

TITLE OF THE INVENTION
ELECTROLYZED WATER PRODUCTION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an electrolyzed water production system of the type which includes an electrolytic cell arranged to electrolyze diluted brine prepared by a mixture of raw water and saturated brine of predetermined concentration for producing electrolyzed water.

2. Description of the Prior Art

Disclosed in Japanese Patent Laid-Open publication 7-155764 is an electrolyzed water production system of this kind which includes an electrolytic cell arranged to be supplied with diluted brine prepared by a mixture of saturated brine of predetermined concentration and raw water supplied from an external source of raw water and activated by predetermined voltage applied at its electrodes. In the conventional production system, the property of the electrolyzed water is influenced by an amount of saturated brine mixed with the raw water. For this reason, the amount of saturated brine is adjusted by feedback control such that the electric current across the electrodes (or the conductivity of the diluted brine) becomes substantially equal to a predetermined target value.

However, since the amount of the saturated brine mixed with the raw water is always increased from constant amount under the feedback control when the system is activated to produce the electrolyzed water, the time required to produce the electrolyzed water having a desired property in one system disposed in the area where the raw water is hard water is largely different from the time required in another disposed in the area where the raw water is soft water.

In the conventional electrolyzed water production system, an



water with the raw water. The fluid pump is in the form of a fluid pump of the pulse driven type which includes a solenoid arranged to be applied with pulse train signals of predetermined period so that piston is reciprocated by attractive force caused by the solenoid energized. On the other hand, the feedback control is effected by an electrical control circuit of the digital type such as a microprocessor which is programmed to detect a value of electric current across the electrodes at a predetermined interval and to control the discharge amount of the fluid pump in such a manner that the value of electric current is adjusted to the target current value. In such feedback control of the fluid pump, however, the conductivity of the diluted brine is discontinuously detected by the digital circuit and fluctuates since the fluid pump is intermittently operated in response to each pulse applied thereto under control of the digital circuit. As a result, the feedback control is carried out depending upon the conductivity different from average conductivity of the diluted brine, and therefore the supply amount of the saturated brine becomes insufficient or excessive, resulting in irregular production of the electrolyzed water.

SUMMARY OF THE INVENTION

It is therefore, a primary object of the present invention is to provide an electrolyzed water production system wherein the amount of saturated brine mixed with the raw water is adjusted in accordance with the property of the raw water so that the concentration of diluted brine supplied to the electric cell is controlled in an optimal value within a predetermined period of time.

A secondary object of the present invention is to provide an electrolyzed water production system wherein the conductivity of diluted brine in the electrolytic cell is accurately detected to produce

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electrolyzed water homogeneous (stable) in quality under the feedback control.

According to the present invention, the primary object is accomplished by providing an electrolyzed water production system having a brine storage tank arranged to store saturated brine of predetermined concentration, brine supply means for supplying the saturated brine from the storage tank for mixing with raw water supplied from a source of raw water and an electrolytic cell arranged to be supplied with diluted brine prepared by a mixture of the raw water and saturated water for producing electrolyzed water, wherein an electric control apparatus for the electrolyzed water production system comprises detection means for detecting the conductivity of the diluted brine supplied to the electrolytic cell, feedback control means for controlling operation of the brine supply means in such a manner that the conductivity of the diluted brine detected by the detection means is adjusted to a predetermined target value, memory means for memorizing an amount of saturated brine mixed with the raw water in operation of the brine supply means under control of the feedback control means and initial control means for controlling operation of the brine supply means in such a manner that a supply amount of saturated brine mixed with the raw water is adjusted on a basis of the instant amount of saturated brine memorized in the memory means during previous operation of the brine supply means under control of the feedback control means when the electrolytic cell is activated to start production of the electrolyzed water.

In a practical embodiment of the present invention, it is preferable that the initial control means is designed to control operation of the brine supply means in such a manner that the supply amount of saturated brine mixed with the raw water is decreased in

a predetermined amount less than that of saturated brine memorized in the memory means. Alternatively, it is preferable that the initial control supply means is designed to delay operation of the brine supply means under control of the feedback control means until the conductivity of the diluted brine detected by the detection means becomes larger than a predetermined reference value.

