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(54) METHOD AND APPARATUS FOR ELECTROLYTIC DISINFECTION OF WATER

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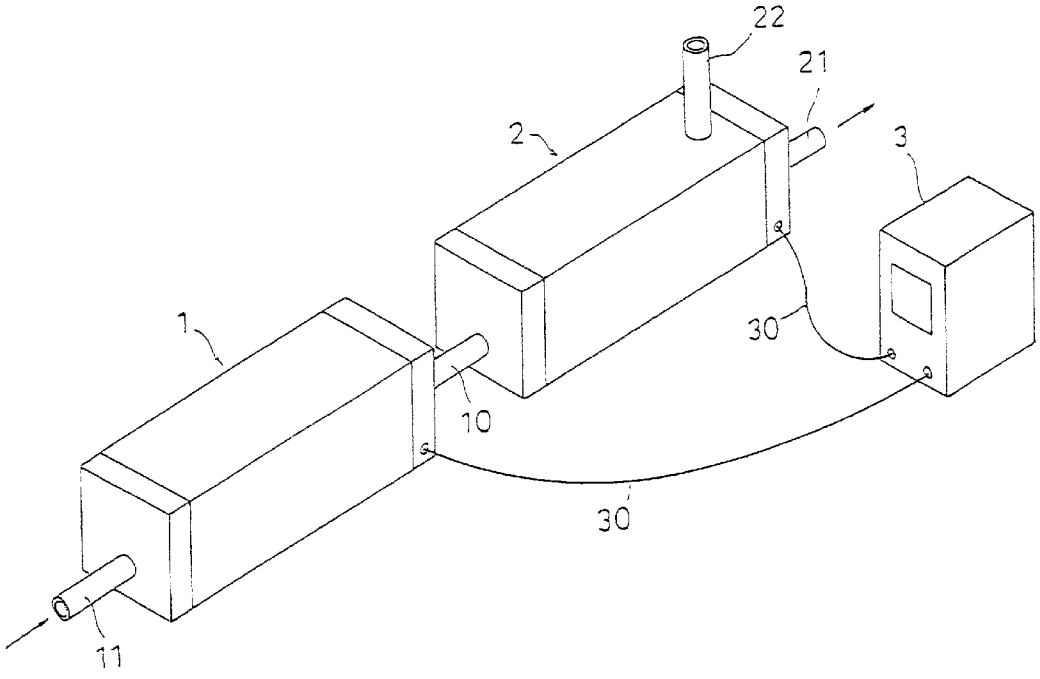
(57) **ABSTRACT**

An electrolytic water disinfection method and apparatus for disinfecting water, using water containing hypochlorite and silver ions, or hypochlorite, silver ions and copper ions in solution.

This method and apparatus is useful for disinfecting in a quick, safe and unfailing way, water, such as swimming pool water, washing water for food materials, sanitizing water for machines and implements or containers and drinking water in ships, without any conventional drawbacks.



