US009134163B2

(12) United States Patent
Horst

(10) Patent No.: US 9,134,163 B2
(45) Date of Patent: Sep. 15, 2015

(54) MULTI-TANK INDIRECT LIQUID-LEVEL MEASUREMENT

(71) Applicant: **John Vander Horst**, Littleton, CO (US)

(72) Inventor: **John Vander Horst**, Littleton, CO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 405 days.

(21) Appl. No.: **13/573,541**

(22) Filed: **Sep. 21, 2012**

(65) **Prior Publication Data**

US 2014/0083185 A1 Mar. 27, 2014

(51) **Int. Cl.**
G01F 23/14 (2006.01)

(52) **U.S. Cl.**
CPC ***G01F 23/14*** (2013.01)

(58) **Field of Classification Search**
CPC G01F 23/00; G01F 23/14; G01F 23/18; G01F 23/162; G01F 23/16; G01F 23/165; G01F 22/02; G01F 1/34
USPC .... 73/299, 290 R, 302, 290 B
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

867,994 A 10/1907 Murphy
1,294,939 A 2/1919 Murphy
1,623,832 A 4/1927 Durant
1,670,207 A 5/1928 Murphy
3,587,316 A 6/1971 Kapteyn
3,803,545 A * 4/1974 Van Dyck et al. 367/152
4,064,752 A * 12/1977 Murphy et al. 73/302
4,489,779 A * 12/1984 Dickinson et al. 166/64
4,665,746 A * 5/1987 Sheppard 73/302
4,869,104 A * 9/1989 Saito et al. 73/299
5,207,251 A 5/1993 Cooks
5,484,336 A 1/1996 McConnell
6,467,343 B1 10/2002 Baird
6,510,736 B1 1/2003 Van Ee
7,389,688 B1 6/2008 Vander Horst
2005/0189275 A1* 9/2005 Stewart 210/86
2006/0086387 A1* 4/2006 Gupta et al. 137/101.25
2009/0007660 A1* 1/2009 Van Ee 73/299

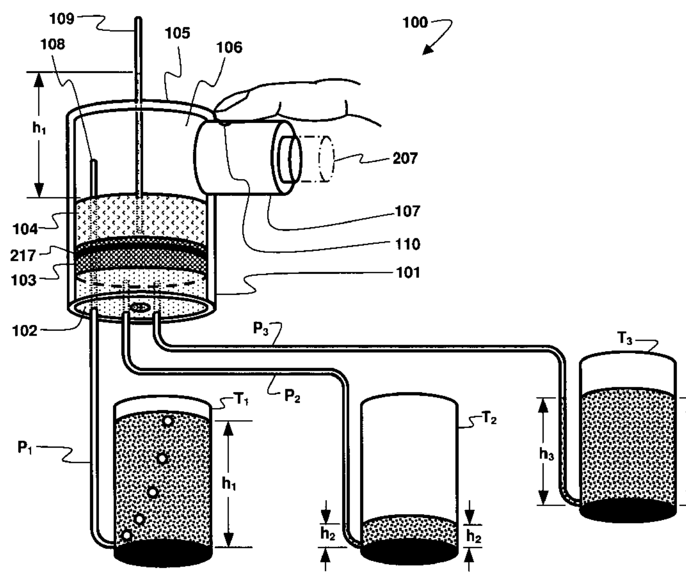
* cited by examiner

Primary Examiner — Hezron E Williams
Assistant Examiner — Marrit Eyassu

(57) **ABSTRACT**

A multi-tank indirect liquid level measurement device and method are disclosed. The device and method may be implemented using a sealable reservoir that holds an indicating liquid and pressurized air, a pump that supplies and/or pressurizes the air in the reservoir, a plurality of pipes each of which connect on one end to the tanks to be gaged and on their other ends to a valve for selectively and exclusively connecting to the pressurized air, and a manometer tube that displays the pressure difference between the sealable reservoir and atmospheric pressure as a height reading of the indicating liquid.

20 Claims, 9 Drawing Sheets



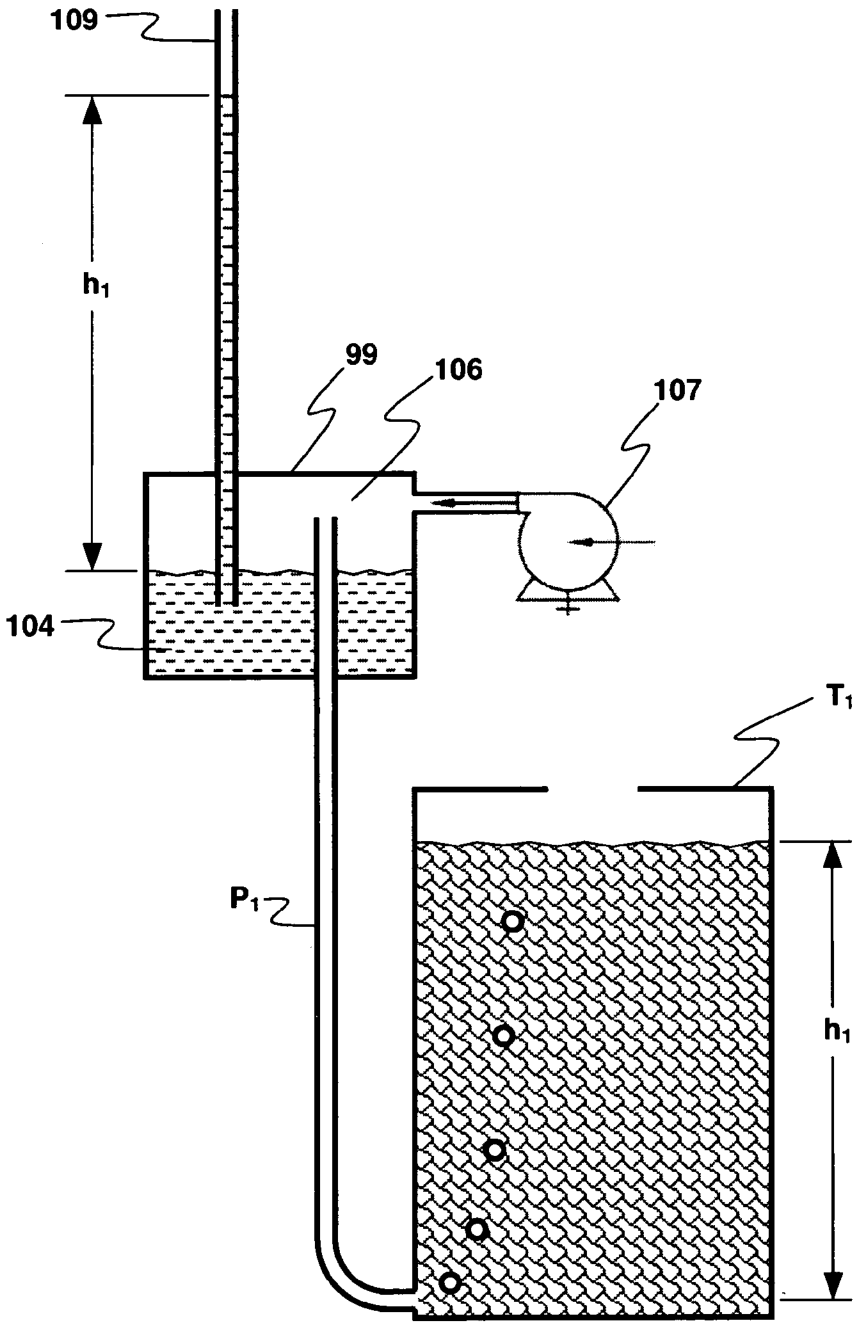


Fig. 1 (Prior Art)

