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(54) **APPARATUS AND METHOD FOR MEASURING WATER QUALITY IN A WATER METER DATA COLLECTION SYSTEM**

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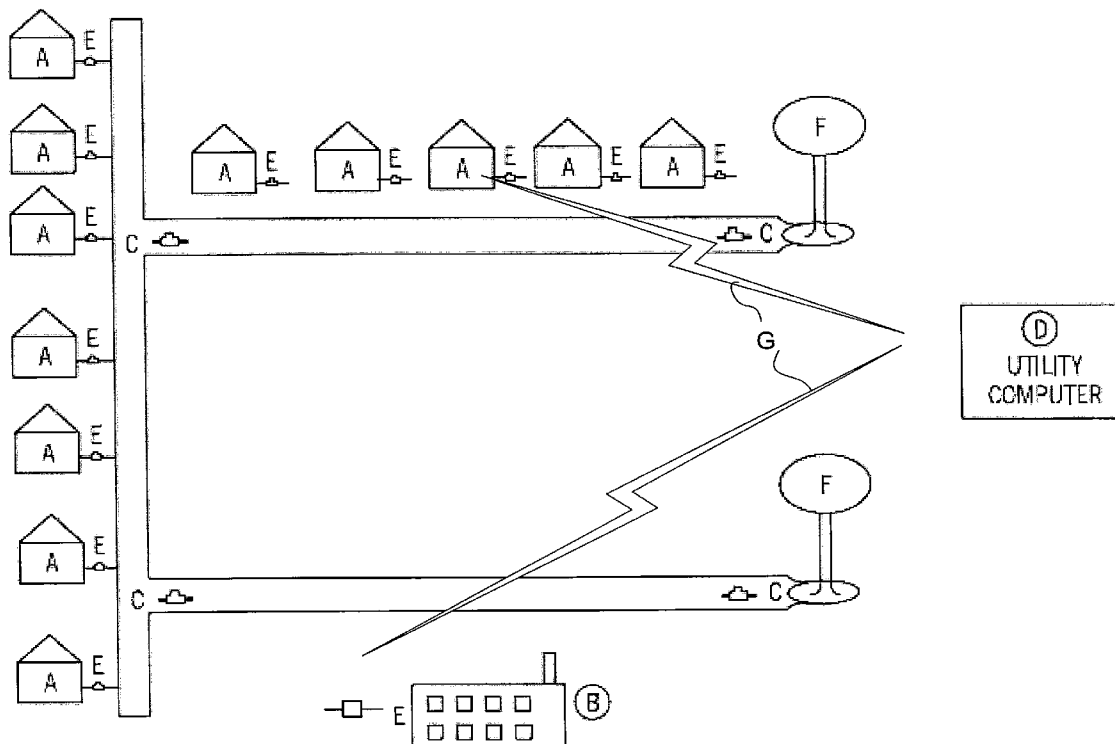
(57) **ABSTRACT**

A system for monitoring water quality in a water meter data collection system having a plurality of metering end points (E) for measuring consumption includes a plurality of chemical biological and environmental sensors (S1, S2) disposed in a distribution system near or within the distribution end points (A, B), with the sensors (S1, S2) generating electrical signals through a network (G) that can be processed and communicated with the water meter data to a collection station (D) from the metering end points (E).

