Title: DISTRIBUTION SYSTEM MONITORING

Abstract: A method of sensing parameters in a fluid distribution system includes the steps of receiving, at a monitoring device, fluid parameter information from a sensor in a fluid distribution system; collecting, by the monitoring device, sampling data of the fluid parameter information from the sensor based on predetermined criteria; receiving, by the monitoring device, a request to collect transient data from the sensor; and communicating the sampling data and the transient data to another device. An apparatus includes a monitoring device including a power source, an antenna, and a parameter sensing portion configured to monitor a parameter of a fluid distribution system; and a sensor array connected to the monitoring device.
DISTRIBUTION SYSTEM MONITORING

BACKGROUND

A utility provider may install and maintain infrastructure to provide utility services to its customers. For example, a water utility provider may implement a fluid distribution system to distribute water to its customers. The fluid distribution system may be maintained, such as to maintain the integrity of the fluid distribution system and the quality of the fluid (e.g., water) within the fluid distribution system.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and components of the following figures are illustrated to emphasize the general principles of the present disclosure. Corresponding features and components throughout the figures may be designated by matching reference characters for the sake of consistency and clarity.

FIG. 1 illustrates a diagram of an environment to monitor a fluid distribution system according to examples of the present disclosure.

FIG. 2 illustrates a block diagram of a monitoring device to monitor a fluid distribution system, such as fluid distribution system of FIG. 1, according to examples of the present disclosure.

FIG. 3 illustrates a computer-readable storage medium storing instructions to monitor a fluid distribution system according to examples of the present disclosure.

FIG. 4 illustrates an assembled view of a monitoring assembly according to examples of the present disclosure.

FIG. 5 illustrates another assembled view of a monitoring assembly according to examples of the present disclosure.

FIG. 6 illustrates a disassembled view of a monitoring assembly according to examples of the present disclosure.

FIG. 7 illustrates a circuit board of a parameter sensing portion having one sensor port according to examples of the present disclosure.

FIG. 8 illustrates another circuit board of a parameter sensing portion having five sensing ports according to examples of the present disclosure.

FIGS. 9-15C represent screenshots 900-1500C of a system for configuring and managing a monitoring device according to examples of the present disclosure.

FIG. 16 illustrates another assembled view of a monitoring assembly according to examples of the present disclosure.

FIG. 17 illustrates a partial cross-sectional side view of a monitoring assembly, according to examples of the present disclosure.
[0014] FIG. 18 illustrates a cutaway side view of a monitoring assembly, according to examples of the present disclosure.

[0015] FIG. 19 is a flow diagram illustrating a method for processing acoustic signals, according to examples of the present disclosure.

[0016] FIG. 20 is a block diagram of a parameter sensing system, according to examples of the present disclosure.

[0017] FIG. 21 is a block diagram illustrating a computer architecture for computing devices described herein as part of the parameter sensing system, according to examples of the present disclosure.

**DETAILED DESCRIPTION**

[0018] A utility provider may utilize a fluid distribution system to distribute fluids such as water or gas to its customers. To provide the fluid to its customers effectively, the utility provider may monitor the efficiency and integrity of the fluid distribution system. For example, the utility provider may monitor pressure, temperature, turbidity, pH, and chlorine, among other parameters, within the fluid distribution system.

[0019] Various implementations are described herein by referring to several examples of monitoring a fluid distribution system. The fluid monitoring system may monitor multiple aspects of the performance of a fluid distribution system and the quality of the fluid within the fluid distribution system, including at least pressure, pH, turbidity, temperature, chlorine, etc. It should be understood that, although the present disclosure discusses a multi-parameter fluid monitoring system, the fluid monitoring system may utilize a single parameter as well as multiple parameters.

[0020] In one exemplary aspect, a method of sensing parameters in a fluid distribution system can comprise receiving, at a monitoring device, fluid parameter information from a sensor in a fluid distribution system, collecting, by the monitoring device, sampling data of the fluid parameter information from the sensor based on predetermined criteria, receiving, by the monitoring device, a request to collect transient data from the sensor, collecting, by the monitoring device, transient data of the fluid parameter information from the sensor based on predetermined criteria, and communicating the sampling data and the transient data to another device.

[0021] In a further exemplary aspect, the sensor can be a first sensor, and the method can further comprise the steps of detecting, by the monitoring device, a second sensor in the fluid distribution system, automatically enabling, by the monitoring device, the second sensor, and updating, by the monitoring device, a configuration status of the second sensor. In a further exemplary aspect, the method can further comprise the steps of receiving, at the monitoring device, fluid parameter information from the
second sensor, and collecting, by the monitoring device, sampling data of the fluid parameter information from the second sensor based on predetermined criteria.

[0022] In a further exemplary aspect, the monitoring device can comprise a power source, an antenna, and a parameter sensing portion configured to monitor a parameter of the fluid distribution system. In a further exemplary aspect, the fluid parameter information can be based on at least one of a pressure parameter, a temperature parameter, a turbidity parameter, a pH parameter, and a chlorine parameter. In a further exemplary aspect, the sensor can comprise one of a pressure sensor, a temperature sensor, a turbidity sensor, a pH sensor, and a chlorine sensor. In a further exemplary aspect, the collected transient data can be based on configurable parameters which can comprise a transient interval and a tolerance.

[0023] In another exemplary aspect, an apparatus can comprise a monitoring device and a sensor array connected to the monitoring device. The monitoring device can comprise a power source, an antenna, and a parameter sensing portion configured to monitor a parameter of a fluid distribution system. In a further exemplary aspect, the parameter can be selected from the group consisting of a pressure parameter, a temperature parameter, a turbidity parameter, a pH parameter, and a chlorine parameter. In a further exemplary aspect, the apparatus can further comprise an auxiliary power input operably connected to the power source. In a further exemplary aspect, the auxiliary power input can comprise a waterproof connector attached to a top of the monitoring device.

[0024] In a further exemplary aspect, the parameter of the fluid distribution system can be a first parameter, and the parameter sensing portion can be further configured to monitor a second parameter of a fluid distribution system, a third parameter of a fluid distribution system, a fourth parameter of a fluid distribution system, and a fifth parameter of a fluid distribution system. In a further exemplary aspect, the apparatus can further comprise a solenoid. In a further exemplary aspect, the parameter sensing portion can be further configured to operate the solenoid to cause a flushing operation to be performed in the fluid distribution system.

[0025] In another exemplary aspect, a monitoring device can comprise a power source, an antenna, and a parameter sensing portion configured to monitor a pressure parameter, a temperature parameter, a turbidity parameter, a pH parameter, and a chlorine parameter of a fluid distribution system. The monitoring device can be configured to connect to a sensor array. The sensor array can comprise a pressure sensor, a temperature sensor, a turbidity sensor, a pH sensor, and a chlorine sensor.

[0026] In another exemplary aspect, a system for sensing parameters in a fluid distribution system can comprise a monitoring device, a sensor array connected to the
monitoring device, and a computing system. The monitoring device can comprise a parameter sensing module configured to monitor a parameter of the fluid distribution system, a power source, and an antenna. The computing system can comprise a processing resource and a computer-readable storage medium. The computing system can be configured to receive configuration data defining a configuration profile for the monitoring device. The configuration profile can be relating to a parameter configuration of the monitoring device. The computing system can be further configured to communicate the configuration data to the monitoring device.