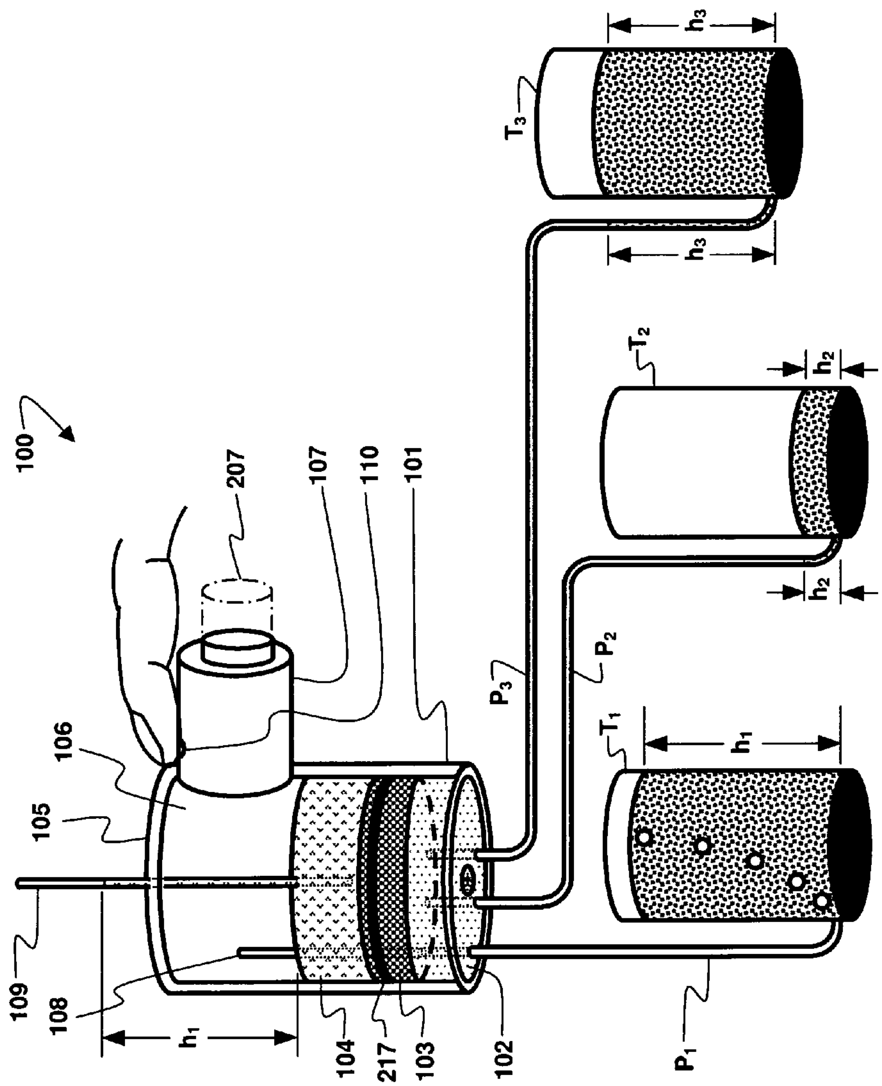

100
207
107
110
101
106
105
109
108
h1
104
217
103
102
P1
P2
P3
T1
T2
T3
h1
h2
h3