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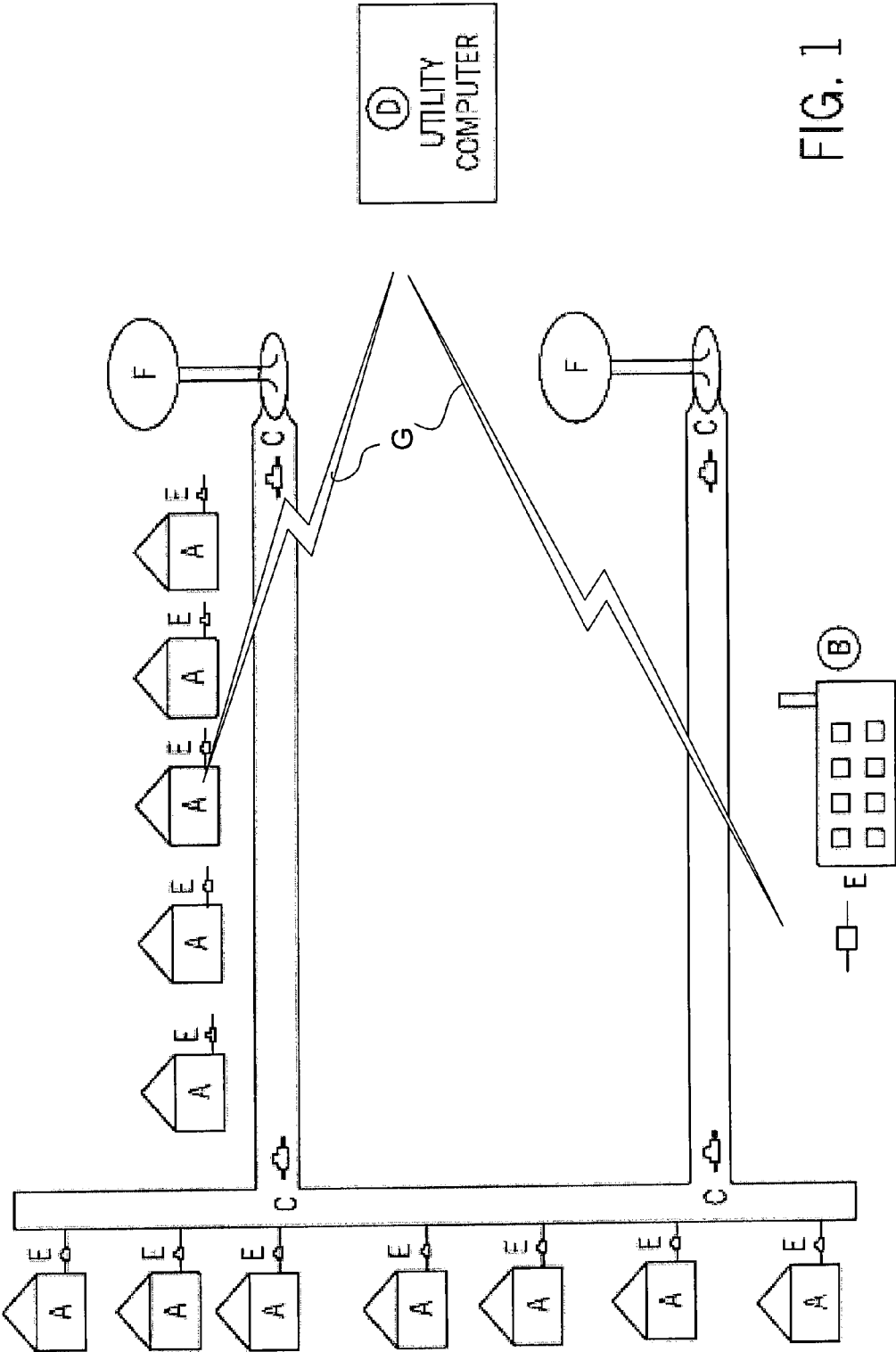


