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(54) WATER PURIFICATION SYSTEM AND PROCESS FOR TREATING POTABLE WATER FOR AT SOURCE USE

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(57) ABSTRACT

An innovative application for the purification of potable water for at source use, specifically focusing on disinfection of water using an electrolytic process. The process uses the discharge of electrical energy between electrodes to create reactive species in water, which then react with pathogens to provide the disinfected water. The invention includes a novel and unique controller system to assure that the reaction process and reactor will function reliably to produce treated water. The controller may respond to flow or pressure conditions, reactor status, treatment effectiveness, or other parameters monitored by various sensing devices. Specific examples of the application are for use in beverage dispensing machines, ice-making machines, tap water purification for domestic and commercial potable water use, water dispenser machines that use tap water, and similar uses for potable water. The invention can also be used with central or alternative at-source power supplies for small-scale applications, such as for purifying water when engaged in outdoor activities, e.g. hiking and camping, or in portable units for travelers who wish to treat water supplies for pathogen destruction.

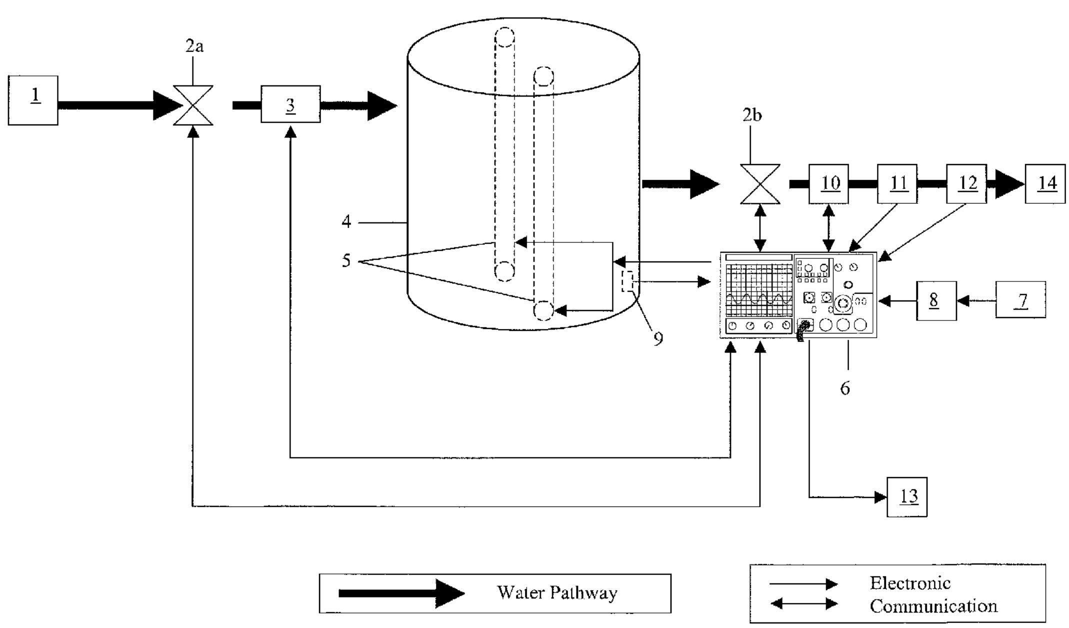
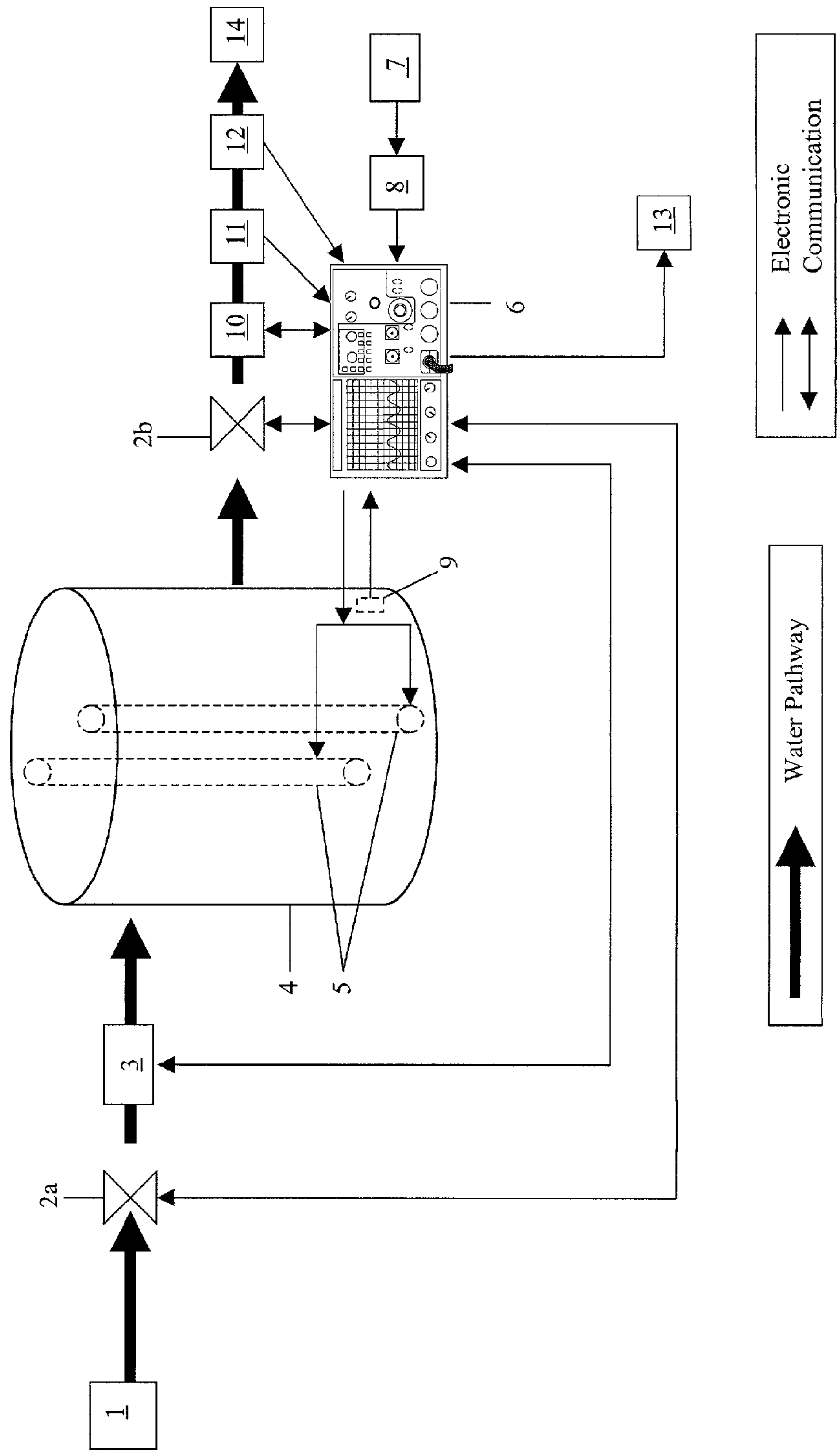