Fig. 2

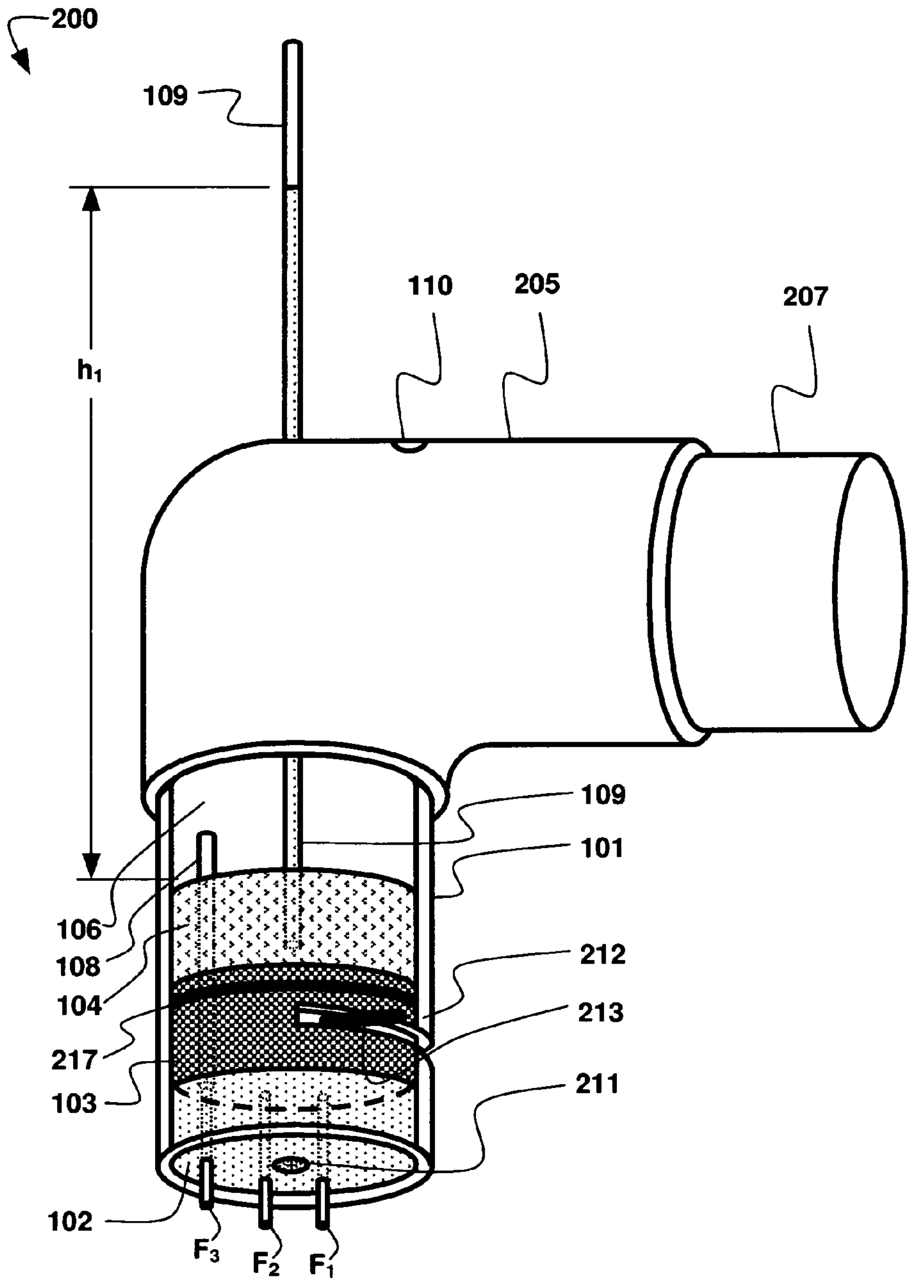

200
109
h1
110
205
207
109
101
106
108
104
212
217
213
103
211
102
F3
F2
F1

Fig. 3

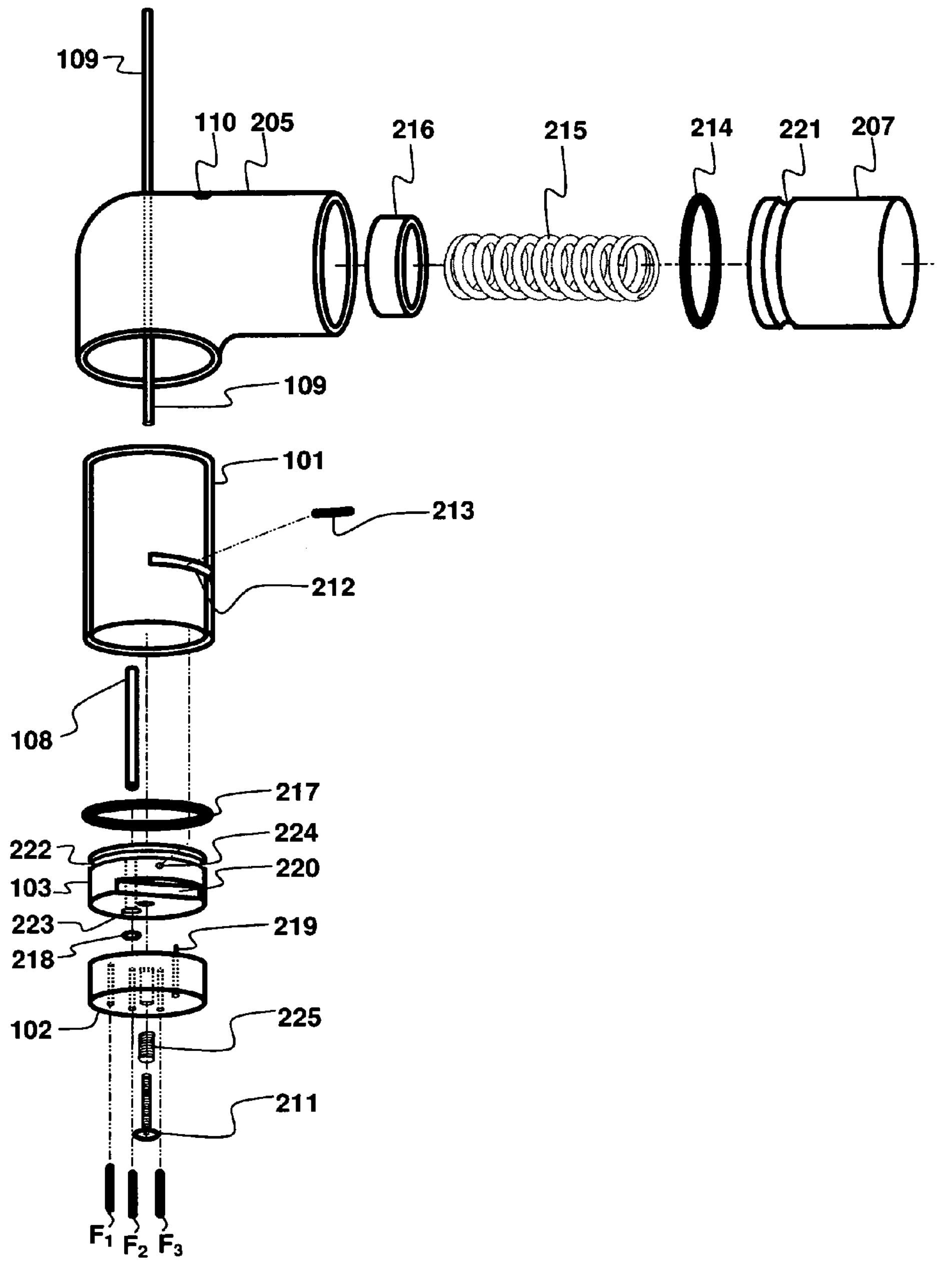

109
110
205
216
215
214
221
207
109
101
213
212
108
217
222
224
103
220
223
219
218
102
225
211
F_1
F_2
F_3

Fig. 4

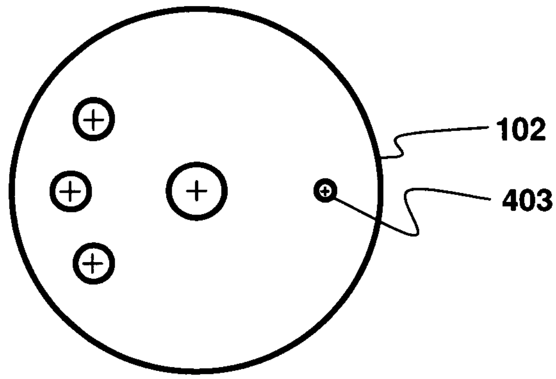


Fig. 5a

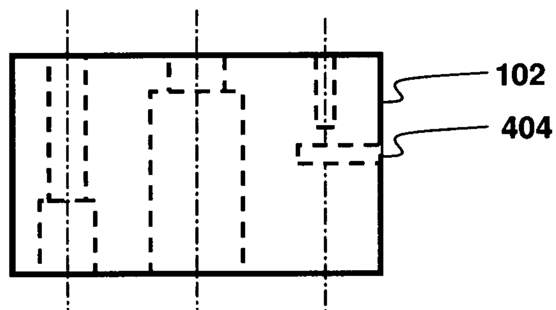


Fig. 5b

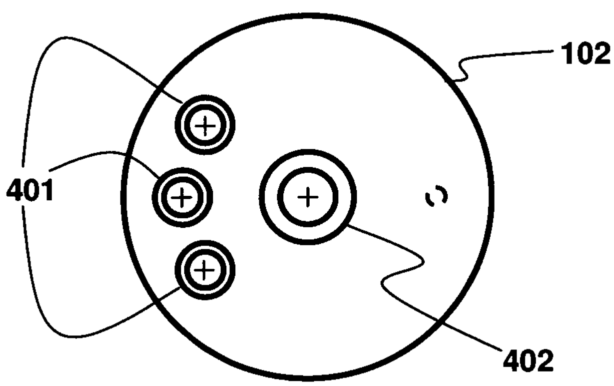


Fig. 5c

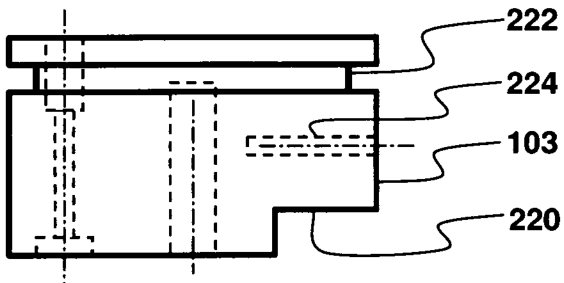


Fig. 6a

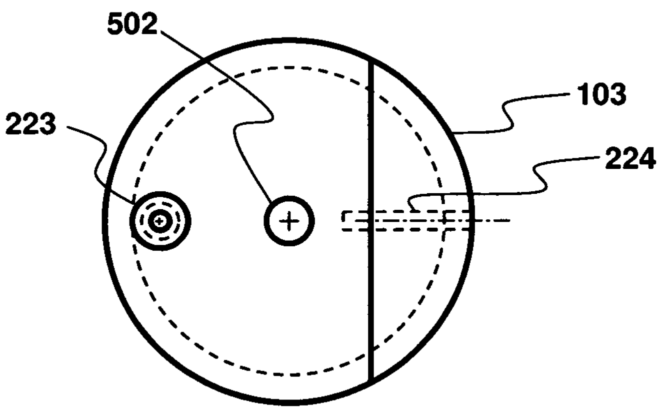


Fig. 6b

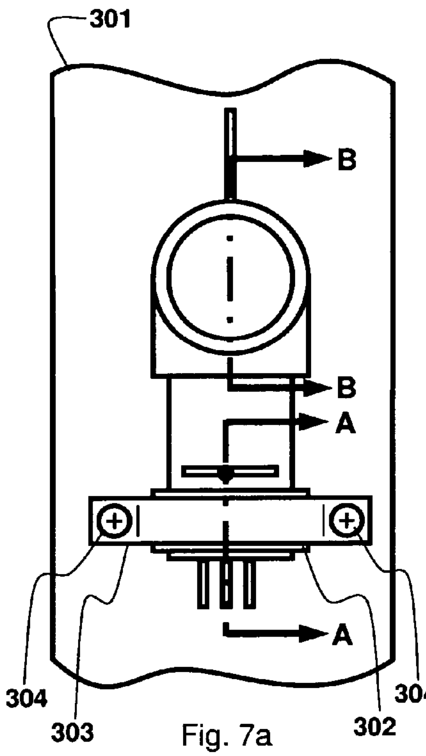


Fig. 7a

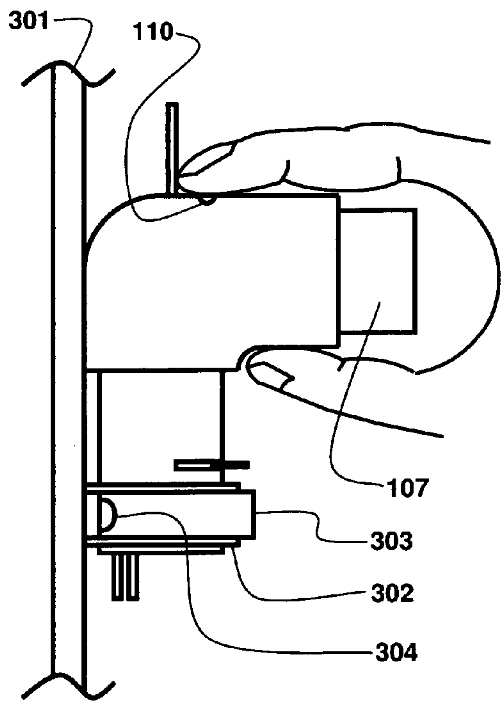


Fig. 7b

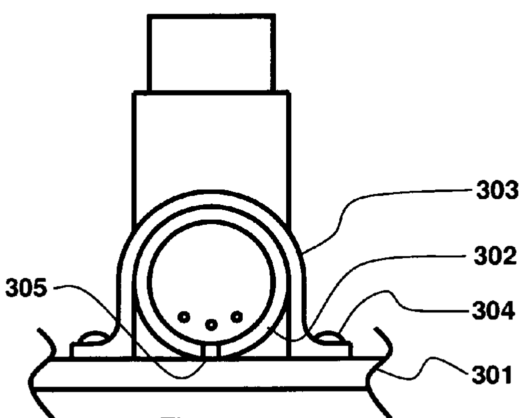


Fig. 7c

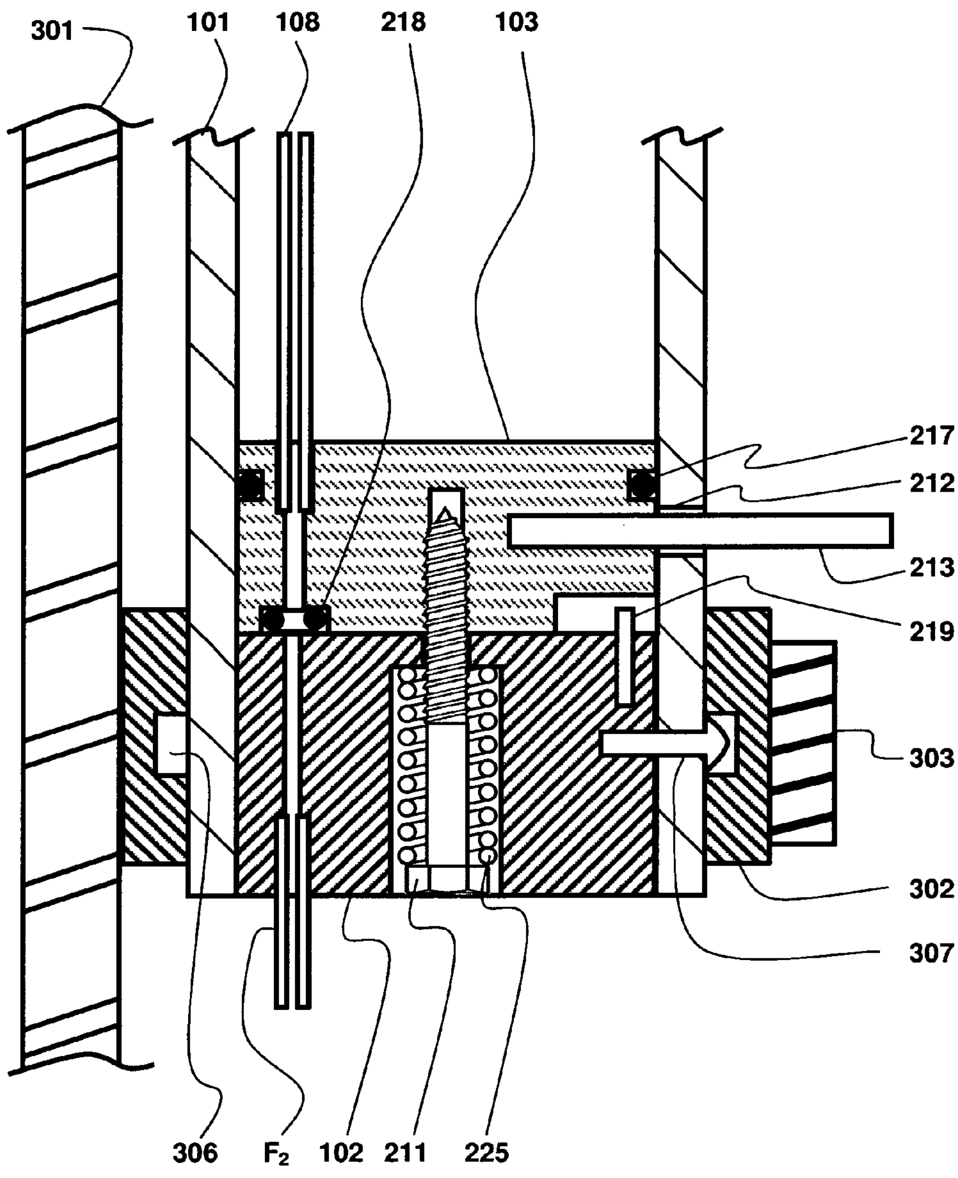

301
101
108
218
103
217
212
213
219
303
302
307
306
F2
102
211
225

Fig. 8

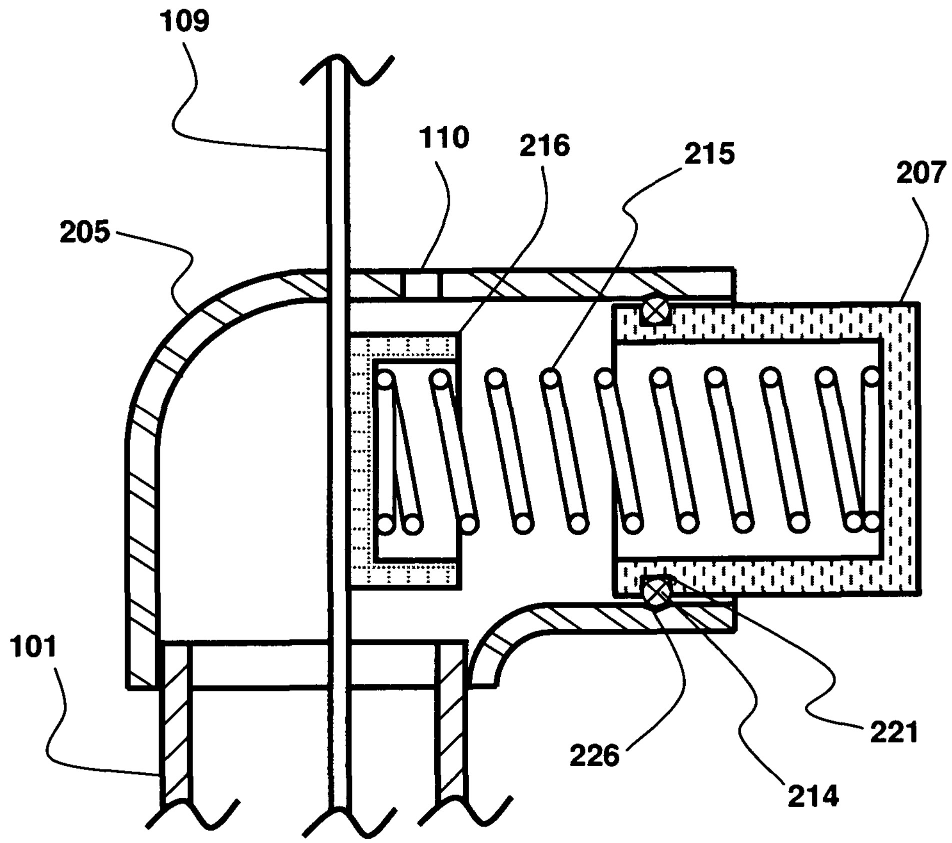


Fig. 9

MULTI-TANK INDIRECT LIQUID-LEVEL MEASUREMENT

BACKGROUND

This disclosure relates to the measurement of liquid levels in recreational vehicle wastewater holding tanks.

Many recreational vehicles, such as campers, trailers, fifth wheelers, and motor homes, have one or more tanks for storing the effluent or wastewater originating in the toilet, sink, or shower. These tanks are typically called black water or gray water tanks. The effluent stored in black water and gray water tanks can easily clog or render inoperable a liquid level measurement apparatus or sensors in direct contact with the wastewater. Examples of typical direct wastewater measurement devices are ones that use conductance, capacitance, floats, or other direct means for measuring the liquid in a tank. Despite the numerous cleaning methods and chemicals that have been developed, many of the existing wastewater level measuring methods and systems can fail within several weeks, resulting in the owner of a recreational vehicle draining the wastewater tank or tanks too frequently or running the risk of a tank overflow.

A typical modern recreational vehicle has a plurality of wastewater holding tanks. There are normally separate tanks for black water (human waste from the toilet) and gray water (waste water from the kitchen sink). There may be a second gray water tank for effluent from a shower.

Indirect liquid level measurement systems exist. One example is U.S. Pat. No. 7,389,688 by John Vander Horst. These devices work, but it was desired to make a simpler purely mechanical device that requires no transducers and is capable of measuring the liquid level in multiple tanks using a single gage.