[0027] In a further exemplary aspect, the system can further comprise a solenoid. In a further exemplary aspect, the parameter sensing module can be further configured to operate the solenoid to cause a flushing operation to be performed in the fluid distribution system.

[0028] In another exemplary aspect, a method of sensing parameters in a fluid distribution system can comprise receiving, at a monitoring device, sampling data of a fluid parameter from a sensor in a fluid distribution system, and communicating the sampling data to another device. In another exemplary aspect, a system for sensing parameters in a fluid distribution system can comprise a monitoring device, a sensor array connected to the monitoring device, and a computing system.

[0029] Other examples are described in the present disclosure. It should be understood that the features of the disclosed examples may be combined in various combinations. It should also be understood that certain features may be omitted while other features may be added.

[0030] The present disclosure enables monitoring a fluid distribution system. For example, a fluid distribution system may be monitored based on parameters such as pressure, temperature, turbidity, pH, and/or chlorine, among others. In examples, multiple parameters may be monitored by the same monitoring device, although a monitoring device may also monitor a single parameter in examples. These and other advantages will be apparent from the description that follows.

[0031] FIGS. 1-3 comprise particular components, modules, instructions, engines, etc. according to various examples as described herein. In different implementations, more, fewer, and/or other components, modules, instructions, engines, arrangements of components/modules/instructions/engines, etc. may be used according to the teachings described herein. In addition, various components, modules, engines, etc. described herein may be implemented as instructions stored on a computer-readable storage medium, hardware modules, special-purpose hardware (e.g., application specific hardware, application specific integrated circuits (ASICs), embedded controllers, hardwired circuitry, etc.), or some combination or combinations of these.
Generally, FIGS. 1-3 relate to components, modules, and instructions of a computing system. It should be understood that the computing system may comprise any appropriate type of computing system and/or computing device, including for example smartphones, tablets, desktops, laptops, workstations, servers, smart monitors, smart televisions, digital signage, scientific instruments, retail point of sale devices, video walls, imaging devices, peripherals, networking equipment, wearable computing devices, or the like.

Fig. 1 illustrates a diagram of an environment 100 to monitor a fluid distribution system 110 according to examples of the present disclosure. In examples, monitoring device 130 monitors a parameter or parameters of a fluid distribution system 110. For example, the monitoring device 130 may monitor pressure, temperature, turbidity, pH, and/or chlorine within the fluid distribution system 110.

As illustrated, the environment 100 comprises a fluid distribution system 110, which may further comprise a pipe 110A. Although illustrated as the pipe 110A, it should be understood that the fluid distribution system 110 may be a plurality of pipes and other fluid distribution system components connected together to form the fluid distribution system 110, of which the pipe 110A is a portion.

Generally, fluid distribution system 110 may be used to distribute fluids such as water to customers of a utility provider, for example. The fluid distribution system 110 may comprise various and numerous components, such as pipes (e.g., pipe 110A), hydrants, valves, couplers, corporation stops, and the like, as well as suitable combinations thereof. In examples, the fluid distribution system 110 may be partially or wholly subterraneous, or portions of the fluid distribution system 110 may be subterraneous, while other portions of the fluid distribution system 110 may be non-subterraneous (i.e., above ground). For example, a pipe such as pipe 110A may be partially or wholly subterraneous while a hydrant or valve (not shown) connected to the pipe 110A may be partially or wholly non-subterraneous. In other examples, the pipe 110A may be partially subterraneous in that the pipe 110A has portions exposed, such as to connect testing and/or monitoring devices (e.g., monitoring device 130) to the pipe 110A.

The monitoring device 130 may utilize one or more sensors to monitor the fluid distribution system 110. For example, the monitoring device 130 may utilize a pressure sensor, a temperature sensor, a turbidity sensor, a pH sensor, and/or a chlorine sensor. These sensors may be connected to a port or ports on the monitoring device. For example, as described herein, the monitoring device may comprise a port for each of the sensors.
[0037] The monitoring device may also comprise an antenna configured to enable the monitoring device to communicate with a computing system such as computing system 120. The computing system 120 may represent any of a variety of computing systems, such as a computing host of a utility provider, a collector node to collect data from the monitoring device 130, another monitoring device, or any other suitable computing system.

[0038] The monitoring device 130 may transmit the first and second acoustical signals respectively to the computing system 120 via a wired or wireless network or other communicative path illustrated in FIG. 1 as a dotted line. In examples, such as shown in FIG. 1, the monitoring device 130 and the computing system 120 may be communicatively coupleable to one another. In examples, the monitoring device 130 may comprise transceivers, which may communicate data between the monitoring device 130 and the computing system 120, which may comprise an interface (not shown) for transmitting and receiving the data. The transceivers may be any suitable device for sending, receiving, or sending and receiving data, such as a receiver, a transmitter, a transmitter-receiver, and/or a transceiver. It should be appreciated that any suitable communication technique may be implemented to transmit the data between the monitoring device 130 and the computing system 120. In examples, cellular technologies such as global system for mobile communications (GSM), general packet radio service (GPRS), code division multiple access (CDMA), short message service (SMS), or other suitable protocol may be utilized. Other techniques may also be utilized, including radio frequency, infrared, Bluetooth®, automated meter reading (AMR), automated meter infrastructure (AMI), or other wireless and/or wired communications techniques.

[0039] The dotted line of FIG. 1 illustrate communicative paths between and among the monitoring device 130 and the computing system 120. The path generally represents a network that may comprise hardware components and computers interconnected by communications channels that allow sharing of resources and information. The network may comprise one or more of a cable, wireless, fiber optic, or remote connection via a telecommunication link, an infrared link, a radio frequency link, or any other connectors or systems that provide electronic communication. The network may comprise, at least in part, an intranet, the internet, or a combination of both. The network may also comprise intermediate proxies, routers, switches, load balancers, and the like. The paths followed by the network between the devices as depicted in FIG. 1 represent the logical communication paths between the monitoring device 130 and the computing system 120, not necessarily the physical paths between and among the devices.
In examples, the monitoring device 130 may be of a three-piece construction. For example, the monitoring device 130 may comprise an antenna section, a power source section, and an electronics section.

In other examples, the monitoring device 130 may be of a four-piece construction. For example, the monitoring device 130 may comprise an antenna section, a first power source section, a second power source section, and an electronics section.

In an example, the monitoring device 130 may be enabled to monitor a fluid level within a fluid tank (not shown). A pressure sensor connected to or a part of the monitoring device 130 may be installed or otherwise inserted into a fluid tank. The monitoring device 130 may then be configured to measure the fluid level within the fluid tank by sensing the fluid level within the fluid tank. The fluid level may be returned as a tank level such as in feet, pounds per square inch (PSI), etc.

In an example, when fluid pressure is measured with a sensor, the measured pressure represents the pressure at the location it was measured measure. In some situations, it is advantageous to know true potential energy of the fluid. True potential energy is the measured pressure plus a known elevation of the fluid at the sensor. The elevation may be input by a customer or technician, may be based on a topology or elevation map, or may be known in some other way.