FIG. 1

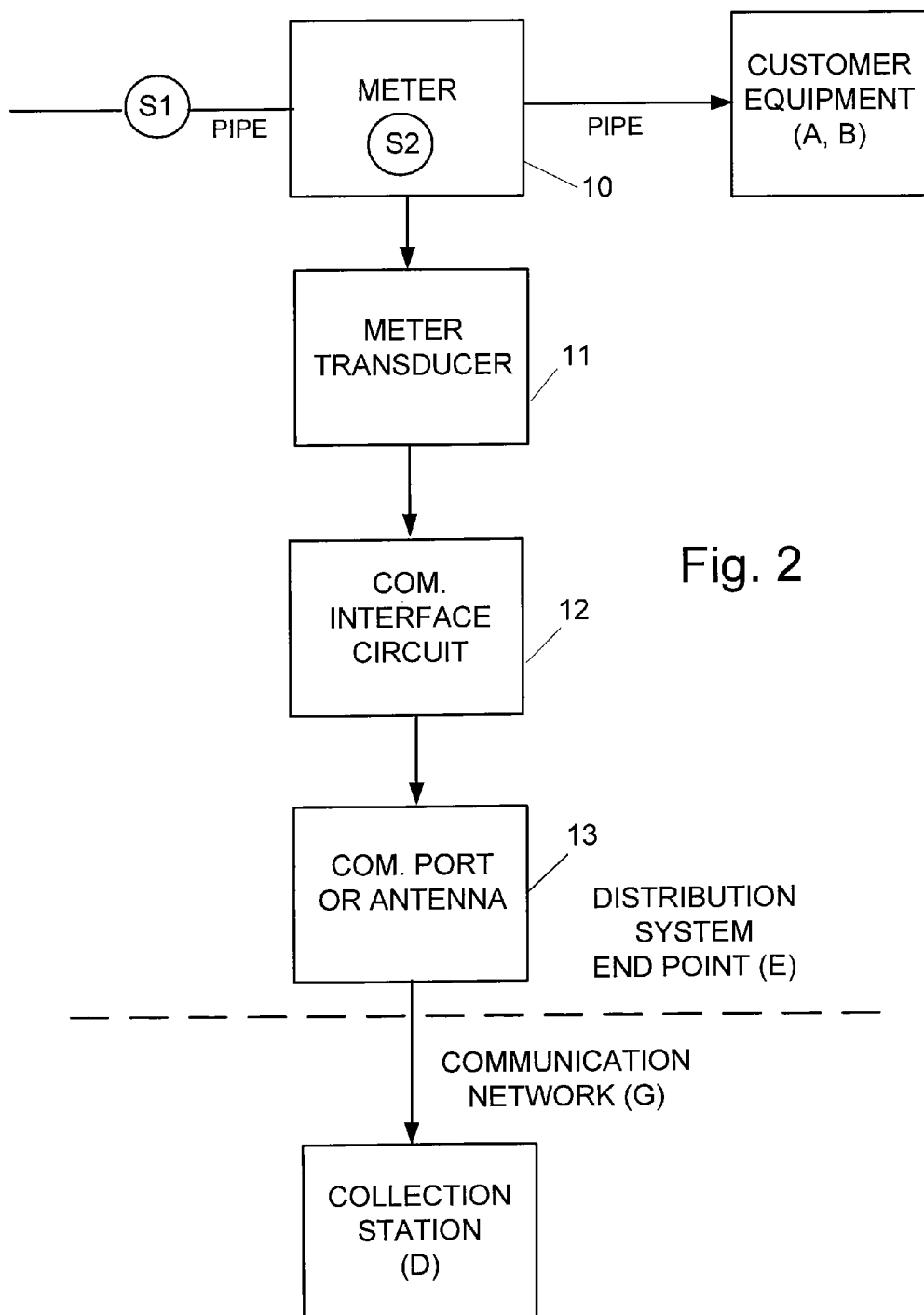


Fig. 2

**APPARATUS AND METHOD FOR MEASURING WATER QUALITY IN A WATER METER DATA COLLECTION SYSTEM**

**CROSS REFERENCE TO RELATED APPLICATION**

[0001] This is a continuation of U.S. patent application Ser. No. 12/439,258, filed Feb. 27, 2009, now copending, which was based on PCT Appl. No. PCT/U.S.08/070,052, filed Jul. 15, 2008. The benefit of priority based on U.S. Prov. Pat. App. No. 60/959,833, filed Jul. 17, 2007, is claimed herein.

**TECHNICAL FIELD**

[0002] The field of the invention is meter data collection systems for metering consumption of water supplied to single-unit residential, multi-unit residential, commercial and industrial customers from a municipal or district utility provider. The invention also relates to instruments for sensing water quality in such a meter data collection system.

**BACKGROUND OF THE INVENTION**

[0003] Current methods and practices for sensing water quality through biological and chemical parameters, as well as environmental parameters such as residual chlorine, TOC (total organic carbon), turbidity, pressure, and others, involve systems with expensive sensors located at special stations within a water system. Many systems currently available on the market to test for environmental parameters require a waste stream, sometimes toxic, as a byproduct of the testing. This methodology cannot be used at the end points of a utility distribution network. Also, the systems provided today provide sensing of several environmental parameters at one time. These systems are installed at source water, underground tanks and elevated tank locations. It has not been economically or environmentally practical to install these systems at end point locations in a water metering system.