SUMMARY

In one embodiment, the present disclosure provides a multi-tank indirect liquid-level measurement device and method that is implemented using a sealable reservoir that holds an indicating liquid and pressurized air, a pump that supplies and/or pressurizes the air in the reservoir, a plurality of pipes each of which connect on one end to the tanks to be gaged and on their other ends to a valve for selectively and exclusively connecting to the pressurized air, and a manometer tube that displays the pressure difference between the sealable reservoir and atmospheric pressure as a height reading of the indicating liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure is described in conjunction with the appended figures in which:

FIG. **1** shows the principle of operation and the prior art;

FIG. **2** shows an indirect liquid level-measuring device connected to a plurality of wastewater tanks;

FIG. **3** shows an embodiment of a transducerless multi-tank indirect liquid level-measuring device;

FIG. **4** is an exploded view of the device of FIG. **3**;

FIG. **5***a* is a top view of the connection disk of FIG. **3** and FIG. **4**;

FIG. **5***b* is a side view of the connection disk of FIG. **3** and FIG. **4**;

FIG. **5***c* is a bottom view of the connection disk of FIG. **3** and FIG. **4**;

FIG. **6***a* is a side view of the selection disk of FIG. **3** and FIG. **4**;

FIG. **6***b* is a bottom view of the selection disk of FIG. **3** and FIG. **4**;

FIG. **7***a* is a front view of the device of FIG. **3** mounted to a wall;

FIG. **7***b* is a side view of the device of FIG. **3** mounted to a wall;

FIG. **7***c* is a bottom view of the device of FIG. **3** mounted to a wall;

FIG. **8** shows section A-A of FIG. **7***a*; and

FIG. **9** shows section B-B of FIG. **7***a*.

To assist in the understanding of one embodiment of the present invention, the following list of components or features and associated numbering found in the drawings is provided herein:

Number	Component or Feature
F_1	First fitting
F_2	Second fitting
F_3	Third fitting
h_1	First height
h_2	Second height
h_3	Third height
P_1	First pipe
P_2	Second pipe
P_3	Third pipe
T_1	First tank
T_2	Second tank
T_3	Third tank
99	Sealable vessel
100	Liquid level measuring system with three tanks
101	Cylindrical tube
102	Connection disk
103	Selection disk
104	Indicator liquid
105	End cap
106	Pressurized air
107	Pressurization source
108	Pressurization tube
109	Manometer tube
110	Pressure relief hole
200	Multi-tank indirect liquid level measuring device
205	End cap pump housing
207	Pump button
211	Assembly screw
212	Cylindrical tube slot
213	Selection disk rotation pin
214	Pump button o-ring
215	Pump spring
216	Spring support
217	Selection disk o-ring
218	Connection tube o-ring
219	Stop pin
220	Slot
221	Pump button o-ring groove
222	Selection disk o-ring groove
223	Connection tube o-ring housing
224	Selection disk rotation pin hole
225	Assembly spring
226	Pump button o-ring stop
301	Recreational vehicle wall
302	Mounting sleeve
303	Mounting bracket
304	Mounting screw
305	Slit in mounting sleeve
401	Connection disk fitting hole
402	Connection disk assembly screw hole
403	Connection disk stop pin hole
404	Anti-rotation pin hole
502	Selection disk assembly screw hole

It should be understood that the drawings are not necessarily to scale. In certain instances, details that are not necessary for an understanding of the invention or that render other details difficult to perceive may have been omitted. It should be understood that the invention is not necessarily limited to the particular embodiments illustrated herein.

DETAILED DESCRIPTION

The ensuing description provides preferred exemplary embodiment(s) only, and is not intended to limit the scope, applicability or configuration of the disclosure. Rather, the ensuing description of the preferred exemplary embodiment (s) will provide those skilled in the art with an enabling description for implementing a preferred exemplary embodiment. It should be understood that various changes could be made in the function and arrangement of elements without departing from the spirit and scope as set forth in the appended claims.

Specific details are given in the following description to provide a thorough understanding of the embodiments. However, it will be understood by one of ordinary skill in the art that the embodiments may be practiced without these specific details. For example, circuits may be shown in block diagrams in order not to obscure the embodiments in unnecessary detail. In other instances, well-known circuits, processes, algorithms, structures, and techniques may be shown without unnecessary detail in order to avoid obscuring the embodiments.

In one embodiment, the present disclosure provides a device suitable for use with one or more wastewater holding tanks of a recreational vehicle. Wastewater holding tanks are typically located downstream of a toilet, sink, shower, or any other place where water is used to clean something or where water is combined with other fluids or solids. In addition to recreational vehicles, vehicle wastewater holding tanks can be used in other transportable or moving applications such as boats, trains, buses, aircraft, or portable lavatories.

This disclosure discusses transducers and the fact that embodiments of the present invention can be made without using a transducer (i.e. transducerless). For purposes of this disclosure, a transducer is defined as a device that converts one form of energy to another, where energy types include electrical, mechanical, electromagnetic (including light), chemical, acoustic, or thermal energy. Therefore, an example of a transducerless device would be one that does not rely on any conversion from mechanical energy to electrical, electromagnetic, chemical, acoustic, or thermal energy.

The present invention relies on the principle that the height of a liquid in a tank can be measured at a distance from such tank by measuring the pressure of a gas induced above the surface of an indicating liquid contained in a suitable gage reservoir, the excess gas being lead by a pipe or tube from the top of the gage reservoir to a point within and near the bottom of the distant tank, so that the pressure on the indicating liquid surface is proportional to the depth of the liquid in the distant tank. This principle is understood in the prior art and is illustrated in FIG. **1** in which a pump **107** pressurizes the air **106** that is part of a sealable vessel **99** that serves as a gage reservoir. This pressurized air **106** has two places to go. It can push the indicator liquid **104** up a manometer tube **109** and it can push air down a pipe P_1 until excess air escapes from the distant tank T_1. If the liquid in the tank T_1 and the indicator liquid **104** have the same density, then the height h_1 of the liquid in the manometer tube **109** as measured from the top of the indicating liquid **104** will be the same as the height h_1 of the liquid in tank T_1 above the inlet of the pipe P_1 in the tank T_1. Note that the pressure reading does not change with the relative vertical position of the tank T_1 and sealable vessel **99**. In one embodiment, the present invention applies this principle described in FIG. **1** to an easy-to-fabricate and easy-to-use transducerless device for measuring the level of multiple wastewater tanks in a vehicle (such as a recreational vehicle) or in a portable application (such as a portable lavatory).

FIG. **2** shows a system comprising an embodiment of an indirect liquid level-measuring device and a plurality of wastewater tanks is shown at **100**. Specifically shown are three tanks, labeled T_1, T_2, and T_3, connected with three pipes P_1, P_2, and P_3, respectively, to the measuring device, which comprises all of the other elements shown in FIG. **2**. Note that in a typical recreational vehicle application the tanks T_1, T_2, and T_3, will generally be larger, flatter, and more distant from the measuring device than the relative scale of the tanks, pipes, and device depicted in FIG. **2**. One end of the pipes P_1, P_2, and P_3 are connected to either the bottom of the tanks T_1, T_2, and T_3, or to the sides of these tanks as close to their bottoms as possible, in order to read as close to the full pressure head of the liquid in the tanks. The other end of the pipes P_1, P_2, and P_3 are connected to a connection disk, shown at **102**. The connection disk **102** is located at the base of the measuring device. The pipes P_1, P_2, and P_3 are typically made of tubing. This tubing may be flexible PVC, it may be some other kind of a flexible or rigid plastic, or it can be some other type of piping capable of being understood by anyone skilled in the art. The tubing may be any length or diameter. However, for performance reasons, one would like to have tubing that has a relatively thin internal diameter as this reduces the displacement required by the pump. The lengths of the pipes needed for using a gage of this type in a recreational vehicle may be a minimum of 20 feet.

Also referring to FIG. **2**, in one embodiment the indirect liquid-level measuring device comprises a cylindrical tube **101**, the connection disk **102**, a selection disk **103**, an end cap **105**, the pressurization source **107**, a pressurization tube **108**, and a manometer tube **109**. The enclosed space in the cylindrical tube **101** between the selection disk **103** and the end cap **105** may be partially filled with the indicator liquid **104** and the multi-tank indirect liquid-level measuring device is oriented so that the remaining volume of the enclosed space between the selection disk **103** and the end cap **105** can serve as the body of a sealable vessel. A selection disk o-ring **217** is part of the system that helps maintain pressure in the measuring device. The indicator liquid **104** can be any liquid understood by someone skilled in the art of manometers, examples of which include mercury and water. If water is to be used, a colorant may be added to make the height of the water easer to see in the manometer tube **109**. The pressurization source **107** generates the pressurized air **106** that makes the device work. Note that the indicator liquid **104** is typically not necessarily part of the device, but will be added by the user during the installation process.