Figure 1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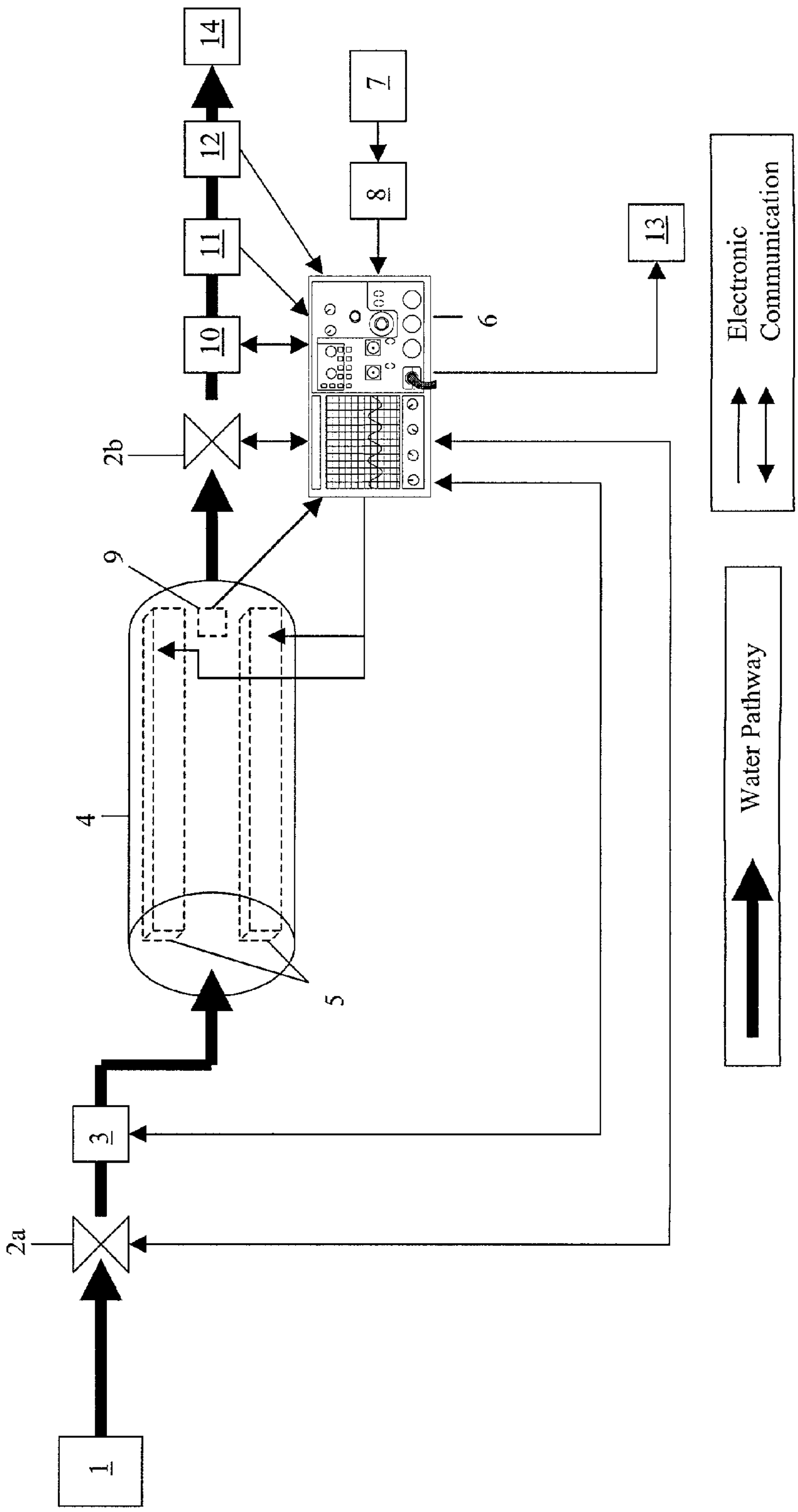
Electronic Communication
Water Pathway