In a modification of the present invention, the reference value may be defined by the target value of the feedback control means or defined to be decreased in accordance with lapse of time after the electrolytic cell is activated to start production of the electrolyzed water. In addition, the initial control means may be designed to operate the brine supply means under control of the feedback control means after lapse of a predetermined time when the electrolytic cell was activated to start production of the electrolyzed water. Alternatively, the initial control means may be modified to operate the brine supply means under control of the feedback control means after change rate of the conductivity of the diluted brine detected by the detection means decreased less than a predetermined reference value.

According to the present invention, the secondary object is accomplished by providing an electrolyzed water production system having a brine storage tank arranged to store saturated brine of predetermined concentration, a fluid pump of the type driven by each pulse of pulse train signals applied thereto from pulse signal generator to supply a predetermined amount of saturated brine from the brine storage tank for mixing with raw water supplied from a source of raw water, and an electrolytic cell arranged to be supplied with the diluted brine prepared by a mixture of the saturated brine and raw water for producing electrolyzed water, wherein an electric

control apparatus for the production system comprises detection means for detecting the conductivity of diluted brine supplied to the electrolytic cell at a first predetermined time interval, calculation means for calculating an average value of the conductivity successively detected by the detection means in sequence, and pulse control means for adjusting a period of the pulse train signals applied from the pulse signal generator in accordance with a difference between the calculated average value of the conductivity and a predetermined target value so that the average conductivity becomes substantially equal to the target value.

In the electrolyzed water production system described above, it is preferable that the pulse control means is designed to adjust the period of the pulse train signals at a second predetermined time interval more than the first predetermined time interval, and wherein the calculation means is designed to calculate the average value of the conductivity on a basis of plural data on conductivity detected by the detection means plural times at the first predetermined time interval during the second predetermined time interval except several data on conductivity detected successively by the detection means immediately after the pulse control means adjusts the period of the pulse train signals. It is also preferable that the calculation means is designed to weight the conductivity with a value which becomes larger as a difference between the conductivity detected by said detection means and the target value becomes larger for calculating a weighted integral of the conductivity. Alternatively the calculation means may be designed to weight the conductivity with a value which becomes smaller as a difference between the conductivity detected by said detection means and the target value becomes larger for calculating a weighted integral of the conductivity. The calculation means may be designed to weight the conductivity with a value which

becomes larger as a difference between the conductivity detected by said detection means and the target value becomes larger until a predetermined condition is satisfied after the electrolytic cell was activated to start production of electrolyzed water and to weight the conductivity with a value which becomes smaller as a difference between the conductivity detected by said detection means and the target value becomes larger after the predetermined condition is satisfied.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the present invention will more readily appreciated from the following detailed description of preferred embodiments thereof when taken together with the accompanying drawings, in which

FIG.1 is a schematic illustration of an electrolyzed water production system of the first embodiment in accordance with the present invention.

FIG.2 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG.1 with respect to the first embodiment.

FIG.3 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG.1 with respect to the second embodiment.

FIG.4 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG.1 with respect to the first modified embodiment of the second embodiment.

FIG.5 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG.1 with respect to the first and the second modified embodiment of the second embodiment.

FIG.6 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG.1 with respect to the second

modified embodiment of the second embodiment.

FIG. 7 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG. 1 with respect to the third modified embodiment of the second embodiment.

FIG. 8 is a time chart for explanation of operation of a conventional electrolyzed water production system.

FIG. 9 is a time chart for explanation of operation of the electrolyzed water production system of the first embodiment.

FIG. 10 is a time chart for explanation of operation of the electrolyzed water production system of the modified embodiment of the first embodiment.

FIG. 11 is a time chart for explanation of operation of the electrolyzed water production system of the second embodiment.

FIG. 12 is a schematic illustration of an electrolyzed water production system of the third, the fourth and the fifth embodiment in accordance with the present invention.

FIG. 13 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG. 12 with respect to the third, the fourth and the fifth embodiment.

FIG. 14 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG. 12 with respect to the third and the fifth embodiment.

FIG. 15 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG. 12 with respect to the third, the fourth and the fifth embodiment for a control of a fluid pump shown in FIG. 12.

FIG. 16 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG. 12 with respect to the fourth embodiment.