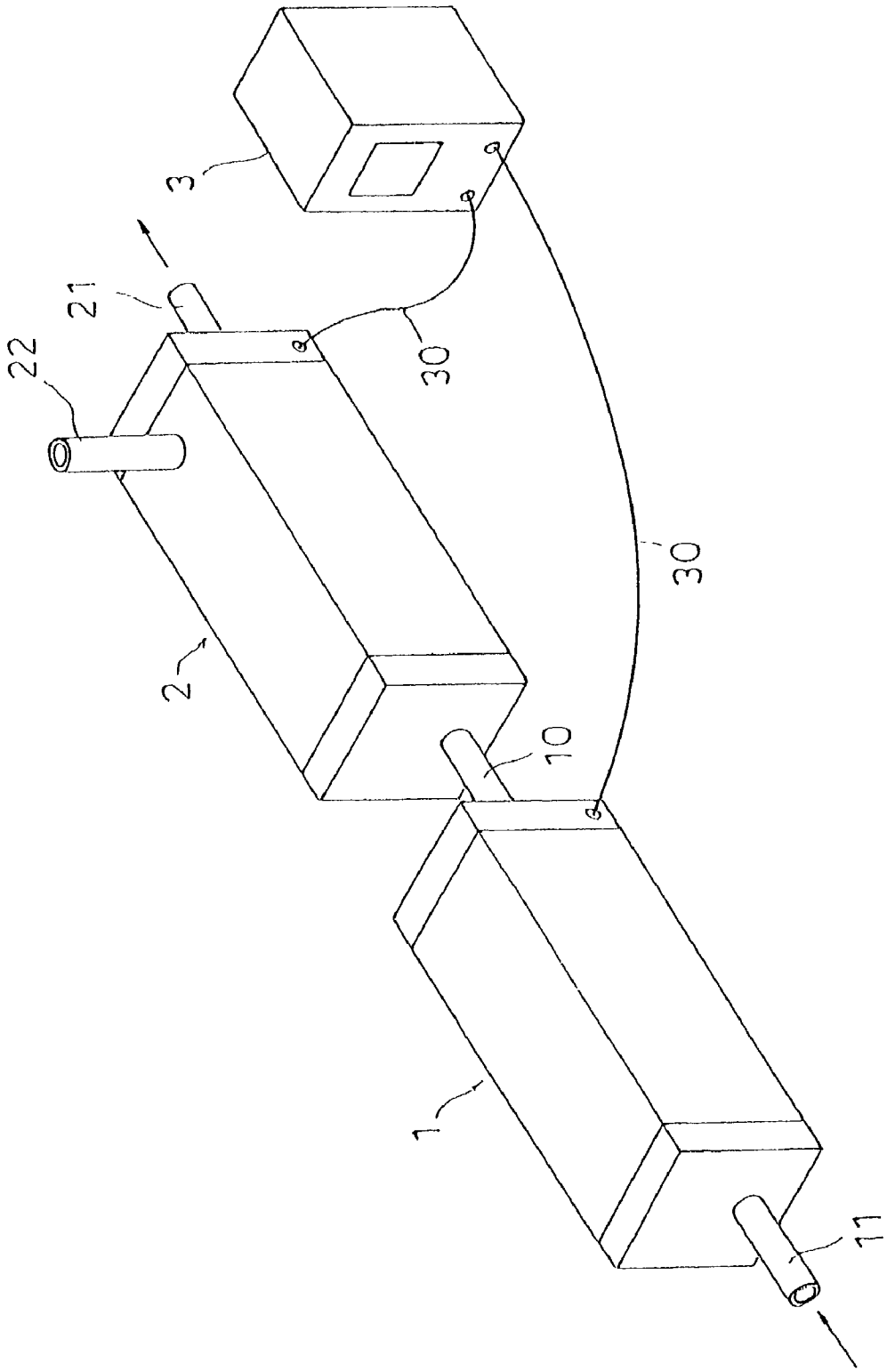


Fig. 1

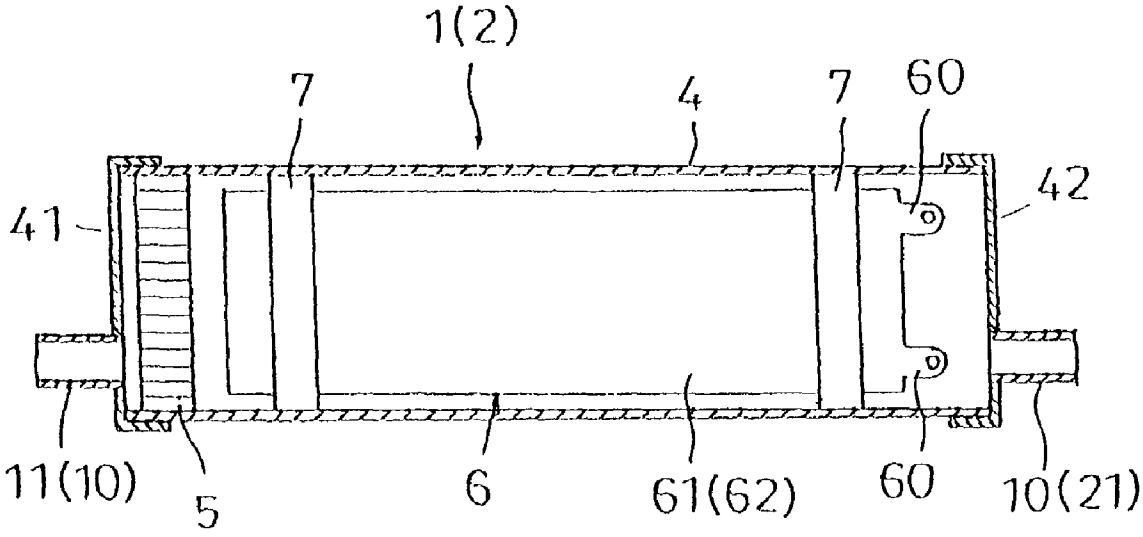


Fig. 2

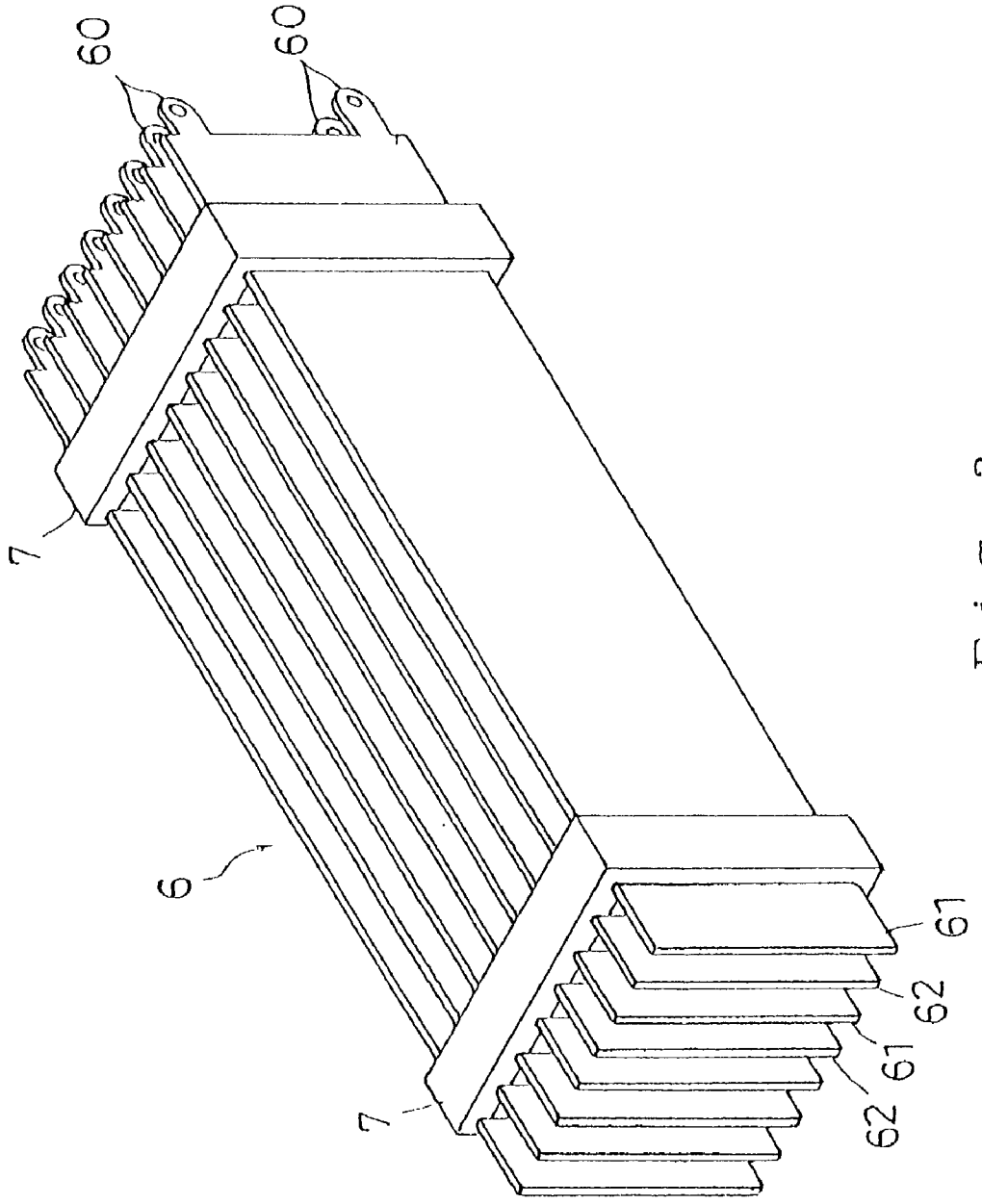


Fig. 3

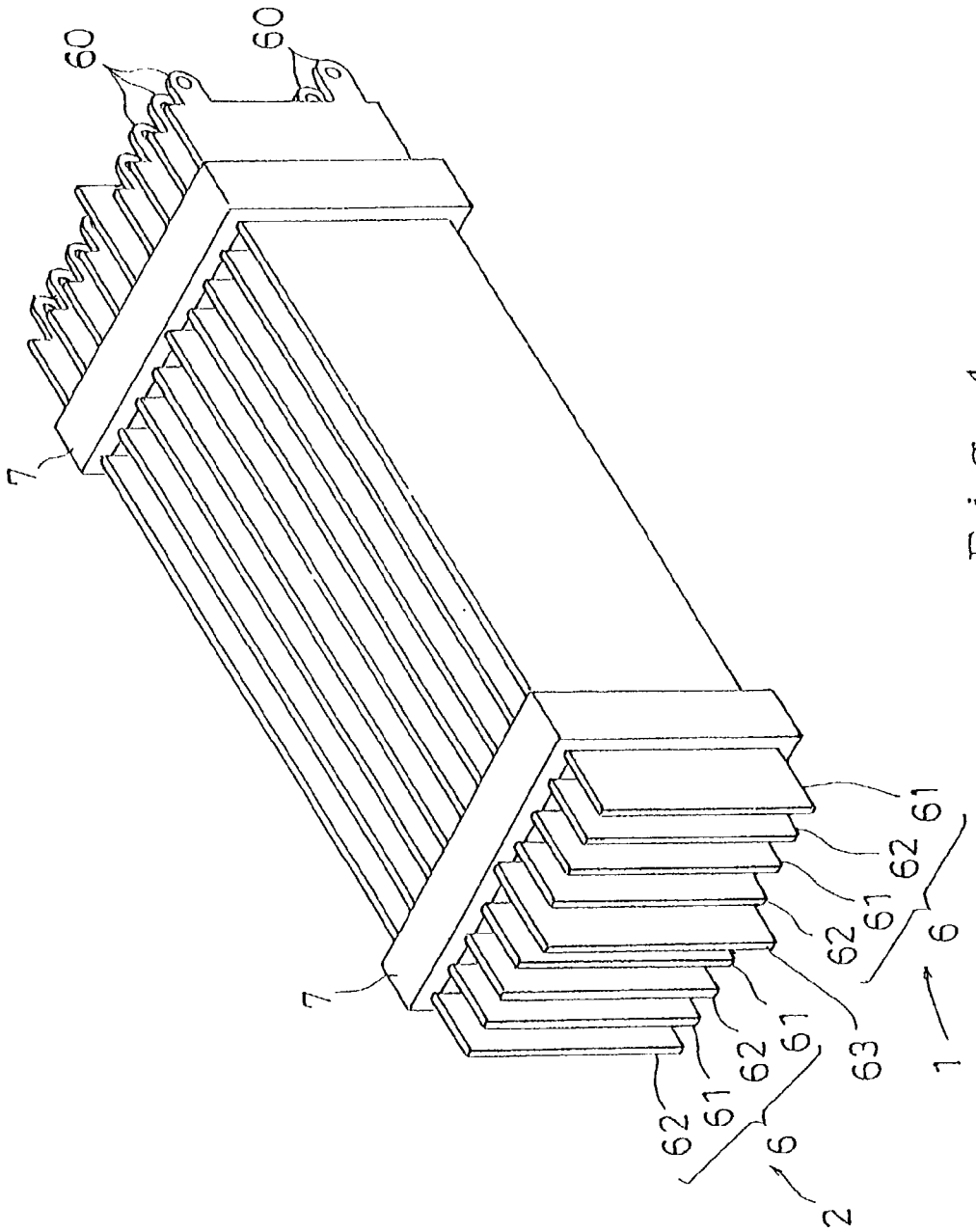


Fig. 4

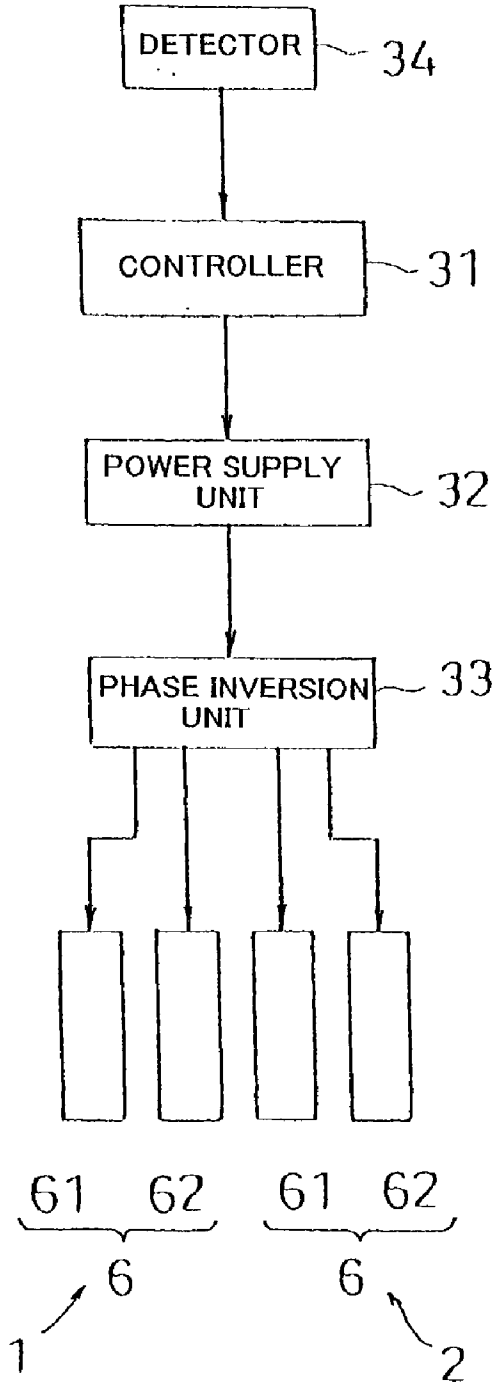

DETECTOR
34
CONTROLLER
31
POWER SUPPLY UNIT
32
PHASE INVERSION UNIT
33
61 62
61 62
6
6
1
2

Fig. 5

METHOD AND APPARATUS FOR ELECTROLYTIC DISINFECTION OF WATER

FIELD OF THE INVENTION

[0001] The present invention relates to an electrolytic water disinfecting method and apparatus for swimming pool water, washing water for food materials, sanitizing water for machines and implements or containers and drinking water in ships.

DESCRIPTION OF THE RELATED ART