Figure 2


1
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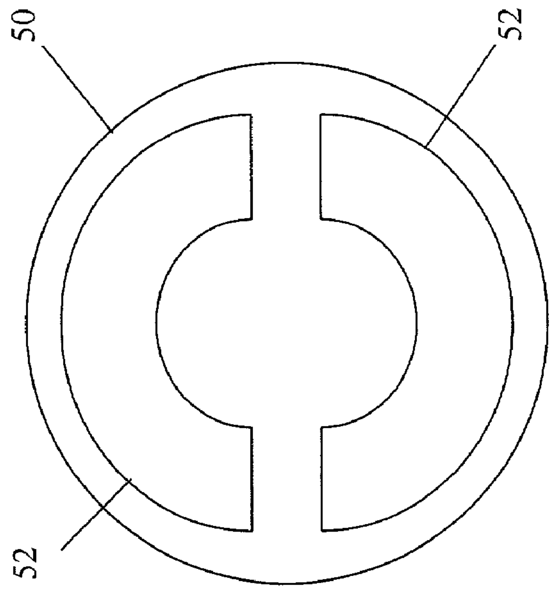
Water Pathway
Electronic Communication

Figure 3



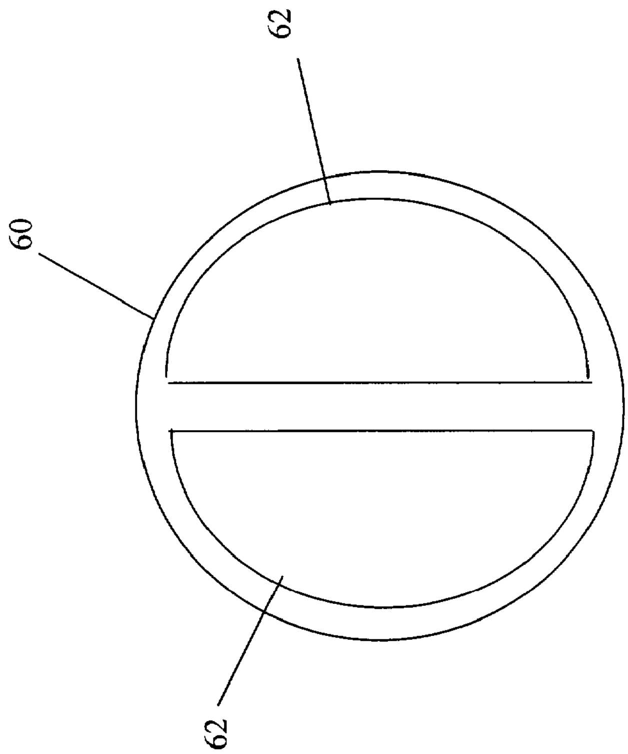


Figure 4

Figure 5

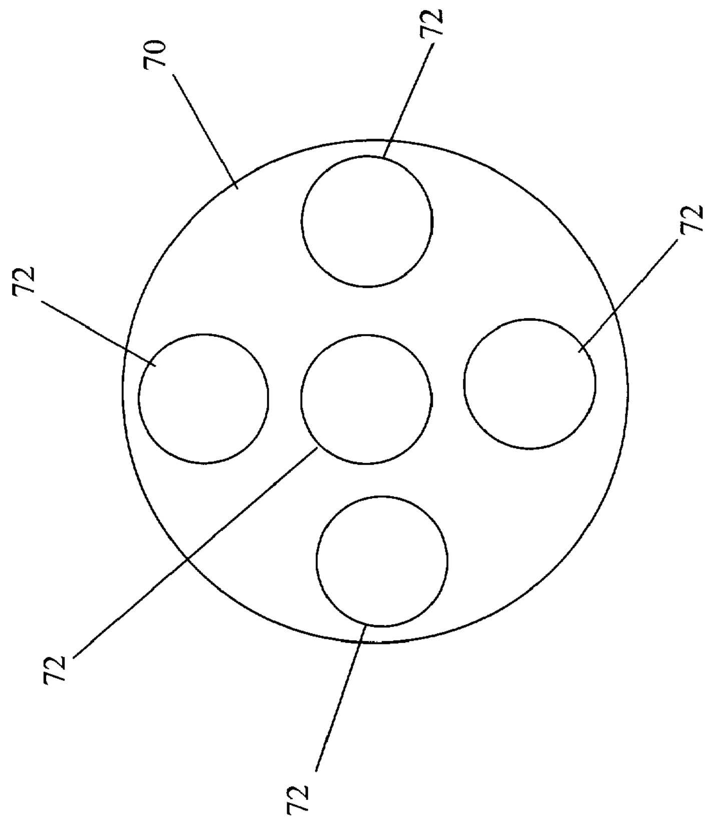
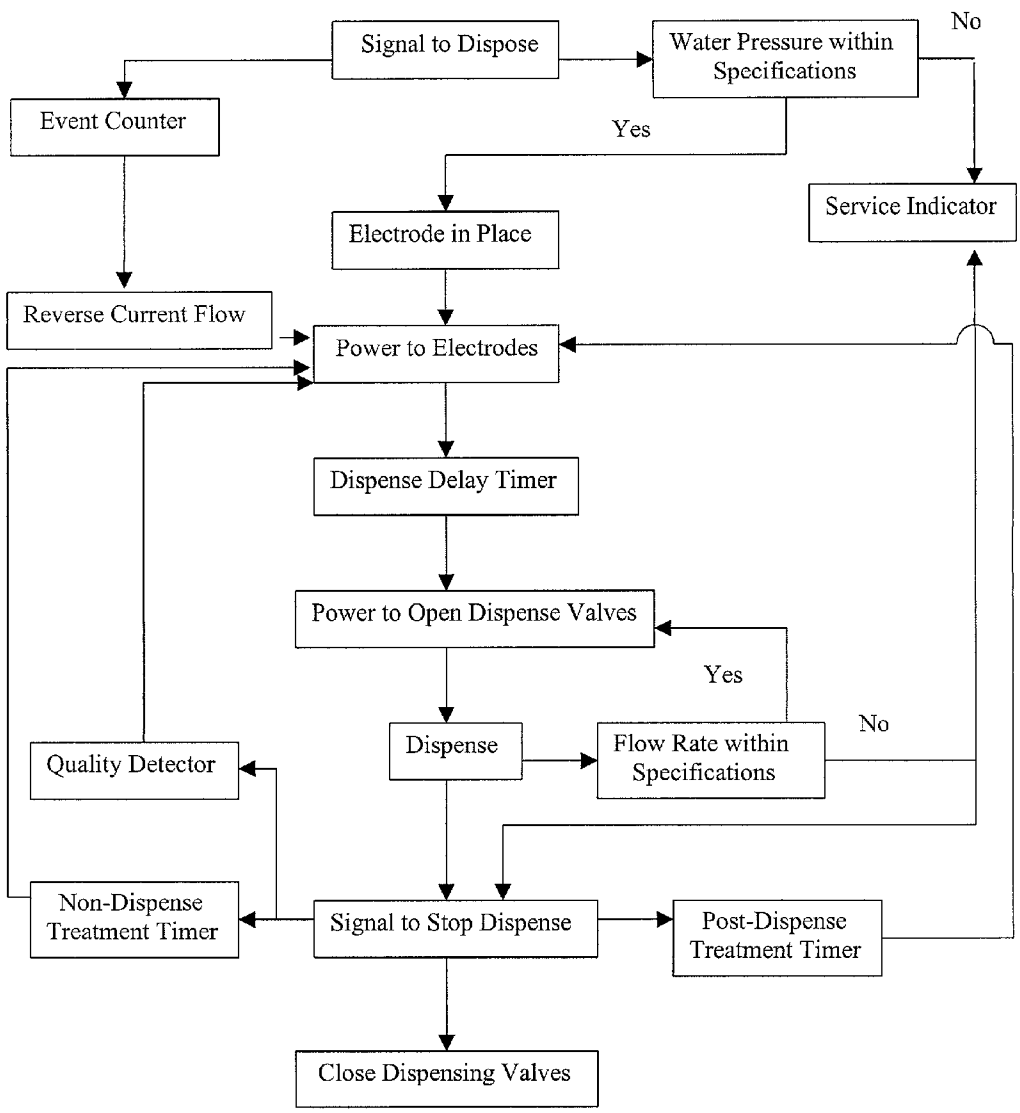


Figure 6


Signal to Dispose
Water Pressure within Specifications
No
Yes
Event Counter
Electrode in Place
Service Indicator
Reverse Current Flow
Power to Electrodes
Dispense Delay Timer
Power to Open Dispense Valves
Yes
No
Quality Detector
Dispense
Flow Rate within Specifications
Non-Dispense Treatment Timer
Signal to Stop Dispense
Post-Dispense Treatment Timer
Close Dispensing Valves

WATER PURIFICATION SYSTEM AND PROCESS FOR TREATING POTABLE WATER FOR AT SOURCE USE

BACKGROUND OF THE INVENTION

[0001] The present invention relates generally to the purification or disinfection of water and, more particularly, to the electrolytic purification or disinfection of water for drinking, commercial, recreational, and industrial uses. Many different systems have been used to purify water to meet these needs. Examples of water purification systems include, but are not limited to, thermo-treatment systems, reverse osmosis systems, ultraviolet-based systems, filter systems, chemical-based systems, copper ionization systems, ozone-generating systems, and recirculating electrolytic hydrolysis systems. Purification systems such as these have been used to combat problems such as corrosion of equipment and illness which can result from the use of unsanitized or improperly purified water. However, these systems also have drawbacks that limit their use. For example, some or all of these systems may introduce additional problems as a byproduct of their purification processes.

[0002] Chemical-based systems commonly use significant amounts of chlorine and/or bromine. However, chlorine and bromine are not effective at controlling certain prevalent forms of pathogens. In addition, water treated with these chemicals may introduce other problems. For example, water treated with chlorine can have a chlorine odor and taste, and the chlorine can react with other chemicals in the water to cause other obnoxious odors and tastes. Furthermore, the chemicals can produce harmful byproducts. For instance, the chemicals can react to form trihalomethanes (THMs), that are classified as carcinogens, which are a potential health concern for consumers.

[0003] Copper ionization systems also have shortcomings in terms of side effects and maintenance. For instance, such systems dispense metal ions into the water that result in undesired taste, and in high concentrations, health problems. Copper ionization systems may also be slow acting, and carbonated water in contact with copper may generate mildly toxic copper compounds. In addition, copper ionization systems commonly must be used in conjunction with chemical-based systems.

