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(54) **Title:** SYSTEM AND METHOD FOR FLUID SAMPLING

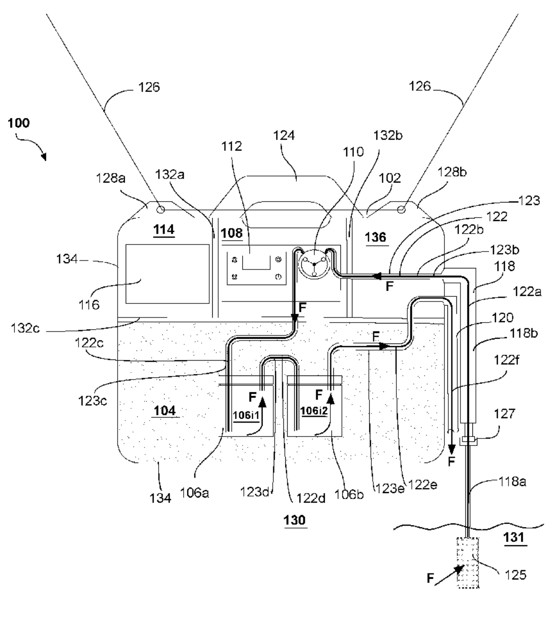

FIG. 1

(57) **Abstract:** A container comprising a fluid sampling system configured for the flow of particulate containing fluid therethrough are provided. The particulate containing fluid enters the container from the exterior through a fluid inlet and flows through a fluid flow path which includes at least two serially fluidically coupled sample collection vessels, which are releasably installed in the container. Fluid flow through the fluid flow path is controlled by a fluid pump in a manner that allows for sequential receipt of the particulate containing fluid in the sample collection vessels, and for particulates in the particulate containing fluid to settle in at least one of the sample collection vessels. Upon receipt and settlement of the particulates, the container can be opened and the sample collection vessels can be released from the container. Related methods for operating the fluid sampling systems are also provided.

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TITLE: SYSTEM AND METHOD FOR FLUID SAMPLING

RELATED APPLICATION

[0001] This application claims the benefit of United States Provisional Patent Application No 63/115,244, filed on November 18, 2020; the entire content of Patent Application No 63/115,244 is hereby incorporated by reference.

FIELD OF THE DISCLOSURE

[0002] The present disclosure generally relates to systems and methods for fluid sampling, and in particular to systems and methods for the collection of particulate containing fluid samples.

BACKGROUND

[0003] The following paragraphs are provided by way of background to the present disclosure. They are not however an admission that anything discussed therein is prior art or part of the knowledge of persons skilled in the art.

[0004] There are many circumstances in which fluid testing is desirable. For example, water can contain chemical or biological substances, such as a water borne pathogens, which must be monitored and maintained within certain tolerances in order to ensure a safe supply of drinking water for domestic purposes. Similarly, wastewater, including domestic and industrial wastewater, must meet certain quality standards in order to be safely discharged. Consequently, a variety of systems and techniques to collect water and other fluid samples and monitor chemical and biological entities therein have been developed.

[0005] However, one substantial ongoing challenge associated with the detection and quantification of chemical or biological attributes in fluid samples arises from the complexity of the fluid samples. In this respect, wastewater samples, also commonly referred to as "effluent samples", can be said to be particularly heterogeneous. In particular, the presence of particulate matter in the form of suspended solids in wastewater samples can be problematic and can compromise the detection of chemical or biological entities in wastewater samples. For example, suspended solids are known to absorb viral particles, and thus interfere with detection or quantification thereof in wastewater samples (see *e.g.*, Corpuz, M.V.A. *et al.*, 2020, Science of the Total Environment, 745, 140910; Chalapati, R. *et al.*, 1984, Appl. and Environ. Microbiol. 404-409).

[0006] The ongoing challenges with known systems to collect fluid samples necessitate improved systems and techniques to collect fluid samples, and notably there is a need in the art for systems and techniques to collect fluid samples comprising particulate matter.

SUMMARY

[0007] The following paragraphs are intended to introduce the reader to the more detailed description that follows and not to define or limit the claimed subject matter of the present disclosure.

[0008] In one broad aspect, the present disclosure relates to systems for the collection of fluid samples.

[0009] Accordingly, in one aspect, in accordance with the teachings herein, the present disclosure provides, in at least one aspect, in at least one embodiment, an openable container constructed and arranged for the flow of particulate containing fluids therethrough, the container comprising:

a sampling system for the collection of fluids, the sampling system comprising:

a fluid inlet in fluid communication with an exterior of the container to receive particulate containing fluids;

at least two serially fluidically coupled sample collection vessels releasably installed in the container and coupled to the fluid inlet, the sample collection vessels including a first sample collection vessel nearest the fluid inlet and a final sample collection vessel;

a fluid flow path through the container from the fluid inlet serially through the at least two sample collection vessels;

a fluid pump that is operably coupled to the fluid flow path and is configured to control the flow of the particulate containing fluids through the fluid flow path; and

a controller configured to control the flow of the particulate containing fluids through the fluid flow path;

wherein during use when the container is in a closed position and the fluid inlet being in fluid communication with a source of particulate containing fluid exterior to the container, the controller is configured to activate the fluid pump at a first time to cause a portion of the particulate containing fluid to enter the container through the fluid inlet and to flow through the fluid flow path at a rate such that the particulate containing fluid is sequentially received by the serially fluidically coupled sample collection vessels, and particulates in the particulate containing fluid settle in the sample collection vessels, the controller further being configured to deactivate the fluid pump at a second time to stop collection of the particulate containing fluid.

[0010] In at least one embodiment, in an aspect, the final sample collection vessel can be fluidically coupled to a fluid outlet in fluid communication with the exterior, the fluid flow path extending from the final sample collection vessel to the fluid outlet.

[0011] In at least one embodiment, in an aspect, the fluid pump can be controlled to pump the fluid through the fluid flow path at a selected rate wherein a greater quantity of the particulates settles in the first sample collection vessel compared to the final sample collection vessel.

[0012] In at least one embodiment, in an aspect, the sampling system can comprise two serially coupled sample collection vessels.

[0013] In at least one embodiment, in an aspect, the sample collection system can comprise three or more serially coupled sample collection vessels.

[0014] In at least one embodiment, in an aspect, the fluid flow path can comprise a fluid coupling system for at least one of the sample collection vessels, the fluid coupling system comprising a sample collection vessel fluid inlet and a sample collection vessel fluid outlet disposed in the at least one sample collection vessel, the sample collection vessel fluid inlet comprising a tubular fluid inlet conduit traversing a top portion of the at least one sample collection vessel at a first aperture and extending downwards therefrom to approximately a bottom portion of the at least one sample collection vessel to permit receipt of incoming fluid at approximately the bottom of the sample collection vessel, and the sample collection vessel fluid outlet comprises a tubular fluid outlet conduit traversing the top portion of the sample collection vessel at a second aperture and extending downwards therefrom no further than to approximately half a height of the at least one sample collection vessel to permit transfer of outgoing fluid downstream from the at least one sample collection vessel.

[0015] In at least one embodiment, in an aspect, the fluid flow path can further include a filter to collect selected chemical or biological species from the particulate containing fluid.

[0016] In at least one embodiment, in an aspect, the filter can be installed in the fluid flow path between the fluid inlet and the first sample collection vessel.

[0017] In at least one embodiment, in an aspect, the filter can be installed in the fluid flow path between the first sample collection vessel and the final sample collection vessel of the at least two serially coupled sample collection vessels.

[0018] In at least one embodiment, in an aspect, the filter can be installed in the fluid flow path in at least one of the sample collection vessels, the filter being disposed within the at least one sample collection vessel at a height above the height of a terminal end of the tubular fluid inlet conduit of the at least one sample collection vessel fluid inlet and so that incoming fluid is received by the at least one sample collection vessel, then traverses the filter, and the outgoing fluid then transfers downstream from the at least one sample collection vessel.

[0019] In at least one embodiment, in an aspect, the filter can be detachably coupled to the tubular fluid inlet conduit of the at least one sample collection vessel fluid inlet.

[0020] In at least one embodiment, in an aspect, filters can be installed in the fluid flow path in all of the sample collection vessels.

[0021] In at least one embodiment, in an aspect, the fluid inlet can include a terminal end that extends to the exterior of the container, and the terminal end includes a mesh filter configured to prevent the entry of debris into the container.

[0022] In at least one embodiment, in an aspect, the container can be compartmentalized and includes a coolable compartment that is configured to house the sample collection vessels.

[0023] In at least one embodiment, in an aspect, the coolable compartment can be configured to hold ice packs.

[0024] In at least one embodiment, in an aspect, the container can include a cooling device controlled by a controller to control the temperature of the coolable compartment.

[0025] In at least one embodiment, in an aspect, the temperature in the coolable compartment can be controlled to be in a range from about 2 °C to about 10 °C.

[0026] In at least one embodiment, in an aspect, the controller can be coupled to an environmental sensor capable of detecting a change in an environmental parameter, and the controller can be configured to activate the fluid pump upon the detection of a change in an environmental parameter by the sensor.

[0027] In at least one embodiment, in an aspect, the environmental sensor can be a rain sensor, a pH sensor, a temperature sensor, a turbidity sensor, a biochemical oxygen demand (BOD) sensor, a chemical oxygen demand (COD), an electrical conductivity (EC) sensor, or a total dissolved solids (TDS) sensor.

[0028] In at least one embodiment, in an aspect, the particulate containing fluid source can be wastewater.

[0029] In at least one embodiment, in an aspect, the openable container can comprise an openable lid and when the lid of the container is in a closed position the sampling system is operable.

[0030] In at least one embodiment, in an aspect, the openable container can comprise a linking portion to attach the container to a suspension arrangement.

[0031] In another aspect, in accordance with the teachings herein, the present disclosure provides, in at least one aspect, in at least one embodiment, a method of collecting samples using the openable container comprising the fluid sampling system according to the present disclosure, the method comprising:

installing the container in a closed position in such a manner that the fluid inlet is fluidically coupled to a source of particulate containing fluid;

activating the fluid pump at a first time to cause a portion of the particulate containing fluid to enter the container through the fluid inlet and flow through the container through the fluid flow path at a rate that allows particulates in the particulate containing fluid to settle in at least one of the sample collection vessels to separate from the fluid, deactivating the fluid pump at a second time to thereafter permit release of the sample collection vessels from the container; and

retrieving the container.

[0032] In at least one embodiment, in an aspect, the method can further comprise opening the container and releasing the sample collection vessels.

[0033] In at least one embodiment, in an aspect, the method can further comprise collecting a settled particulate fraction and/or a liquid fraction from the released sample collection vessels.

[0034] In at least one embodiment, in an aspect, the method can further comprise assaying a chemical or biological parameter in the settled particulate fraction and/ or the liquid fraction.

[0035] In at least one embodiment, in an aspect, a terminal end of the fluid inlet can be suspended in a stagnant fluid source.

[0036] In at least one embodiment, in an aspect, a terminal end of the fluid inlet can be suspended in a flowing fluid source.

[0037] In at least one embodiment, in an aspect, a terminal end of the fluid inlet can be suspended in the wastewater fluid source.

[0038] In at least one embodiment, in an aspect, the method comprises periodically activating and deactivating the fluid pump.

[0039] In at least one embodiment, in an aspect, each period of activating and deactivating the pump is separated by a hold time interval during which no fluid flows through the fluid path.

[0040] In at least one embodiment, in an aspect, the periodic activating and deactivating is continued until the sample collection vessels are full.

[0041] In at least one embodiment, in an aspect, the method comprises periodically activating the fluid pump at a first time and deactivating the fluid pump at a second time, wherein each period is separated by a hold time interval during which no fluid flows through the fluid path, wherein the second time occurs from about 5 seconds to about 30 seconds later than the first time, and wherein the hold time interval is at least 15 minutes.

[0042] In at least one embodiment, in an aspect, the method can comprise activating the fluid pump upon an environmental sensor detecting a change in an environmental parameter.

[0043] In at least one embodiment, in an aspect, the method comprises activating the fluid pump upon an environmental sensor detecting a change in an environmental parameter, and deactivating the fluid pump at a set time thereafter, or deactivating the fluid pump when the sample collection vessels are full.

[0044] In at least one embodiment, in an aspect, the environmental sensor is a rain sensor, a pH sensor, a temperature sensor, a turbidity sensor, a biochemical oxygen demand (BOD) sensor, a chemical oxygen demand (COD), an electrical conductivity (EC) sensor, or a total dissolved solids (TDS) sensor.

[0045] In another aspect, in accordance with the teachings herein, the present disclosure provides, in at least one aspect, in at least one embodiment, a use of the openable container comprising a fluid sampling system according to the present disclosure, to collect from each sample collection vessel a particulate fraction and/or a liquid fraction.

[0046] In another aspect, in accordance with the teachings herein, the present disclosure provides, in at least one aspect, in at least one embodiment, a use of a settled particulate fraction and/or a liquid fraction collected using the openable container comprising a fluid sampling system according to the present disclosure to assay a chemical or biological parameter therein.

[0047] Other features and advantages or the present disclosure will become apparent from the following detailed description. It should be understood, however, that the detailed description, while indicating preferred implementations of the present disclosure, is given by way of illustration only, since various changes and modification within the spirit and scope of the disclosure will become apparent to those of skill in the art from the detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048] The disclosure is in the hereinafter provided paragraphs described, by way of example, in relation to the attached figures. The figures provided herein are provided for a better understanding of the example embodiments and to show more clearly how the various embodiments may be carried into effect. Like numerals designate like or similar features throughout the several views possibly shown situated differently or from a different angle. Thus, by way of example only, part **102** in **FIG. 1**, **FIG. 3**, **FIG. 4**, and **FIG. 5** refers to a container in each of these figures. The figures are not intended to limit the present disclosure.

[0049] **FIG. 1** is a schematic of an example embodiment of a sampling system for the collection of particulate containing fluids.

[0050] **FIGS. 2A – 2F** are schematic views of two example serially fluidically coupled sample collection vessels in first, second, third, fourth, fifth and sixth states, respectively.

[0051] **FIGS. 3** to **5** are schematics of other example embodiments of a sampling system for the collection of particulate containing fluids.

[0052] **FIGS. 6A** and **6B** are front and side views, respectively, of the example embodiment of **FIG. 4** of a sampling system for the collection of particulate fluids contained in a container shown in open position.

[0053] **FIGS. 6C** and **6D** are front and side views, respectively, of the example embodiment of **FIG. 4** of a sampling system for the collection of particulate fluids contained in a container shown in closed position.

[0054] **FIGS. 7A – 7D** are flow charts showing example embodiments of a method of collecting samples using the sampling system of **FIG. 4.**

[0055] **FIG. 8A** is a schematic view of an example embodiment of a sample collection vessel configuration of a sampling system for the collection of particulate fluids.

[0056] **FIG. 8B** is a perspective view of the portion labeled **8B** of the sample collection vessel configuration depicted in **FIG. 8A**.

[0057] **FIG. 8C** is a schematic view of the portion labeled **8C** of the sample collection vessel configuration depicted in **FIG. 8A**, in two different states **s1** and **s2**.

[0058] The figures together with the following detailed description make apparent to those skilled in the art how the disclosure may be implemented in practice.

DETAILED DESCRIPTION

[0059] Various processes, systems and compositions will be described below to provide at least one example of at least one embodiment of the claimed subject matter. No embodiment described below limits any claimed subject matter and any claimed subject matter may cover processes, systems, or compositions that differ from those described below. The claimed subject matter is not limited to any process, system, or composition having all of the features of processes, systems, or compositions described below, or to features common to multiple processes, systems, or compositions described below. It is possible that a process, system, or composition described below is not an embodiment of any claimed subject matter. Any subject matter disclosed in processes, systems, or compositions described below that is not claimed in this document may be the subject matter of another protective instrument, for example, a continuing patent application, and the applicants, inventors or owners do not intend to abandon, disclaim or dedicate to the public any such subject matter by its disclosure in this document.

[0060] As used herein and in the claims, the singular forms, such as "a", "an" and "the" include the plural reference and vice versa unless the context clearly indicates otherwise. Throughout this specification, unless otherwise indicated, the terms "comprise," "comprises" and "comprising" are used inclusively rather than exclusively, so that a stated integer or group of integers may include one or more other non-stated integers or groups of integers. The term "or" is inclusive unless modified, for example, by "either". The term "and/or" is intended to represent an inclusive or. That is "X and/or Y" is intended to mean X or Y or both, for example. As a further example, X, Y and/or Z is intended to mean X or Y or Z or any combination thereof.