Although not shown in FIG. 1, it should be appreciated that the computing system 120 may comprise additional components. For example, the computing system 120 may comprise a processing resource 122 that represents generally any suitable type or form of processing unit or units capable of processing data or interpreting and executing instructions. The processing resource 122 may be one or more central processing units (CPUs), microprocessors, digital signal processors, and/or other hardware devices suitable for retrieval and execution of instructions. The instructions may be stored, for example, on a memory resource (not shown), such as computer-readable storage medium 360 of FIG. 3, which may comprise any electronic, magnetic, optical, or other physical storage device that store executable instructions. Thus, the memory resource may be, for example, random access memory (RAM), electrically-erasable programmable read-only memory (EEPROM), a storage drive, an optical disk, and any other suitable type of volatile or non-volatile memory that stores instructions to cause a programmable processor (i.e., processing resource) to perform the techniques described herein. In examples, the memory resource comprises a main memory, such as a RAM in which the instructions may be stored during runtime, and a secondary memory, such as a nonvolatile memory in which a copy of the instructions is stored.
Additionally, the computing system 120 may comprise engines for executing programmatic instructions. In examples, the engines may be a combination of hardware and programming. The programming may be processor executable instructions stored on a tangible memory, and the hardware may comprise processing resource, for example, for executing those instructions. Thus a memory resource (not shown) can be said to store program instructions that when executed by the processing resource implement the engines described herein. Other engines may also be utilized to comprise other features and functionality described in other examples herein.

Alternatively or additionally, the computing system 120 may comprise dedicated hardware, such as one or more integrated circuits, Application Specific Integrated Circuits (ASICs), Application Specific Special Processors (ASSPs), Field Programmable Gate Arrays (FPGAs), or any combination of the foregoing examples of dedicated hardware, for performing the techniques described herein. In some implementations, multiple processing resources (or processing resources utilizing multiple processing cores) may be used, as appropriate, along with multiple memory resources and/or types of memory resources.

Additionally, the computing system 120 may comprise a display. The display may be or comprise a monitor, a touchscreen, a projection device, and/or a touch/sensory display device. The display may display text, images, and other appropriate graphical content. The computing system 120 may also comprise a network interface to communicatively couple the computing system 120 to the monitoring device 130 via the network and to other computing systems and/or computing devices. The computing system 120 may also comprise any suitable input and/or output device, such as a mouse, keyboard, printer, external disk drive, or the like.

FIG. 2 illustrates a block diagram of a monitoring device 230 to monitor a fluid distribution system, such as fluid distribution system 110 of FIG. 1, according to examples of the present disclosure. The computing system monitoring device 230 may comprise a parameter sensing module 232, a first power source 234a, and an antenna 236. A second power source 234b is illustrated and may be comprised in some examples or omitted in other examples.

In examples, the modules described herein may be a combination of hardware and programming instructions. The programming instructions may be processor executable instructions stored on a tangible memory resource such as a computer-readable storage medium or other memory resource, and the hardware may comprise a processing resource for executing those instructions. Thus the memory resource can be said to store program instructions that when executed by the processing resource implement the modules described herein.
Other modules may also be utilized as will be discussed further below in other examples. In different implementations, more, fewer, and/or other components, modules, instructions, and arrangements thereof may be used according to the teachings described herein. In addition, various components, modules, etc. described herein may be implemented as computer-executable instructions, hardware modules, special-purpose hardware (e.g., application specific hardware, application specific integrated circuits (ASICs), and the like), or some combination or combinations of these.

The parameter sensing module 232 monitors conditions of the water distribution system, including a fluid within the water distribution system, using sensors that sense various parameters of the water distribution system's fluid including pressure, temperature, turbidity, pH, and chlorine levels. The parameter sensing module 232 may be a printed circuit board (PCB) or other electrical components configured to receive electronic signals, either via wires or wirelessly, from sensors such as pressure sensor 240, temperature sensor 242, turbidity sensor 244, pH sensor 246, and/or chlorine sensor 248. Additionally, the monitoring device 230 may be connected to a solenoid 250. The parameter sensing module 232 may operate the solenoid 250 to cause a flushing operation to be performed in the fluid distribution system. Examples of parameter sensing modules as PCBs are illustrated in FIGs. 7 and 8.

As shown in those figures, the parameter sensing module 232 may comprise a sensor port or ports for connecting a sensor to the parameter sensing module 232. In examples, the sensors may communicate with the parameter sensing module 232 wirelessly, such as using near field communication (NFC), Bluetooth®, radio frequency, infrared, or other suitable wireless techniques.

In examples, the parameter sensing module 232 comprises a processing resource, such as a central processing units (CPUs), microprocessors, digital signal processors, and/or other hardware devices suitable for retrieval and execution of instructions. The parameter sensing module 232 may also comprise suitable memory such as random access memory (RAM), electrically-erasable programmable read-only memory (EPPROM), a storage drive, an optical disk, and any other suitable type of volatile or non-volatile memory that stores instructions to cause a programmable processor (i.e., the processing resource) to perform the techniques described herein. The parameter sensing module 232 may comprise additional electrical components in other examples.

The parameter sensing module 232 is configured to receive data from connected sensors indicative of the parameters sensed by the sensors. The parameter
sensing module 232 may log/store the data and/or transmit the data, in whole or in part, to a host computing system such as computing system 120 of FIG. 1. The parameter sensing module 232 may also transmit event notifications when certain parameter conditions are triggered, such as if a pressure level exceeds a threshold. The trigger events may also cause the parameter sensing module 232 to operate a solenoid (e.g., solenoid 250) to cause a flushing operation to be performed in the fluid distribution system.

Each sensor may have a configurable reading period (e.g., pressure every 15 seconds, chlorine every 2 minutes, etc.). In these cases, the sensors perform the appropriate reading at the defined time, which may be preconfigured and/or user customizable. In examples, a threshold can be set, such as for pressure, and if threshold for pressure is exceeded, a flushing operation may occur. Likewise, flushing may occur when any of the parameters is sensed as exceeding a high threshold, not meeting a low threshold, falling outside of a threshold range, and/or falling within a threshold range, depending on the desired settings.

In examples, the parameter sensing module 232 may be encased in a potting material such as epoxy or other suitable material to protect the parameter sensing module 232 from adverse elements, such as water, ice, dirt, dust, and the like.

The first power source 234a may be any suitable power source that supplies electric energy to the monitoring device 230 and/or its individual component modules, directly or indirectly. In examples, the first power source 234a may be suitable battery, such as a lithium polymer battery.

In examples, a second power source 234b may be implement. In some examples, the second power source 234b acts as a backup battery for the first power source 234a. In additional examples, the second power source 234b provides additional power to increase the overall usable life of the monitoring device 230 and/or to power additional devices connected to the monitoring device 230, such as a solenoid valve to alter the flow of a fluid through the fluid distribution system.

In examples, the first power source 234a and/or the second power source 234b may be changed, such as by a field technician or through a refurbishing process by the manufacturer of the monitoring device 230. The first power source 234a and/or the second power source 234b may be encased in a potting material such as epoxy or other suitable material to protect the first power source 234a and/or the second power source 234b from adverse elements, such as water, ice, dirt, dust, and the like.