[0002] In the case of a swimming pool, water is generally disinfected by a chlorine component of a sodium hypochlorite solution pumped in. However, it is difficult to control the concentration of the solution in this method. Too small an injection of the solution cannot achieve sufficient disinfecting effect and may still cause microorganism and algae propagation. Excessive injection, on the other hand, may cause some harmful results such as damaged eyes or decolorized hair. Especially in a hot swimming pool in winter, due to its closed windows and high water temperature, chlorine in water evaporates and the room is filled with chlorine gas, which is harmful for human health and may erode metallic articles inside. In addition, there are viruses which can survive chlorine disinfection, as seen in the case of molluscum contagiosum viruses in a swimming pool. Moreover, evaporation of chlorine during a long-term voyage causes a non-sterilized state in drinking water tanks of ships, which may have an adverse effect on crew's health.

[0003] To study water disinfection and sterilization effects, the present inventors compared the use of water containing hypochlorite and silver ions, or hypochlorite and silver ions and copper ions in solution with that of hypochlorite alone. They found the former achieves far stronger effects, while reducing hypochlorite used, i.e., keeping lower chlorite concentration in water disinfected. To be specific, water containing hypochlorite and silver ions, or hypochlorite and silver ions and copper ions in solution achieves strong disinfection and sterilization effects; i.e., the water bonds with enzyme in the cells of lower organisms such as micro organisms or algae, effectively inhibits physiological action which transforms sources of nutrition into energy and destroys their cells by coagulating the protein. The water also has a deterrent effect on infectious bacteria propagation.

[0004] The object of the present invention is to provide an electrolytic water disinfecting method and apparatus for disinfecting, in a quick, safe and unfailing way, water such as swimming pool water, washing water for food materials, sanitizing water for machines and implements or containers and drinking water in ships, using water containing hypochlorite and silver ions, or hypochlorite, silver ions and copper ions in solution, without any conventional drawbacks.

SUMMARY OF THE INVENTION

[0005] To achieve the above object, a method according to the present invention is to disinfect water by dissolving hypochlorite and silver ions.