[0061] When ranges are used herein for physical properties, such as molecular weight, or chemical properties, such as chemical formulae, all combinations and sub-combinations of ranges and specific embodiments therein are intended to be included. Other than in the operating examples, or where otherwise indicated, all numbers expressing quantities of ingredients or reaction conditions used herein should be understood as being modified in all instances by the term “about.” The term “about” when referring to a number or a numerical range means that the number or numerical range referred to is an approximation within experimental variability (or within statistical experimental error), and thus the number or numerical range may vary between 1% and 15% of the stated number or numerical range, as will be readily recognized by the context. Furthermore, any range of values described herein is intended to specifically include the limiting values of the range, and any intermediate value or sub-range within the given range, and all such intermediate values and sub-ranges are individually and specifically disclosed (*e.g.,* a range of 1 to 5 includes any number from 1 to 5 such as, but not limited to 1, 1.5, 2, 2.75, 3, 3.90, 4, and 5, for example). Similarly, other terms of degree such as "substantially" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed. These terms of degree should be construed as including a deviation of the modified term, such as up to 15% for example, if this deviation would not negate the meaning of the term it modifies.

[0062] Several directional terms such as “above”, “below”, “lower”, “upper”, “inner” and “outer” are used herein for convenience including for reference to the drawings. In general, the terms “upper”, “above”, “upward” and similar terms are used to refer to an upwards direction or upper portion in relation to a sample collection vessel generally standing upright, or a container holding the sample collection vessel while the sample collection vessel is generally standing upright, for example, such as shown for the orientation shown in **FIG. 1**. Similarly the terms “lower”, “below”, ”downward”, and “bottom” are used to refer to a downwards direction or a lower portion in relation to a sample collection vessel generally standing upright, or a container holding the sample collection vessel while the sample collection vessel is generally standing upright, for example, such as shown for the orientation shown **FIG. 1**. Furthermore, the terms “front”, “front view”, and similar terms, refer to a view from a vantage point directed towards a container positioned such as shown in **FIG. 6A**.

[0063] Unless otherwise defined, scientific and technical terms used in connection with the formulations described herein shall have the meanings that are commonly understood by those of ordinary skill in the art. The terminology used herein is for the purpose of describing particular embodiments only, and is not intended to limit the scope of the present teachings herein, which is defined solely by the claims.

[0064] All publications, patents, and patent applications referred to are herein incorporated by reference in their entirety to the same extent as if each individual publication, patent or patent application was specifically indicated to be incorporated by reference in its entirety.

[0065] In general, the various embodiments of the fluid sampling system of the present disclosure can be used to collect a fluid sample, notably a fluid sample containing particulate matter suspended therein.

[0066] In broad terms, the fluid sampling system includes a container configured for the flow of particulate containing fluid therethrough. The particulate containing fluid can enter the container from the exterior through a fluid inlet and flow along or through a fluid flow path which travels through at least two serially fluidically coupled sample collection vessels, which are releasably installed in the container. Fluid flow through the flow path is controlled by a fluid pump in a manner that allows for the sequential receipt of the particulate containing fluid in the sample collection vessels, and for the particulates to settle in the sample collection vessels. Upon receipt and settlement of the particulates in the sample collection vessels, the container can then be opened, and at least one of the sample collection vessels can be releasably removed from the container.

[0067] In conventional systems which receive fluid samples containing particulate matter, the presence of the particulate matter in the fluids represents an analytical challenge as the particulate matter can interfere with assaying of the fluid sample. However, the sampling system of the present disclosure allows for sampling of particulate containing fluids while reducing interference from particulate matter in a subsequent assay. In particular, the sampling system can yield samples contained in sample collection vessels. The samples are fractionated into fluid and solid fractions, each of which can be assayed for biological or chemical parameters.

[0068] Furthermore, since the sampling system of the present disclosure includes a fluid pump coupled to a controller, the system can be conveniently deployed at a sampling site, and, in an aspect, samples can be collected at specific times, by operating the fluid pump with the controller according to a specified sampling time sequence.

[0069] In what follows selected example embodiments are described with reference to the drawings.

[0070] In general overview, **FIG. 1** shows a first example embodiment of a schematic of a sampling system **100** for the collection of particulate containing fluids. **FIGS. 2A – 2F** show two serially fluidically coupled sample collection vessels of sampling system **100** in a first, second, third, fourth, fifth and sixth states, respectively. **FIG. 3** shows a second example embodiment of a schematic of a sampling system **200** for the collection of particulate containing fluids. **FIG. 4** shows a third example embodiment of a schematic of a sampling system **300** for the collection of particulate containing fluids. **FIG. 5** shows a fourth example embodiment of a schematic of a sampling system **400** for the collection of particulate containing fluids. **FIGS. 6A – 6D** show several views of an example embodiment of a sampling system **300**. **FIGS. 7A – 7D** show flow charts of example embodiments of methods **700**, **701**, **702** and **703** for collecting samples using the sampling system **200** of **FIG. 3**, in accordance with the teachings herein. **FIGS. 8A – 8C** show an example configuration **800** of two serially connected sample collection vessels, notably a configuration wherein the sample collection vessels include a detachable filter disposed therein.

[0071] Referring initially to **FIG. 1**, shown therein is a schematic of an example embodiment of a sampling system **100** for the collection of particulate containing fluids. Sampling system **100** includes openable container **102** (shown in an opened position) comprising interior compartments **104**, **108**, **114** and **136** formed by outer container wall **134** and inner compartment walls **132a, 132b** and **132c**. Openable container **102** further includes hand grip **124** formed by a central upper portion of openable container **102** to allow for transport of openable container **102**. Linking portions **128a** and **128b**, formed by upper portions of openable container **102**, are located so that they are laterally offset relative to both sides of handgrip **124**. Linking portions **128a** and **128b** may be attached to suspension arrangement **126** in some cases. Thus, openable container **102** can be suspended thereby allowing for the implementation of certain operational aspects of sampling system **100**, as further hereinafter described. When in a closed position, most preferably openable container

102 is substantially water tightly sealed, so that when container **102** is suspended in a fluid in a closed position, fluid which is in contact with the exterior of the container **102**, does not enter interior compartments **104**, **108**, **114** or **136**. When in an opened position the contents of openable container **102**, notably sample collection vessels **106a** and **106b** housed in interior compartment **104**, can be accessed and removed from the container. It is to be understood that in general, the term "openable container", as used herein, refers to a container which may be opened and closed, using any means for opening and closing the container. In this respect, example embodiment **100**, includes a hinged lid (as hereinafter further described with reference to **FIGS. 6A – 6D**). However, in other embodiments other means of opening and closing the container (*e.g.*, a sliding lid, a snap-and-lock lid *etc.*) may be constructed.

[0072] Continuing to refer to **FIG. 1**, and turning to interior compartments, **104**, **108**, **114** and **136**, interior compartment **104** is arranged to house sample collection vessels **106a** and **106b**. Interior compartment **108** is arranged to house peristaltic fluid pump **110** and controller **112**. Controller **112** is operably coupled to peristaltic fluid pump **110** to control peristaltic fluid pump **110**. Furthermore, controller **112** and peristaltic fluid pump **110** are each electrically coupled to and powered by battery **116** housed in interior compartment **114**. Battery **116** can be any battery suitable to power controller **112** and peristaltic fluid pump **110**, and in general is selected to be compatible with the physical dimensions of openable container **102**, and notably interior compartment **114**, while providing the desired power. Thus, for example, battery **116** can be a 12 Volt battery. Battery **116** can further be a rechargeable or non-rechargeable battery, including a battery that is rechargeable by renewable energy sources, such a solar power, wind power, geothermal power, or vibrational power, for example. In further alternate embodiments, the fluid pump **110** may be powered by an electric power transmission system providing alternating current (AC) or direct current (DC). In the example embodiment shown in **FIG. 1**, interior compartment **136** is empty, but for a portion **123b** of fluid conduit **123**, however in other embodiments (*see:* embodiments **300** and **400** in **FIG. 4** and **FIG. 5** below, respectively, for example) interior compartment **136** can additionally house a filtering device.

[0073] Controller **112** can be implemented using a suitable controller that includes at least one processor, memory, as well as hardware for sending and receiving signals including an analog to digital convertor (ADC), a digital to analog converter (DAC) and a communication unit that includes a wireless radio, and optionally a USB port. The DAC can be used to convert digital control signals to analog control signals, such as signals to control the pump flow rate, to the fluid pump **110** and also optionally a cooling system for embodiments which include the cooling system. The ADC can be used to digitize analog measurement signals such as an analog temperature signal provided by the cooling system for embodiments which include the cooling system, as well as signals from environmental sensors (not shown), which, in some embodiments, may be used by the processor to control activation of the fluid pump **110**. The wireless radio can be used for receiving control signals from a remote device that may be used to remotely control the operation of the fluid pump **110**, and optionally the cooling system, and optionally environmental sensors.

[0074] The memory can be implemented using ROM or RAM and comprises software that includes program instructions, which when executed by a processor of the controller **112**, configures the controller **112** to operate in a new, specific and predefined manner for controlling the fluid pump **110** in accordance with the teachings herein, and optionally with a cooling system that has a settable thermostat so that the controller **112** can control the temperature of the container **102** that includes sample collection vessels.

[0075] The software may be implemented using high-level procedural language and/or firmware. The high-level procedural language may be C, C^{++} or any other suitable programming language and may comprise modules or classes, as is known to those skilled in object-oriented programming. The firmware software may be written in some form of assembly of machine language. The program code may be preinstalled and embedded during manufacture and/or may be later installed as an update for an already deployed controller. The medium may be provided in various forms, including non-transitory forms such as, but not limited to, one or more diskettes, compact disks, tapes, chips, USB keys and magnetic and electronic storage. In alternative embodiments, the medium may be transitory in nature such as, but not limited to, wire-line transmissions, satellite transmissions, internet transmissions (*e.g.*, downloads), media, digital and analog signals, and the like. The computer useable instructions may also be in various formats, including compiled and non-compiled code.

[0076] Openable container **102** further includes fluid inlet **118** and fluid outlet **120**, each traversing outer container wall **134** and extending to be in fluid communication with exterior **130** of the container **102**. Fluid inlet **118** includes first portion **118a** and second portion **118b**. Second portion **118b** traverses outer container wall **134** and is fluidically coupled to first portion **118a** via flexible coupling **127**. Thus, first portion **118a** represents a further extension into exterior **130**. Furthermore, the end portion of first portion **118a** of fluid inlet **118** may include mesh filter **125**. Mesh filter **125** may have a mesh size ranging from about 0.5 mm to about 2.0mm, and may be, for example, a tubular stainless steel filter that is about 10 cm to 25 cm long having a mesh size (*i.e.*, size of the openings in the mesh) of about 1.0 mm. Mesh filter **125** prevents the entry and flow of debris and larger size organic material through fluid inlet **118**. The fluid path from fluid inlet **118** to fluid outlet **120** is fluidically coupled to fluid conduit **123**, comprising fluid conduit portions **123b**, **123c, 123d** and **123e**. Fluid inlet **118** and fluid outlet **120** together with interiors **106i1** and **106i2** of serially fluidically connected sample collection vessels **106a** and **106b**, respectively, are portions of fluid path **122** for fluid flow **F** through openable container **102**. In this respect, fluid path **122** is formed by: fluid path portion **122a**, corresponding with fluid inlet **118**; fluid path portion **122b** corresponding with fluid conduit portion **123b** running from fluid inlet **118** to peristaltic fluid pump **110**; fluid path portion **122c** corresponding with fluid conduit portion **123c** running from peristaltic fluid pump **110** to interior **106i1** of the interior of sample collection vessel **106a**; fluid path portion **122d** corresponding with fluid conduit portion **123d** which runs from interior **106i1** of the interior of sample collection vessel **106a** to interior **106i2** of the interior of sample collection vessel **106b**, and serially connects sample collection vessel **106a** and sample collection vessel **106b**; fluid path portion **122e** corresponding with fluid conduit portion **123e** running from interior **106i2** of the interior of sample collection vessel **106b** to fluid outlet **120**; and fluid path portion **122f**, corresponding with fluid outlet **120**. Together fluid inlet **118**, fluid conduit **123**, and serially fluidically coupled sample collection vessels **106a** and **106b** are configured and fluidically coupled so that fluid can flow from fluid inlet **118** through fluid path **122** through openable container **102** to fluid outlet **120**. In general, fluid can be caused to flow through fluid path **122** by fluidically coupling fluid inlet

118, notably first portion **118a** thereof, to a fluid source **131** situated in exterior **130** and activating peristaltic fluid pump **110** through controller **112**.

[0077] Next, fluid flow and collection of sample materials with particular reference to sample collection vessels **106a** and **106b** will be discussed. Referring now to **FIGS. 2A** to **FIG. 2F** (in conjunction with **FIG. 1**), shown therein are two serially coupled sample collection vessels **106a** and **106b**, situated in compartment **104** in openable container **102**, in six different states, including first state **s1** (**FIG. 2A**), second state **s2** (**FIG. 2B**), third state **s3** (**FIG. 2C**), fourth state **s4** (**FIG. 2D**), fifth state **s5** (**FIG. 2E**) and sixth state **s6** (**FIG. 2F**). States **s1**, **s2**, **s3**, **s4**, **s5** and **s6** occur at successively different time points, *i.e.*, first state **s1** occurs at a first time point. Second state **s2** corresponds with a second time point occurring later than the first time point. Third state **s3** corresponds with a third time point occurring later than the second time point, and so forth. Sampling system **100** is positioned so that fluid inlet **118** is fluidically coupled to sample fluid source **131** (as shown in **FIG. 1**) during states **s1** to **s6**.

[0078] Referring to **FIG. 2A**, at first state **s1**, collection vessels **106a** and **106b** are empty, and, as such, state **s1** reflects a time prior to initiation of sampling from fluid source **131**, *i.e.*, a time prior to activation of peristaltic fluid pump **110**. Upon activation of peristaltic fluid pump **110**, fluid from fluid source **131** will enter openable container **102** via fluid inlet **118**. It is noted, that, in general, controller **112** includes a software module with software instructions for setting and controlling the activation and deactivation time for peristaltic fluid pump **110**. The activation and deactivation time thus can be set by an operator of sampling system **100** prior to installing sampling system **100** for fluid sampling. In other embodiments, controller **112** may include a wireless communication unit, such as a wireless receiver (*i.e.*, wireless radio) that is operable to receive a signal from a remotely located device, such as a smart phone, a tablet or desktop computer, that is configured to control controller **112** to thereby allow activation and deactivation of peristaltic fluid pump **110**. Thus, it will be clear that controller **112** and peristaltic fluid pump **110** are operably connected to one another as well as the fluid path **122** including inlet **118**, fluid conduit **123** and serially fluidically coupled sample collection vessels **106a** and **106b**, and that controller **112** can be provided, *e.g.*, via software instructions, with activation and deactivation times for predefined sampling intervals or receive control signals remotely for activation and deactivation thereby allowing for installment of sampling system **100** at any suitable sample location for sampling fluids, and once installed, sampling system **100** may be used to collect a fluid sample, at a suitable time, as desired through operation of the controller **112**.

[0079] Referring next to **FIG. 2B**, at second state **s2**, a quantity of fluid has been pumped by peristaltic fluid pump **110** from fluid source **131** into openable container **102** and fluid has flown through fluid path sections **122a**, **122b** and **122c**, to reach interior **106i1** of sample collection vessel **106a**. It is noted that fluid conduit portion **123c** traverses top portion **208** of sample collection vessel **106a** through an aperture **210** in top portion **208** of sample collection vessel **106a**. Furthermore, fluid conduit portion **123d** traverses top portion **208** of sample collection vessel **106a** through another aperture **212** in top portion **208** of sample collection vessel **106a**. Fluid outlet **202**, formed by the bottom portion of fluid conduit portion **123c**, is positioned closely to the bottom portion **206** of sample collection vessel **106a**. Thus, for example, fluid outlet **202** may be separated from the bottom of sample collection vessel **106a** by 2 cm, 1 cm, 0.5 cm or less. By contrast, fluid inlet **204** formed by a bottom portion of fluid conduit portion **123d** is positioned closely to the top portion **208** of sample collection vessel **106a**. Thus, for example, fluid inlet **204** may be separated from the top of sample collection vessel **106a** by 2 cm, 1 cm, 0.5 cm or less. The configuration (*e.g.*, location and dimensions) of fluid outlet **202** and fluid inlet **204**, in an aspect hereof, allows filling of sample collection vessel **106a** to its full capacity (as shown in **FIG. 2D**). Furthermore, in an aspect hereof, the configuration of fluid outlet **202** and fluid inlet **204** generally limits contact of the received fluid with the air in the sample collection vessels, which reduces the occurrence of oxidation reactions thereby potentially altering sample constituents, since fluid is received at the bottom portions of sample collection vessels **106a** and **106b**, and following initial receipt of a small quantity of fluid, fluid inlet **204** becomes submerged, as more fluid is received in sample collection vessels **106a** or **106b**. At the same time, the configuration permits for mixing and homogenization of the fluid in sample collection vessel **106a**, as sample collection vessel **106a** gradually fills. Furthermore, in an aspect hereof, the configuration of fluid outlet **202** and fluid inlet **204** reduces the transfer of solids from sample collection vessel **106a** to **106b** since solids are received at the bottom portion of sample collection vessel **106a** where particulate matter (**PM**) sediments form (see: **FIG. 2F**). In different embodiments, the configuration and relative positions of fluid outlet **202** and fluid inlet **204** may be varied, however in preferred embodiments, fluid conduit portion **123c** extends downwards into sample collection vessel **106a** to approximately bottom portion **206** of sample collection vessel **106a**. Fluid conduit portion **123d** extends downwards into sample collection vessel **106a** extending downwards therefrom no further than to approximately half the height (**h**) of sample collection vessel **106a**, and, more preferably, even closer to top portion **208** of sample collection vessel **106a**, such as extending into sample collection vessel **106a**, for example, approximately one quarter of the height (**h**) of sample collection vessel **106a**, or even less. It is noted that fluid inlet **216** and fluid outlet **214** in sample collection vessel **106b** are configured similarly as fluid inlet **202** and fluid outlet **204**.