In examples including the second power source 234b, voltage may be decreased for certain components such as the parameter sensing module 232 or while increased for higher voltage components such as an attached solenoid 250. In an
example, both power sources 234a and 234b may be 3.6 volts arranged in series to operate at 7.2 volts for a solenoid while the voltage is bucked down to 3.6v to operate the parameter sensing module 232, the antenna 236, etc. In examples, solar and/or fluid generating power options are available.

[0061] The antenna 236 enables the monitoring device 230 to communicate with other devices, such as computing system 120 of FIG. 1, or any other suitable device, such as another monitoring device (not shown). The communications may be one directional (the monitoring device 230 sends information but does not receive information or the monitoring device 230 receives information but does not send information) or bi-directional (the monitoring device 230 sends and receives information).

[0062] In examples, antenna 236 is contained within an assembly that causes the antenna 236 to be aligned the same direction with respect to the rest of the monitoring device 230 when the antenna is installed. This enables more predictable communication and behavior from the antenna 236. In examples, a global positioning system (GPS) antenna (not shown) may be integrated with or otherwise comprised in antenna 236. The GPS antenna may also be configured to align the same direction when the GPS antenna is installed. The antenna 236, optionally including the GPS antenna, may be encased in a potting material such as epoxy or other suitable material to protect antenna 236 from adverse elements, such as water, ice, dirt, dust, and the like.

[0063] In some examples, during the manufacture of the antenna, a hot melt technique may be implemented. In this example, hot glue is applied by potting the hot glue to hold the antenna in place, then potting over the glue and antenna. This provides a more efficient assembly process.

[0064] In examples, the sensor may be connected to the monitoring device 230 through a jumper. When the sensor is connected to the jumper, the power circuit is "closed" thereby causing the monitoring device 230 to power on. In this way, the jumper acts as a mechanical switch and "enables by connection" the monitoring device 230. When a sensor is connected, an initialization process begins and may comprise preforming the following: 1) boots up the monitoring device 230; 2) establishes a communicative connection to a nearby receiver through the antenna 236; 3) synchronizes with GPS, 4) transmits a GPS location to a host (e.g., the computing system 120 of FIG. 1). In this way, the monitoring device 230 is a self-identifying GPS locating device. While this process may be performed automatically, it may also be performed manually.
FIG. 3 illustrates a computer-readable storage medium 360 storing instructions 362 and 364 to monitor a fluid distribution system according to examples of the present disclosure. The computer-readable storage medium 360 is non-transitory in the sense that it does not encompass a transitory signal but instead is made up of one or more memory components configured to store the instructions 362 and 364. The computer-readable storage medium 360 may be representative of a memory resource and may store machine executable instructions 362 and 364, which are executable on a computing system such as computing system 120 of FIG. 1 as well as the computing system 320 of FIG. 3 in conjunction with processing resource 322.

In the example shown in FIG. 3, the instructions 362 and 364 may comprise configuration data receiving instructions 362 and communication instructions 364. The configuration data receiving instructions 362 enabling receiving configuration data defining a configuration profile for a monitoring device (e.g., monitoring device 130 of FIG. 1 and monitoring device 230 of FIG. 2), the configuration profile relating to a parameter configuration of the monitoring device. The communication instructions 364 enable communication of the configuration data to the monitoring device.

FIG. 4 illustrates an assembled view of a monitoring assembly 400 according to examples of the present disclosure. The monitoring device 430 may comprise a parameter sensing portion 432, a power supply portion 434, and an antenna portion 436. The monitoring device 430 may be constructed as an industrial product such that it can be installed in any environment. The monitoring device 430 may be contained in a case made of durable plastic, metal, or other suitable substance. For example, the case may be manufactured, in whole or in part, from a suitable plastic, such as acrylonitrile butadiene styrene (ABS) plastic or 30% glass filled high density polyethylene (HDPE) with carbon black to block ultra-violet (UV).

The case may be in multiple parts such that the individual components are contained in separate sections. This modular design enables easy assembly and serviceability. The case may comprise weep holes in the outer surface of the case to prevent freezing water from cracking/rupturing the case. In examples, the case may be keyed for easy assembly, and one size screw may be used for uniformity.

The case may also be manufactured to comprise a relief and bolt hole on a top portion. The relief and bolt hole provide the ability to use a crowbar or other suitable device to lift the monitoring device 430 from a flush mount installation. The relief and bolt hole also provide the ability to fasten the monitoring device 430 in place, such as with a bolt, to prevent the monitoring device 430 from moving.

In examples, the monitoring device 430 may be installed in a pit in a roadway, such that a surface of the monitoring device 430 sits flush with the surface of
the roadway. This enables automobiles to pass the roadway without receiving interference from the monitoring device 430. The construction of the monitoring device 430 may enable the monitoring device 430 to withstand the pressure and force caused by automobiles, trucks, and other items from passing on top of the monitoring device 430 such that the monitoring device 430 remains unaffected. Additionally, the potting material such as epoxy or other suitable material encasing the individual components of the monitoring device 430 protects the individual components from adverse elements, such as water, ice, dirt, dust, and the like.

[0071] FIG. 5 illustrates another assembled view of a monitoring assembly 500, including monitoring device 530 according to examples of the present disclosure. The parameter sensing portion 532 is shown as having a sensor port 538 for connecting a sensor and a service port 539 for connecting a service device, such as for maintenance. In the example illustrated in FIG. 5, the sensor port 538 is recessed such that a connecting cable for a sensor may be attached without interfering with the flat nature of the design of the parameter sensing portion 532. In examples with the parameter sensing portion 532 making up the bottom of the monitoring device 530, this recession enables the monitoring device to be set on a flat surface without the sensor cable interfering. In examples, the service port 539 may be omitted and the monitoring device 530 may be serviced remotely via the communication techniques discussed herein.

[0072] FIG. 6 illustrates a disassembled view of a monitoring assembly 600 according to examples of the present disclosure. The monitoring device 630 comprises a parameter sensing portion 632, a power supply portion 634, and an antenna portion 636.

[0073] Although FIG. 5 illustrates a monitoring device 530 with one sensor port 538, additional sensor ports may be implemented. FIG. 7 illustrates a circuit board 700 of a parameter sensing portion (e.g., sensing portion 632) having one sensor port 738 according to examples of the present disclosure. FIG. 8 illustrates another circuit board 800 of a parameter sensing portion having five sensing ports 838a-e according to examples of the present disclosure. It should be understood that various other numbers of sensor ports may be implemented in various examples.

[0074] FIGs. 9-1 5C represent screenshots 900-1 500C of a system for configuring and managing a monitoring device, such as monitoring device 130 of FIG. 1, monitoring device 230 of FIG. 2, and other monitoring devices as disclosed herein according to examples of the present disclosure. The system for configuring and managing the monitoring device (or monitoring devices) may be configured to execute on a computing system such as computing system 120 of FIG. 1 and/or computing system
320 of FIG. 3. The screenshots 900-1500C may be generated by the computing system when the computing system executes computer executable instructions configured to generate the screenshots.