[0004] However, end point locations in a water metering system have been identified as a potential source point for the introduction of contaminants into a water distribution network. If this were to occur, it is probable the current technologies and equipment would not detect the contamination event.

**SUMMARY OF THE INVENTION**

[0005] The invention provides a method for the sensing of various biological and chemical contaminants and environmental parameters at the end points of a water utility metering network.

[0006] In the system of the invention, at least one sensor is associated with each end point (meter) in a water metering system to measure a different biological, chemical or environmental parameter within the specified region of the water distribution network. While more than one sensor might be utilized at a particular water meter, it is an objective of the invention to reduce the high cost of the various sensors that are necessary by distributing them among the end points in a zone of a water distribution system. Sensors can also be located at zone meters to monitor a specific parameter for a zone of the water distribution system, with different sensors being distributed to different zones.

[0007] A water utility distribution system can be protected from a wide array of potential biological and chemical contaminants and environmental parameters and can be economically deployed using the present invention, as there is

only one parameter sensed per meter. It also provides early automatic detection of potential contamination events.

[0008] The invention can be used to provide a first indication of contamination from which further field or lab testing can be performed to confirm anomalous conditions.

[0009] Other objects and advantages of the invention, besides those discussed above, will be apparent to those of ordinary skill in the art from the description of the preferred embodiments which follows. In the description, reference is made to the accompanying drawings, which form a part hereof, and which illustrate examples of the invention.

**BRIEF DESCRIPTION OF THE DRAWING**

[0010] FIG. 1 is schematic diagram of a water utility distribution and water metering system incorporating the present invention; and

[0011] FIG. 2 is a block diagram of an apparatus at a single metering end point.

**DETAILED DESCRIPTION**

[0012] FIG. 1 illustrates a subsection of a water utility distribution system, where "A" designates individual single-unit end points within the distribution system. "B" designates individual commercial, industrial or multi-unit end points within the distribution system. "C" designates zone water meters that measure the quantity or quality of water distributed to one zone or section of the distribution system. "D" designates the utility main office computer system. "E" designates the end point meters that measure the quantity or quality of water distributed to a single Residential, commercial or industrial end point. "F" designates a water storage facility (tanks or vaults) for water used within the distribution system. And, "G" designates a wireless network such as SMS, GPRS, GSM, private radio network, PSTN, or wireless Internet.

[0013] Currently, water utilities must report several parameters to a governmental environmental protection agency on a quarterly basis. These parameters include chlorine residual, TOC (total organic carbon), dissolved oxygen, etc. To accomplish this reporting, utilities typically take water samples from various locations throughout the distribution system and send these samples to a laboratory for analysis of parametric testing. An alternate method is the installation of expensive computer controlled systems that automatically take samples from each location and provide parametric analysis.

[0014] While these systems provide more data on a more frequent basis, they have a waste stream that requires maintenance and special handling. As they are expensive, most utilities are limited to installations at source water locations or storage facilities, and the equipment is not distributed throughout the distribution system.

[0015] In the present invention, individual sensors monitor respective parameters and are co-located with a meter, as illustrated by C or E in the illustration. Meters, illustrated as the element E, typically measure quantity of water consumed at a single end point within the distribution system. These meters can also be assembled with, or connected to, one or more sensors to measure the quality of water supplied to the single end point. It is often advantageous to take readings from several places in the distribution system due to different concentrations of substances due to dilution. Likewise, zone meters, illustrated as the element C, typically measure quantity of water consumed with a specific zone, or section, of the

distribution system. When fitted with one or more sensors, these meters could provide water quality readings for an entire zone, or section. Also, a set of sensors for measuring or detecting respective chemical, biological and environmental parameters can be arranged to measure different parameters within a zone of the distribution system, thus providing coverage for many parameters.