[0080] Referring next to **FIG. 2C**, at third state **s3**, as pumping of fluid from fluid source **131** has continued, the fluid level in sample collection vessel **106a** has risen to fill most of interior **106i1** of fluid sample collection vessel **106a**.

[0081] Referring next to **FIG. 2D**, at fourth state **s4**, as pumping of fluid from fluid source **131** has further continued, interior **106i1** of sample collection vessel **106a** is entirely filled, and fluid has flown through fluid path section **122d** towards sample collection vessel **106b** to reach interior **106i2** of sample collection vessel **106b**.

[0082] Referring next to **FIG. 2E**, at fifth state **s5**, as pumping of fluid source **131** has further continued, interior **106i1** of sample collection vessel **106a** and interior **106i2** of sample collection vessel have entirely filled. At fifth state **s5**, peristaltic fluid pump **110** may be deactivated. In this respect, controller **112** may be set to pump for a sufficiently long period of time to pump a volume of fluid source **131** that is sufficient to fill sample collection vessel **106a** and **106b** *i.e.*, a volume corresponding approximately with the total volume of sample collection vessel **106a** and **106b**, and to deactivate more or less immediately following filling of sample collection vessel **106b**. In some embodiments (not shown), sampling system **100** may not include fluid pathway section **122e** and fluid outlet **120**. However, in general it is deemed beneficial to include fluid path section **122e** and fluid outlet **120** since this allows for potential overflow, and may not require as much accuracy in carefully controlling the pumping time.

[0083] Referring next to **FIG. 2F**, at sixth state **s6**, peristaltic fluid pump **110** has been deactivated for a period of time and particulate matter (**PM**) has been permitted to settle at the bottom of sample collection vessel **106a**. In general, it is desirable to control the flow rate through flow path **122** so that significant quantities of particulate matter (**PM**) settle in sample collection vessel **106a**, while limited quantities of particulate matter (**PM**) are conveyed to sample collection vessel **106b**. In some embodiments, a significant quantity of particulate matter (**PM**) may be at least or up to about 75% (w/w), at least or up to about 80% (w/w), at least or up to about 85% (w/w), at least or up to about 90% (w/w), at least or up to about 95% (w/w), or at least or up to about 99% (w/w) of the total mass of particulate matter collected in sample collection vessels **106a** and **106b** and this significant quality of particulate matter (**PM**) is collected in sample collection vessel **106a**, with the balance being collected in sample collection vessel **106b**. In this manner, in sample collection vessel **106b** a fluid sample is obtained from which a substantial quantity, substantially all or all of particulate material (**PM**) has been removed. It is noted that although it generally takes a certain period of time for particulate matter (**PM**) to settle after fluid flow through flow path **122** has stopped, portions of particulate matter (**PM**) present in fluid from fluid source **131** may also settle in sample collection vessel **106a** prior to deactivation of peristaltic fluid pump **110**. Furthermore, it will be understood by those of skill in the art that the settlement kinetics of the particulate matter (**PM**) depend on various variables, including, for example, the fluid flow rate through fluid flow path **122**, and the constituents of fluid from the fluid source **131**, including, for example, the constituents and concentration of the particulate matter (**PM**). Accordingly, the period of time for particulate matter (**PM**) to fully settle after deactivation of peristaltic fluid pump **110** may vary and can range for example from at least about 15 minutes up to about 6 hours.

[0084] It is noted that, flow rates through fluid path **122** may be controlled and adjusted by an operator of the fluid sampling systems of the present disclosure. Suitable flow rates in this respect may vary and include, for example, flow rates ranging from about 1.5 ml/sec to about 7 ml/sec. Flow rates through fluid path **122** may be controlled in a number of ways, including by varying the rotational rate of the rotor of peristaltic pump **110** through controller **112**. Thus, as will be understood by those of skill in the art, at lower rotational rates, peristaltic pump **110** will provide lower flow rates. The flow rate may also be controlled by selection of the inner diameter of the flexible tube of peristaltic pump **110**. As will be understood by those of skill in the art, flexible tubes having a larger inner diameter will provide a higher flow rate. Furthermore, the flow rate may be controlled by selection of pump **110**. Thus, for example, some peristaltic pumps **110** may be able to provide a variable flow rate ranging from about 1.5 ml/sec to about 3 ml/sec, while other peristaltic pumps **110** may be able to provide a variable flow rate ranging from about 3 ml/sec to about 7 ml/sec. Thus, the present disclosure further includes, in some embodiments, a removable peristaltic pump **110**, allowing an operator to replace pumps to thereby control flow rates through fluid path **122**.

[0085] It is noted that for the sampling systems of the present disclosure, the sampling times may be varied. In some embodiments, a fluid sample is collected following a single activation and deactivation of peristaltic pump **110**. This may, for example, be a suitable manner to operate a fluid sampling system according to the present disclosure when substantially no temporal variations in constituents in fluid from the fluid source **131** is occurring, or when it is desirable to exclude any temporal variations, *i.e.*, when it is desirable to obtain a fluid sample at a specific time. Thus, in a relatively brief period, for example, a period of from about 1 to about 10 minutes following activation of peristaltic pump **110**, sample collection vessels **106a** and **106b** may be filled. The thus collected fluid sample may be referred as a 'grab sample'.

[0086] In other embodiments, a sample is collected following multiple activations and deactivations of peristaltic pump **110**. Thus, peristaltic pump **110** may be activated and deactivated multiple times during a period of time in which it is desirable to collect a fluid sample, for example, a period of 1 day, 2 days, 10 days, 1 week, or 1 month. This period of time may be referred to as the sample collection period. Thus, peristaltic pump **110** may be activated for a first period, for example, for about five 5 seconds to about 30 seconds, then be deactivated, for a first hold time interval, for example for 15 minutes to 60 minutes, then be activated a second time and deactivated for a second hold time interval, then be activated a third time and deactivated for a third hold time interval, and so on. Thus, if, by way of example only, a 30 minute hold time interval was selected, and the sample collection period is 24 hours, then activation/deactivation of peristaltic pump **110** would occur 48 times, and 48 fluid volumes would be collected during the sample collection period. It will be clear that by selecting an appropriate combination of flow rate, activation/deactivation periodicity, hold time interval, and sample collection period, sample collection vessels **106a** and **106b** may be filled at the end of a selected sample collection period. The collected fluid sample may be said to be representative of fluid from the fluid source **131** over the sample collection period. This embodiment may be implemented when it is desirable to limit the effects of temporal variations in fluid constitution that may occur, such as, for example, in sewer fluids in which constituents may vary depending on the time of the day, and when instead it is desirable to obtain a sample that reflects an average over a certain time period. Samples collected following multiple activations and deactivations of peristaltic pump **110** may be referred to as 'composite samples'.

[0087] In one embodiment, the controller can be coupled to an environmental sensor (not shown) capable of detecting a change in an environmental parameter related to exterior **130** of the container **102**, and the controller **112** can be configured to activate the fluid pump **110** upon the detection of a change in an environmental parameter by the sensor. Such a change in the environment can, for example, be a weather change, or a change in a parameter in the fluid source **131**, or any other physical condition in the environment. Thus, for example, the environmental sensor can be a rain sensor, a temperature sensor, a pH sensor, a turbidity sensor, a biochemical oxygen demand (BOD) sensor, a chemical oxygen demand (COD), an electrical conductivity (EC) sensor, or a total dissolved solids (TDS) sensor. The environmental sensor may be installed in close proximity of the sample collection system, and may, for example, be attached to the exterior of openable container **102**, or the sensor may be more remotely installed and coupled to the controller **112** by, for example, a wireless sensor network (WSN) connection. This embodiment of the sampling system of the present disclosure permits the collection of a sample when a change occurs in an environmental parameter, and thus the effect of the change in environmental parameter on the constitution of source fluid may be evaluated, notably by evaluating and comparing samples collected prior to and following a change in the environmental parameter.

[0088] It is further noted that in some embodiments, the sample collection period and flow rate, activation/deactivation periodicity, hold time interval, and sample collection period, may be selected so that a specific sample volume (*e.g.*, 1 liter, 2 liters) is collected in sample vessels **106a** and **106b**. Upon completion of sampling, sample vessels **106a** and **106b** may be filled or partially filled, depending on the volumes of sample vessels **106a** and **106b**. In other embodiments, the sample collection period and flow rate, activation/deactivation periodicity, hold time interval, and sample collection period, may be selected so that sampling is performed during a specific sample collection period (*e.g.*, 24 hrs). Again, sample vessels **106a** and **106b** may be filled or partially filled, depending on the volumes of sample vessels **106a** and **106b** and the amount of fluid which is sampled.

[0089] It is clear however that when operating peristaltic pump **110**, the activation/deactivation periodicity, the hold time interval, the sample collection period, and the flow rate, in accordance herewith may all be selected and controlled as desired.

[0090] Upon settlement of the particulate matter (**PM**) in sample collection vessel **106a**, openable container **102** may be retrieved and opened to release sample collection vessels **106a** and **106b** from openable container **102**, for assaying of the contents of the sample collection vessels **106a** and **106b**. In this respect, it is noted that both the liquid fraction and the solid, settled particulate matter fraction (**PM**), may be separately recovered from sample collection vessel **106a**, for example, by decanting the liquid fraction from sample collection vessel **106a** in an additional vessel, and then separately removing the solid, settled particulate matter (**PM**) fraction from sample collection vessel **106a**. Each of the fractions recovered from sample collection vessel **106a**, as well as the liquid fraction recovered from sample collection vessel **106b**, may subsequently be assayed, for example, for chemical or biological parameters.

[0091] To briefly recap, various embodiments of a fluid sampling system comprising a container configured for the flow of particulate containing fluid therethrough have been provided. In an example embodiment, the particulate containing fluid can enter container **102** from an exterior fluid source **131** through fluid inlet **118** and can flow through fluid flow path **122**, including two serially fluidically coupled sample collection vessels **106a** and **106b**. Fluid flow through flow path **122** is controlled by a peristaltic fluid pump **110** in a manner that allows sequential receipt of the sampled fluid in the first and second sample collection vessels **106a** and **106b**, and for particulates to settle in the first sample collection vessel **106a**. Upon receipt and settlement of the particulates in the first collection vessel **106a**, the container **102**

can be retrieved and opened and sample collection vessels **106a** and **106b** can be released from container **102**.

[0092] Next, other selected example embodiments of sampling systems provided in accordance with the present disclosure will be discussed.

[0093] Referring next to **FIG. 3**, shown therein is an alternate embodiment of a fluid sampling system **200** which includes four sample collection vessels **106a**, **106b**, **106c** and **106d**. Fluid path **122** includes fluid path portions **122d1**, **122d2** and **122d3**. It is noted that for purposes of clarity, in the schematic view on **FIG. 3** fluid path **122** is shown, while no fluid conduits are shown. It is to be understood, however, that fluid path **122** is formed by fluid conduits, similar to fluid conduit **123** shown in **FIG.** 1, and further as shown in **FIG. 6A**. Example sampling system **200** allows for the collection of larger sample volumes than example system **100** since there are more sample collection vessels **106a** to **106d** that are each of similar size as the sample collection vessels **106a** and **106b** used in sampling system **100**, although in other embodiments different sized sample collection vessels may be used. Furthermore, sampling system **200** can facilitate fluid sampling of fluids with higher concentrations of particulate matter (**PM**). Thus, notably in instances where the concentration of particulate matter (**PM**) is sufficiently high in the fluid obtained from the fluid source **131** so that not all or substantially all particulate matter settles in sample collection vessel **106a**, with the sampling system **200**, and instead fluid containing some quantity of particulate matter is also transferred to sample collection vessel **106b**, and possibly even onwards to sample collection vessel **106c**, and therefore further quantities of particulate matter (**PM**) may settle in sample collection vessels **106b** and, optionally in sample collection vessel **106c**. The distribution of relative quantities of particulate matter (**PM**) across the four sample collection vessels may vary, as will generally be clear based on the discussion herein with respect to **FIGS. 2A – 2F**. In some embodiments, the final sample collection vessel (*i.e.*, sample collection vessel **106d** in **FIG. 3**) can contain less than about 5% (w/w), less than about 4% (w/w), less than about 3% (w/w), less than about 2% (w/w), or less than about 1% (w/w) of the total amount of particulate matter collected in all sample collection vessels (*i.e.*, sample collection vessels **106a**, **106b**, **106c** and **106d** in **FIG. 3**), with the balance of the particulate matter being collected in the other sample collection vessels (*i.e.*, sample collection vessels **106a**, **106b** and **106c** in **FIG. 3**). For example, in some cases, the first sample collection vessel (*i.e.*, sample collection vessel **106a** in **FIG. 3**) can contain from at least up to about 25% (w/w), up to about 50%, up to about 60%, up to about 65%, up to about 70%, or up to about 75% (w/w) of the total amount of particulate matter collected in all sample collection vessels (*i.e.*, sample collection vessels **106a**, **106b**, **106c** and **106d** in **FIG. 3**), with the balance of the particulate matter being collected in the other sample collection vessels (*i.e.*, sample collection vessels **106b**, **106c** and **106d** in **FIG. 3**). As herein before noted, and as will be understood by those of skill in the art, the settlement kinetics and relative distribution across the sample collection vessels of the particulate matter (**PM**) depend on various variables, including, for example, the fluid flow rate through fluid flow path **122**, and the constituents of the fluid from fluid source **131**, including, for example, the constituents and concentration of the particulate matter (**PM**). It is noted that in further alternative embodiments of the sampling systems described in accordance with the teachings herein, there may be various numbers of sample collection vessels, including three, five, six, seven, eight, or more sample collection vessels (not shown). Furthermore, the volume of the sample collection vessels in different embodiments, may vary, and may range, for example, from about 50 ml vessels to about 4 liter vessels. It will be understood, therefore that in different embodiments of the fluid sampling system of the present disclosure, the total maximum collectable sample volume may range, for example, from about 100 ml (*e.g.*, in an embodiment including two 50 ml sample collection vessels) to about 32 liters (*e.g.*, in an embodiment including eight 4 liter sample collection vessels), and thus, the total maximum collectable sample volume may, in different embodiments of the fluid sampling system, for example, be about 100 ml, 500 ml, 1 liter, 2 liter, 5 liter, 10 liter, 12 liter 15 liter, 20 liter, 24 liter, 30 liter, 32 liter, or more.

[0094] Referring next to **FIG. 4**, shown therein is an alternative embodiment of a fluid sampling system **300** which includes four sample collection vessels **106a**, **106b**, **106c** and **106d**, and which further includes, disposed in fluid path **122**, filter **302** housed in compartment **136**. In particular, filter **302** is disposed in fluid path portion **122b**, wherein filter **302** together with fluid path portions **122b1** and **122b2** forms fluid path portion **122b**. Thus fluid upon entering openable container **102** via fluid inlet **118** initially traverses filter **302** before flowing through fluid path **122** towards sample collection vessel. **106a**. Filter **302** can, for example, be a filter having a pore size of from about 0.25 μm to about 5 μm, for example, a pore size of about 0.45 μm. The pore size may be selected based on the particulate containing fluid being collected. In general, the pore size can be selected to be sufficiently large to prevent clogging of filter **302** during the period of time sample fluid is being collected in sample collection vessels **106a** and **106b**, and sufficiently small to trap at least a modicum of particulate matter (**PM**). Thus, where the fluid contains larger size particulates, filter **302** generally can be selected to have a matching larger pore size. For example, when the particulate containing fluid contains particulates sized to have an average particulate size of about 1 μm, the filter size can be selected to be between about 1 μm and about 1.2 μm so that at least a quantity of the particulates can be trapped by filter **302**. It is noted that where municipal wastewater is assayed, in general the pore size of filter **302** can be selected to be in a range of between about 0.3 μm and about 0.6 μm, for example, about 0.45 μm. Filters may be fabricated from different materials, including for example, polyethersulfone (PES) or polyvinylidene fluoride (PVDF). Furthermore it is noted that filter **302** is preferably releasably installed in compartment **136**. Upon completion of the sampling, filter **302** may be released (*i.e.*, removed) and the fluid source material retained within the filter **302** may be analyzed, for example, for the presence of chemical and biological entities therein.