[0006] Water containing hypochlorite and silver ions quickly achieves strong disinfection and sterilization effects, with hypochlorite to be used reduced, i.e., chlorite concentration in water to be disinfected kept lower. Adding the above water to water to be disinfected, such as swimming pool water, deters microorganisms and algae unfailingly and safely from propagating without causing the erosion of metal articles. Likewise, washing water for food materials, sanitizing water for machines and implements or containers and drinking water in ships are disinfected unfailingly, safely and quickly by adding the above water.

[0007] In disinfecting water, it is preferable to dissolve copper ions in addition to hypochlorite and silver ions. This brings more effective results for water disinfection and infectious bacteria propagation determent.

[0008] An apparatus according to the present invention comprises a first electrolysis device having at least a pair of electrodes, which generate silver ions by electric conduction and a second electrolysis device having at least a pair of electrodes, which generate hypochlorite by electric conduction.

[0009] By being simply connected to a water circulation path of a swimming pool or a drinking water tank in a ship, the above electrolytic apparatus makes it possible for water to be disinfected unfailingly, safely and quickly. To be specific, as swimming pool water is generally employed tap water disinfected by sodium hypochlorite, in which sodium chloride to act as an electrolyte component remains. Electrolyzation by electric conduction to each electrode in the second electrolysis device generates Cl_2 on the anode side, and NaOH on the cathode side, both of which react and generate NaClO in the water to be disinfected. In the first electrolysis device, electrolyzation by electric conduction to each electrode generates silver ions Ag^+ on the anode side, which are held in water to be disinfected. By such water containing NaClO and Ag^+, water is disinfected.

[0010] The above first electrolysis device is preferably provided with at least a pair of electrodes which generate silver ions and copper ions by electric conduction. By electrolyzation by electric conduction to each electrode, this device generates silver ions Ag^+ and copper ions Cu^{2+} on the anode side which are held in water to be disinfected. And by using the water containing both ions Ag^+ and Cu^{2+}, and NaClO, effective water disinfection is achieved.

[0011] The electrodes of the above first and second electrolysis devices are preferably housed in parallel in each casing. This allows the whole apparatus to be small, which leads to its compact installation in a swimming pool or a drinking water tank in a ship.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] **FIG. 1** is a perspective view of an embodiment according to the present electrolytic water disinfecting apparatus;

[0013] **FIG. 2** is a vertical sectional view of the first and second devices in the apparatus;

[0014] **FIG. 3** is a perspective view of an electrode assembly inside the present apparatus;

[0015] **FIG. 4** is a perspective view of another embodiment of the electrode assembly;

[0016] **FIG. 5** is a schematic block flow diagram illustrating the control of electric conduction to the electrode assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Referring to the drawings, embodiments of the invention are described as follows:

[0018] **FIG. 1** is a schematic view according to the present electrolytic water disinfecting apparatus. The electrolytic water disinfecting apparatus comprises the first electrolysis device **1** which generates silver ions and the second electrolysis device **2** which generates sodium hypochlorite as an example of hypochlorite. The two devices are connected in series via a communicating tube **10**, and an inflow tube **11** formed on the inlet side of the first electrolysis device **1** and an outflow tube **21** formed in the second electrolysis device **2** are connected with a water supply and drain path of a swimming pool and the like (not shown). Water in the above water supply and drain path, which is disinfected by sodium hypochlorite and the like, still contains sodium chloride to act as an electrolyte component. Electrolyzation is conducted with the above water introduced into the two devices **1, 2**, which generate silver ions and sodium hypochlorite. And by water containing these, water such as swimming pool water is disinfected.

[0019] The above first and second electrolysis devices **1, 2** are connected with a control unit **3** via lead wires **30**, in which a controller controls current conduction to the electrodes in the above two devices **1, 2**. The two devices **1, 2** may be installed forward or backward in the direction of water advection.

[0020] Because the above first and second electrolysis devices **1, 2** have almost the same structure, the two are described with reference to the same drawing. The two devices **1, 2** are different only in that they use different materials for their electrodes inside and that the second device is provided with a vent line **22** for hydrogen gas generated together with sodium hypochlorite on electrolyzation. As shown in **FIG. 2**, both devices **1, 2** are provided, in a casing whose longitudinal ends are closed by lids **41,42**, a rectifier **5** positioned forward in the direction of water advection and an electrode assembly **6** positioned backward. One of the lids **41, 42** is connected with the inflow tube **11** or communicating tube **10**, and the other is connected with the communicating tube **10** or outflow tube **21**.