[0075] FIGs. 9 and 10 illustrate screenshots 900 and 1000 respectively of a map of multiple monitoring devices over a geographic area. The monitoring devices are illustrated by dots. A dot represents a multi-parameter monitoring device and a dot with P represents a pressure monitor (single parameter monitoring device). In examples, an indicia may be used to indicate the status of the monitoring devices. As illustrated, red, yellow, and green dots represent as follow: red = if any one parameter is critical; yellow = if any one parameter is warning (such as low or high); green = no parameters are warning or critical. FIG. 10 illustrates a screenshot 1000 showing additional details for each of the monitoring devices including the current readings for each sensor for each monitoring device.

[0076] FIG. 11 illustrates a screenshot 1100 of a table of the monitoring devices of FIGs. 9 and 10. The table comprises the sensor reads for each sensor connected to each of the monitoring devices. In the example of FIG. 11, device 0 through device 6 represent single parameter (pressure) monitoring devices, while V2 device represents a multi-parameter monitoring device measuring turbidity, temperature, pressure, pH, and chlorine values.

[0077] FIGs. 12A and 12B illustrate screenshots 1200A and 1200B of a configuration screen for a single parameter monitoring device. A map illustrates the geographic position of the monitoring device.

[0078] Additionally, various configuration options are available, including description, mode, status, auto GPS, latitude/longitude, elevation, uploads per day, and unit ID. The auto GPS enables a GPS in the monitoring device to automatically determine the longitude, latitude, and/or elevation of the pressure monitor. In examples, these values may be manually entered, as may the rest of the configuration options. To edit the monitoring device settings, click on edit, change the values accordingly, then click on Save. A brief description of the Settings fields are given below:

[0079] Description: Each monitoring device can be given a description name. The description can be used as a way to identify monitoring device without having to reference the monitoring device ID. Street addresses could be used as an example.

[0080] Mode: Selecting "Request Maintenance Mode" will set the monitoring device into maintenance mode after the next upload occurs by the monitoring device unit. This may take up to 24 hours. Once in maintenance mode, any configuration changes made to the unit will take affect within minutes in some examples.
Status: This field reports the current pressure range that the monitoring device is in (i.e., Normal, Warning, or Critical).

Latitude and Longitude: These fields are automatically filled when the monitoring device is initially installed if the monitoring device receives a strong GPS satellite signal.

Elevation: This field is entered in manually in some examples or may be entered automatically in others.

Uploads Per Day: This field indicates how many uploads should be performed by the monitoring device daily. For example, 12 would result in the monitoring device uploading every 2 hours, 6 would produce an upload every 4 hours, and so on. Note: The recommended Uploads Per Day interval is 1 (i.e. one upload per day).

Monitoring Device ID: This is the unique identifier for the monitoring device. In some examples, this field cannot be changed.

FIGs. 13A-13D illustrate screenshots 1300A-1300D of a configuration screen for a single parameter monitoring device. Like the configuration screen for the single parameter monitoring device, multiple configuration options are available. As also illustrated, thresholds may be set for critical high, high, low, and critical low values for pressure, temperature, pH, turbidity, and chlorine. The Pressure Sensor range allows users to be notified when pressure is entering or exiting a certain pressure range. Three ranges are used: Normal, Warning, and Critical (with high and low bounds for Warning and Critical). In examples, when two consecutive measurements are taken for any range, the pressure sensor automatically uploads the data and users registered to receive alerts are notified.

Additionally, a flush schedule indicates when a solenoid connected to the monitoring device may be activated to cause the fluid distribution system to perform a flushing operation. In the present example, flushing may occur when any of the following occur: if pressure is higher than 4 PSI; if temperature is higher than 4°F; if temperature is lower than 3°F; if chlorine is lower than 3ppm; if acidity is higher than 3 pH; or if turbidity is higher than 5 nephelometric turbidity units (NTU).

FIGs. 14A-14C illustrate screenshots 1400A-1400C of a calendar of events and event setup options. The events may capture transient data readings of pressure, temperature, chlorine, acidity (pH), and turbidity for example, or may cause events to occur such as flushing of the fluid distribution system, connection of the monitoring device, and maintenance of the monitoring device. The capturing and processing of transient data is discussed further below, and as shown in FIG. 19.
FIGs. 15A-15C illustrate screenshots 1500A-1500C of graphs plotting the monitored parameters. In the case of FIG. 15A, device 0 through device 6 and V2 device are illustrated on the same graph over a one day period. FIG. 15B illustrates a graph of the same devices over a five day period. The graphs may be viewed over different periods, such as one day, two days, five days, week, two weeks, month, six months, year, and all time. FIG. 15C illustrates a graph of chlorine for V2 device, for example, over a one day period. Any parameter may be displayed individually, and devices may be viewed individually or multiple devices may be displayed together. These graphs are merely examples.

The graphs may contain the collected data gathered by the monitoring devices belonging to a client's organization. Data can be viewed within a specified time frame, both, graphically and by downloading the data as a comma-separated values (CSV) or Microsoft Excel® open extensible markup language (XML) format spreadsheet (XLSX) file to be viewed in any spreadsheet program. The collected measurements are represented on the graph with the y axis being psi (or ppm for chlorine levels) and the x axis being the time that the measurement was taken. Each monitoring device belonging to the client's organization is represented by a different colored line, for example. The Legend button (located in the upper right section of the graph in FIG. 15A for example) displays the monitoring device to color-coding mapping currently being used. Clicking on Legend allows the user to select and de-select monitoring device to be displayed. Clicking on any of the lines within the graph may navigate to a page to view data collected by the individual monitoring device selected. In examples, Users can zoom in and out of the graph.

FIG. 16 is diagram of a monitoring assembly 1600, according to various examples of the present disclosure. As seen in FIG. 16, a monitoring device 1630 can be mounted within an enclosure 1620. Enclosure 1620 is provided to house equipment, such as monitoring device 1630, that may provide protection from vandalism or the environment. Enclosure 1620 is designed for extended life and performance of the monitoring device 1630. In some examples, enclosure 1620 may be UV and impact resistant polyethylene and provide lockable solutions for a wide range of utility applications. In some examples, enclosure 1620 may be a metal housing made of high-strength aluminum.

FIG. 17 is partially cutaway side view of a monitoring assembly 1700, according to various examples of the present disclosure. As seen in FIG. 17, the monitoring assembly 1700 comprises a monitoring device 1730 and a valve box 1710. To communicate data and receive orders, the monitoring device 1730 comprises an antenna portion 1736, such as antenna portion 436 and antenna
portion 636, as discussed herein for FIGs. 4 and 6, respectively. The antenna portion 1736 is mounted to an adjustable top 1712. The adjustable top 1712 connects to the valve box 1710, forming an enclosure extending from a ground surface to the top of a pipe to protect the enclosed monitoring equipment. The adjustable top 1712 can be adjusted telescopically to vary the overall height of the monitoring assembly 1700, based on the depth of the pipe below ground level. Other sensors may be used with monitoring assembly, such as pressure, temperature, turbidity, pH, chlorine, and flow sensors.