[0095] Referring next to **FIG. 5**, shown therein is an alternate embodiment of a fluid sampling system **400** which includes four sample collection vessels **106a**, **106b**, **106c** and **106d**, and which further includes, disposed in fluid path **122**, filter **402** housed in compartment **136**. In particular, filter **402** is disposed in fluid path portion **122d**, wherein filter **402** together with fluid path portions **122d2a** and **122d2b** forms fluid path portion **122d2**. Thus fluid upon entering openable container **102** via fluid inlet **118** flows through fluid path **122** through sample collection vessels **106a** and **106b**, and then traverses filter **402** before flowing towards sample collection vessels **106c** and **106d**. Filter **402** may be similar to filter **302** and can, for example, be a filter having a pore size of from about 0.25 μm to 1 μm, for example, a pore size of about 0.45 μm. Furthermore it is noted that filter **402** is preferably releasably installed in compartment **136**. Filter **402** may be removed after sample fluid has been collected and the fluid source material retained within the filter **402** may be analyzed, for example, for the presence of certain chemical and biological entities therein using known analytical techniques.

[0096] Continuing to refer to **FIG. 5**, it is furthermore noted that the disposition of filter **402** within fluid path portions **122d2a** and **122d2b** of fluid path **122** allows for a further filtering step to remove fine particulate matter (**PM**) which has not settled in sample collection vessels **106a** and **106b**. Such fine particulate matter generally has a size less than about 1 μm, less than about 0.75 μm, less than about 0.5 μm, less than about 0. 25 μm, or less than 0.1 μm. Further removal of particulate matter (**PM**) may be desirable when subsequent assaying of the liquid sample collected in sample collection vessels **106a** and **106b** involves assaying techniques in which the presence of particulates may interfere with the assaying technique. Thus, for example, where the collected liquid sample subsequently is subjected to mass spectrometry, liquid chromatography mass spectrometry-mass spectrometry (LC-MS/MS), or to liquid chromatography quadrupole time-of-flight (LC-QTOF), as may be the case, for example, when assaying for constituents having a low n-octanol water/partition coefficient (KoW), such as in many pharmaceutical compounds or inorganic compounds. The inclusion of filter **402** allows for the collection of a fluid sample that is substantially free of fine particulate matter in sample collection vessels **106c** and **106d**. It is noted that using fluid sampling system **400** it is possible to collect samples which contain particulate matter (**PM**) in sample collection vessels **106a** and **106b**, and samples which are substantially free of particulate matter (**PM**), even fine particulate matter, in sample collection vessels **106c** and **106d**.

[0097] Referring next to **FIGS. 8A – 8C**, shown therein is an alternate embodiment of a configuration **800** of sample collection vessels **106a** and **106b**, including detachable filter assemblies **806a** and **806b**, respectively. It is to understood that configuration **800** can be used in conjunction with various embodiments of the fluid sampling systems of the present disclosure, including, for example, embodiments **100** and **200**. Detachable filter assemblies **806a** and **806b** have a diameter **d** equal to the inside diameter of sample collection vessels **106a** and **106b** and are disposed within sample collection vessels **106a** and **106b**, respectively, to form bottom sections **812a** and **812b**, and top sections **811a** and **811b** within sample collection vessels **106a** and **106b**, respectively, such that bottom sections **812a** and

812b, and top sections **811a** and **811b** are separated by detachable filter assemblies **806a** and **806b.** Furthermore, detachable filter assemblies **806a** and **806b** are attached to the terminal end portions of fluid conduit portions **123c** and **123d**, respectively. Detachable filter assemblies **806a** and **806b** also include filters **807a** and **807b**.

[0098] Referring to **FIG. 8C**, shown therein is detachable filter **806b** in a first state **s1** and a second state **s2**. In first state **s1**, detachable filter **806b** is attached to and secured in place to fluid conduit portion **123d**, via support ring **808b** which is a part of detachable filter **806b**. Support ring **808b** includes fastening screw **809b**, penetrating the ring wall of supporting ring **808b**. Upon loosening of fastening screw **809b** fluid conduit portion **123d** may be moved upwards (**u**) through support ring **808b**, and in this manner, detachable filter assembly **806b** may be removed from fluid conduit portion **123d**, as shown in **s2**. It will be clear that similarly, detachable filter assembly **806b** may be attached to fluid conduit portion **123d** by inserting fluid conduit portion **123d** into supporting ring **806b** and fastening screw **809b** to thereby secure filter assembly **806b** in place.

[0099] Referring again to **FIG. 8A**, fluid flow (**F**) through filter assemblies **806a** and **806b** is such that fluid entering sample collection vessels **106a** and **106b** is filtered by filter **807a** and **807b** respectively, prior to fluid migrating from bottom sections **812a** and **812b** of sample collection vessels **106a** and **106b** to top sections **811a** and **811b** of sample collection vessels **106a** and **106b**. Thus, filter assemblies **806a** and **806b** may be used to collect fluid constituents, notably insoluble particulates that are unable to traverse filters **807a** and **807b**, by retaining such particulates in sample vessels **106a** and **106b**, respectively, in suspension in bottom sections **812a** or **812b**. Furthermore, filter assemblies **806a** and **806b** may be used to collect fluid constituents which adhere to filter **807a** and **807b**. Upon removal of filter assemblies **806a** and **806b**, these fluid constituents may be evaluated by evaluation of filters **807a** and/or **807b**.

[00100] Filters **807a** and **807b** can, for example, be filters having a pore size of from about 0.25 μm to about 5 μm, for example, 0.5 μm, 1 μm, 1.5 μm, 2 μm, 2.5 μm, 3 μm, 3.5 μm, 4 μm, or 4.5 μm. The pore size may be selected based on the particulate containing fluid being collected. Filters **807a** and **807b** may be fabricated from different materials, including for example, polyethersulfone (PES) or polyvinylidene fluoride (PVDF). Filters **807a**

and **807b** may further include specific sorbents as a receiving phase. Sorbent materials in this respect may include copolymer poly(divinylbenzene)-*co*-*N*-vinylpyrrolidone, styrene/divinylbenzene (*e.g.*, Dowex Optipore®), (poly)styrene-divinyl benzene, or a polymethacrylate, or surface modified forms thereof (*e.g.*, Strata-X®, a surface modified N-vinylpyrrolidone), such as described in U.S. Patent 7,119,145, which may be used to capture illicit drugs, pharmaceuticals, endocrine disrupting substances, personal care products, or (poly)phenol, for example. Furthermore, the filter may be assembled as a polar organic chemical integrative sampler (POCIS) (see: U.S. Patent 6,478,961). As noted, upon completion of the sampling, filters **807a** and **807b** may be released (*i.e.*, removed) and the fluid source material retained by filters **807a** and **807b** may be analyzed, for example, for the presence of chemical and biological entities therein, such as Illicit drugs, pesticides, microplastics, pharmaceuticals, bacteria, algae, viruses, pathogens, industrial contaminants, perfluoroalkyl and polyfluoroalkyl substances (PFAS), human biomarkers, or endocrine disrupting substances.

[00101] Next, another example embodiment of an openable container will be further discussed. Referring next to **FIGS. 6A - 6D** shown therein is example openable container **102**, which includes elements of fluid sampling system **300** shown in the schematic view shown in **FIG. 4**. It is to be understood that example openable container **102** generally can be used in conjunction with other fluid sampling systems in accordance with the present disclosure, including example fluid sampling systems **100**, **200**, and **400**.

[00102] Thus, referring next to **FIGS. 6A-6D** openable container **102** includes lid **602** and hinges **604** to allow opening and closing of container **102**. Lid **602** can be securely closed by clips or latches **606a** and **606b**. It is generally preferable to construct openable container **102** from a sturdy durable material, such as a more or less contiguous hard plastic, *e.g.*, a polypropylene, a polystyrene, a polycarbonate, a polyamide, or the like, having a thickness of from about 0.25 cm to about 1 cm. Furthermore, it is noted that since openable container **102** may come into contact with fluid sources, openable container **102** is generally preferably constructed so that upon closure of openable container **102**, the container **102** has a substantially watertight seal, and is impervious to entry of fluids into interior compartments **104**, **108**, **114** and **136** from exterior **130**, other than via fluid inlet **118**. Openable container

102 further includes hand grip **124** to allow for easy transport of openable container **102**, for example, to a location in close proximity of a fluid sampling site, as well as linking portions **128a** and **128b** for attaching a suspension arrangement **126** thereto (as shown in **FIG.** 1). Openable container **102** further includes releasable attachment devices (not shown) to securely and releasably attach sample collection vessels **106a**, **106b**, **106c** and **106d** into compartment **104** (not shown). Examples of releasable attachment devices include clips, straps, or the like, to operably match the geometry of sample collection vessels **106a**, **106b**, **106c** and **106d**.

[00103] It is further noted that fluid outlet **120** and second portion **118b** of fluid inlet **118** are similarly preferably constructed from a sturdy durable material. First portion **118a** of fluid inlet **118**, on the other hand, is preferably constructed from a more flexible material to form a flexible fluid line. First portion **118a** may also have a significant length, for example, at least about 1m, at least about 2m, or at least about 7m. This allows, for openable container **102** to be suspended in, for example, a manhole, in such a manner that openable container **102** is suspended above the fluid level, while portion **118a** extends below the fluid level of fluid source **131**. As shown in **FIG. 6B**, fluid inlet **118** and fluid outlet **120** can be rotatably attached to the exterior of side wall **605** of container **102** using a rotatable attachment. The rotatable attachment provides further flexibility and helps establish or maintain a fluidic coupling between fluid source **131** and fluid inlet **118**. Furthermore, the rotational flexibility of fluid inlet **118** and fluid outlet **120** can prevent breakage of fluid inlet **118** or fluid outlet **120**, for example, when fluid levels of fluid source **131** rapidly surge, and fluid inlet **118** and fluid outlet **120** become subject to upward fluid pressure.

[00104] It is further noted that in some embodiments, interior compartment **104**, housing sample collection vessels **106a**, **106b**, **106c** and **106d**, may be cooled for example to a temperature in a range of from about 2 °C to about 10 °C. Accordingly, compartment **104** may be referred to as a coolable compartment. Cooling of compartment **104** can be desirable to prevent alteration in the fluid constituents while the collected fluid samples await analysis. Cooling may be achieved, for example, by configuring the coolable compartment **104** to include releasable ice packs, *e.g.*, a plastic container or bag filled with a refrigerant gel or liquid. In other embodiments, a thermoelectric cooling system may be included, for example, a cooling system based on Peltier plates. In such embodiments, in order to control the temperature in interior compartment **104**, a thermostat may be installed in interior compartment **104**. The thermostat may be operably coupled to controller **112**, thus allowing an operator of the sampling system to control the temperature within compartment **104** by remotely monitoring the temperature of interior compartment **104.** For example, the controller **112**, in conjunction with a communication unit, may receive temperature measurements from the thermostat and transmit the temperature measurements to the operator who can then send a thermostat control signal to the controller **112** so that the controller **112** may alter the operation of the thermoelectric cooling system to maintain a desired temperature in the compartment **104**. Alternatively, the controller **112** may be provided with software instructions for automatically controlling the thermoelectric cooling system by receiving temperature measurements from the thermostat, comparing the temperature measurements with a desired temperature range for the compartment **104** and if the temperature measurements are outside of the desired temperature range applying a control signal to adjust the thermostat until the measured temperature is within the desired temperature range described earlier. It is noted that in embodiments hereof, in which compartment **104** is cooled, it is preferable that interior wall **132c** and the portion of the exterior wall **134** together forming interior compartment **104** are constructed to include insulation material to minimize temperature increases caused by heat transfer from the exterior, using, for example, an insulating foam or reflective insulation tape.

[00105] Methods for operating the sampling systems of the present disclosure will next be discussed. In general terms, in an aspect hereof, in an example embodiment, the present disclosure includes a method of collecting fluid samples comprising installing the sampling system of the present disclosure, while the container is in a closed position, in such a manner that the fluid inlet is fluidically coupled to a particulate containing fluid source. Following installation, the fluid pump, which is controlled by a controller is activated at a first time (*e.g.*, an activation time) to cause a portion of the particulate containing fluid source to enter into the container through the fluid inlet and flow through the container through the fluid flow path. The pump is then deactivated at a second time (*e.g.*, a deactivation time). Thereafter the sampling system is retrieved from the fluid source.

[00106] Referring next to **FIGS. 7A** - **7D** shown therein are flowcharts showing example embodiments of methods **700, 701, 702** and **703**, respectively, for collecting sample materials using one of the fluid sampling systems of the present disclosure in accordance with the teachings herein. Methods **700, 701, 702** and **703** refer to fluid sampling system **300** of **FIG. 4** for illustrative purposes only and it should be understood that methods **700, 701, 702** and **703** can be applied to alternative embodiments of the fluid sampling systems, including fluid sampling systems **100**, **200** and **400** shown in **FIG. 1**, **FIG. 3**, and **FIG. 5**, respectively.

[00107] Referring to **FIG. 7A**, at act **705** of method **700**, the fluid sampling system is installed in a such a manner that fluid inlet **118**, is fluidically coupled to fluid source **131**. The fluid sampling system is installed while openable container **102** is in a closed position. In general, this involves installing the fluid sampling system **300** in such a manner that fluid inlet **118**, notably at least the end portion of first portion **118a** of fluid inlet **118** is submerged into fluid source **131**. Furthermore, typically, and preferably, the fluid sampling system **300** is installed in such a manner that prolonged contact between the fluid source **131** and the openable container **102** is avoided to limit potential adverse effects caused by fluid source **131** of which the constituents may not be known, and which may include for example, harsh chemicals. However, provided that when openable container **102** is constructed such that when it is in a closed position it is impervious to fluid, occasional fluid contact, for example during installation, sampling or retrieval, is not generally expected to cause any adverse effects. In certain selected embodiments, installation of the fluid sampling system **300** may involve suspending the fluid sampling system above fluid source **131** in such a manner that first portion **118a** of fluid inlet **118** can extend downwards into fluid source **131**. It is noted that fluid source **131** can be any fluid source, notably any particulate containing fluid source, including any flowing fluid source or stagnant fluid source, and further including, without limitation, any flowing wastewater source or stagnant wastewater source or effluent source, including any domestic, municipal or industrial wastewater source, for example. Thus, in one example, the fluid sampling system **300** may be suspended downwards in a manhole leading to a sewer, for example, by connecting suspension arrangement **126** to a manhole grating of cover.

[00108] At act **710** of method **700**, peristaltic fluid pump **110** is activated to initiate the flow of fluid through fluid path **122** through openable container **102** so that fluid can be received by sample collection vessels **106a**, **106b**, **106c** and **106d**. As previously noted, controller **112** may be used to activate peristaltic fluid pump **110** and initiate pumping of fluid from the fluid source **131** into openable container **102** at a specific time (*e.g.*, a predefined activation time).

[00109] At act **715**, once sample collection vessels **106a**, **106b**, **106c** and **106d**, have received sample fluid, peristaltic fluid pump **110** may be deactivated and fluid pumping may be stopped at a specific time. As previously noted, controller **112** may be used to deactivate the peristaltic fluid pump **110** at a specific time (*e.g.*, a deactivation time) or the controller **112** may be used to monitor the amount of sample fluid within the fluid sampling system **300**, determine when the sample collection vessels on vessels **106a**, **106b**, **106c** and **106d**, have been filled with sample fluid and then stop fluid pumping of peristaltic fluid pump **110**.

[00110] At act **720**, the fluid sampling system **300** may be retrieved from the sampling site. For example, when the fluid sampling system **300** is suspended in a manhole using suspension arrangement **126**, the fluid sampling system **300** may be retrieved by pulling the fluid sampling system **300** upwards and out of the manhole using suspension arrangement **126**.

[00111] Referring next to **FIG. 7B**, it is noted that example method **701** includes acts **705, 710, 715** and **720**, as previously described with respect to example method **700** and **FIG. 7A**. Method **701**, additionally includes act **725**. At act **725**, sample collection vessels **106a**, **106b**, and optionally additional sample collection vessels are released from openable container **102**. As previously noted, sample collection vessels **106a**, **106b**, **106c** and **106d** are releasably installed within compartment **134**. Thus, upon opening openable container **102**, sample collection vessels **106a**, **106b**, **106c** and **106d** can readily be released and separated from openable container **102**.

[00112] Referring next to **FIG. 7C**, it is noted that example method **702** includes acts **705, 710, 715 720** and **725**, as previously described with respect to example methods **700** and **702** and **FIGS. 7A** and **7B**, respectively. Method **702**, additionally includes act **730**. At act **730**, fluid and/or particulate fractions are collected from collection vessels **106a**, **106b**,

106c and **106d**. Such fraction collection may occur at a laboratory site following transport of the sample collection vessels thereto, whether contained in openable container **102**, or separately following release from openable container **102**. Fraction collection may occur at the sampling site, or, for example, at a laboratory.

