveness in removing any residual water from the fuel while the fuel is ultimately being dispensed.

[0043] It should again be emphasized that the above-described embodiments of the invention are intended to be illustrative only. Other embodiments can use different types and arrangements of elements, as well as different process steps, for implementing the described functionality and the results will still come within the scope of the invention. For example, in another embodiment, the air tank may not be present or the air tank may be removable, and the fueling system may be configured to receive compressed air from an external source such as an external compressed air tank or an air compressor. In another example, a detector might use capacitive, inductive, or optical measurements instead of a conductivity measurement to determine the presence and absence of ethanol-water. Alternatively or additionally, another embodiment may even comprise several air tanks and/or several fuel tanks to increase the capacity of the fueling system as well as to provide for even faster fuel flow rates. These numerous alternative embodiments within the scope of the invention will be apparent to one skilled in the art.

[0044] Moreover, all the features disclosed herein may be replaced by alternative features serving the same, equivalent, or similar purposes, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

What is claimed is:

1. An apparatus for providing fuel, the apparatus comprising:

a fuel handling portion, the fuel handling portion comprising a fuel tank adapted to store fuel, and a fuel nozzle in fluid communication with the fuel tank and adapted to dispense fuel from the fuel tank; and

an air handling portion, the air handling portion comprising an air tank adapted to be filled with pressurized gas from a pressurized gas source and the air handling portion operative to, after the pressurized gas source is removed, apply the pressurized gas from the air tank to the fuel in the fuel tank so as to provide a motive force for dispensing fuel through the fuel nozzle.

2. The apparatus of claim **1**, wherein the fuel handling portion comprises a fuel filter.

3. The apparatus of claim **1**, wherein the air handling portion comprises a pressure regulator operative to modify a pressure of the pressurized gas from the air tank before it is applied to the fuel in the fuel tank.

4. The apparatus of claim **1**, wherein the air handling portion comprises an air filter operative to filter the pressurized gas from the air tank before it is applied to the fuel in the fuel tank.

5. The apparatus of claim **1**, further comprising an electronic controller.

6. The apparatus of claim **5**, wherein the electronic controller is in signal communication with a detector that allows the electronic controller to determine a composition of fluid received from the fuel tank.

7. The apparatus of claim **6**, wherein the determination is based at least in part on an electrical conductivity of the fluid.

8. The apparatus of claim **5**, wherein the electronic controller is operative to control one or more pumps.

9. The apparatus of claim **5**, wherein the electronic controller is operative to control one or more motorized selector valves.

10. The apparatus of claim **5**, wherein the electronic controller is operative to cause fluids from the fuel tank to be returned back to the fuel tank.

11. The apparatus of claim **5**, wherein the electronic controller is operative to cause fluids from the fuel tank to be delivered to a waste container.

12. The apparatus of claim **5**, wherein the electronic controller is operative to cause water from a water source to be introduced into the fuel tank.

13. The apparatus of claim **1**, wherein the apparatus is at least partially implemented in the form of a rolling cart.

14. A method of providing fuel, the method comprising the steps of:

filling a fuel tank with fuel, the fuel tank in fluid communication with a fuel nozzle;

pressurizing an air tank with a gas from a pressurized gas source;

removing the pressurized gas source; and

dispensing the fuel from the fuel tank through the fuel nozzle while allowing pressurized gas from the air tank to provide a motive force for dispensing the fuel.

15. The method of claim **14**, further comprising the step of introducing water into the fuel.

16. The method of claim **14**, further comprising the steps of introducing water into the fuel tank a plurality of separate times.

17. The method of claim **14**, further comprising the step of mixing the contents of the fuel tank.

18. The method of claim **14**, further comprising the step of waiting a predetermined time for the contents of the fuel tank to settle without mixing the fluid in the fuel tank.

19. The method of claim **14**, further comprising the step of determining a composition of fluid received from the fuel tank.

20. The method of claim **14**, further comprising the step of pumping fluid from the bottom of the fuel tank and sending the fluid to a waste container.

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