[0004] Likewise, ozone-generating systems and ultraviolet-based systems have drawbacks. Ozone-generating systems require the production and introduction of ozone gas into the water to kill bacteria and algae and to aid in the reduction of organics through oxidation. As a result, a substantial amount of electricity is necessary to power an ultraviolet light source or corona discharge elements for the production of ozone. In addition, excessive exposure to ozone can degrade many plastics that are used in water systems. Excessive exposure to ultraviolet radiation from ozone-generating systems and ultraviolet-based systems can also harm plastics that are used in water systems, and the radiation or excessive contact with the ultraviolet system can harm people as well.

[0005] The electrolytic process passes a current through water in order to create hydroxyl radicals. This results in a short-lived, but highly reactive oxidizing environment that kills microscopic organisms in the water. However, the electrolytic purification systems used in recirculating water systems commonly lack an adequate control system for controlling the flow of water and the flow of electricity. In addition, the treatment chambers of such systems may not be designed to be used in certain applications such as single pass systems. Consequently, the use of known electrolytic purification systems has been limited.

[0006] In light of the shortcomings of known purification systems, a need exists for a system that purifies water at least as well as known purification systems but in a more cost-efficient manner and without the above drawbacks. A need also exists for a purification system that can effectively be used to treat water for domestic and commercial applications of potable water. Another need exists for a purification system that treats contaminated water at a point of use. Still another need exists for improved controls of an electrolytic purification system. In addition, a need exists for an electrolytic system that can effectively purify infected water without recirculation or chemical treatment.

SUMMARY OF THE INVENTION

[0007] The present invention is an electrolytic system and method for the purification of water. The present invention uses the discharge of electrical energy between electrodes to create reactive species in the water. The reactive species then react with pathogens, contaminants, germs, microorganisms, viruses, and/or other undesired components to purify the water.

[0008] Preferred embodiments of the present invention do not add any residual materials to the water that change the chemical composition, taste, or odor. The process is fast reacting, and the reactive species are short-lived and do not appear in the end product. In addition, there may be additional side reactions with organics or reduced inorganics that benefit the overall process by improving the quality of the water.

[0009] Any suitable power source can be used to supply the power to the electrodes. The present invention can be used with water systems that either have or do not have a power supply. For example, the system of the present invention may include and/or use a DC power supply that does not require any input, e.g., a battery. Alternatively, the system of the present invention may include a power supply that is adapted to convert AC power to DC power.

[0010] The present invention may include an improved system and method that can control the flow of water, the flow of the electricity, and the reaction time. The controls can be used to assure continuous functioning of the purification process. Moreover, the controls can assure that water is not delivered through the disinfecting unit unless the disinfecting unit is operational.

[0011] The present invention may operate on a demand system with a flow-through mode of operation, although flow may be, and often is, intermittent. For instance, the purification system may be positioned in-line without interfering with the desired flow of the water. In addition, the purification system can be used to treat water at a point of use such as in an apparatus that dispenses water or a mixture that includes water.

[0012] Preferred embodiments of the present invention do not require recirculation, the use of chemical additives or copper ionization, or the production of ozone in order to purify the water. Nevertheless, it should be recognized that the present invention can be used in place of, or in conjunction with, known water disinfection and purification systems including, but not limited to, thermo-treatment systems, reverse osmosis systems, ultraviolet-based systems, filter systems, chemical-based systems, copper ionization systems, ozone-generating systems, and recirculating electrolytic hydrolysis systems. Moreover, the present invention can be used to purify water for industrial, recreational, commercial, or drinking uses. The present invention is particularly useful for the purification of water contained in single-pass water systems. However, it should be recognized that various embodiments of the present invention can be used in both recirculating and non-recirculating water systems. For instance, the present invention can be used for the purification of pools, spas, air conditioners, hot tubs, saunas, home water systems, canneries, bottleries, waste water treatment systems, sewage systems, cooling towers, industrial water supplies, pasteurizers, homogenizers, chillers, boilers, water storage tanks, well tanks, well heads, and other types of contaminated water supplies. It can also be used to purify tap water for domestic and commercial potable water use. In addition, the present invention can be used to produce potable water for beverage dispensing machines (e.g., a soft drink machine that mixes water and one or more concentrates to produce a beverage), ice-making machines, water dispensing machines which use tap water, and other known, similar, or conventional uses of potable water.

[0013] In addition to the novel features and advantages mentioned above, other objects and advantages of the present invention will be readily apparent from the following descriptions of the drawings and preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] **FIG. 1** is a schematic of an example of a treatment unit of the present invention;

[0015] **FIG. 2** is a schematic of another example of a treatment unit of the present invention;

[0016] **FIG. 3** is a cross section view of an alternative embodiment of a treatment reactor of the present invention;

[0017] **FIG. 4** is a cross section view of another alternative embodiment of a treatment reactor of the present invention;

[0018] **FIG. 5** is a cross section view of still another alternative embodiment of a treatment reactor of the present invention; and

[0019] **FIG. 6** is a flow control diagram of an example of a controller of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT(S)

[0020] The present invention is directed to a purification system that utilizes a hydrolysis reaction that occurs when current flows in water between two electrodes. The reaction creates free radical forms of oxygen including, but not limited to, hydroxyl radicals, atomic oxygen, hydrogen peroxide, hydroxide ions, and oxygen. These reactants result in very high oxygen-reduction potentials (ORPs). Under these strong oxidizing conditions, pathogens, contaminants, germs, microorganisms, viruses, and/or other undesired components are killed or deactivated. For example, the process can be used to kill or deactivate giardia cysts, cryptosporidium, pseudomonas, *E-coli,* legionella, bacteria (e.g., coliform), protozoan oocysts, algae, viruses, and other types of microorganisms. In addition, the reactants can cause the reduction of the concentrations of organics and inorganics to further purify the water. For example, the reactants can cause the reduction of the concentrations of metals [e.g., iron, total dissolved solids (TDSs), arsenic, copper, and manganese], inorganic anions (sulfides and nitrites), and organic compounds [e.g., trihalomethanes (THMs), volatile organic compounds (VOCs), phenol, and toluene].