FIG. 17 is a flow chart of a control program (routine) executed by an electric circuit shown in FIG. 12 with respect to the fifth

embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In figure 1 of the drawings, there is schematically illustrated a first preferred embodiment of an electrolyzed water production system in accordance with the present invention. The electrolyzed water production system includes a cabinet 10 containing an electrolytic cell 20, a power source 30, an electric control circuit 50 including a microprocessor (not shown) and a fluid pump 60, a storage tank 40 disposed on the cabinet 10, and a remote controller 70 operated by an operator.

The electrolytic cell 20 is subdivided into a pair of electrode chambers by the membrane 21 and contains a pair of electrodes 24, 25 in each chamber in such a manner that they face each other through the membrane 21. The electrolytic cell 20 is connected to a first supply conduit P1 at the lower portion of the cell 20 and is connected to outlet conduits P3, P4 at the upper portion of the cell 20.

The power source 30 is a constant-voltage power supply. The constant voltage generated by the power source 30 can be adjusted according to a control signal from the electric control circuit 50 when an apparatus for adjusting the voltage (not shown) disposed on the cabinet 10 is operated by the operator. An ammeter 32 is connected through a shunt leads 31 to a power supply circuit between the power source 30 and the electrodes 24, 25 and measures (detects) electric current flowing between the electrodes 24, 25 (i.e. current across the electrodes 24, 25). The ammeter 32 is also connected to the electric control circuit 50 to provide a signal indicative of the measured current I , which the ammeter 32 measures, representing a conductivity of diluted brine in the cell 20.

A second supply conduit P2 is connected to an external source

of raw water (e.g. a water pipe of the water supply service) at one end and is connected to the first supply conduit P1 at the other end. The conduit P2 is equipped with a pressure reducing valve 26 and a solenoid-controlled water supply valve 27 in order of the water stream between those two ends. The pressure reducing valve 26 reduces and regulates the pressure of the water in the conduit P2 supplied from the external source of raw water within the predetermined pressure range. The water supply valve 27 is designed to be opened or to be closed by the electric control circuit 50 to provide the electrolytic cell 20 with the raw water from the external source of raw water through the first and the second supply conduits P1, P2.

The storage tank 40 stores brine (generally saturated brine of predetermined concentration). The tank 40 is equipped with a water level sensor (level switch) S and a brine outlet pipe (hose) P5 in such a manner that the sensor S and the outlet pipe P5 are removable from the upper portion of the tank 40. The water level sensor S is connected to the electric control circuit 50 to provide a signal indicative of the water level L.

The fluid pump 60 is a type driven by an electric motor or other electric device (e.g. solenoid) to mix the raw water flowing in the first supply conduit P1 with the saturated brine stored in the storage tank 40. An inlet opening of the pump 60 is connected to the brine outlet pipe P5 and an outlet opening of the pump 60 is connected to the brine supply pipe P6 which is connected to the portion between the first supply conduit P1 and the second supply conduit P2 at the downstream of the water supply valve 27. The pump 60 is designed to adjust its discharge flow amount P (output flow rate) in accordance with a signal the electric control circuit 50 generates while the system is producing the electrolyzed water in the cell 20.

The remote controller 70 is disposed near outlet openings P3a, P3b of the outlet conduits P3, P4. The remote controller 70 is equipped with a brine make-up lump 71 which indicates the lack of brine in the storage tank 40 and with a start switch 72 operated by the operator. The brine make-up lump 71 is turned on or off in accordance with a control signal generated by the electric control circuit 50. The start switch 72 generates and provides the electric control circuit 50 with operation control signals for having components in the cabinet 10 start and stop producing the electrolyzed water.

Hereinafter, operation of the first embodiment of the electrolyzed water production explained above will be described with reference to FIGs. 2, 8 and 9 showing programs (routine) executed by the microprocessor of the electric circuit 50. The description will begin with the stage when the power supply switch (not shown) of the electric control circuit 50 is turned on by the operator.

The microprocessor of the electric control circuit 50 starts from execution of the step 200 shown in FIG. 2 at a predetermined time interval when and after the power supply switch is turned on, and determines whether or not the state of the start switch 72 has been changed from the "off" state to the "on" state at step 205. Therefore, when the operator turns on the start switch 72 to produce electrolyzed water, the electric control circuit 50 detects the change of the state of the start switch 72 and starts operation to produce the electrolyzed water. More concretely, when the electric control circuit 50 obtains "Yes" answer at step 205, it proceeds to step 210 to open the water supply valve 27 to supply the electrolytic cell 20 with the raw water and proceeds to step 220 to apply the constant voltage between the electrodes 24 and 25 by the power source 30.