[00113] Referring next to **FIG. 7D**, it is noted that example method **703** includes acts **705, 710, 715 720, 725**, and **730** as previously described with respect to example methods **700, 701** and **702** and **FIGS. 7A, 7B,** and **7C**, respectively. Method **703**, additionally includes act **735**. At act **735**, fluid and/or particulate fractions that are collected at act **730** are then assayed for a chemical or biological parameter. The exact chemical or biological parameter may vary and may be selected as desired. The assay may be performed at the fluid sampling site or following transport to a laboratory. Example parameters that may be assayed include, without limitation, chemical entities, including for example, heavy metals, such as cadmium (Cd), lead (Pb), chromium (Cr). Mercury (Hg) or nickel (Ni), and further including, without limitation, pharmaceutical compounds, illicit drug compounds, industrial pollutants or toxins, or agrochemical compounds. Biological compounds that may be assayed for are microbial pathogens, including, without limitation, bacterial pathogens, including, for example, enteric bacterial pathogens such as *Escherichia coli, Campylobacter* species, *Vibrio* species, *Salmonella* species, and *Clostridioides* species; viral pathogens, including, for example, corona viruses (*e.g.*, SARS-CoV-2), Zika virus, adenovirus, hepatitis virus (A and E), Norwalk virus, and protozoal species, for example *Entamoebe* species and *Giardia* species. Furthermore, it will be understood by those of skill in the art that the assay that will be performed will vary depending on the selected chemical or biological parameter.

[00114] It will be clear from the foregoing that the fluid sampling systems of the present disclosure, upon having been deployed to collect sample materials, may be manipulated to collect sample collection vessels, which in turn may be used to collect particulate and/or liquid fractions. Accordingly, in a further aspect, the present disclosure provides, in at least one aspect, in at least one embodiment, a use of a fluid sampling system of the present disclosure to collect from each sample collection vessel a particulate fraction and/or a liquid fraction.

[00115] It will further be clear from the foregoing that collected particulate and/or liquid fractions may be assayed. Accordingly, in a further aspect, the present disclosure provides, in at least one aspect, a use of a settled particulate fraction and/or a liquid fraction collected using a sampling system of the present disclosure to assay a chemical or biological parameter therein.

[00116] As can now be appreciated, the fluid sampling systems of the present disclosure can be used for collecting sample materials from particulate containing fluid sources. The sample materials are collected in sample collection vessels contained in the container and can be used to assay for chemical or biological parameters.

[00117] Of course, the above described example embodiments of the present disclosure are intended to be illustrative only and in no way limiting. The described embodiments are susceptible to many modifications of composition, details and order of operation. Various embodiments of the invention, rather, is intended to encompass all such modifications within its scope, as defined by the claims, which should be given a broad interpretation consistent with the description as a whole.

CLAIMS

1. An openable container constructed and arranged for the flow of particulate containing fluids therethrough, the container comprising:

a sampling system for the collection of fluids, the sampling system comprising:

a fluid inlet in fluid communication with an exterior of the container to receive particulate containing fluids;

at least two serially fluidically coupled sample collection vessels releasably installed in the container and coupled to the fluid inlet, the sample collection vessels including a first sample collection vessel nearest the fluid inlet and a final sample collection vessel;

a fluid flow path through the container from the fluid inlet serially through the at least two sample collection vessels;

a fluid pump that is operably coupled to the fluid flow path and is configured to control the flow of the particulate containing fluids through the fluid flow path; and

a controller configured to control the flow of the particulate containing fluids through the fluid flow path;

wherein during use when the container is in a closed position and the fluid inlet being in fluid communication with a source of particulate containing fluid the container, the controller is configured to activate the fluid pump at a first time to cause a portion of the particulate containing fluid to enter the container through the fluid inlet and to flow through the fluid flow path a rate such that the particulate containing fluid is sequentially received by the serially fluidically coupled sample collection vessels, and particulates in the particulate containing fluid settle in the sample collection vessels, the controller further being configured to deactivate the fluid pump at a second time to stop collection of the particulate containing fluid.

2. An openable container according to claim **1**, wherein a final sample collection vessel of the at least two serially coupled sample collection vessels is fluidically coupled to a fluid outlet in fluid communication with the exterior, the fluid flow path extending from the final sample collection vessel to the fluid outlet.

3. An openable container according to claim **2**, wherein the fluid pump is controlled to pump the fluid through the fluid flow path at a selected rate wherein a greater quantity of the particulates settles in a first sample collection vessel compared to the final sample collection vessel.

4. An openable container according to any one of claims **1** to **3**, wherein the sampling system comprises two serially coupled sample collection vessels.

5. An openable container according to any one of claims **1** to **3**, wherein the sample collection system comprises at least three serially coupled sample collection vessels.

6. An openable container to any one of claims 1 to **5**, wherein the fluid flow path comprises a fluid coupling system for at least one of the sample collection vessels, the fluid coupling system comprising a sample collection vessel fluid inlet and a sample collection vessel fluid outlet disposed in the at least one sample collection vessel, the sample collection vessel fluid inlet comprising a tubular fluid inlet conduit traversing a top portion of the at least one sample collection vessel at a first aperture and extending downwards therefrom to approximately a bottom portion of the at least one sample collection vessel to permit receipt of incoming fluid at approximately the bottom of the sample collection vessel, and the sample collection vessel fluid outlet comprises a tubular fluid outlet conduit traversing the top portion of the sample collection vessel at a second aperture and extending downwards therefrom no further than to approximately half a height of the at least one sample collection vessel to permit transfer of outgoing fluid downstream from the at least one sample collection vessel.

7. An openable container according to any one of claims **1** to **6**, wherein the fluid flow path further includes a filter to collect selected chemical or biological species from the particulate containing fluid.

8. An openable container according to claim **7**, wherein the filter is installed in the fluid flow path between the fluid inlet and the first sample collection vessel.

9. An openable container according to claim **8**, wherein the filter is installed in the fluid flow path between the first sample collection vessel and the final sample collection vessel of the at least two serially coupled sample collection vessels.

10. An openable container according to claim **7**, wherein the filter is installed in fluid flow path in at least one of the sample collection vessels, the filter being disposed within the sample collection vessel at a height above the height of a terminal end of the tubular fluid inlet conduit of the at least one sample collection vessel fluid inlet and so that incoming fluid is received by the at least one sample collection vessel, then traverses the filter, and the outgoing fluid then transfers downstream from the at least one sample collection vessel.

11. An openable container according to claim **10**, wherein the filter is detachably coupled to the tubular fluid inlet conduit of the at least one sample collection vessel fluid inlet.

12. An openable container according to claims **10** or **11**, wherein filters are installed in the fluid flow path in all of the sample collection vessels.

13. An openable container according to any one of claims **1** to **12**, wherein the fluid inlet includes a terminal end that extends to the exterior of the container, and the terminal end includes a mesh filter configured to prevent the entry of debris into the container.

14. An openable container according to any one of claims **1** to **13**, wherein the container is compartmentalized and includes a coolable compartment that is configured to house the sample collection vessels.

15. An openable container according to claim **14**, wherein the coolable compartment is configured to hold ice packs.

16. An openable container according to claim **14**, wherein the container includes a cooling device controlled by a controller to control the temperature of the coolable compartment.

17. An openable container according to any one of claims **13** to **15**, wherein the temperature in the coolable compartment is controlled to be in a range from about 2 °C to about 10 °C.

18. An openable container according to any one of claims **1** to **17**, wherein the controller is coupled to an environmental sensor capable of detecting a change in an environmental parameter, and the controller is configured to activate the fluid pump upon the detection of a change in an environmental parameter by the sensor.

19. An openable container according to claim **18**, wherein the environmental sensor is a rain sensor, a pH sensor, a temperature sensor, a turbidity sensor, a biochemical oxygen demand (BOD) sensor, a chemical oxygen demand (COD), an electrical conductivity (EC) sensor, or a total dissolved solids (TDS) sensor.

20. An openable container according to any one of claims **1** to **19**, wherein the particulate containing fluid source is wastewater.

21. An openable container according to any one of claims **1** to **20**, wherein the openable container comprises an openable lid and when the lid of the container is in the closed position the sampling system is operable.

22. An openable container according to any one of claims **1** to **21**, wherein the openable container comprises a linking portion to attach the container to a suspension arrangement.

23. A method of collecting samples using the openable container comprising the fluid sampling system according to any one of claims **1** to **22**, the method comprising:

installing the container in a closed position in such a manner that the fluid inlet is fluidically coupled to a source of particulate containing fluid;

activating the fluid pump at a first time to cause a portion of the particulate containing fluid to enter the container through the fluid inlet and flow through the container through the fluid flow path at a rate that allows particulates in the particulate containing fluid to settle in at least one of the sample collection vessels to separate from the fluid, deactivating the fluid pump at a second time to thereafter permit release of the sample collection vessels from the container; and

retrieving the container.

24. A method according to claim **23**, wherein the method further comprises opening the container and releasing the sample collection vessels.

25. A method according to claim **24**, wherein the method further comprises collecting a settled particulate fraction and/or a liquid fraction from the released sample collection vessels.

26. A method according to claim **25**, wherein the method further comprises assaying a chemical or biological parameter in the settled particulate fraction and/or the liquid fraction.

27. A method according to any one of claims **23** to **26**, wherein a terminal end of the fluid inlet is suspended in a stagnant fluid source.

28. A method according to any one of claims **23** to **26**, wherein a terminal end of the fluid inlet is suspended in a flowing fluid source.

29. A method according to claim **27** or **28**, wherein the terminal end of the fluid inlet is suspended in a wastewater fluid source.

30. A method according to any one of claims **23** to **29**, wherein the method comprises periodically activating and deactivating the fluid pump.

31. A method according to claim **30**, wherein each period of activating and deactivating the pump is separated by a hold time interval during which no fluid source flows through the fluid path.

32. A method according to claim **30** or **31**, wherein the periodic activating and deactivating is continued until the sample collection vessels are full.

33. A method according to claim **30**, wherein the method comprises periodically activating the fluid pump at a first time and deactivating the fluid pump at a second time, wherein each period is separated by a hold time interval during which no fluid flows through the fluid path wherein the second time occurs from about 5 seconds to about 30 seconds later than the first time, and wherein the hold time interval is at least 15 minutes.

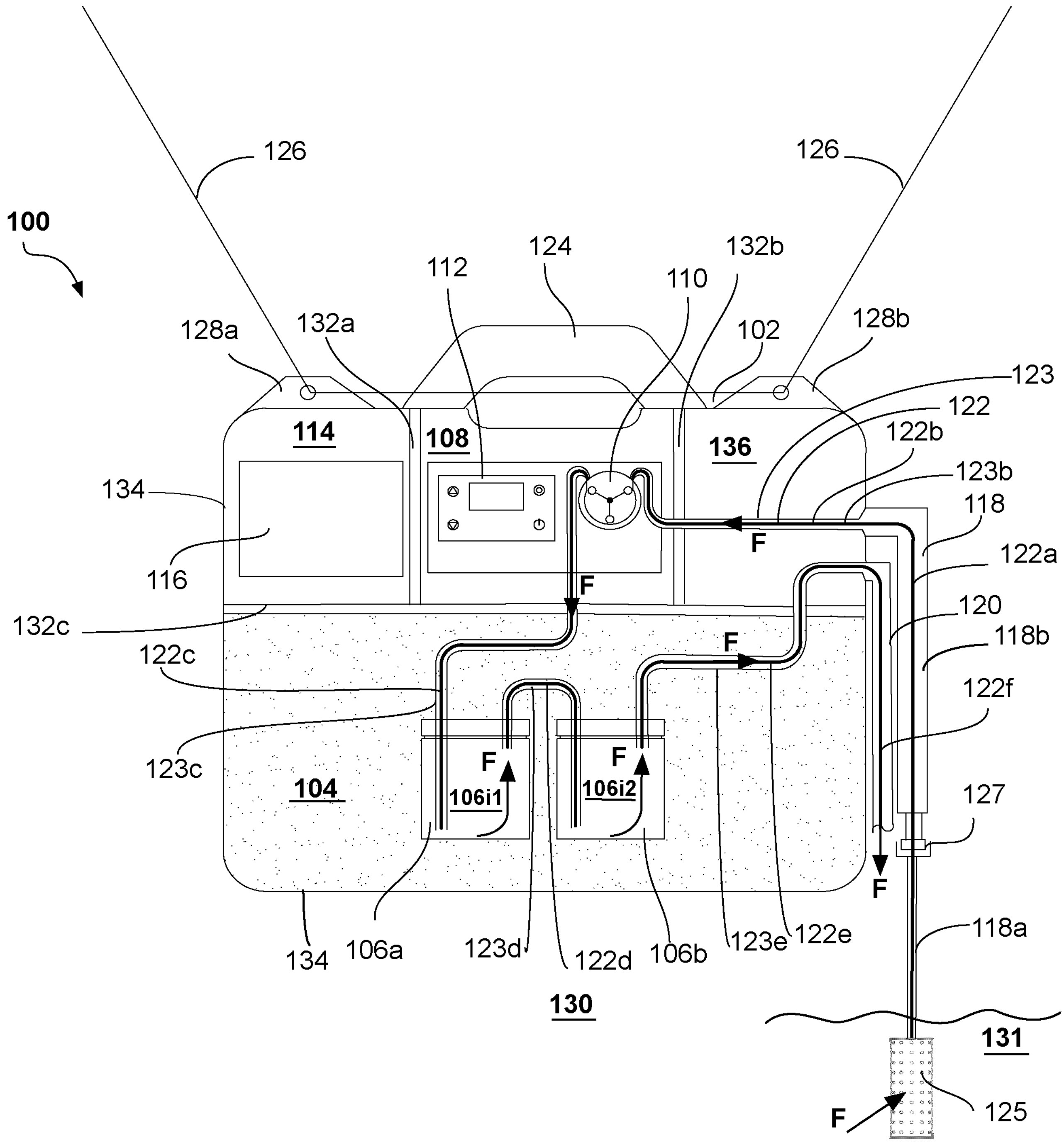
34. A method according to any one of claims **23** to **33**, wherein the method comprises activating the fluid pump upon an environmental sensor detecting a change in an environmental parameter.

35. A method according to claim **34**, wherein the method comprises activating the fluid pump upon the environmental sensor detecting a change in the environmental parameter, and deactivating the fluid pump at a set time thereafter, or deactivating the pump when the sample collection vessels are full.

36. A method according to claim **34** or **35**, wherein the environmental sensor is a rain sensor, a pH sensor, a temperature sensor, a turbidity sensor, a biochemical oxygen demand (BOD) sensor, a chemical oxygen demand (COD), an electrical conductivity (EC) sensor, or a total dissolved solids (TDS) sensor.

37. A use of the openable container comprising a fluid sampling system according to any one of claims **1** to **22**, to collect from each sample collection vessel a particulate fraction and/or a liquid fraction.

38. A use of a settled particulate fraction and/or a liquid fraction collected using the openable container comprising a fluid sampling system according to any one of claims **1** to **22** to assay a chemical or biological parameter therein.