[0016] Consumption and water quality data can be transmitted wirelessly to a collection station, such as a utility computer, D, over a wireless network, G, such as SMS, GPRS, GSM, private radio network, PSTN, or wireless Internet. Water quality reporting to the EPA could then be completed on a real-time basis, instead of on a quarterly or semi-annually.

[0017] FIG. 2 illustrates the components of a single distribution end point apparatus E at customer locations, A and B. As shown there, a meter 10 is connected in a pipe supplying water to the customer equipment at sites A, B. The parameter sensor can be a sensor S1 mounted in or on the pipeline near the meter 10, or it can be sensor S2 integrated into the meter 10. The meter 10 communicates with a communication interface circuit 12 through a transducer 11 which may convert movements of a magnet to electrical signals. It also feasible to use electronic meters which produce an electrical signal directly to the circuit 12. The sensors S1 and S2 also communicate electrical sensing signals to the communication interface circuit 12. This circuit 12 converts device input signals to data and in this embodiment, modulates a carrier wave with information signals representing the data, so that a radio signal can be transmitted over a wireless network through an antenna 13. It is also possible for the communication interface circuit to transmit data signals through a communication port 13 to an external modulator/antenna unit. In either situation, radio signals encoded with metering data, including sensor data, are transmitted back to the collection station D including the utility computer seen in FIG. 1.

[0018] The electronic circuitry 12 within the end point (meter) can in some embodiments poll the microsensor S2 that resides within the meter 10 in the flow stream. When the electronic circuitry detects an anomalous condition from the sensor, a tamper flag is set and an alarm transaction is transmitted to the collections station D via the communication interface circuit 12. Upon notification of the anomalous condition, utility personnel will know which potential contaminant has been detected because of the identification number of the end point that transmits the alarm transaction. The water utility can then go to the source for further field testing to validate the contamination event.

[0019] Other sensors fitted into meters can be for first level detection of various bio-toxins, chemical toxins or other hazardous substances. This first level detection could greatly improve the response time and public notification of hazardous events.

[0020] The system components at each meter C and E can be further described as follows.

[0021] Microelectronic sensors S1 and S2 are located at an end point (meter) within the flow stream of a water utility distribution system. A parameter sensor detects the presence or threshold of a single respective biological, chemical or environmental parameter (e.g. TOC or dissolved oxygen). Each sensor with a zone detects a different respective biological, chemical or environmental parameter. As the sensor is located in the supply flow stream, the system does not have a waste stream.

[0022] The flow meter 10 is located at the lowest point in the distribution system where the utility would like to measure the quantity of water. Also, the meter 10 may be the lowest point within the distribution system where the utility desires to measure the quality of water. In this case, the parameter sensors S1, S2 would be located near or inside the meter 10. In cases where water quantity and quality are important at that location the meter would measure the amount of water to pass through it and house the parameter sensor to measure the quality of the water passing through it.

[0023] There is typically a transducer 11 for converting mechanical movement of the flow meter to electrical signals, a memory to store readings and transmitter circuitry 12, 13 for transmitting electrical signals to a remote receiver. This transmitter can be part of a transceiver for receiving RF signals as well as transmitting RF signals. In cases where water quality is sensed at the meter 10, the circuitry 11, 12 and 13 would also read and act on water quality data and alarm conditions from the parameter sensor and transmit these to a remote receiver. Many AMR systems are known for transmitting utility consumption data from the distribution end points (E) to a central location (D) for processing. Such systems can be modified to communicate and process water quality data as well. The zone meters (C) can also be provided with this type of electronic signaling equipment. The water quality data from various locations within the system can then be collected at the collection station D for further processing to determine water quality on a system basis.

[0024] This has been a description of the preferred embodiments, but it will be apparent to those of ordinary skill in the art that modifications may be made in the details of these specific embodiments. Such modifications are intended to be encompassed by the broadest aspects of the present invention unless excluded by the following claims.