At steps following step 225, the electric control circuit 50 determines what initial flow amount of the saturated brine supplied to

the electrolytic cell 20 (i.e. an initial flow amount of the saturated brine to be mixed with the raw water which corresponds to initial brine density) is appropriate to start to produce the electrolyzed water. More concretely, the electric control circuit 50 determines at step 225 whether it executes this step (i.e. step 225) for the first time since the power supply switch was turned on. Because the circuit 50 can reach the step 225 only when the start switch 72 is turned on, and because the start switch 72 has never been turned on after the power supply switch was turned on by this point of time, the electric control circuit 50 obtains "Yes" answer at step 225 and proceeds to step 230 to set flow amount P to be discharged by the pump 60 at a predetermined constant value R0 just like a conventional (See FIG. 8, timing t1). Then, the circuit 50 proceeds to step 295 to finish this routine tentatively.

The reason why the initial flow amount P to be discharged by the pump 60 is set at the predetermined constant value R0 is that a memorized value (learned value) RS, which will be described below, has not been obtained yet. It should be noted that the constant value R0 is determined to be a value which is smaller by an appropriate value than the necessary flow amount P to be discharged by the pump 60 to produce electrolyzed water under standard condition. That is, the constant value R0 is determined on the assumption that the system uses the raw water having standard property and that the flow amount of the raw water is equal to standard amount.

When the electric control circuit 50 resumes to execute the routine shown in FIG. 2 from step 200 at a lapse of the predetermined time interval, the circuit 50 obtains "No" answer at step 205 because the state of the start switch 72 has not been changed during the interval, and it proceeds to step 240 to determine whether the start switch remains in the same "on" state. The circuit 50 obtains "Yes" answer at step 240, then proceeds to step 245.

The electric control circuit 50 carries out feedback control for the flow amount P to be discharged by the pump 60 to obtain diluted brine having desired (optimal) conductivity (i.e. optimal density of brine density) by execution of step 245. That is, the circuit 50 sets flow amount P to be discharged by the pump 60 at value obtained by adding value proportional to difference obtained by subtracting the measured (detected) current I from predetermined target value I_0 (i.e. $K \cdot (I_0 - I)$, K ; positive constant) to present (instant) flow amount P discharged by the pump 60. Since the electrolytic cell 20 is supplied with only raw water for cleaning after the system stop producing electrolyzed water as explained below, it is filled with the remaining raw water when the system resumes to produce electrolyzed water. Thus, the measured current I is always smaller than the target value I_0 when the system starts to produce the electrolyzed water, and therefore the flow amount P to be discharged by the pump 60 is increased because the value " $K \cdot (I_0 - I)$ " is positive.

Subsequently, the electric control circuit 50 proceeds to step 250 to set the memorized value RS at the present flow amount P at step 250 (i.e. the circuit 50 stores (memorize) the instant flow amount P as the memorized value RS in the memory such as a RAM or an EEPROM), then proceeds to step 295 to finish this routine tentatively. From this time, the electric control circuit 50 repeats operations mentioned above (i.e. steps 200, 205, 240, 245, 250, and 295) at the predetermined time interval until the operator turns off the start switch 72, thereby it carries out the feedback control for the flow amount P discharged by the pump 60 and renews memorized value RS . Through the operation described above, the electrolyzed water with stable and desired property is produced while the memorized value RS becomes substantially equal to value corresponding to the kind of the raw water (e.g. conductivity of the raw water that the system uses).

Under this stage, when the operator turns off the start switch 72 (i.e. the operator changes the state of the start switch 72 from "on" state to "off" state), the electric control circuit 50 executes necessary steps to stop production of the electrolyzed water. More concretely, the electric control circuit 50 obtains "No" answers at both steps of 205 and 240, it proceeds to step 255 to stop applying voltage to the electrodes 24, 25 and to stop operation of the pump 60. Then, the electric control circuit 50 carries out necessary operation to turn the water supply valve 27 off after a lapse of predetermined time period in order to clean the electrolytic cell 20 at step 260, and proceeds to step 295 to finish this routine tentatively. By operation described above, the system stops producing electrolyzed water and cleans inside of the electrolytic cell 20 by the raw water.