[0021] The present invention may be configured in many different ways to suit a variety of different applications. A preferred embodiment of the present invention provides control of the current, control of water flow to assure disinfection, and configuration of the reaction chamber to assure contact of the reacting solution with the ORP-generating system. **FIG. 1** is a schematic representation of one example of a purification system of the present invention. In this example, water may be provided from any source **1**. The source **1** may be any public or private supply, surface or groundwater, or even collected rainwater which may be stored in cisterns or other storage devices. The water flow may be controlled by an inlet valve **2***a* which may also incorporate backflow control devices. The inlet may also include a pressure and/or flow sensor **3**. The water enters the treatment reactor **4** after passing through the control valve **2***a* and sensor **3**. The treatment reactor **4** houses at least two electrodes **5**. In order to purify the contaminated water, electrical energy is passed between the electrodes **5**, thereby creating reactive species. The current is supplied by a controller/converter **6**, which may receive power from a power source **7**. The power source **7** may be either alternating current (AC) or direct current (DC). In one example, the voltage supplied may be greater than 6 volts, but the converter **6** is preferably adapted to change the voltage and power from higher voltage or from AC to DC as needed (at least 6 volts DC being preferred). The power source **7** may be from public or private supplies, from storage devices, from generators, powered by internal combustion engines, hydraulic, solar, or wind, or any other similar, suitable, or conventional source. The controller/converter **6** may also be in communication with several sensing and control devices including, but not limited to, a power sensor **8**, reactor sensor(s) **9** (e.g., a chlorine sensor, a pH sensor, and/or an ORP sensor), a pressure and/or flow sensor **10**, a water quality sensor **11**, a counter **12**, a service indicator **13**, and other similar, suitable, or conventional devices. Each may be a commercially available component. Although the sensors are shown either inside or outside of the treatment reactor **4** in this example, it should be recognized that each of the sensors may be positioned at any desired location inside or outside of the treatment reactor **4**. The power sensor **8** may be used to assure that the controller/converter **6** is receiving the desired input power. There may be at least one sensing device **9** within the fluid phase in the reactor **4** to detect the level of reacting power, such as with an ORP measuring device, to detect the level of chlorine, to detect the pH level, to assure that current is flowing across the electrodes **5**, and/or to perform other desired sensing functions. The inlet valve **2***a* and the outlet valve **2***b* may be controlled by the controller/converter **6**. The flow and/or pressure sensors **3** and **10** may send information to the controller/converter **6** to indicate flow and or pressure levels. The water quality sensor **11** may be included to indicate that treatment has been achieved or other quality parameters are met. Examples of the water quality sensor **11** include turbidimeters, biosensors, biological sensors, and other similar, suitable, and conventional devices. The counter **12** on the demand side of the reactor **4** can be used to determine and/or indicate number of cycles/uses. The service indicator **13** is an alarm/notification device that may be used to notify the user that service is needed for the system. Each of the exemplary sensing and control devices can be used to provide information to the controller to obtain the desired operation of the system. The resulting product water **14** may then be discharged from the system to the use device or any other desired location.

[**0022**] The treatment reactor **4** may be configured in various ways. For optimum performance, the reaction chamber **4** is configured to obtain maximum contact of the reacting solution with the ORP-generating system. Accordingly, it is desired to configure the reaction chamber **4** such that as much water as possible passes generally between the electrodes **5** or otherwise through the electric field created by the flow of current between the electrodes **5**. The electrodes **5** are preferably parallel to one another and may be geometrically arranged either perpendicular or parallel to the flow, with or without baffles for directing flow. For example, **FIG. 2** shows an alternative embodiment in which the electrodes **5** are arranged parallel to the flow of water. The preferred orientation of the electrodes **5** is to maximize the time of flow of water between the electrodes **5** or otherwise through the electric field created by the electrodes **5**. In many applications, this will be when the flow direction is parallel to the longitudinal dimensional of the electrodes **5**, such as shown in **FIG. 2**.

[**0023**] Nevertheless, it should be recognized that the treatment reactor may have any configuration and orientation which is suitable for the intended application. The configuration of the treatment reactor is not limited to parallel electrodes or electrodes that are perpendicular or parallel to the flow of water. **FIGS. 3 through 5** show some alternative configurations of treatment reactors. **FIG. 3** shows a treatment reactor **50** and electrodes **52**, and **FIG. 4** shows a treatment reactor **60** and electrodes **62**. In addition, **FIG. 5** illustrates a treatment reactor **70** having electrodes **72**. In **FIG. 5**, the central electrode **72** could, for example, serve as the common for the surrounding electrodes **72**.

[**0024**] Any suitable material may be used to make the electrodes of the present invention. In order to limit deposition and corrosion reactions at the electrodes, it is preferred to select a material that is highly conductive, but non-reactive, in a water environment. Examples of the electrodes include, but are not limited to, carbon electrodes, ceramic electrodes, metallic electrodes, carbon/ceramic ash electrodes, and other similar, suitable, or conventional types of electrodes.