[0021] **FIG. 3** shows an embodiment of the electrode assembly **6** for the devices **1, 2**. In the drawing, four pairs of two opposing electrodes **61, 62** are retained at both their longitudinal side portions by space holding members **7, 7** so that the electrodes may be approximately evenly spaced. Terminals **60** are formed in the upper and lower longitudinal ends of the electrodes **61, 62**, and connected with lead wires **30** extending from the control unit **3**. In this embodiment, a pair of electrodes **61, 62** in the first electrolysis device **1** are made of silver or a silver-copper alloy. The electrodes made of these materials are immersed in the water containing sodium chloride to act as an electrolyte component. And electrolyzation with current conduction to such electrodes generates silver ions and copper ions. For example, with silver and a silver-copper alloy, or silver-copper alloys phase-inverted as counter electrodes, direct current electrolyzation generates silver ions and copper ions. With silver materials as counter electrodes, direct current electrolyzation generates silver ions alone. On the other hand, the second electrolysis device **2** employs a pair of electrodes **61, 62** made of titanium coated with platinum on one or both titanium surfaces. With these electrodes phase-inverted as counter electrodes, direct current electrolyzation generates sodium hypochlorite.

[0022] It is important that the electrode assembly **6** employs with even-numbered electrodes, e.g., a pair of electrodes. If direct current electrolyzation is conducted with odd-numbered electrodes phase-inverted, an equal amount of electric current does not flow to each electrode at phase inversion time and hardly any electrolyzation takes place. For example, if electrolyzation is conducted using seven electrodes, four of which are impressed positive and three of which are impressed negative, electric current markedly decreases at phase inversion time and electrolyzation becomes impossible.

[0023] In the embodiment shown in **FIG. 4**, assembled electrodes **6** in the first and second electrolysis devices **1, 2** are positioned in parallel in the latitudinal direction orthogonal to their longitudinal direction with a partition **63** interposed at their latitudinal center and are held at both longitudinal end portions by space holding member **7, 7** so that each electrode **61, 61** may be approximately evenly spaced. The electrode assembly **6** thus retained is placed in a casing **4**. This allows the whole apparatus to be small, which leads to its compact installation in a swimming pool or a drinking water tank in a ship.

[0024] **FIG. 5** shows a schematic block flow diagram illustrating the control of electric conduction to the electrode assembly **6**. The output side of a controller **31** provided in the control unit **3** is connected with a power supply **32** and a phase inversion unit **33** controlled by a timer and the like provided in the controller **31**. The output side of the phase inversion unit **33** is connected with each electrode **61, 62** of the electrode assembly **6** in the first and second electrolysis devices **1, 2**. The input side of the controller **31** is connected with a detector **34** which detects the necessity of disinfecting water. The detector **34** may be a pH meter or an electric conduction meter which detects how sodium hypochlorite, silver ions and copper ions are dissolved in water.

[0025] The operation of the present electrolytic water disinfecting apparatus is described in the following. The detector **34** detects how sodium hypochlorite, silver ions and copper ions are dissolved in water. When the amount of the dissolved matter is less than a certain level and water disinfection is needed, electric current is passed, based on output from the controller unit **31**, from the power supply unit **32** to each electrode **61, 62** of the electrode assembly **6** through the phase inversion unit **33**.

[0026] In current conduction, positive and negative electric charges are alternately impressed on the electrodes **61,62** by phase inversion by the phase inversion unit **33** and silver ions and copper ions or silver ions are consequently generated on the electrodes in the first electrolysis device **1**, which are dissolved in water. On the electrodes in the second electrolysis device **2**, sodium hypochlorite is generated and dissolved in water. Water is disinfected by the water in which sodium hypochlorite, silver ions and copper ions are dissolved.

[0027] Sodium hypochlorite concentrations in water to be disinfected are preferably between 0.01 and 0.04 ppm, specifically between 0.015 and 0.03 ppm. Silver ion con-

centrations in water to be disinfected are preferably between 0.03 and 0.08 ppm, while copper ion concentrations in water to be disinfected are preferably between 0.1 and 0.5 ppm. As for silver ions, the more preferable concentrations are between 0.04 and 0.06 ppm. As for copper ions, more preferable concentrations are between 0.2 and 0.4 ppm. These ranges of concentrations can quickly achieve strong disinfection and sterilization effects, deter unfailingly and safely microorganisms and algae from propagating and further have exceptional deterrent effects on infectious bacteria propagation.