[0093] FIG. 18 is a cutaway side view of a monitoring assembly 1800, according to various examples of the present disclosure. The monitoring assembly 1800 comprises an antenna portion 1836. The monitoring assembly 1800 also comprises a battery portion 1834 enclosing a battery pack 1810. Extending from a lower end of the battery portion 1834 is the sensing portion 1832 enclosing a circuit board 1840, such as circuit board 700 and circuit board 800, as discussed herein for FIGs. 7 and 8, respectively. In various examples, the antenna portion 1836 may comprise an auxiliary power input 1860. The auxiliary power input 1860 may be connected to the battery pack 1810 by a wire, so that the battery pack 1810 may be recharged by another power source, such as a portable battery pack. The auxiliary power input 1860 may comprise a waterproof connector to prevent corrosion over the life of the monitoring device 1830 and the auxiliary power input 1860.

[0094] FIG. 19 is a process flow diagram illustrating an embodiment of a method 1900 for capturing and processing transient data. In this embodiment, the method 1900 comprises the step of activating a monitoring device/assembly, as indicated in step 1902. The monitoring device/assembly may comprise the monitoring device 230 shown in FIG. 2, or in some examples, may comprise any of the monitoring devices described herein. In the example embodiment, activation may be accomplished by turning on the monitoring device 230 by a field engineer. In other examples the monitoring device 230 may be in a sleep mode, and step 1902 requires the computing system 320 to activate the monitoring device 230 with a software code.

[0095] The monitoring device 230 hardware is designed to handle and connect to a number of hardware resources based on configurable requirements. At step 1904, the monitoring device 230 continuously checks and determines when a new hardware resource, such as a sensor or a solenoid, is connected. According to some examples, the hardware resources of the monitoring assembly may comprise a pressure sensor, a temperature sensor, a turbidity sensor, a pH sensor, and a chlorine sensor, either all integrated into one sensor, or combined in separate sensors. The sensors may operate continually to provide the sampling and transient data.
[0096] The hardware resource is automatically enabled by the monitoring device 230 at step 1906. The monitoring device 230, at step 1910, updates its configuration status and begins to process sampling data from the hardware resource. The monitoring device 230 may communicate the hardware change during the next session initialization message. The computing system 320 connects to the monitoring device 230 at step 1912, and begins a session initialization message protocol. If the session initialization message indicates the change in hardware, the computing system, at step 1914, detects the new hardware resource, scans through the updated monitoring device 230 configuration and every hardware resource, and updates its status.

[0097] In some examples, the monitoring device 230 may have a sensor resource class for each physical sensor. The sensor resource class is a generic interface definition to handle multiple sensor types with a common interface. Sensor resources, as described herein, can handle sampling data and transient data. Sampling data may refer to sample parameters at relatively slow rate and keeps average, maximum and minimum of every hour. Sampling data may comprise several configurable parameters such as a sampling interval and period. The sampling interval may comprise a time span between samples, in seconds. The monitoring device 230 may drop samples and only keep the minimum and maximum for a period. A period is a period of time for minimum and maximum samples in seconds. In the example embodiment, the default is 3600 seconds.

[0098] Transient data may comprise samples processed at a high rate, and the monitoring device 230 or computing system 320 compresses the data. Transient data may comprise several configurable parameters such as transient interval and tolerance. Transient interval is an exponent for power of base 2 of time between samples in 1/4096 seconds. In the example embodiment, the default transient interval is 5 for a 1/128 second period. Tolerance is the minimum delta required for a sample to be recorded, recorded in raw analog-to-digital converter (ADC) conversion units. For an ADC, the most popular convention is to draw a straight line through the mid-points of the codes, or the code centers. If the sample is less than the delta from the straight line, it is dropped.

[0099] The computing system 320 may allow the parameters of the data, and the rates that the data is captured, to be changed based on predetermined criteria defined by the user. In some examples, sensor actions are used by the computing system to define the transient and sample data parameters. Sensor actions may comprise a start time and duration during which the monitoring device 230 will take transient measurements.
In the example embodiment, during the transient data process of step 1920, the monitoring device 230 does not keep the state of the data. Instead, it is the responsibility of the computing system 320 to keep the state of the data. After the monitoring device 230 responds with data, the data remains recoverable till the computing system 320 instructs the monitoring device 230 to permanently delete the data by a delete action. If the session unexpectedly ends after the samples of data are sent to the server but the monitoring device 230 does not get a request to delete the sent data, the monitoring device 230 will automatically recover the data.

In some examples there may be action resources which may handle scheduling of transient data monitoring of the corresponding sensor(s). These actions require the start time and the duration. The action is a sub-resource of multiple types of resources with a purpose of scheduled actions with or without duration. An example of an action with duration is flushing, which requires duration. An example of an instantaneous action is connection to the server because it does not have a duration requirement.

In another example embodiment, the computing system 320 may level load connect actions by choosing the least busy time for connection within the next hour of each "Wake Up" action, and schedule the exact time for the monitoring device 230. For example, the user may schedule an upload action at 9:00am. The computing system 320 scans actions of the monitoring device 230 that upload between 9:00am and 10:00am and builds a frequency chart. The computing system 320 chooses the least busy time within that hour and sets the action for that time, for example, 9:01:13am. The next time the monitoring device 230 connects, the computing system 320 posts the Wake Up action at 9:01:13am to the monitoring device 230.

FIG. 20 is a block diagram of a parameter sensing system 2000 according to various implementations of the present disclosure. The parameter sensing system 2000 comprises one or more user devices, such as user devices 2010, 2012, and 2014, and a parameter sensing server 2020. These and other systems are capable of interacting and communicating via one or more communication network(s) 2022. The user devices 2010, 2012, 2014 may comprise mobile devices such as smart phones, including iPhones, BlackBerries, and Android-based devices, application-enabled mobile phones, personal computers, etc. The communication network(s) 2022 may represent telephone lines, such as land line or public switched telephone network (PSTN) systems, mobile phone channels and systems, communication channels for exchanging data and information, such as a local area network (LAN), wide area network (WAN), and/or other data, communication, or telecommunication networks that
collectively make up the Internet. In some examples, any communication network(s) 2022 that support the TCP/IP protocol may be utilized.

[0104] FIG. 21 is a block diagram illustrating an embodiment of a computer system 2100 utilized in the parameter sensing system 2000, according to various implementations of the present disclosure. The computer system 2100 may represent a user device 2010, 2012, 2014, the parameter sensing server 2020 shown in FIG. 20, or another computer system comprising the systems described herein or for performing the methods described herein. As shown in this embodiment, the computer system 2100 comprises a processing device 2110 and a memory device 2120. The memory device 2120 may comprise a client/web application 2122, a parameter sensing program 2124, a database 2126, and/or the like. The computer system 2100 further comprises input/output devices 2130 and interface devices 2140. The components of the computer system 2100 are interconnected and may communicate with each other via a computer bus interface 2150 or other suitable communication devices. The parameter sensing program 2124 may perform the same functions as the parameter sensing module 232, as described herein for FIG. 2, and vice versa.

[0105] In some examples, each component of the computer system 2100 as shown may comprise multiple components on multiple computer systems of a network. For example, the computer system 2100 may comprise servers, such as application servers, file servers, database servers, web servers, etc., for performing various functions described herein. The servers of the computer system 2100 may for example be physically separate computer servers or virtual servers in a VMware ESXi 4.0 virtual environment, among other implementations.