An operation of this system will be described hereinafter in case which the operator again turns on the start switch 72 after production of electrolyzed water has been carried out at least once (i.e. the state of the start switch has been changed its state from "on" to "off" after "off" to "on") after the power supply switch was turned on. Under this stage, the operation to set the initial flow amount P to be discharged by the pump 60 at the value based on the memorized value RS is carried out, since the memorized value (learned value) RS has already been obtained (renewed).

More concretely, the electric control circuit 50 executes steps 200, 205, 210, and 220 shown in FIG.2 described above when the operator turns on the start switch 72 again, and it proceeds to step 225. Since it is not for the first time for the electric control circuit 50 to execute step 225 after the power supply switch was turned on at this point of time, the circuit 50 obtains "No" answer at step 225 and proceeds to step 235 to set initial flow amount P to be discharged by the pump 60 at the value in accordance with the memorized value RS ($f(RS)$). The function "f" can be various form, however, " $f(RS)=RS$ "

is adopted here for instance. Therefore, the initial flow amount P to be discharged by the pump 60 is set at the value equal to the memorized value RS at step 235.

After above setting, when the electric control circuit 50 resumes the routine shown in FIG.2 after the lapse of the predetermined time interval, it sets the flow amount P to be discharged by the pump 60 at value " $P+K \cdot (I_0-I)=RS+K \cdot (I_0-I)$ " at step 245, which follows steps 200, 205, and 240, to carry out the feedback control for the flow amount P by the pump 60. Subsequently, the electric control circuit 50 proceeds to step 250 to set the memorized value RS at flow amount P just obtained at step 245 and finish this routine tentatively at step 295. From this time, the circuit 50 repeats steps 200, 205, 240, 245 and 250 to carry out the feedback control for the amount of the saturated brine to be mixed with raw water and to renew the memorized value RS, until it obtains "No" answer at step 240 when the start switch 72 changes its state from "on" to "off" state. When the circuit obtains "No" answer at step 240, it proceeds to step 255 and 260 to stop producing electrolyzed water.

It should be understood, according to the first embodiment described above, that the initial flow amount P to be discharged by the pump 60 is set at the memorized value RS which becomes value representing the kind of raw water used (and/or pressure of raw water as well as density of the brine in the storage tank 40) by the feedback control, and therefore it can be avoided for the two electrolyzed water production system used in the different area (places) where a kind (property) of the raw water is different, such as hard water or soft water, to take different time period from the timing that the start switch 72 is turned on up to the timing that the measured current I (i.e. conductivity of the diluted brine or density of the brine) reaches the target value I_0 (target conductivity of the diluted brine or target density of the brine). That is, the excess or the shortage in the flow

amount by the pump 60 compared to the optimal flow amount when the saturated brine from the storage tank 40 reaches the electrolytic cell 20 is reduced and is about the same as the excess or the shortage in another system used in the different place. Thus, since the change rate of the measured current I from the timing that the saturated brine from the storage tank 40 reaches the electrolytic cell 20 for the first time after the start of the production of the electrolyzed water between those two systems becomes about the same, the density of the diluted brine given to the cell 20 can become an appropriate (optimal) value within the predetermined time period in both systems.

FIGs.8 and 9 shows the difference in operation between the conventional system and the system according to the first embodiment. Note that FIG.8 shows flow amount P discharged by the pump 60 and the measured current I , in the course of time lapse, in the conventional systems in which initial flow amount P is always set at the constant value $R0$. Fig.8 shows two cases where the kind of the raw water is different each other (i.e. the flow amount becomes different value RS and RS'), each case being shown by using a solid line and a dotted line. FIG.9 shows flow amount P discharged by the pump 60 and the measured current I , in the course of time lapse, in the system of the first embodiment of the present invention in which initial flow amount P is set at the memorized value RS . FIG.9 also shows two cases where the kind of the raw water is different each other, each case being shown by using a solid line and a dotted line. It is understood that the difference in time between the timing that the optimal electrolyzed water (optimal density of the diluted brine) is obtained in one system and in another system is very large in the conventional system (see $T10$ in FIG. 8), whereas it is very small in the first embodiment (see $T20$ in FIG. 9).