1.-20. (canceled)

21. Apparatus for sensing water quality at a water metering system end point, the apparatus comprising:

a fluid flow metering element and a device that converts metering signals or movements of a flow metering element to electrical signals representing units of consumption;

communication interface circuitry for converting the electrical signals representing units of consumption to meter data signals;

means for electronically communicating the meter data signals to an external data collection device; and

a sensor disposed in or near the fluid flow metering element to associated therewith and to sense a quality of the water, said sensor producing a water quality status signal to the communication interface circuitry, and

wherein the communication interface circuitry is responsive to the water quality status signal to incorporate said water quality status signal into a group of data signals including meter data signals; and

wherein said means for electronically communicating the meter data will also communicate the water quality status signal in a transmission to a collection station in a water meter data collection network.

22. The apparatus of claim 21, wherein the means for communicating the meter data signals includes a data port for communicating meter data signals from the meter register device to an external transmitter.

23. The apparatus of claim 21, wherein the communication interface circuitry includes circuitry for producing radio fre-

quency meter data signals and wherein the means for communicating the meter data signals to an external device includes an antenna for communicating the radio frequency meter data signals to an external device.

**24.** The apparatus of claim **21**, wherein the water quality status signal is representative of at least one of a chemical, biological or environmental parameter.

**25.** The apparatus of claim **21**, wherein the apparatus is installed as part of a metering system at a site of one water utility customer.

**26.** The apparatus of claim **21**, wherein the apparatus is installed as a zone meter for measuring water quality in a branch of a water distribution system serving a plurality of water utility customers.

**27.** A system comprising a plurality of apparatuses as recited in claim **21**, wherein the apparatuses are each associated with, and are adapted to electrically communicate with, respective sensors for sensing various different ones of a plurality of chemical biological, or environmental parameters of water quality in a water distribution system, said sensors generating electrical signals that can be communicated through a wireless network to a fixed, non-mobile meter data collection station.

**28.** The system of claim **27**, wherein there are a plurality of sensors for different biological, chemical or environmental parameter that are distributed to respective distribution end points within a specified zone of the water metering network and wherein said sensors generate electrical signals that are communicated to the data collection station to provide data on a plurality of parameters related to water quality with the specified zone.

**29.** The system of claim **27**, wherein there are no more than two biological, chemical or environmental sensors associated with each respective water metering system end point.

**30.** The system of claim **27**, wherein each water metering system end point comprises a meter and wherein at least one biological, chemical or environmental sensor that is located in a distribution line in a vicinity of the meter.

**31.** The system of claim **27**, wherein each water metering system end point is represented by a meter and wherein the at least one sensor is located within the meter.

**32.** The system of claim **27**, wherein the apparatuses are installed as part of a water metering system at respective sites for a plurality of respective residential customers.

**33.** The system of claim **27**, wherein the apparatuses are installed as zone meters for measuring water quality in

respective branches of a water distribution system, wherein said branches distribute water to respective pluralities of residential customers.

**34.** A method for sensing water quality at a water metering system end point, the method comprising:

converting movements of a fluid flow metering element to electrical signals representing units of consumption;

converting the electrical signals representing units of consumption to meter data signals;

electronically communicating the meter data signals to an external data collection device; and

sensing a quality of the water in or near the fluid flow metering element, said sensor producing a water quality status signal; and

including said water quality status signal in a group of meter data signals to be transmitted to a collection station; and

electronically communicating the water status signal with the meter data to a collection station in a water meter data collection network.

**35.** The method of claim **34**, wherein the water quality status signal is representative of at least one of a chemical, biological or environmental parameter.

**36.** The method of claim **34**, wherein the water quality status signal is sensed by a water consumption meter adapted to be installed at the site of one water utility customer.

**37.** The method of claim **34**, wherein the water quality status signal is sensed by a zone meter that is configured for measuring water quality in a branch of a water distribution system serving a plurality of water utility customers.

**38.** The method of claim **34**, wherein respective sensors for sensing various different ones of a plurality of chemical biological, or environmental parameters of water quality are distributed with a plurality of water meters in a water distribution system, said sensors generating electrical signals through the water meter system end points and through a wireless network to a fixed, non-mobile meter data collection station.

**39.** The method of claim **34**, wherein there are a plurality of sensors for different biological, chemical or environmental parameter that are distributed to respective meter data end points within a specified zone of the water metering network and wherein said sensors generate electrical signals that are communicated to the data collection station to provide data on a plurality of parameters related to water quality with the specified zone.

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