[0028] In the following description, the data comparison of disinfecting effects between the addition of sodium hypochlorite NaClO alone and that of sodium hypochlorite and silver ions is made.

[0029] Test 1

[0030] Make sample solutions by adding NaClO (0.02 ppm) alone to water to be disinfected or different chlorine concentrations (0.1; 0.15; 0.2; 0.35; 0.5 ppm) and additional sample solutions by dissolving this NaClO and Ag^+ (0.06 ppm). And after making 80000 parts/ml *Escherichia coli* contact these sample solutions for one minute, remaining *Escherichia coli* parts are examined. The data are shown in Table 1.

[0031] As is obvious from Table 1, in comparison with sample solutions to which NaClO alone is added, those in which NaClO and Ag^+ are dissolved can achieve far stronger sterilization effects and sterilize *Escherichia coli* with a reduced chlorine concentration, i.e., a reduced amount of NaClO usage. While, with NaClO alone added, 10000 parts of *Escherichia coli* still exist in water with a chlorine concentration of between 0.1 and 0.2 ppm, a solution in which NaClO and Ag^+ are dissolved reduces remaining *Escherichia coli* to 600 parts and destroys almost all *Escherichia coli*, in water with a chlorine concentration of approximately 0.1 ppm.

TABLE 1

Chlorine concentration (ppm)	NaC10 Alone Added	NaC10 + Silver Ions added
0.1	10000	600
0.15	10000	600
0.2	10000	600
0.35	500	0
0.5	0	0

[0032] TEST 2

[0033] Make sample solutions by adding NaClO (0.02 ppm) alone to water to be disinfected of a given chlorine concentration (0.05 ppm) and additional sample solutions by dissolving this NaClO and Ag^+ (0.06 ppm). And after making 80000 parts/ml *Escherichia coli* contact these sample solutions for different periods (5; 15; 35; 60; 85; 120 seconds), remaining *Escherichia coli* parts are examined. The data are shown in Table 2.

[0034] As is obvious from Table 2, in comparison with a sample solution to which NaClO alone is added, that in which NaClO and Ag^+ are dissolved can quickly achieve stronger sterilization effects and sterilize *Escherichia coli* in a short time. While, with NaClO alone added, *Escherichia coli* still exist after 85 seconds of contact time, a solution in which NaClO and Ag^+ are dissolved can destroy almost all *Escherichia coli* in approximately 15 seconds.

TABLE 2

Contact time (seconds)	NaC10 Alone Added	NaC10 + Silver Ions added
5	8000	4500
15	1800	0
35	700	0
60	50	0
85	50	0
120	0	0

[0035] While sodium hypochlorite is employed as an example of hypochlorite in the aforesaid embodiments, calcium hypochlorite may also be employed. In the case of disinfecting water in which hypochlorite are not dissolved beforehand, hypochlorite is added to the water, which is passed through the first and second electrolysis devices **1**,**2**.

INDUSTRIAL APPLICABILITY

[0036] As described in the foregoing, the rpesent invention makes it possible to disinfect in a quick, safe and unfailing way water such as swimming pool water, washing water for food materials, sanitizing water for machines and implements or containers and drinking water in ships without any conventional drawbacks, using water containing hypochlorite and silver ions or hypochlorite, silver ions and copper ions in solution.

What is claimed is:

1. A method of electrolytic water disinfection, wherein hypochlorite and silver ions are dissolved in water.

2. The method of claim 1, wherein hypochlorite, silver ions and copper ions are dissolved in water.

3. An apparatus for electrolytic water disinfection, comprising

a first electrolysis device having at least a pair of electrodes, which generate silver ions by electric conduction;

a second electrolysis device having at least a pair of electrodes, which generate hypochlorite by electric conduction.

4. The apparatus of claim 3, wherein said first electrolysis device comprises at least a pair of electrodes, which generate silver ions and copper ions by electric conduction.

5. The apparatus of claim 3 or **4**, wherein said electrodes of said first and second electrolysis devices are housed in parallel in a casing.

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