Hereinafter, a modified embodiment of the first embodiment

will be described. In the modified embodiment, the function $f(RS)$ at step 235 in FIG. 2 is substituted for the function $f(RS) = RS - Y$, where Y is positive value. That is, the initial flow amount P to be discharged by the pump 60 when the feedback control for the flow amount P is started is set at a value that is smaller than the memorized value RS by the predetermined value Y . Except this point, the modified embodiment is the same as the first one (see FIG. 10).

During time period from the start timing to produce the electrolyzed water when the start switch 72 is turned on up to the timing that the saturated brine provided by the pump 60 from the storage tank 40 reaches the electrolytic cell 20, the measured current I represents conductivity of the raw water as described above, and is smaller than the target value $I0$ by a large amount. In other words, the measured current I does not respond to the flow amount P during this time period (see Figs. 8-10, timing $t1-t2$). Accordingly, during this period, the flow amount P discharged by the pump 60 is increased regardless of whether or not the flow amount P is appropriate.

On the other hand, except for the very rare case where a kind of raw water rapidly changes, for instance as when the electrolyzed water production system is moved to remote place, the flow amount P is usually saturated into the value close to the memorized value RS already learned and memorized. Therefore, if the initial flow amount to be discharged by the pump 60 is set at the memorized value RS , the flow amount P may become too large during above mentioned period (see FIG.9, OS1). If the flow amount P becomes too large, chlorine gas is generated and may cause gas smell problem or erosion of metal used for the system.

To solve this problem, in the modified embodiment described above, the initial flow amount P is defined to be a value obtained by subtracting the value Y from the memorized value RS , and the value Y is designed to be a value corresponding to time period the saturated

brine discharged by the pump 60 takes to reach the electrolytic cell 20 (i.e. time delay of the feedback control). By this means, the density of the diluted brine can be adjusted to optimal value within the predetermined time period, and generation of the chlorine gas is avoided since the excess in the density becomes small (see Fig.9,10, OS 2 < OS 1).

Hereinafter, a second embodiment in accordance with the present invention will be described. The second embodiment is the same as the first embodiment except that the second embodiment substitutes a routine shown in FIG. 3 for the routine shown in FIG.2. In operation, the first embodiment starts the feedback control for the flow amount P discharged by the pump 60 immediately after the initial value of the flow amount P to be discharged by the pump 60 is set at the stored amount RS when the system starts producing electrolyzed water, whereas the second embodiment delays operation of the feedback control for the flow amount discharged by the pump 60 and holds the amount P until the measured current I becomes larger than a predetermined reference value (for instance, the target value I0). Note that the description will be given according to the routine shown in FIG.3, however, detailed explanation will be omitted on the steps which are the same as steps in FIG.2 and are labeled the same numerical number. It is also noted that FIG.11 is a time chart to show the flow amount P and the measured current I in the course of time after the start switch 72 is turned on in the second embodiment.

Now, the electric control circuit 50 executes steps shown in FIG.3 to start producing electrolyzed water (steps 300, 205, 210, 220, 225 and 230) when the operator turns on the start switch 72 for the first time since the power supply switch was turned on, as the system according to the first embodiment does, and sets the initial flow amount P to be discharged by the pump 60 at the constant value R0 at

step 230.

When the electric control circuit 50 executes this routine from step 300 again, it proceeds to step 315 through steps 205 and 240 to determine whether flag "F" is "0". The flag "F" is used to prohibit the feedback control for the flow amount P discharged by the pump 60 and is set at "0" by an initial routine not shown. Thus, the electric control circuit 50 obtains "Yes" answer at step 315 and proceeds to step 245 to start the feedback control immediately in which the flow amount P to be discharged by the pump 60 is set at $P+K \cdot (10-I)$. Subsequently, the electric control circuit 50 stores the present flow amount P as the memorized value RS at step 250, and finishes this routine tentatively at step 395. From this time, the electric control circuit 50 repeats steps above to produce electrolyzed water and to renew the memorized value RS.