100
126
126
124
112
132b
110
132a
128a
102
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123
122
122b
114
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118
116
F
122a
132c
F
120
122c
F
118b
122f
123c
F
F
104
106i1
106i2
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106a
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130
131
F
125

FIG. 1

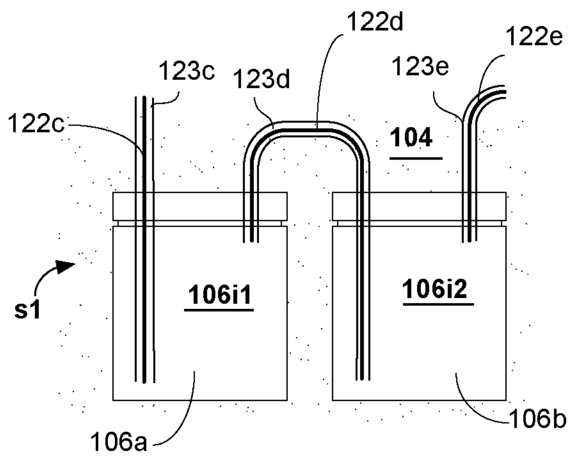


FIG. 2A

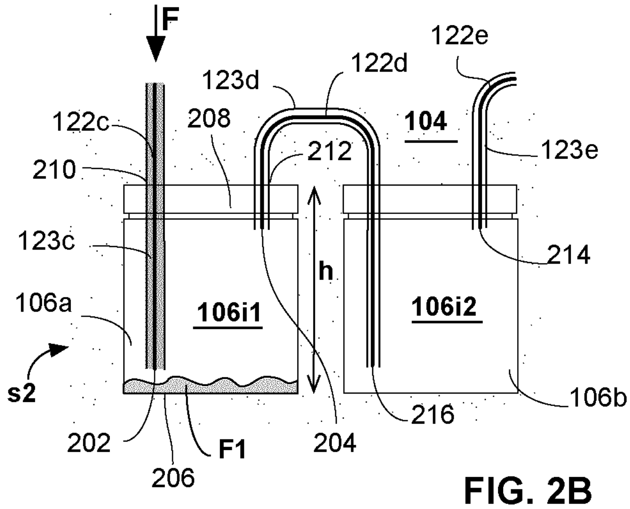


FIG. 2B

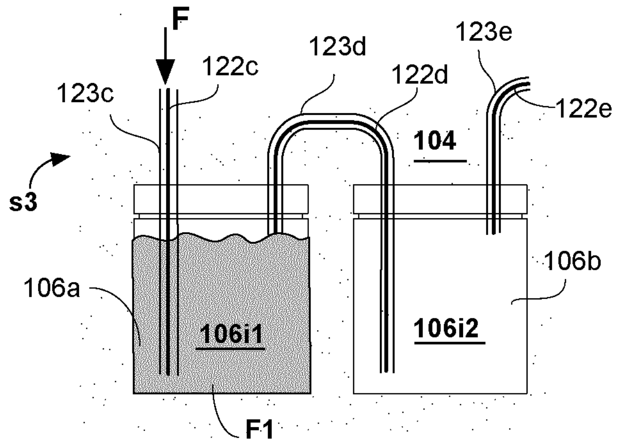


FIG. 2C

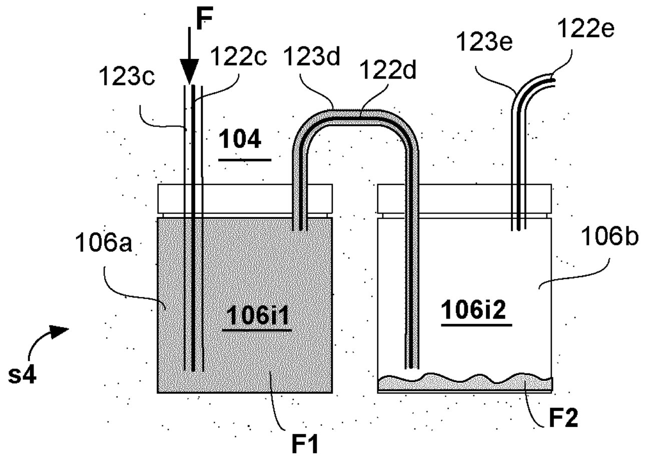


FIG. 2D

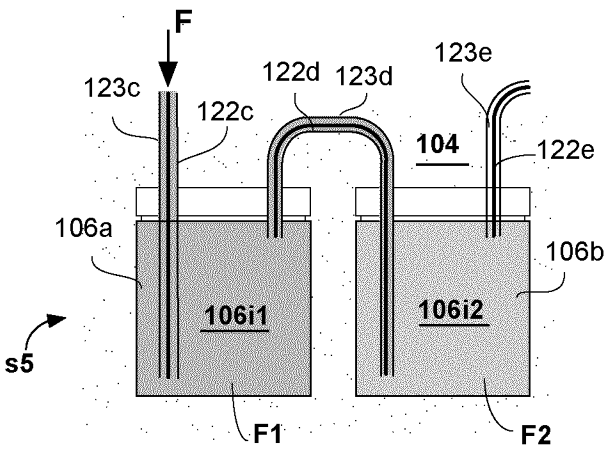


FIG. 2E

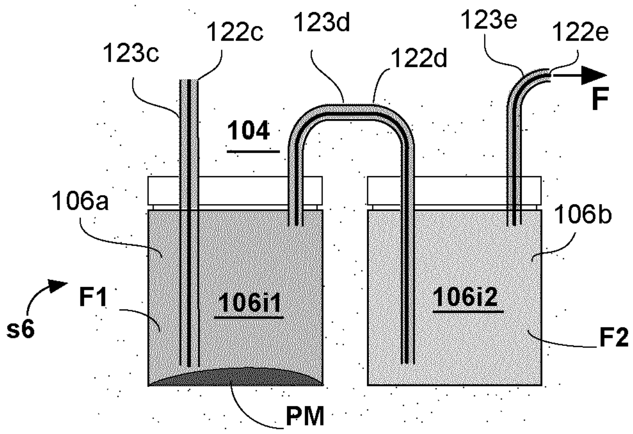


FIG. 2F

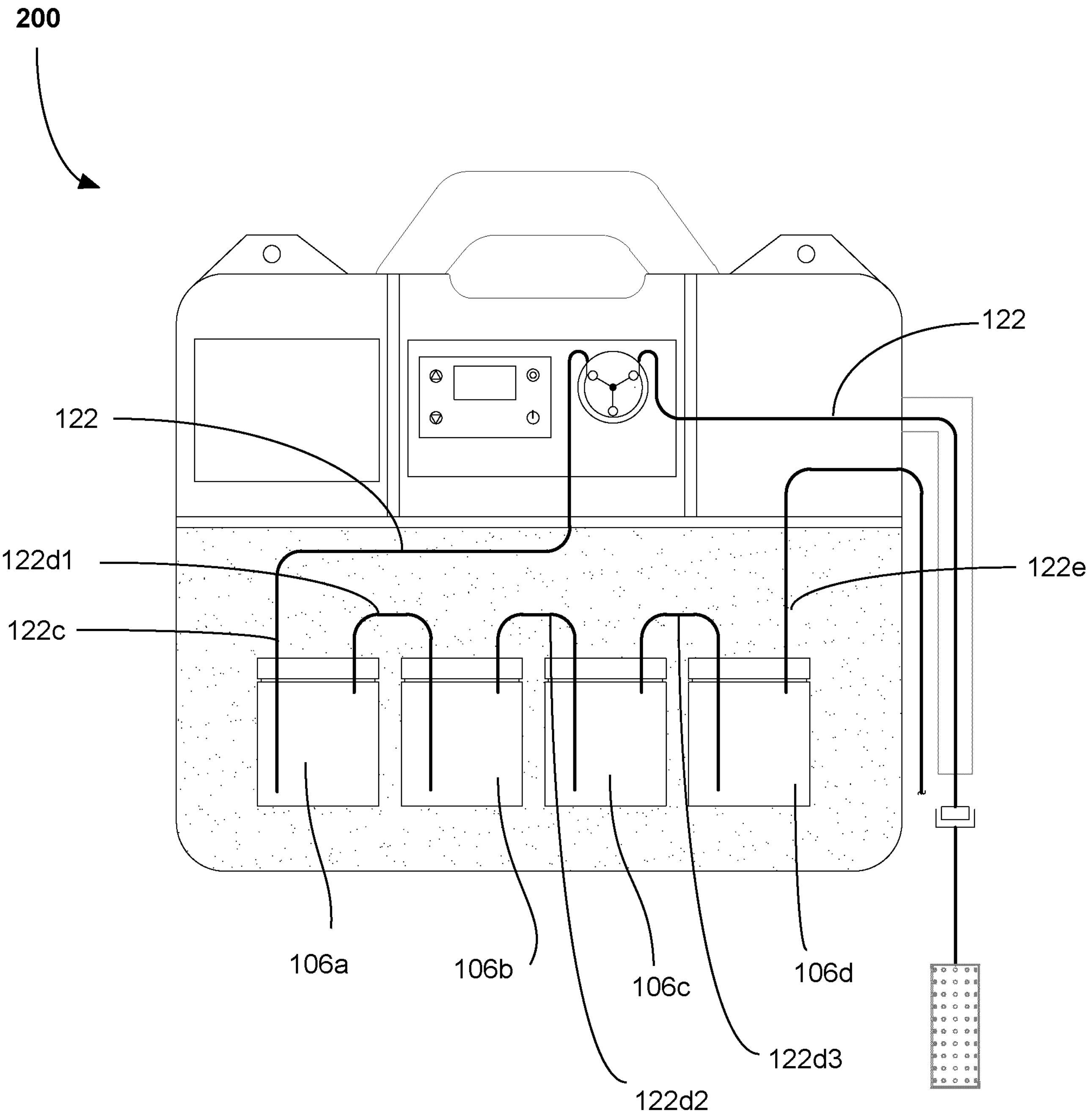


FIG. 3

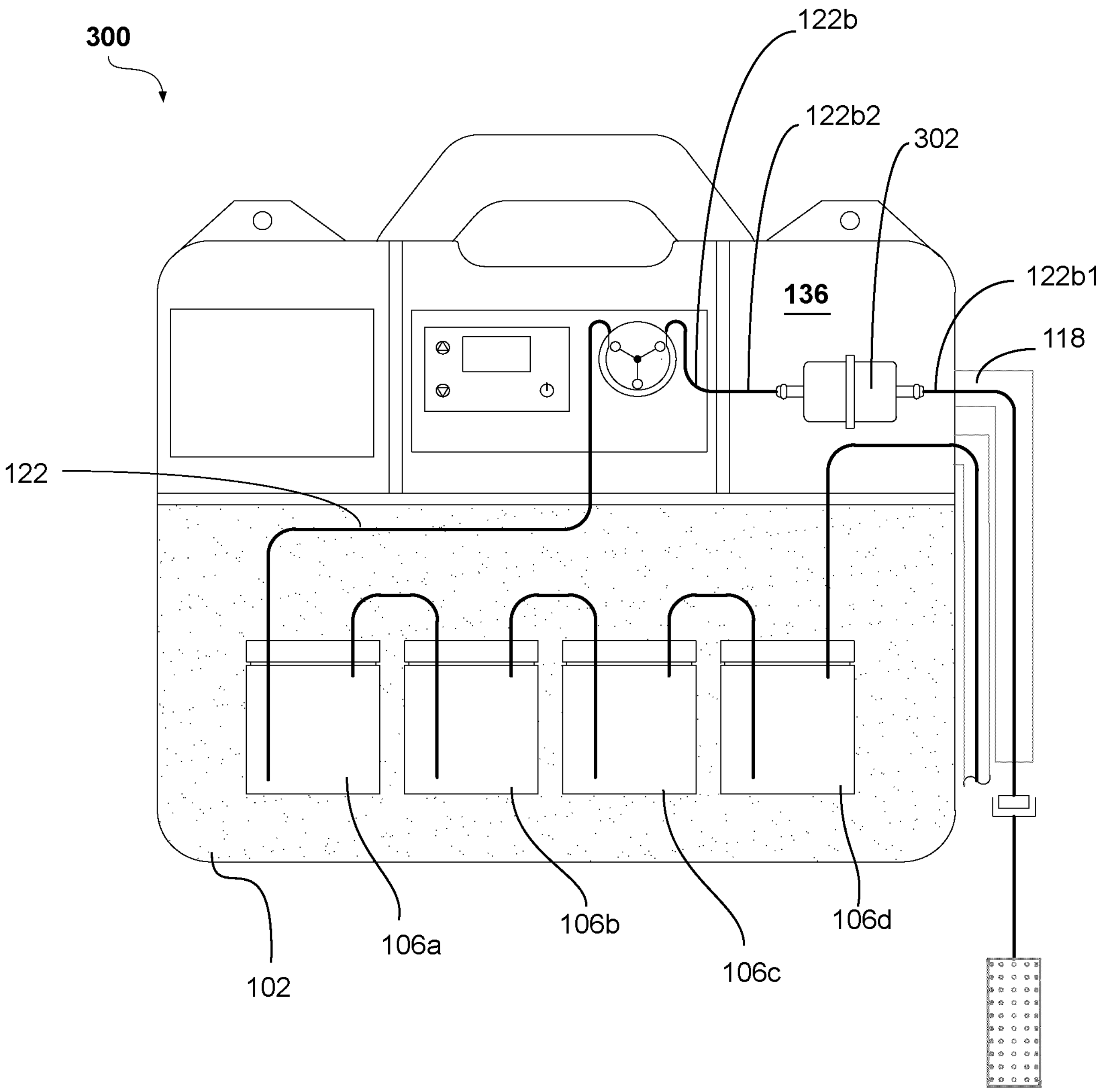


FIG. 4

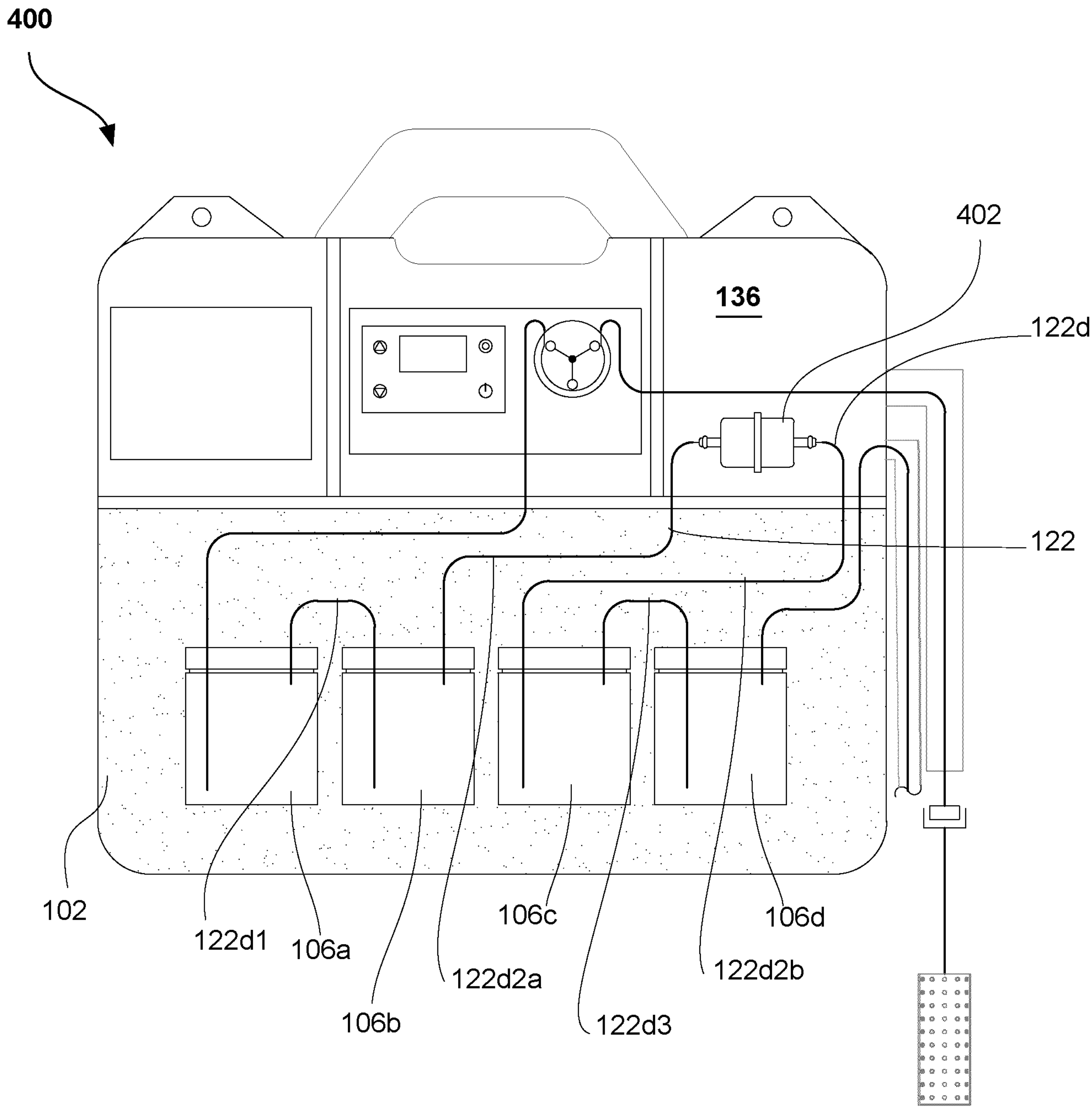
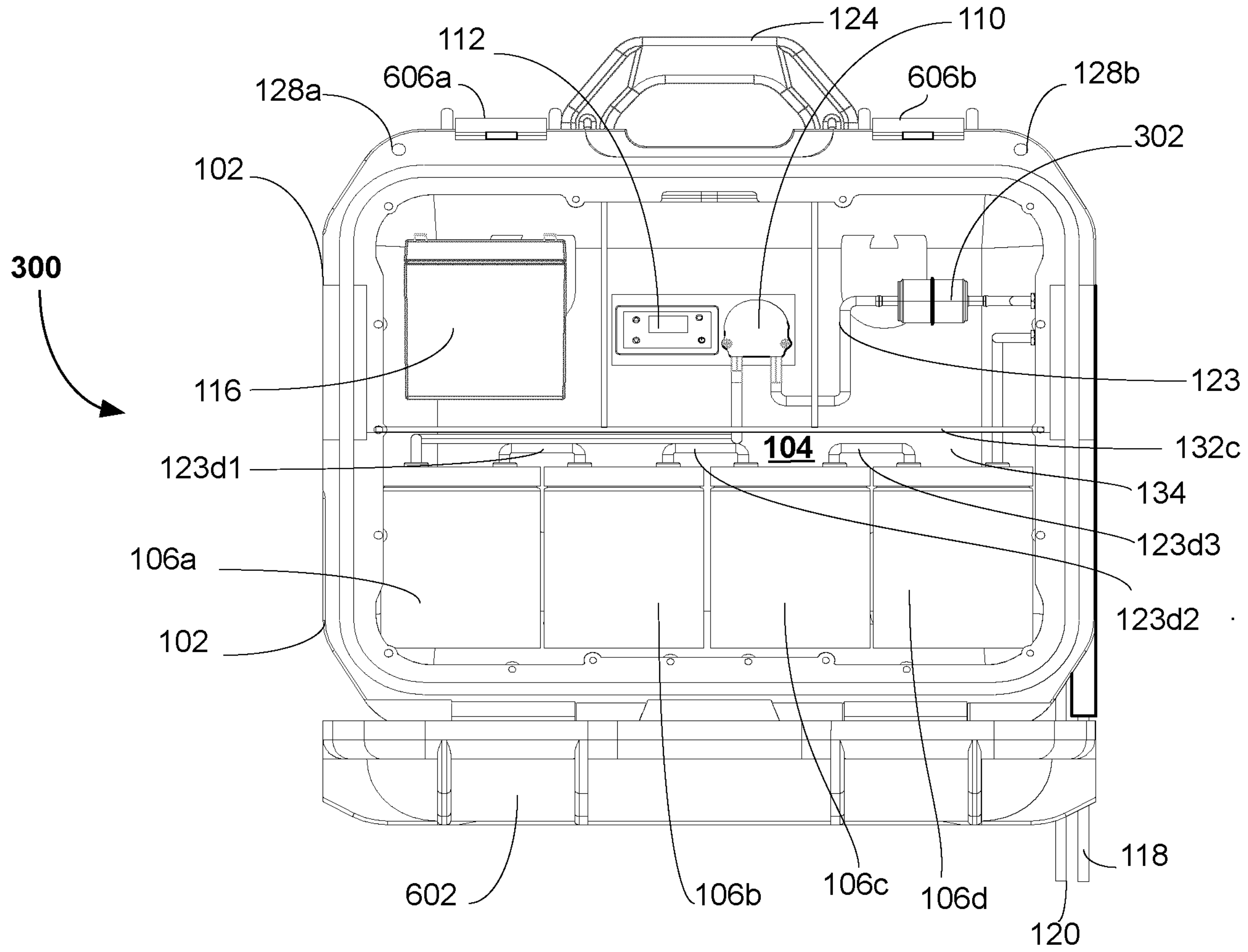
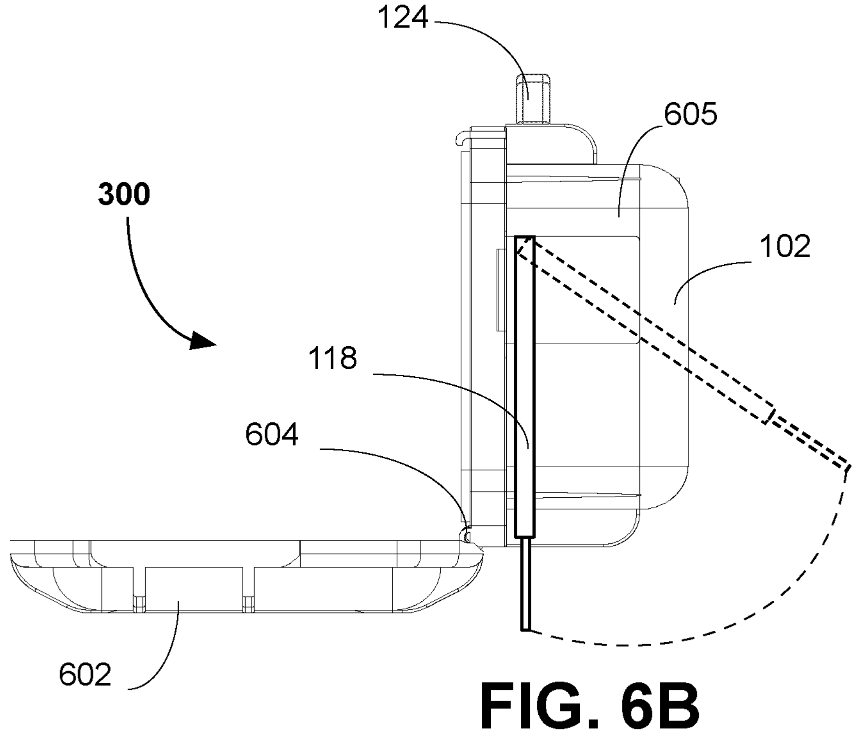