[0106] The processing device 2110 may be one or more general-purpose or specific-purpose processors, microcontrollers, or microprocessors for controlling the operations and functions of the parameter sensing server 1210. In some implementations, the processing device 2110 may comprise a plurality of processors, computers, servers, or other processing elements for performing different functions within the computer system 2100.

[0107] The memory device 2120 may comprise one or more internally fixed storage units, removable storage units, and/or remotely accessible storage units, each including a tangible storage medium. The various storage units may comprise any combination of volatile memory and non-volatile memory. For example, volatile memory may comprise random access memory (RAM), dynamic RAM (DRAM), etc. Non-volatile memory may comprise read only memory (ROM), electrically erasable programmable ROM (EEPROM), flash memory, etc. The storage units may be configured to store any combination of information, data, instructions, software code, etc. The client/web
application 2122, the parameter sensing program 2124, the database 2126, and/or the
like may be stored in one or more memory devices 2120 and run on the same or
different computer systems and/or servers.

In addition to the memory device 2120, the computer system 2100 may
comprise other computer-readable media storing information, data, instructions,
software code, etc. It will be appreciated by those skilled in the art that computer-
readable media can be any available media that may be accessed by the computer
system 2100, including computer-readable storage media and communications media.
Communications media comprises transitory signals. Computer-readable storage
media comprises volatile and non-volatile, removable and non-removable storage
media implemented in any method or technology for the non-transitory storage of
information. For example, computer-readable storage media comprises, but is not
limited to, RAM, ROM, erasable programmable ROM ("EPROM"), electrically-erasable
programmable ROM ("EEPROM"), FLASH memory or other solid-state memory
technology, compact disc ROM ("CD-ROM"), digital versatile disk ("DVD"), high
definition DVD ("HD-DVD"), BLU-RAY or other optical storage, magnetic cassettes,
magnetic tape, magnetic disk storage or other magnetic storage devices and the like.
According to some examples, the computer system 2100 may comprise computer-
readable media storing computer-executable instructions that cause the computer
system to perform aspects of the method 1900 described herein in regards to FIG. 19.

The input/output devices 2130 may comprise various input mechanisms and
output mechanisms. For example, input mechanisms may comprise various data entry
devices, such as keyboards, keypads, buttons, switches, touch pads, touch screens,
cursor control devices, computer mice, stylus-receptive components, voice-activated
mechanisms, microphones, cameras, infrared sensors, or other data entry devices.
Output mechanisms may comprise various data output devices, such as computer
monitors, display screens, touch screens, audio output devices, speakers, alarms,
notification devices, lights, light emitting diodes, liquid crystal displays, printers, or other
data output devices. The input/output devices 2130 may also comprise interaction
devices configured to receive input and provide output, such as dongles, touch screen
devices, and other input/output devices, to enable input and/or output communication.

The interface devices 2140 may comprise various devices for interfacing the
computer system 2100 with one or more types of servers, computer systems and
communication systems, such as a network interface adaptor as is known in the art.
The interface devices 2140 may comprise devices for communicating between the
parameter sensing server 2020 and the user devices 2010, 2012, or 2014 over the
communication network(s) 2022, for example. In some examples, the interface devices
2140 may comprise a network interface adapter or other hardware or software interface elements known in the art.

[0111] The client/web application 2122 may comprise a user application for facilitating the monitoring device(s) and the data captured from the one or more sensors, as described herein. In some examples, the client/web application 2122 may execute directly on a user device 2010, 2012, 2014 and interface with the parameter sensing server 2020 over the communication network(s) 2022. The client/web application 2212 may further represent a web-based application executing on the parameter sensing server 2020 or other web server and delivered to a web browser executing on the user devices 2010, 2012, 2014 over the communication network(s) 2022. The client/web application 2122 may be implemented in hardware, software, or any combination of the two on the user devices 2010, 2012, 2014, the parameter sensing server 2020, and/or other computing systems in the parameter sensing system 2000.

[0112] The parameter sensing program 2124 may comprise any suitable instructions for processing the sample and transient data from the one or more sensors connected to any one of the monitoring device(s) or monitoring assemblies described herein. For example, the parameter sensing program 2124 may receive any data from resource hardware of the parameter sensing system 2000 including at least pressure, pH, turbidity, temperature, chlorine, etc., as well as other fluid measurements known in the art, such as oxidation reduction potential (ORP), conductivity, resistivity, flow rate, etc. The parameter sensing program 2124 may be omitted from the parameter sensing server 2020 in some examples or placed in a separate processing system according to other examples. The parameter sensing program 2124 may be implemented in hardware, software, or any combination of the two on the user devices 2010, 2012, 2014, the parameter sensing server 2020, and/or other computing systems in the parameter sensing system 2000.

[0113] Other examples may comprise additional options or may omit certain options shown herein. One should note that conditional language, such as, among others, "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain examples comprise, while other examples do not comprise, certain features, elements and/or steps. Thus, such conditional language is not generally intended to imply that features, elements and/or steps are in any way required for one or more particular examples or that one or more particular examples necessarily comprise logic for deciding, with or without user input or prompting, whether these features, elements and/or steps are comprised or are to be performed in any particular embodiment.
It should be emphasized that the above-described examples are merely possible examples of implementations and set forth for a clear understanding of the present disclosure. Many variations and modifications may be made to the above-described examples without departing substantially from the spirit and principles of the present disclosure. Further, the scope of the present disclosure is intended to cover any and all appropriate combinations and sub-combinations of all elements, features, and aspects discussed above. All such appropriate modifications and variations are intended to be included within the scope of the present disclosure, and all possible claims to individual aspects or combinations of elements or steps are intended to be supported by the present disclosure.
What is claimed is:

1. A method of sensing parameters in a fluid distribution system, comprising the steps of:
   receiving, at a monitoring device, fluid parameter information from a sensor in a fluid distribution system;
   collecting, by the monitoring device, sampling data of the fluid parameter information from the sensor based on predetermined criteria;
   receiving, by the monitoring device, a request to collect transient data from the sensor;
   collecting, by the monitoring device, transient data of the fluid parameter information from the sensor based on predetermined criteria; and
   communicating the sampling data and the transient data to another device.

2. The method of claim 1, wherein the sensor is a first sensor, and wherein the method further comprises the steps of:
   detecting, by the monitoring device, a second sensor in the fluid distribution system;
   automatically enabling, by the monitoring device, the second sensor; and
   updating, by the monitoring device, a configuration status of the second sensor.

3. The method of claim 2, further comprising the steps of:
   receiving, at the monitoring device, fluid parameter information from the second sensor;
   collecting, by the monitoring device, sampling data of the fluid parameter information from the second sensor based on predetermined criteria.

4. The method of claim 1, wherein the monitoring device comprises:
   a power source;
   an antenna; and
   a parameter sensing portion configured to monitor a parameter of the fluid distribution system.

5. The method of claim 1, wherein the fluid parameter information is based on at least one of a pressure parameter, a temperature parameter, a turbidity parameter, a pH parameter, and a chlorine parameter.
6. The method of claim 1, wherein the sensor comprises one of a pressure sensor, a temperature sensor, a turbidity sensor, a pH sensor, and a chlorine sensor.

7. The method of claim 1, wherein the collected transient data is based on configurable parameters, the configurable parameters comprising a transient interval and a tolerance.