When the start switch 72 is turned off, the electric control circuit 50 stops operation for producing electrolyzed water. More concretely, the circuit 50 obtains "No" answers at both steps of 205 and 240, and it proceeds to step 330 to determine whether the state of the start switch 72 was "on" state when it executed this routine previously. In this case, the circuit 50 obtains "Yes" answer at step 330 and carries out necessary operation to stop producing electrolyzed water such as stopping applying voltage to the electrodes 24, 25, stopping the operation of the pump 60, and closing the water supply valve 27 at a lapse of a predetermined time period at steps 255, 260. Note that operation described so far is substantially the same as operation of the system according to the first embodiment carries out.

When the operator changes the state of the start switch 72 from "off" state to "on" state (i.e. the operator turns on the start switch 72) again, the electric control circuit 50 executes steps 300, 205, 210 and 220 to open the water supply valve 27 and to supply the

voltage from the power source 30. It then proceeds to step 225, as the system according to the first embodiment does. The electric control circuit 50 obtains "No" answer at step 225, because the start switch 72 has already changed its state from "off" state to "on" state after the power supply switch was turned on by this point of time, and therefore, it is not the first time for the circuit 50 to execute step 225. Accordingly, the circuit 50 proceeds to step 305 to set the initial flow amount P discharged by the pump 60 at the memorized value RS . The electric control circuit 50, then, sets flag "F" at "1" at step 310 to prohibit the feedback control for the flow amount discharged by the pump 60, and proceeds to step 395 to finish this routine tentatively.

By the change in flag "F" from "0" to "1", when this routine is executed next time, the system carries out a control to hold the initial flow amount P discharged by the pump 60 ($=RS$) instead of the feedback control for the flow amount P . More concretely, the electric control circuit 50 proceeds to steps 300, 205, 240 and 315 to determine whether the flag "F" is "1". At this point of time, since the flag "F" was changed from "0" to "1" at the previous step 310, the electric control circuit 50 obtains "No" answer at step 315 and proceeds to step 320 instead of step 245.

The electric control circuit 50 determines whether the measured current I becomes equal to or larger than the reference value $I(T)$ at step 320. Note that, here, the reference value $I(T)$ is defined to be equal to the target value I_0 . Since the electrolytic cell 20 is filled with raw water immediately after the system starts producing the electrolyzed water, the measured current I is relatively small. Accordingly, The circuit 50 obtains "No" answer at step 320 and proceeds to step 395 to finish this routine tentatively. From this time, the electric control circuit 50 repeats steps above until it obtains "Yes" answer at step 320. Therefore, the flow amount P discharged by the pump 60 remains to be the initial flow amount

which is equal to the stored amount (memorized value) RS.

By operation described above, the production of the electrolyzed water is started and the saturated brine from the storage tank 40 reaches the electrolytic cell 20. Thus, the measured current I increases. At a lapse of predetermined time period after the start of the production of electrolyzed water, the measured current I becomes larger than the target value $I(T)$ (reference value I_0), because the cell 20 is filled with the diluted brine which contains an amount of the saturated brine in accordance with the memorized value RS. Thus, the electric control circuit 50 obtains "Yes" answer at step 320 and proceeds to step 325 to change flag "F" from "1" to "0". As a result, when the circuit 50 execute this routine next time, it obtains "Yes" answer at step 315 following the steps 300, 205 and 240, and proceeds to step 245 to start the feedback control. The circuit 50, then, proceeds to step 250 to renew the memorized value RS by setting the memorized value RS at the present flow amount P obtained at previous step 245. This feedback control and the renewal of the memorized value RS is continued until the operation for stopping production of the electrolyzed water is carried out at both steps of 255 and 260 that follow steps 300, 205, 240, and 330 when the start switch 72 is turned off.

According to the second embodiment described above, during the time period between the start of the production of the electrolyzed water and the timing that the measured current I becomes larger than the target value I_0 (see FIG. 11, t_1 - t_3), the flow amount discharged P by the pump 60 remains at the memorized value RS which was renewed under the previous feedback control. Therefore, the generation of the chlorine gas is avoided since the flow amount P discharged by the pump 60 does not become too large.