[**0025**] The controller controls the electrical power applied to the electrodes. In addition, the controller may be adapted to provide one or more of the following functions:

[**0026**] (1) Provide a means to delay dispensing treated water for a variable period of seconds after a signal is received to dispense treated water;

[**0027**] (2) Provide a means to continue power to the electrodes for a set time period after dispensing of treated water has ended;

[**0028**] (3) Provide a means to reverse the current to the treatment electrodes after a predetermined number of treated water dispense cycles;

[**0029**] (4) Provide a means to prevent the dispensing of treated water if the supply water pressure is outside specifications;

[**0030**] (5) Provide a means to prevent dispensing treated water if the water flow rate is outside specifications;

[**0031**] (6) Provide a means to time the interval between treated water dispenses and provide power to the treatment electrodes after a predetermined time period;

[**0032**] (7) Based on dispensed water flow rate, vary the power supplied to the treatment electrodes;

[**0033**] (8) Provide a source of DC power (preferably at least 6 volts) to the treatment electrodes when supplied with power from 120/240 volt AC 50-60 hertz power source;

[**0034**] (9) Provide the ability to accept power from alternative sources, e.g., storage cells (batteries), solar, hydraulic, wind, etc.; and

[**0035**] (10) Provide a means to apply variable power to the treatment electrodes as a function of a signal from a water quality sensor.

[**0036**] **FIG. 6** is an example of the flow control logic of a controller that provides some or all of the above functions. When provided with a signal to dispense treated water, the controller of this embodiment is adapted to verify that the following conditions are met in order to dispense the treated water: (1) Electric power is available to the treatment electrodes; (2) Electrodes are in place; (3) Water flow rate is within specification; and (4) Water supply pressure is within specification. In addition, if available and relevant, a water quality sensor may be incorporated to assist in controlling the power to the electrodes and the valves. The water quality sensor may be of any type that monitors a condition of the water. For instance, a sensor may be provided to sense the presence of bacteria, viruses, protozoa, or other pathogens that require treatment and/or to detect the oxygen-reducing potential of the water. If the quality of the water does not satisfy a desired standard, the sensor can communicate with the controller to not dispense the water. In addition, the system may be configured to supply power to the electrodes when the sensor senses a predetermined condition of the water, e.g., an unpurified condition.

[**0037**] The controller may intermittently or periodically reverse the current flow to the electrodes. By reversing the current flow, the controller may help to limit the corrosion or deposition reactions at the electrodes. For example, as shown in **FIG. 6, a** counter may be used to count the number of times that power is supplied to the electrodes or that there is a demand for the water. Alternatively, a counter may be used to accumulate the amount of time that power is supplied to the electrodes. When the counter reaches a predetermined level, the controller can then reverse the current to the electrodes, and the counter can be reset.

[**0038**] As noted in the above examples, the controller may control the opening and closing of the inlet and outlet control valves to assure adequate purification of the water. Alternatively, the controller may be adapted to sense when the valves are closed, or the controller may be adapted to sense when water is not flowing through the treatment reactor. As a result, in any of the embodiments, the controller can be adapted to assure continuous functioning of the process by providing adequate contact of the water with the electrolysis system and adequate reaction time. Moreover, the controller can be adapted to stop the flow of water through the treatment reactor when the treatment reactor is not operational.

[**0039**] When there is demand for the water, i.e., water is flowing through the treatment reactor, the controller may continuously provide power to the electrodes to purify the water. However, it should be recognized that the system may be configured differently. For instance, the system may be configured to periodically or intermittently supply power to the electrodes when there is demand for the water.

[**0040**] The controller may continue to supply electricity to the electrodes when there is no demand for the water. However, in an alternative embodiment, the controller can shut off the supply of electricity to the electrodes when there is no demand for the water. For instance, the controller may close one or both of the control valves if there is no demand for the water. Alternatively, the controller may sense that one or both of the control valves have been closed, or the controller may sense that water is not currently flowing through the treatment reactor. In such instances, it may not be desired or necessary to continuously supply electricity to the electrodes. Accordingly, the controller may shut off the flow of electricity to the electrodes until there is demand for the water again. Alternatively, the controller may periodically or intermittently supply a flow of electricity to the electrodes while there is no demand for the water. By periodically or intermittently supplying electricity to the electrodes when there is no demand for the water, the purified condition of the water may be maintained so that it is substantially ready for use when the demand returns.

[**0041**] When demand returns for the water after a period of inactivity, the system may be configured to assure that the water is purified prior to restoring the flow of water. For example, when demand returns for the water, the controller may restore power to the electrodes prior to opening the inlet and/or outlet valve. After a period of time or when a desired condition of the water is achieved, the controller may open the valve or valves to restore the flow of water. In this manner, the present invention can assure desired purification of the water when demand returns after a period of inactivity.

[**0042**] The inventors have surprisingly discovered that improved design and operational controls enable the present invention to treat water at the point of use, especially to achieve disinfection of the water. For example, the present invention may be used to purify water in a beverage dispensing machine, an ice-making machine, a tap water dispensing apparatus for domestic or commercial use, a water dispensing machine that uses tap water, or any other known, similar, or conventional use of potable water. An example of a beverage dispensing machine is a soft drink machine that mixes water with concentrate to produce beverages. Examples of an ice-making machine include those incorporated in beverage dispensing machines and refrigerators.

[**0043**] The present invention can be used to purify water from any desired source. For example, the present invention can be used in portable models for uses such as disinfecting water in remote areas, such as in hiking and camping, using water from natural sources such as streams, springs, lakes, and other types of natural water sources. In addition, a portable embodiment of the present invention could be used by travelers who wish to disinfect water supplied at hotels, motels, or from other public or private supplies.