8. An apparatus comprising:
a monitoring device comprising
   a power source,
an antenna, and
   a parameter sensing portion configured to monitor a parameter of a fluid distribution system; and
a sensor array connected to the monitoring device.

9. The apparatus of claim 8, wherein the parameter is selected from the group consisting of a pressure parameter, a temperature parameter, a turbidity parameter, a pH parameter, and a chlorine parameter.

10. The apparatus of claim 8, further comprising an auxiliary power input operably connected to the power source.

11. The apparatus of claim 10, wherein the auxiliary power input comprises a waterproof connector attached to a top of the monitoring device.

12. The apparatus of claim 8, wherein the parameter of the fluid distribution system is a first parameter, and wherein the parameter sensing portion is further configured to monitor a second parameter of a fluid distribution system, a third parameter of a fluid distribution system, a fourth parameter of a fluid distribution system, and a fifth parameter of a fluid distribution system.

13. The apparatus of claim 8, further comprising a solenoid.

14. The apparatus of claim 13, wherein the parameter sensing portion is further configured to operate the solenoid to cause a flushing operation to be performed in the fluid distribution system.
15. A monitoring device comprising:
a power source;
an antenna; and
a parameter sensing portion configured to monitor a pressure parameter, a
temperature parameter, a turbidity parameter, a pH parameter, and a
chlorine parameter of a fluid distribution system;
wherein the monitoring device is configured to connect to a sensor array, the
sensor array comprising a pressure sensor, a temperature sensor, a turbidity
sensor, a pH sensor, and a chlorine sensor.

16. A system for sensing parameters in a fluid distribution system, the system
comprising:
a monitoring device, the monitoring device comprising
a parameter sensing module configured to monitor a parameter of the
fluid distribution system,
a power source, and
an antenna;
a sensor array connected to the monitoring device; and
a computing system comprising a processing resource and a computer-
readable storage medium, the computing system configured to
receive configuration data defining a configuration profile for the
monitoring device, the configuration profile relating to a
parameter configuration of the monitoring device; and
communicate the configuration data to the monitoring device.

17. The system for of claim 16, further comprising a solenoid.

18. The system for of claim 17, wherein the parameter sensing module is further
configured to operate the solenoid to cause a flushing operation to be
performed in the fluid distribution system.

19. A method of sensing parameters in a fluid distribution system, comprising the
steps of:
receiving, at a monitoring device, sampling data of a fluid parameter from a
sensor in a fluid distribution system; and
communicating the sampling data to another device.
20. A system for sensing parameters in a fluid distribution system, the system comprising:
   a monitoring device;
   a sensor array connected to the monitoring device; and
   a computing system.
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FIG. 12B

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**Prev** Today **Next** Month

**Sunday** Monday Tuesday Wednesday Thursday Friday Saturday

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**FIG. 15C**
MONITORING DEVICE ACTIVATED

NEW HARDWARE RESOURCE CONNECTED? NO

AUTOMATICALLY ENABLE NEW HARDWARE RESOURCE

UPDATE CONFIGURATION STATUS AND BEGIN PROCESSING SAMPLING DATA FROM HARDWARE RESOURCE

COMPUTING SYSTEM CONNECTS AND BEGINS SESSION INITIALIZATION MESSAGE PROTOCOL

COMPUTING SYSTEM DETECTS NEW HARDWARE RESOURCE, SCANS FOR EVERY HARDWARE RESOURCE CONNECTED, AND UPDATES CONFIGURATION STATUS

RECEIVE REQUEST FOR TRANSIENT DATA? NO CONTINUE PROCESSING SAMPLING DATA

BEGIN PROCESSING TRANSIENT DATA FROM HARDWARE RESOURCE

FIG. 19
**FIG. 20**

**FIG. 21**
INTERNATIONAL SEARCH REPORT

International application No. PCT/US 16/36007

A. CLASSIFICATION OF SUBJECT MATTER

CPC: G01N 33/18; G05D 21/02; G01F 1/20 (2016.01)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) Classifications: G01N 33/18; G05D 21/02; G01F 1/20; G01N 27/06; F17D 5/02 (2016.01)

IPC Classification: G01N 33/18, 33/1886; C02F 1/006

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>X Y</td>
<td>US 2014/0272824 A1 (MUELLER INTERNATIONAL LLC) September 18, 2014; abstract; figure; 1A-IB, 2, 3a/ary/aJPls [0004-0005]; [0036003]; [U/1]</td>
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<td>US 2012/0298220 A1 (TAYLOR, T et al.) November 29, 2012; abstract; figures 1, 3; paragraphs [0023]; [0033]</td>
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Date of the actual completion of the international search: 19 September 2016 (19.09.2016)

Date of mailing of the international search report: 06 OCT 2016

Name and mailing address of the ISA:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-8300

Authorized officer: Shane Thomas
PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

Form PCT/ISA/2 (second sheet) (January 2015)
This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. [ ] Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.; because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. [x] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  

**Remark on Protest**

- [ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- [ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- [x] No protest accompanied the payment of additional search fees.
-Continued from Box Mi: Observations where unity of invention is lacking-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-14, 19, & 20 appear to be directed towards receiving, by the monitoring device, a request to collect transient data from a sensor.

Group II: Claim 15 appears to be directed towards monitoring several parameters.

Group III: Claims 16-18 appears to be directed towards a configuration profile or a monitoring device.

The inventions listed as Groups I-III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features.

The special technical features of Group I are at least collecting, by the monitoring device, sampling data of the fluid parameter information from the sensor based on predetermined criteria; receiving, by the monitoring device, a request to collect transient data from the sensor; collecting, by the monitoring device, transient data of the fluid parameter information from the sensor based on predetermined criteria; and communicating the sampling data and the transient data to another device, which are not present in Groups II and III.

The special technical features of Group II are at least a parameter sensing portion configured to monitor a pressure parameter, a temperature parameter, a turbidity parameter, a pH parameter, and a chlorine parameter of a fluid distribution system; wherein the monitoring device is configured to connect to a sensor array, the sensor array comprising a pressure sensor, a temperature sensor, a turbidity sensor, a pH sensor, and a chlorine sensor, which are not present in Groups I and III.

The special technical features of Group III are at least monitoring device, the configuration profile relating to a parameter configuration of the monitoring device; and communicate the configuration data to the monitoring device, which are not present in Group III.

The common technical features of Groups I-III are at least receiving, at a monitoring device, fluid parameter information from a sensor sensory array in a fluid distribution system, a power source, an antenna, and a computing system comprising a processing resource and a computer readable storage medium.

US 2004/0199340 A1 to Kersey, A et al. (KERSEY) discloses receiving, at a monitoring device, fluid parameter information from a sensor array in a fluid distribution system (receiving at a flow meter (monitoring device), volumetric flow rates (fluid parameter information) from sensors 40.42 (sensor array) in a pipe (fluid distribution system); paragraphs [0041], [0042]), a power source (inherent power source), an antenna (transmitter/receiver; paragraph [0064]), and a computing system comprising a processing resource and a computer readable storage medium (signal processor and data accumulator; figure 3).

Since the common technical features are previously disclosed by KERSEY, these features are not special and Groups I-III lack unity.