400
402
136
122d
122
102
122d1
106a
106b
122d2a
106c
122d3
122d2b
106d

FIG. 5



124
110
112
606a
606b
128b
128a
302
102
300
116
123
132c
104
123d1
134
123d3
106a
123d2
102
118
602
106b
106c
106d
120

FIG. 6A



124
605
300
102
118
604
602

FIG. 6B

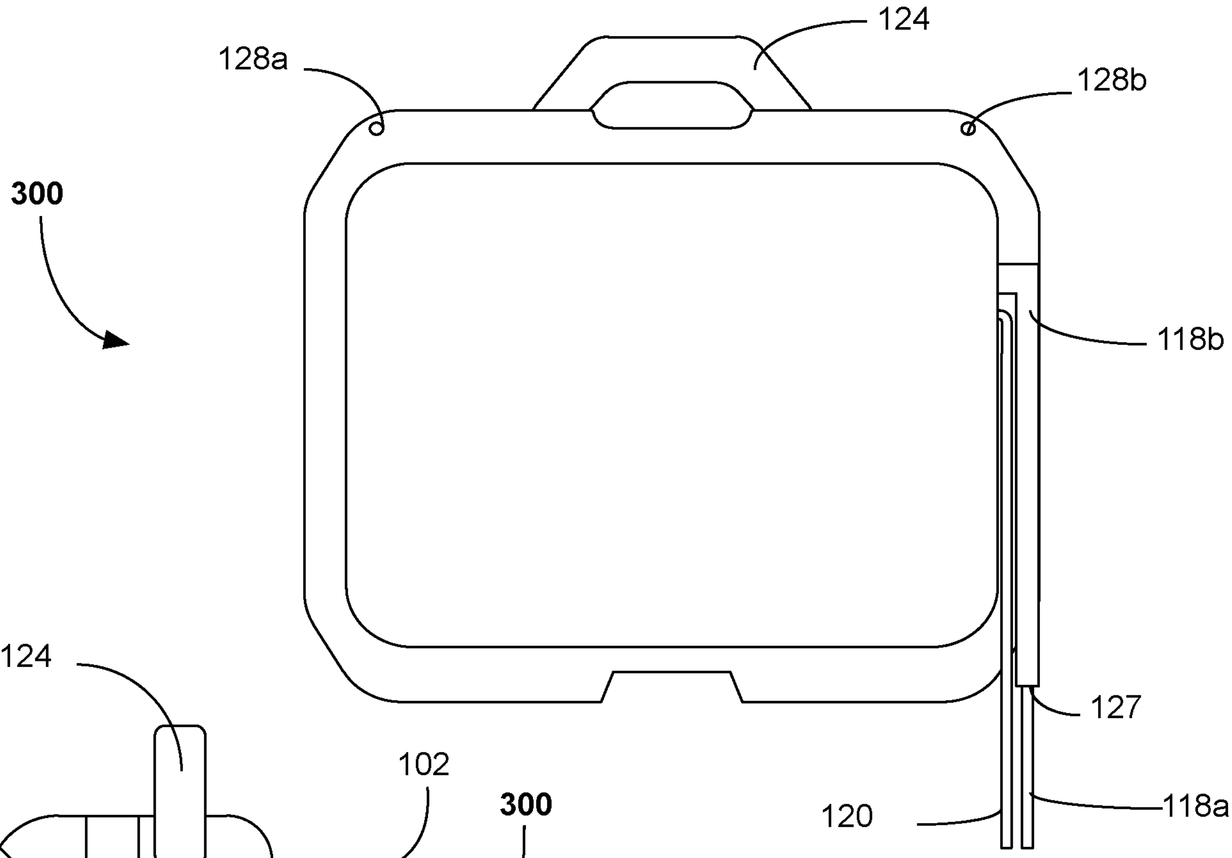

124
128a
128b
300
118b
127
120
118a

FIG. 6C

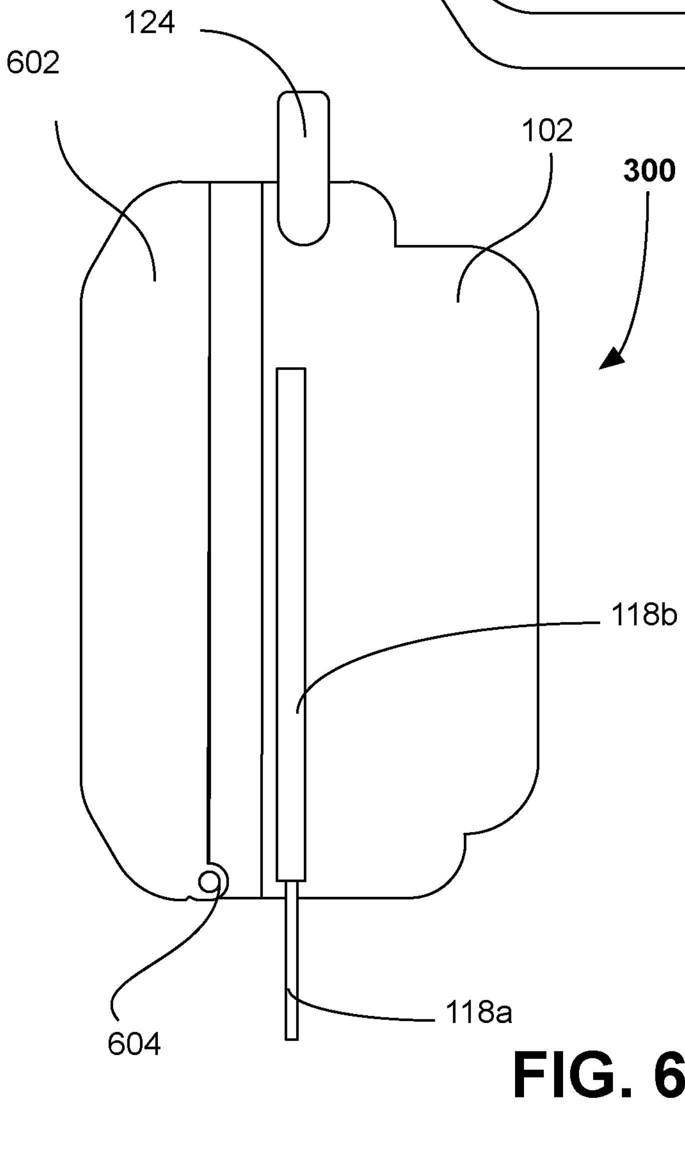

124
602
102
300
118b
604
118a

FIG. 6D

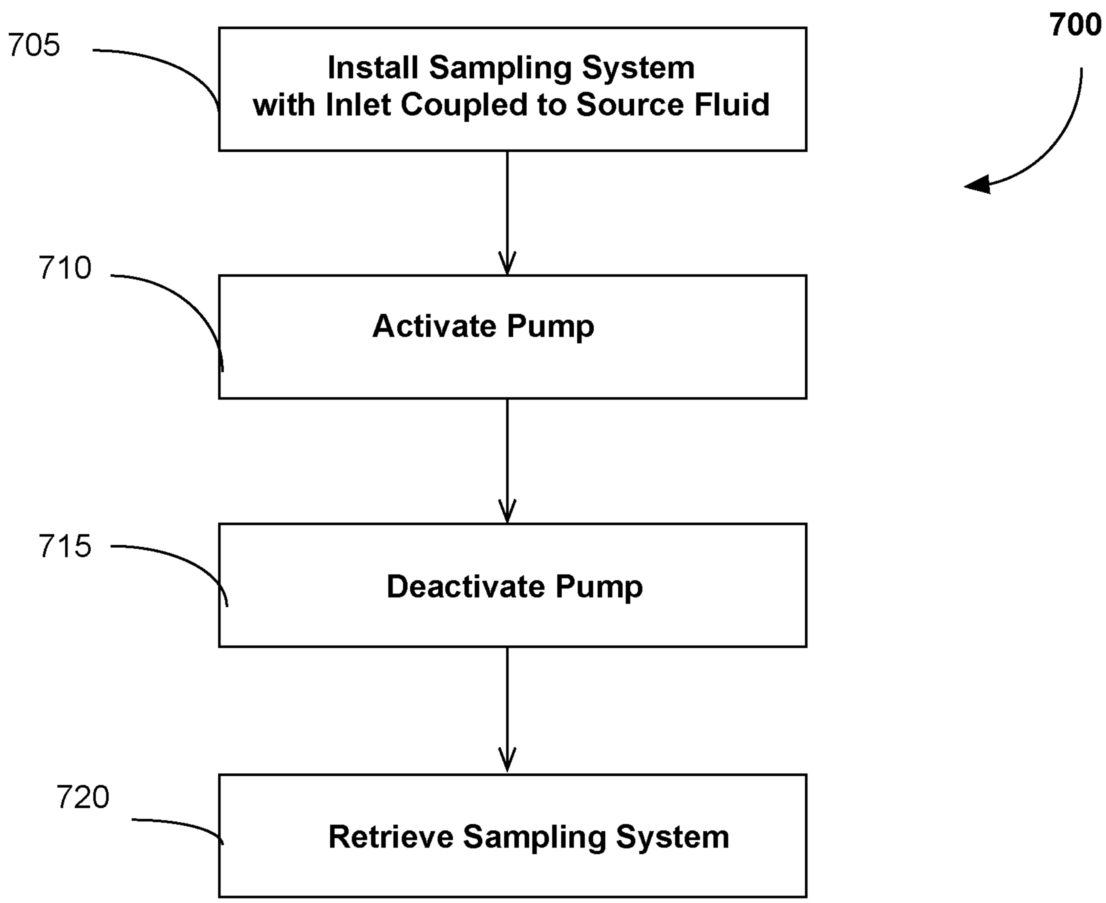

700
705
Install Sampling System
with Inlet Coupled to Source Fluid
710
Activate Pump
715
Deactivate Pump
720
Retrieve Sampling System

FIG. 7A

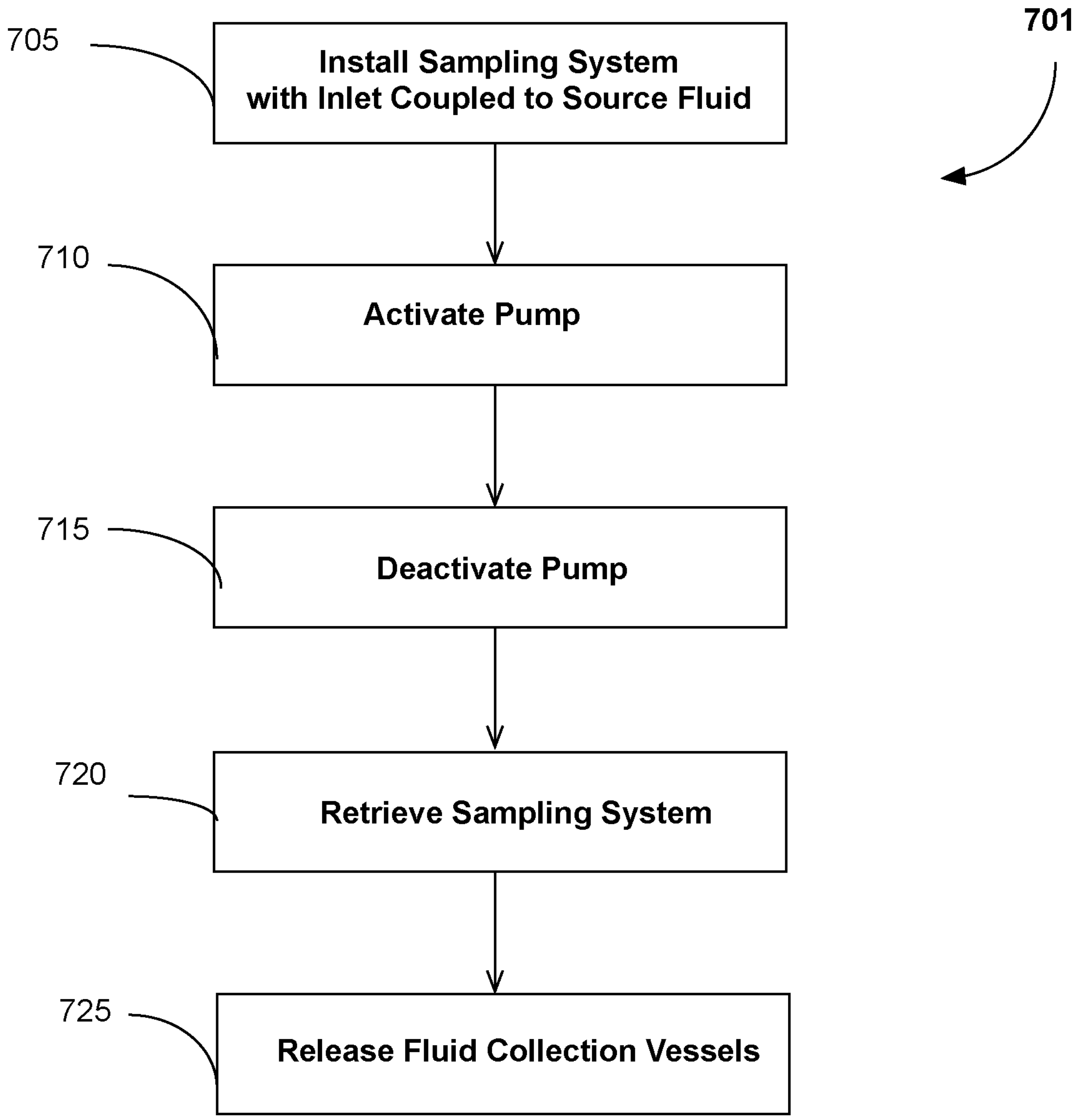

701
705
Install Sampling System with Inlet Coupled to Source Fluid
710
Activate Pump
715
Deactivate Pump
720
Retrieve Sampling System
725
Release Fluid Collection Vessels