Further referring to FIG. **2**, the pipes P_1, P_2, and P_3, are attached to the connection disk **102** at three points on one end of the cylindrical disk with each of the attachment points being located the same distance from the central axis of the connection disk. The attachment points comprise axial holes through the connection disk that allow air to pass through the connection disk to one of the pipes P_1, P_2, and P_3, when a pressurization tube **108** mounted in the selection disk **103** is rotated to align with the hole in the connection disk **102** opposite that pipe, The selection disk **103** is assembled into the cylindrical tube in a way that allows an operator to rotate the selection disk **103** inside the cylindrical tube. The details of one implementation will be explained later in this disclosure. This pressurization tube **108** that is mounted in the selection disk, extends through the indicator liquid **104** to the pressurized air **106**.

Additionally FIG. **2** shows the end cap **105** that helps to seal the pressurized air **106** into an enclosed space. The end cap **105** can either be an integral part of the cylindrical tube **101** as illustrated in FIG. **2**, or it can be a separate component that is attached to the cylindrical tube **105**. The pressurization source **107** shown in FIG. **2**, can be a simple single-stroke hand-operated push button positive displacement pump cylinder **207** that, when depressed, pressurizes the air **106**. A user's thumb would typically press this push button. There is also a pressure relief hole, shown at **110**, which can be sealed by a user's fingers while pressing the push button. Examples of hand-operated positive displacement pumps include, but are not limited to piston pumps, pumps that use a bulb (such as a turkey baster), other kinds of squeeze pumps, bellows pumps, and diaphragm pumps. The pump also doesn't need to be limited to one that is operated by the operator's hands. Other examples of manual human-operated pumps can include pumps in which the user blows into a tube, presses a footpad, or uses an arm or leg action to crank a handle.

FIG. **2** also illustrates the operation of the system when the first tank T_1 has been selected and has its liquid level measured. The first pipe P_1 has been selected and pneumatically connected to the volume of air in the device through the pressurization tube **108**. The pump button **207** has been depressed from its relaxed state while a pressure relief hole **110** has been sealed by a user's finger, causing air to push through the first pipe P_1 and create air bubbles in the first tank T_1 as excess air escapes. The pressurized air **106** also forces water up the manometer tube **109** making the reading of the pressure head h_1 equal to the vertical height of the liquid in the first tank T_1 from the point at which the first pipe P_1 enters the first tank T_1. If the indicator liquid **104** and the liquid in the first tank are both water, or are both liquids having the same densities, the vertical height of the indicator liquid in the manometer tube and the vertical height of the water in the first tank T_1 from the point of the inlet of the first pipe P_1 will both be the same as shown by the two h_1's in FIG. **2**. If liquids of different densities are used, there will be a ratio in the two heights that is directly proportional to the ratio of the densities of the two liquids.

Note that the second pipe P_2 and third pipe P_3 have liquid in them to the same height as the liquid that is in the respective tanks T_2 and T_3 because these pipes have not been connected to the pressurized air **106** by the valve that is part of the multi-tank liquid-level measuring device. The volume of liquid in these two pipes h_2 and h_3, respectively, must be purged if the liquid level were to be measured in these tanks. To minimize the amount of liquid that must be pumped from these pipes it is desirable to minimize the inside diameter of the pipes and to run the pipes directly vertically until they are a sufficient distance above the highest liquid level that could be in any of these tanks. As a reference, the system shown in FIG. **2** has been implemented using pipe that has an inside diameter of 3/32 inch. Other inside diameters such as 1/16 inch and 1/8 inch could also be used for a typical recreational vehicle. If a 3/32 inch inside diameter pipe is used and the length of pipe is 15 inches before it is above the tank, a displacement of 0.1 cubic inches would be required to purge the liquid from the pipe. The method of attachment and sealing of the pipes P_1, P_2, and P_3 to the tanks T_1, T_2, and T_3 and to the connection disk **102** of the measuring device can be accomplished via a mechanical fitting, through ultrasonic bonding, through plastic welding, or through some other means capable of being understood by someone skilled in the art.

Note that the entire indirect liquid level-measuring device shown in FIG. **2** is transducerless, in that it uses only mechanical energy (in the form of pressure) to provide a reading of liquid levels in a plurality of recreational vehicle wastewater tanks, without converting this to an other form of energy such as electrical, electromagnetic, chemical, acoustic, or thermal energy.

Further referring to FIG. **2** the operation of a push button positive displacement pump can cause the indicating liquid in the manometer tube **109** to overshoot. To prevent this, a flow damper can be placed into the manometer tube **109** close to the point at which the indicator liquid **104** enters the manometer tube **109**. Placing a 1/8 inch long plug into the manometer tube **109** at the end close to the inlet for the indicator liquid **104** has been found to work well as a flow damper.

FIG. **3** and FIG. **4** show another embodiment of an indirect liquid level-measuring device at **200**. The embodiment shown in FIG. **3** and FIG. **4** is similar to the device shown in FIG. **2**, but the tanks and pipes have been removed to reveal more detail of the device. In the device shown in FIG. **3** the end cap (**105** in FIG. **2**) and the housing for the pressurization source (**107** in FIG. **2**) have been integrated into a single end cap housing, shown at **205**. In this embodiment, the end cap housing **205** is made from a standard 90-degree polyvinylchloride (PVC) elbow joint that can be obtained at hardware stores. In one specific embodiment, the end cap housing is a 90-degree elbow joint for standard 3/4 inch PVC pipe. This means the inside diameter of the elbow joint is 1.050 inches because 3/4 inch PVC pipe has an inside diameter of approximately 3/4 inch and a wall thickness of approximately 0.15 inches. In the embodiment shown in FIG. **3**, one leg of the elbow joint has been reduced in length to fit the cylindrical tube, shown at **101**. There is a hole drilled into the elbow for the manometer tube, shown at **109**. In the embodiment shown, the manometer tube is made of 1/4 inch outside diameter rigid acrylic tubing with a 1/16 inch wall thickness giving an inside diameter of 1/8 inch. The manometer tube **109** has lines marked on it to show the height of the indicator liquid. In the embodiment shown, the manometer tube hole is drilled so the manometer tube **109** has its one end centered in the center of the indicator liquid, shown at **104**. The manometer tube hole and the fitting of the manometer tube into this hole must be done in a way that provides a good seal for the pressurized air **106**. This can be done using any technique capable of being understood by someone skilled in the art. One technique is to use a fitting made of pliable PVC tubing that provides a hermetic seal. There are also adhesives that can be used to provide such a hermetic seal.

Further referring to FIG. **3** and FIG. **4**, there is a pressure relief hole (or vent) drilled into the elbow, which is shown at **110**. This hole serves the same function as the equivalent hole shown in FIG. **2**. A pump button, shown at **207** is used to pressurize the air **106**. More details of the pump button **207** and other pump elements will be described later in this disclosure. The exact configuration, materials, and manufacturing process for the end cap housing **205** can be anything capable of being understood by someone skilled in the art.

FIG. **3** and FIG. **4** also show the cylindrical tube at **101**. The cylindrical tube **101** in this embodiment is made from 0.80 inch inside diameter, 1.05 inch outside diameter transparent PVC pipe that has been cut to a length of approximately 2.5 inches. The cylindrical tube **101** has a cylindrical tube slot, shown at **212**, cut into it. In the embodiment shown, the cylindrical tube slot **212** is approximately 0.10 inch wide; it is located about 0.70 inches from one end (the bottom) of the cylindrical tube; and it extends approximately 90 degrees around the circumference of the cylindrical tube **101**. The end of the cylindrical tube **101** furthest from the cylindrical tube slot **212** is attached and sealed to the end cap pump housing

205 using any technique capable of being understood by someone skilled in the art. One example of an attachment and sealing technique for the cylindrical tube **101** and end cap housing **205** is the use of an adhesive.