[**0044**] The present invention does not require a recirculation line or other treatment systems. However, it should be recognized that the present invention may be employed in conjunction with a recirculation line. In addition, it is appreciated that the present invention can be used in conjunction with, or in place of, other water purification systems.

[**0045**] In addition, the present invention is relatively easy to service. The present invention reduces the need to run a sanitizing solution through the entire device for cleansing purposes. The controller of the present invention can stop the flow of water through the treatment reactor, and the electrodes can be replaced or cleaned if desired or necessary. The electrodes may be replaced or cleaned periodically, intermittently, or in response to a specific condition. For instance, the controller may monitor one or more counters to determine if one or both of the electrodes should be replaced or cleaned. In addition, a service indicator may be in communication with the controller to indicate that the electrodes should be replaced or cleaned or that another feature of the system needs service.

[**0046**] The preferred embodiments herein disclosed are not intended to be exhaustive or to unnecessarily limit the scope of the invention. The preferred embodiments were chosen and described in order to explain the principles of the present invention so that others skilled in the art may practice the invention. Having shown and described preferred embodiments of the present invention, those skilled in the art will realize that many variations and modifications may be made to affect the described invention. Many of those variations and modifications will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

What is claimed is:

1. A system for the purification of water, said system comprising:

a treatment reactor having an inlet for receiving water and an outlet for dispensing water, said treatment reactor housing at least two electrodes;

an outlet valve in fluid communication with said outlet of said treatment reactor; and

a controller in electronic communication with said at least two electrodes and said outlet valve, said controller adapted to control the power supplied to said at least two electrodes, said controller further adapted to control the power supplied to said outlet valve for opening and closing said outlet valve.

2. The system of claim 1 further comprising:

an inlet valve in fluid communication with said inlet of said treatment reactor;

wherein said controller is in electronic communication with said inlet valve, said controller further adapted to control the power supplied to said inlet valve for opening and closing said inlet valve.

3. The system of claim 2 wherein said controller is adapted to close said inlet valve after determining that there is an undesirable amount of at least one contaminant in the water.

4. The system of claim 1 wherein said controller is adapted to close said outlet valve after determining that there is an undesirable amount of at least one contaminant in the water.

5. The system of claim 1 wherein said controller is adapted to stop the flow of water through said treatment reactor after determining that at least one of the conditions is satisfied selected from the group consisting of: no electric power to said at least two electrodes, at least one of said at least two electrodes is not in place, water flow rate is outside of a desired range, and water supply pressure is outside of a desired range.

6. The system of claim 1 further comprising a water quality sensor in electronic communication with said controller, said water quality sensor adapted to detect the presence of at least one contaminant in the water.

7. The system of claim 6 wherein said controller is adapted to adjust the power to said at least two electrodes as a function of the presence of said at least one contaminant in the water.

8. The system of claim 1 wherein said controller is adapted to periodically provide power to said at least two electrodes when said outlet valve is closed.

9. The system of claim 1 wherein said controller is adapted to delay opening said outlet valve for a predetermined period of time after providing power to said at least two electrodes.

10. The system of claim 1 further comprising a counter in electronic communication with said controller, said counter adapted to monitor the amount of use of the system.

11. The system of claim 1 further comprising a service indicator in electronic communication with said controller, said service indicator adapted to indicate that service is needed in response to input from said controller.

12. The system of claim 11 wherein said service indicator is adapted to indicate that service is needed when at least one of the conditions is satisfied selected from the group consisting of: at least one of said at least two electrodes is not in place, an insufficient amount of water is in said treatment reactor, water flow rate is outside of a desired range, and water supply pressure is outside of a desired range.

13. The system of claim 1 further comprising a water pressure sensor in electronic communication with said controller, said water pressure sensor adapted to measure the water pressure.

14. The system of claim 1 further comprising a water flow sensor in electronic communication with said controller, said water flow sensor adapted to measure the flow of water through the system.

15. The system of claim 1 wherein said controller is adapted to shut off the power to said at least two electrodes when at least one of the conditions is satisfied selected from the group consisting of: at least one of said at least two electrodes is not in place, and an insufficient amount of water is in said treatment reactor.

16. The system of 1 wherein:

said controller is adapted to receive AC or DC power from a power source; and

said controller is adapted to provide DC power to said treatment reactor.

17. A control system for an electrolytic water purification system, said control system comprising:

a controller adapted to control the power provided to electrodes of said electrolytic water purification system, said controller further adapted to control the flow of water through said electrolytic water purification system.

18. The control system of claim 17 wherein said controller is adapted to control the power to said electrodes and the flow of water through said electrolytic water purification system to ensure desired treatment of contaminants in the water.

19. A treatment reactor for an electrolytic water purification system having a control system, said treatment reactor comprising:

a reaction chamber having an inlet and an outlet for transferring a flow of water;

a plurality of electrodes in said reaction chamber, said electrodes in electronic communication with said control system; and

at least one sensor in said reaction chamber, said at least one sensor in electronic communication with said control system, said at least one sensor selected from the group consisting of a biological sensor, an oxygen-reduction potential sensor, a pH sensor, a turbidimeter, and a chlorine sensor;

wherein, based on communication from said at least one sensor, said control system is adapted to perform at least one function selected from the group consisting of: controlling the power to said electrodes, and controlling the flow of water through said reaction chamber.

20. The treatment reactor of claim 19 wherein said electrodes are arranged parallel to the flow of water through said reaction chamber.

* * * * *