FIG. 7B

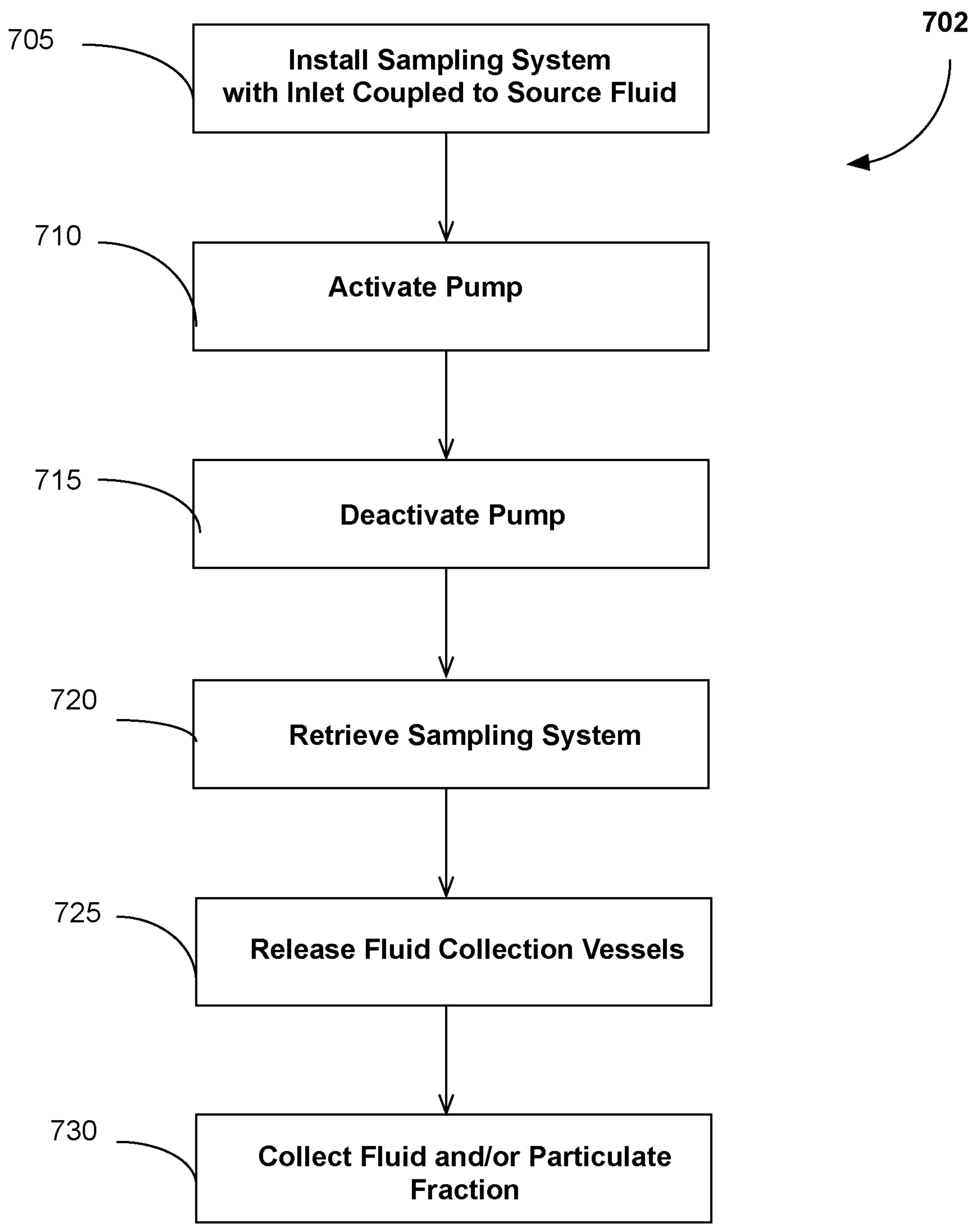

702
705
Install Sampling System with Inlet Coupled to Source Fluid
710
Activate Pump
715
Deactivate Pump
720
Retrieve Sampling System
725
Release Fluid Collection Vessels
730
Collect Fluid and/or Particulate Fraction

FIG. 7C

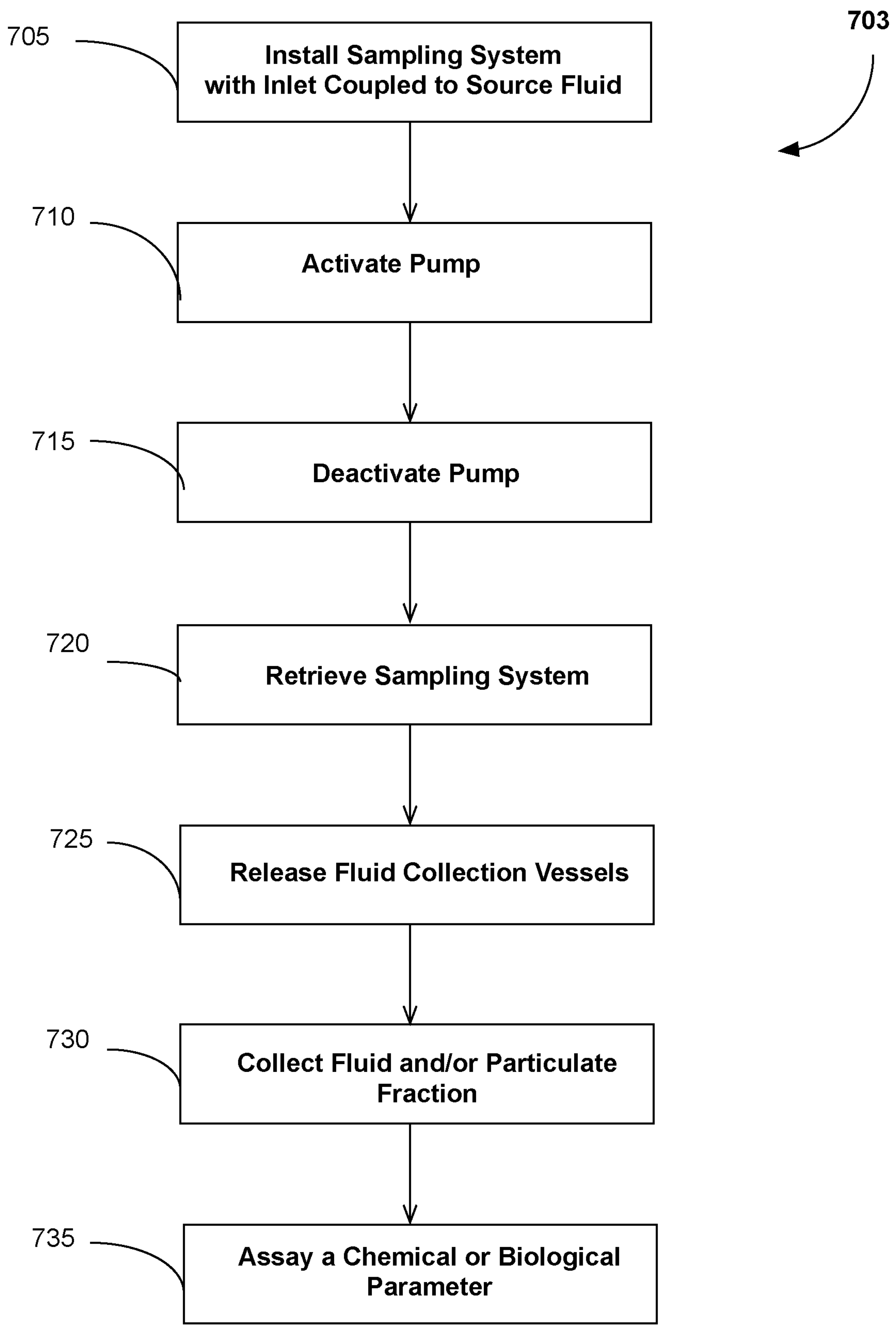

703
705
Install Sampling System with Inlet Coupled to Source Fluid
710
Activate Pump
715
Deactivate Pump
720
Retrieve Sampling System
725
Release Fluid Collection Vessels
730
Collect Fluid and/or Particulate Fraction
735
Assay a Chemical or Biological Parameter

FIG. 7D

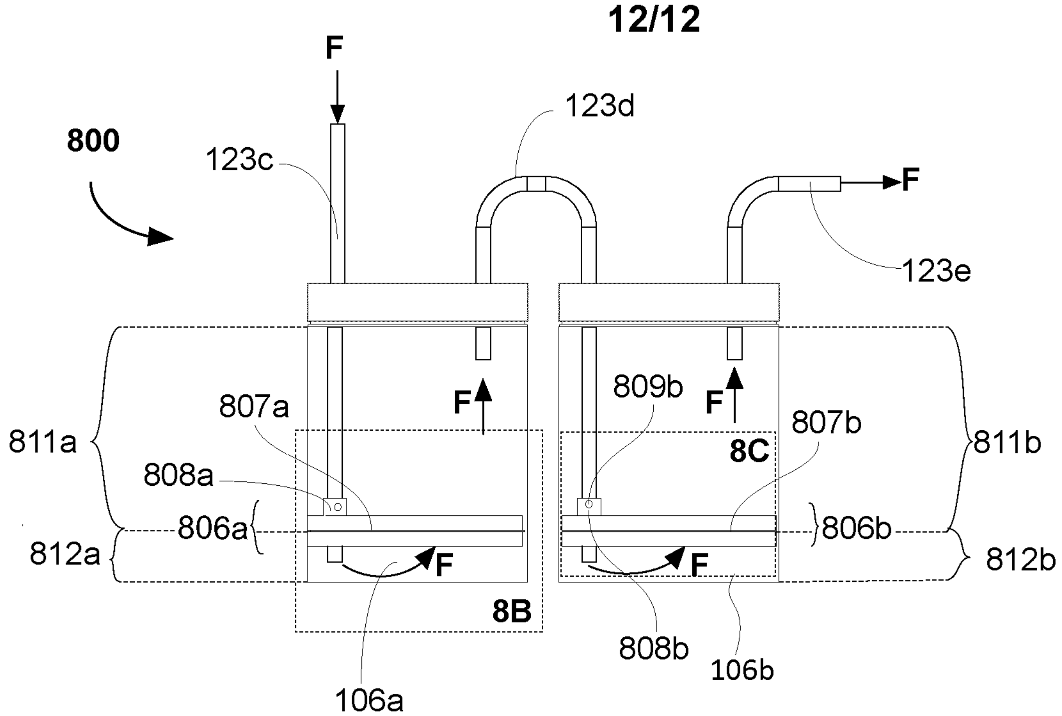


FIG. 8A

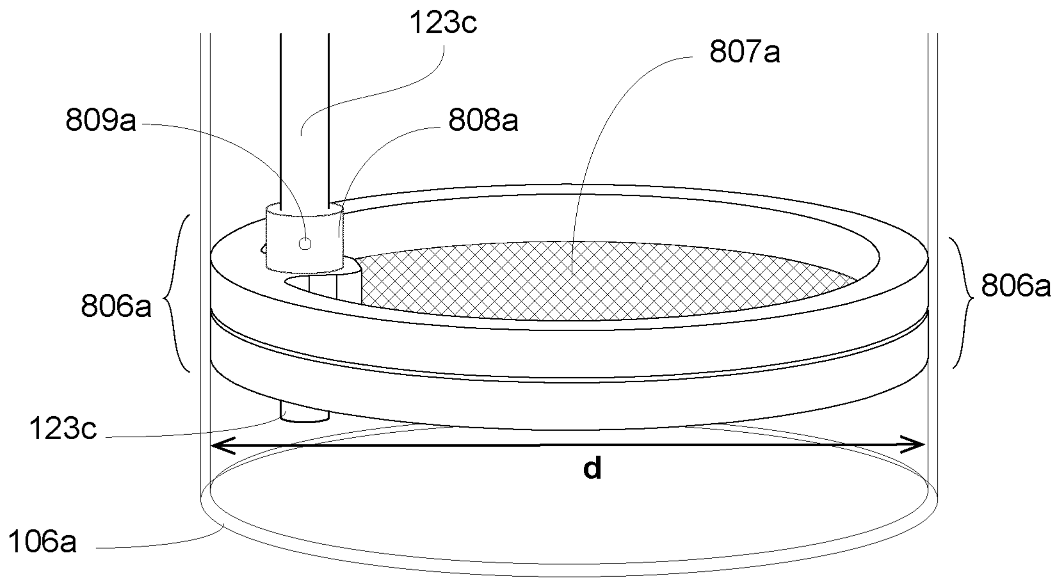


FIG. 8B

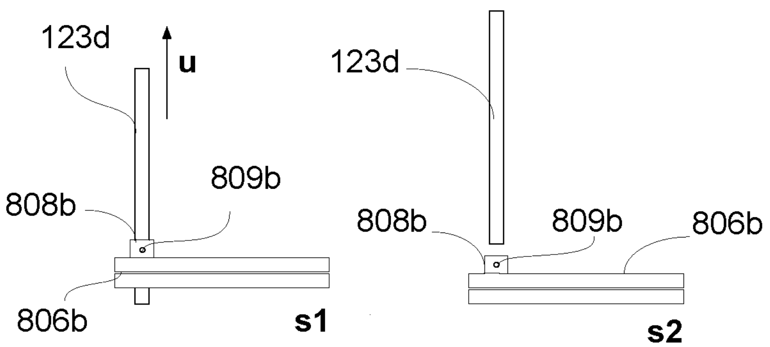


FIG. 8C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2021/051634

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***G01N 1/14*** (2006.01) , ***G01N 1/34*** (2006.01)

CPC: , G01N 1/14 (2020.01) , G01N 1/34 (2020.01) , G01N 2001/4083 (2020.01)

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)
IPC: G01N-001/14, G01N-001/34
CPC: G01N-001/14, G01N-001/34, G01N-2001/4083

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Scopus, Questel Orbit / FAMPAT: particulate, suspension, settle, precipitate, sediment, removable container/tank/vessel, peristaltic/roller pump, slurry, wastewater, sewer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 720,161 A (DOWD, A. et al) 15 December 1954 (15-12-1954) *whole document*	1-38
A	US 2012/0309644 A1 (LOMAS, L. O. et al) 6 December 2012 (06-12-2012) *Abstract, Figs. 9A-9I*	1-38

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D"	document cited by the applicant in the international application	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
01 December 2021 (02-12-2021)	14 February 2022 (14-02-2022)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	David Dalrymple Ph: 1-873-354-5237

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
GB720161A	15 December 1954 (15-12-1954)	None	
US2012309644A1	06 December 2012 (06-12-2012)	US8491791B2	23 July 2013 (23-07-2013)
		AT534444T	15 December 2011 (15-12-2011)
		CA2616976A1	15 February 2007 (15-02-2007)
		CA2616976C	28 August 2012 (28-08-2012)
		EP1888213A2	20 February 2008 (20-02-2008)
		EP1888213A4	05 October 2011 (05-10-2011)
		EP1888213B1	18 October 2017 (18-10-2017)
		EP1907089A2	09 April 2008 (09-04-2008)
		EP1907089A4	09 December 2009 (09-12-2009)
		EP1907089B1	23 November 2011 (23-11-2011)
		JP2009503498A	29 January 2009 (29-01-2009)
		JP4976391B2	18 July 2012 (18-07-2012)
		JP2008542712A	27 November 2008 (27-11-2008)
		JP5123847B2	23 January 2013 (23-01-2013)
		US2009179146A1	16 July 2009 (16-07-2009)
		US8246832B2	21 August 2012 (21-08-2012)
		US2007039891A1	22 February 2007 (22-02-2007)
		WO2006127056A2	30 November 2006 (30-11-2006)
		WO2006127056A3	18 January 2007 (18-01-2007)
		WO2007018589A2	15 February 2007 (15-02-2007)
		WO2007018589A3	15 November 2007 (15-11-2007)