Further referring to the embodiment shown in FIG. **3** and FIG. **4**, the selection disk, shown at **103** and the connection disk, shown at **102** are attached to one another using an assembly screw, shown at **211**. The assembly screw **211** is axially centered in the selection disk **103** and connection disk **102**. An assembly spring **225** creates a constant force between the selection disk **103** and connection disk **102**, while still allowing the two disks to rotate relative to one another. In the embodiment shown in FIG. **3** and FIG. **4**, the connection disk **102** has three fittings, shown at F_1, F_2, and F_3 that allow pipes or tubes, shown as P_1, P_2, and P_3 in FIG. **2**, from the tanks shown as T_1, T_2, and T_3 in FIG. **1**, to attach to the liquid level measuring device **200**. In the embodiment shown in FIG. **3** and FIG. **4**, these fittings F_1, F_2, and F_3 are pressed into axial through holes in the connection disk **102**. By rotating the selection disk **103** relative to the connection disk **102**, the user can select which of the three fittings F_1, F_2, or F_3 in the connection disk **102** lines up with an axial through hole in the selection disk **103**. The outside diameters of the connection disk **102** and the selection disk **103** are designed to allow these to disks to fit snugly into the cylindrical tube **101**. There is an o-ring grove around the circumference of the selection disk **103** near the end of the selection disk **103** that is opposite the connection disk **102**. This groove has an o-ring, shown at **217**, placed in it to provide a seal between the pressurized air **106** and outside atmosphere when the selection disk and connection disk are placed inside the cylindrical tube **101**. The pressurization tube, shown at **108**, is placed into the hole in the selection disk. The pressurization tube **108** extends out the end of the selection disk **103** that is opposite the connection disk **102** and extends through the indicator liquid, shown at **104**, to the pressurized air **106**.

FIG. **3** and FIG. **4** also show how the selection disk **103** can be rotated when the device **200** has been assembled. There is a hole in the selection disk **103** that lines up with the cylindrical tube slot **212** in the cylindrical tube **101**. In the embodiment shown in FIG. **2**, a selection disk rotation pin, shown at **213**, is pressed into this hole in the selection disk **103**. The connection disk **102** is fixed so that it cannot move relative to the cylindrical housing **101**, which can be accomplished using any method capable of being understood by someone skilled in the art, such as the use of a pin that goes radially through the cylindrical housing **101** and into the connection disk **102**. The selection disk **103** will then rotate relative to the connection disk when a user rotates the selection disk rotation pin **213** relative to the cylindrical housing **101**. A rotary valve is created through the combination of the cylindrical selection disk **103** placed in a cylindrical tube **101** with a selection disk rotation pin **213** that is accessed through the cylindrical tube slot **212**.

Further referring to FIG. **4**, the pump button **207** includes an o-ring groove, shown at **221**, into which a pump button o-ring, shown at **214**, can be placed. The pump button o-ring **214** helps ensure that there is a good seal for maintaining the pressurized air (**106** in FIG. **2** and FIG. **3**). There is a coil spring, shown at **215**, which becomes compressed when the pump button **207** is pressed. One end of the coil spring **215** is retained inside the pump button **207**. A spring support, shown at **216**, retains the other end of the coil spring **215**. When the device shown in FIG. **4** is assembled, the spring support **216** rests against the manometer tube, shown at **109**. The pump button **207**, pump button o-ring **214**, coil spring **215**, and spring support **216** can be made of any materials capable of being understood by anyone skilled in the art. For example, the pump button **207** can be made of machined or molded plastic, the pump button o-ring **214** can be a commercially purchased rubber o-ring, the coil spring **215** can be a commercially purchased plastic or steel spring, and the spring support **216** can be molded or machined ring or cap capable of retaining the coil spring.

FIG. **4** also shows how the manometer tube, shown at **109**, and the cylindrical tube, shown at **101**, fit into the end cap pump housing **205**. The assembly spring, shown at **225**, provides a compressive force to ensure that the connection disk **102** and selection disk **103** are always pressed together. A connection tube o-ring, shown at **218**, is placed into a selection tube o-ring housing, shown at **223**, before the selection disk **103** and connection disk **102** are fastened together. A stop pin, shown at **219**, is also placed into a hole in the connection disk before the selection disk **103** and connection disk **102** are fastened together. One end of the stop pin **219** fits into a slot, shown at **220** in the selection disk to limit the amount of rotation between the connection disk **102** and selection disk **103** to the three through holes in the connection disk **102** that line up with the three fittings, shown at F_1, F_2, and F_3, that are pressed into the connection disk **102**. A pressurization tube, shown at **108** is pressed into the selection disk **103**. A selection disk o-ring, shown at **217**, is placed into a selection disk o-ring groove, shown at **222**.

Further referring to FIG. **4**, the completed subassembly comprising the connection disk **102**, the selection disk **103**, and various attachments can be placed into the cylindrical tube **101** once the operations described in the previous paragraph have been completed. The completed selection disk+assembly disk subassembly is pushed in far enough so that the selection disk rotation pin hole, shown at **224**, is in the cylindrical tube slot, shown at **212**, allowing the selection disk rotation pin, shown at **213**, to be placed in the selection disk rotation pin hole **224**.

Referring to FIG. **3** and FIG. **4**, the easiest way to fill the indirect liquid level measuring device with an indicator liquid, shown at **104** in FIG. **3**, is to remove the pump button **207** and pump button o-ring **214** in FIG. **3**, as well as the coil spring **215** in FIG. **4**, and spring support **216** in FIG. **4** from the end cap pump housing **205**. The user can then pour the indicator liquid **104** in FIG. **3** directly into the vessel.

FIG. **5***a* is a top view of the connection disk **102**. FIG. **5***b* is a side view of the connection disk **102**. FIG. **5***c* is a bottom view of the connection disk **102**. These views illustrate the fitting holes, shown at **401**, which connect to the three fittings (F_1, F_2, and F_3 in FIG. **4**). FIG. **5***a*, FIG. **5***b*, and FIG. **5***c* also illustrate the assembly screw hole, shown at **402**, that houses the assembly screw (**211** in FIG. **4**) and assembly spring (**225** in FIG. **4**). Additionally, FIG. **5***a*, FIG. **5***b*, and FIG. **5***c* illustrate the stop pin hole, shown at **403**, which houses the opposite end of the stop pin (**219** in FIG. **4**)

FIG. **6***a* shows a side view of the selection disk at **103**. FIG. **6***b* shows a bottom view of the selection disk at **103**. FIG. **6***a* and FIG. **6***b* depict the o-ring groove at **222**. FIG. **6***a* and FIG. **6***b* depict the connection tube o-ring housing at **223**. FIG. **6***a* and FIG. **6***b* depict the selection disk rotation pin hole at **224**. FIG. **6***a* and FIG. **6***b* depict the assembly screw hole at **502**.

FIG. **7***a*, FIG. **7***b*, and FIG. **7***c* provide three orthogonal views of a liquid level-measuring device mounted on the wall of a recreational vehicle. In these three views, the wall of the recreational vehicle is shown at **301**. The device is mounted using a mounting sleeve, shown at **302**. The mounting sleeve **301** surrounds the device near the bottom of the device. This sleeve has a slot, shown at **305**, which allows the sleeve **302** to fit snugly around the device regardless of tolerances of the device and the sleeve **302**. The sleeve is surrounded by a mounting bracket, shown at **303**, which is attached to the wall, shown at **301**, using two mounting screws, shown at **304**.

FIG. **7b** also shows how an operator's index finger might be used to seal the pressure relief hole **110**. Typically, the thumb of the operator's other hand (not shown) would simultaneously the press the pump button **207** to make a liquid level reading using the embodiment of the device shown.

FIG. **8** is section A-A of FIG. **7a** that shows the wall of the recreational vehicle at **301**. The mounting sleeve is shown at **302**. There is a groove, shown at **306**, in the mounting sleeve **302**. This groove **306** facilitates the placement of an anti-rotation pin, shown at **307**, that goes through the wall of the cylindrical tube, shown at **101**, to prevent the connection disk, shown at **102**, from rotating relative to the cylindrical tube **101**. The mounting bracket, shown at **303**, goes over the mounting sleeve **302**. One end of the stop pin, shown at **219**, is pressed into the connection disk **102**. The selection disk rotation pin, shown at **213**, is pressed into the selection disk **203** and is accessible to the user through a slot in the cylindrical tube **101**.

Further referring to FIG. **8**, the assembly screw, shown at **211**, compresses the assembly spring, shown at **225**, to provide a pressure that keeps the connection disk **102** pressed against the selection disk **103**. This ensures that the connection tube o-ring, shown at **218**, provides a proper seal. This seal is needed to ensure that the pressurized air delivered by the fitting, shown at F_2, is transmitted to the pressurization tube, shown at **108** without leakage.

FIG. **9** is section B-B of FIG. **7a**. This shows the end cap pump housing **205** and pressure relief hole **110**. It also shows how the spring cap **216** rests against the manometer tube **109**. It further shows the pump spring **215** being compressed between the spring cap **216** and pump button **207**. The pump button o-ring **214** rides in the pump button o-ring groove **221**. There is also a small ring machined out of the end cap pump housing **205** that helps serve as a pump button o-ring stop shown at **226**. Also shown at **101** is a partial section of the cylindrical tube. For reference purposes, one embodiment of the design shown in FIG. **9** has an end cap pump housing inside diameter of approximately 1.05 inches and a pump button stroke of about 0.5 inches giving a displacement in excess of 0.4 cubic inches in a single stroke. The following is a list of minimum pump displacements (Minimum Displacement) needed assuming various choices of pipe inside diameters (Pipe IDs for pipes shown P_1, P_2, and P_3 in FIG. **2**), manometer tube (**209** in FIG. **2**) inside diameters (Tube IDs), and tank heights (h_1, h_2, and h_3 in FIG. **2**, heights in list below) that are suitable for various typical recreational vehicles:

Pipe ID	Tube ID	Height	Minimum Displacement
1/16"	3/32"	5 inches	0.05 cubic inches
1/16"	3/32"	10 inches	0.10 cubic inches
1/16"	3/32"	15 inches	0.15 cubic inches
1/16"	3/32"	20 inches	0.20 cubic inches
1/16"	3/32"	25 inches	0.25 cubic inches
3/32"	1/8"	5 inches	0.10 cubic inches
3/32"	1/8"	10 inches	0.20 cubic inches
3/32"	1/8"	15 inches	0.30 cubic inches
3/32"	1/8"	20 inches	0.40 cubic inches
3/32"	1/8"	25 inches	0.50 cubic inches

A number of variations and modifications of the disclosed embodiments can also be used. The principles described here can also be used for in applications other than recreational vehicles such as bioreactors, etc. While the principles of the disclosure have been described above in connection with specific apparatuses and methods, it is to be clearly understood that this description is made only by way of example and not as limitation on the scope of the disclosure.

What is claimed is:

1. An apparatus for indicating the depth of liquid in a plurality of recreational vehicle wastewater tanks comprising:

a sealable reservoir suitable for holding an indicating liquid and pressurized air wherein the indicating liquid comprises water and a colorant;

the reservoir comprising:

a vertically oriented cylindrical tube; and

a manually sealable pressure relief hole;

a manual piston pump that pressurizes the air in the reservoir;

a connection element comprising a plurality of pipe fittings wherein each pipe fitting comprises a detachable connection to a pipe that communicates with liquid in the bottom of one of the recreational vehicle wastewater tanks to be gaged;

a selection element for selectively and exclusively connecting one of said fittings to the pressurized air;

wherein the selection element further comprises a selection disk that is axially aligned with the cylindrical tube and snugly fits in the cylindrical tube;

the selection disk is manually rotated using a radially oriented in that fits in a slot of the cylindrical tube;

the connection element further comprises a connection disk wherein the connection disk is axially aligned and vertically beneath the selection disk; and

a manometer tube that displays the pressure difference between the pressurized air and atmospheric pressure as a vertical height of the indicating liquid wherein the manometer tube further comprises a flow damper and the flow damper is located at an end of the manometer tube.

2. The apparatus of claim **1** wherein:

the pump further comprises a push button, an o-ring, and a coil spring;

the selection disk further comprises an o-ring groove;

the selection disk further comprises an axial through hole;

a pressurization tube extends through the indicating liquid and connects the pressurized air to the axial through hole;

the connection element fits snugly in the cylindrical tube;

the connection element is secured to the cylindrical tube;

the connection element is located near the bottom of the cylindrical tube;

the connection disk is attached to the selection disk with a screw that is axially aligned and located on the axis of rotation of the selection disk;

the pipe fittings are axially aligned into axial connection holes that go through the connection disk; and

the selection disk is rotated to selectively and exclusively couple the pressurized air to each of said fittings.

3. The apparatus of claim **1** wherein:

the apparatus further comprises a bracket for attaching the apparatus to the wall of a recreational vehicle using screws.

4. The apparatus of claim **1** wherein:

the pump is a single stroke hand pump that displaces a minimum volume selected from the set of 0.05 cubic inches, 0.1 cubic inches, 0.15 cubic inches, 0.2 cubic inches, 0.25 cubic inches, 0.3 cubic inches, 0.4 cubic inches, and 0.5 cubic inches; and the pipe fittings comprise detachable connections for flexible PVC tubing having an inside diameter less than ⅛ inch.

5. The apparatus of claim **1** wherein:

the pump further comprises a push button, an o-ring, and a coil spring; and

the push button is removable for filling the reservoir with the indicating liquid.

6. The apparatus of claim **1** wherein:

the pump further comprises a pump o-ring and a housing comprising polyvinyl chloride;

the pump o-ring rests in an o-ring stop when the pump is not being actuated; and

the o-ring stop comprises a small ring machined out of the polyvinyl chloride housing.

7. The apparatus of claim **1** further comprising a closable vent that connects the contents of the sealable reservoir to atmospheric pressure when the apparatus is not measuring the depth of liquid in a tank, wherein:

the vent comprises a drilled hole; and

the vent is manually blocked when the pump is being used to pressurize the air in the sealable reservoir.

8. The apparatus of claim **1** wherein the manometer tube further comprises rigid acrylic tubing.

9. The apparatus of claim **1** wherein:

the measurement of air pressure in the sealable reservoir is a transducerless measurement;

the selection disk further comprises an axial connection tube; and

the axial connection tube further comprises an o-ring housing.

10. A multi-tank recreational vehicle wastewater liquid level gage comprising:

a sealable vessel for holding a liquid and air, wherein the liquid comprises water;

a manual piston pump for displacing the air in the vessel wherein the pump further comprises a push button, an o-ring seal, and a coil spring;

a selection disk, that is axially aligned within the sealable vessel, for selectively connecting said air to a plurality of tubes that connect to tanks;

wherein the selection disk selects using rotary motion about a vertical axis by turning relative to a connection disk that is axially connected to the selection disk; and

a mechanical pressure gage for providing a visual indication of the pressure of said air, wherein the pressure gage further comprises a manometer and said visual indication further comprises a level of the liquid in the vessel.

11. The gage of claim **10** wherein the selection disk and the connection disk are connected with a screw and a coil spring.

12. The gage of claim **10** wherein the pump displaces the air in response to a mechanical motion without the use of electrical, electromagnetic, chemical, acoustic or thermal energy.

13. The gage of claim **10** wherein the pump is a positive displacement pump displacing a minimum volume selected from the set of 0.05 cubic inches, 0.1 cubic inches, 0.15 cubic inches, 0.2 cubic inches, 0.25 cubic inches, 0.3 cubic inches, 0.4 cubic inches, and 0.5 cubic inches in a single motion.

14. The gage of claim **10** wherein the pump further comprises a removable pump button for filling the vessel with said liquid.

15. The gage of claim **10** wherein the pump further comprises an o-ring and wherein the pump o-ring rests in a pump button o-ring stop when the pump is not being actuated and the pump button o-ring stop comprises small ring machined out of the housing of the pump.

16. The gage of claim **10** further comprising a vent that, when open, connects the contents of the sealable vessel to atmospheric pressure and the vent comprises a drilled hole.

17. The gage of claim **10** wherein the manometer further comprises a flow damper and the flow damper is located at an end of the manometer tube.

18. The gage of claim **10** wherein the measurement of air pressure in the sealable vessel is a transducerless measurement.

19. A transducerless method of displaying the level of wastewater in a plurality of recreational vehicle wastewater tanks comprising the steps of:

establishing a pneumatic connection between a selection disk and a point near the bottom of a first tank;

establishing a pneumatic connection between said selection disk and a point near the bottom of a second tank;

establishing a pneumatic connection between said selection disk and a sealable vessel;

establishing a connected tank by selecting to connect either said first tank or said second tank with said sealable vessel;

pressurizing said sealable vessel with air sufficiently so that air is expelled into said connected tank;

reading the pressure of said sealed vessel using a manometer tube connected to a liquid in said sealed vessel;

wherein:

establishing a pneumatic connection further comprises a connection disk wherein the connection disk is axially aligned with the selection disk and the connection disk comprises:

a first connection disk axial through hole that is coupled to the first tank; and

a second connection disk axial through hole that is coupled to the second tank;

establishing a pneumatic connection further comprises a selection disk axial through hole; and

selecting further comprises rotational alignment of the selection disk axial through hole with either the first connection disk axial through hole or the second connection disk axial through hole.

20. The method of claim **19** wherein:

pressurizing comprises mechanical energy that is applied to a manual pump that further comprises a spring; and

reading the pressure comprises liquid water.

* * * * *