Note that, although the flow amount P discharged by the pump 60 is held in the second embodiment, the control to substantially

maintain the flow amount P can be adopted where the flow amount P is adjusted by an predetermined amount per second which is very small compared to the amount per second by which the flow amount P is adjusted under the feedback control. That is, the flow amount P can be substantially held by the feedback control with using the gain value " K " which is extremely small compared to the value " K " that is used in the normal feedback control described above. Also, to ensure to have feedback control start, the reference value $I(T)$ can be the value which is smaller than the target value I_0 by a predetermined amount.

Hereinafter, a first modified embodiment of the second embodiment will be described. In this first modified embodiment, routines shown in FIGs. 4 and 5 is added to the routine shown in Fig. 3. The added routines are executed at a predetermined time interval by the electric control circuit 50 to decrease the reference value $I(T)$ used at step 320 in accordance with lapse of time after the system starts to produce electrolyzed water.

When the start switch 72 is turned on, the electric control circuit 50 starts the routine shown in Fig 4 from step 400 and proceeds to step 410 to determine whether flag " G " is " 1 ". The electric control circuit 50 obtains "No" answer at step 410 since the flag " G ", explained afterwards, is set at " 0 " at step 530 in FIG. 5. The circuit 50, then, proceeds to step 420 to determine whether the state of the start switch 72 is changed from "off" to "on" state. Since it is time immediately after the start switch 72 was turned on, the electric control circuit 50 obtains "Yes" answer at step 420 and proceeds to step 430 to set flag " G " at " 1 ". At the next step 440, the circuit 50 increases the value in timer T , which is set at " 0 " at step 520, explained later, by " 1 ". Then, it proceeds to step 450 to obtain $I(T)$ from the table in accordance with the value in the timer T and finishes this routine at step 495 tentatively.

When the electric control circuit 50 executes this routine next time, it proceeds to step 440 from step 410, since the flag "G" was changed to "1" at step 430 executed previously, to increase the value in the timer T and proceeds to step 450 to obtain $I(T)$ from the table in accordance with the value in the timer T. By the operation described above, the timer T indicates time period after the system starts the production of the electrolyzed water, and therefore, the reference value $I(T)$ is obtained in accordance with the time period after the system starts the production of the electrolyzed water at step 450. Note that, although the table used at step 450 is the one labeled (a) which is designed to decrease or maintain the reference value $I(T)$ in accordance with the value in the timer T, it is substituted by a table labeled (b) in which the value $I(T)$ decreases stepwise in accordance with the value in the timer T or one labeled (c) in which the value $I(T)$ decreases continuously in accordance with the value in the timer T.

FIG. 5 shows a routine to reset flag "G" and the value in the timer T at "0". When the electric control circuit 50 executes this routine at a predetermined time interval, the circuit 50 proceeds to step 510 to determine whether the start switch 72 changed its state from "on" to "off" state. If the circuit 50 obtains "Yes" answer, it proceeds to steps 520 and 530 to reset both of the value in the timer T and the flag "G" at "0" respectively.

According to the first modified embodiment described above, since the reference value $I(T)$ decreases in accordance with lapse of time after the system starts to produce electrolyzed water, it is avoided that the feedback control for the flow amount P is not carried out because the electric control circuit 50 continues to obtain "No" answer at step 320 in FIG. 3 in rare case where the measured current I does not increase large enough to start the feedback control because of changes in pressure of the raw water from the external source of raw water or in density of brine stored in the storage tank 40 (i.e.

changes in surrounding condition of the system). Accordingly, it can be avoided that the system can not produce electrolyzed water which has desired property because the feedback control is not carried out.

Hereinafter, a second modified embodiment of the second embodiment will be described with reference to FIGs. 3, 5 and 6. The second modified embodiment uses routines shown in FIGs. 3 and 5 as the first modified embodiment does, and substitutes a routine shown in FIG 6 for one shown in FIG. 4 adopted by the first modified embodiment. The routine shown in FIG. 6 is executed by the electric control circuit 50 at a lapse of predetermined time interval to enforce to start the feedback control for the flow amount P discharged by the pump 60 at a predetermined time period after the system starts to produce electrolyzed water.

That is, the electric control circuit 50 starts to execute the routine shown in FIG. 6 at step 600 and determines whether the flag "G" is "1" at step 605. When the start switch 72 is in the "off" state, flag "G" has been set at "0" because of steps 510 and 530 shown in FIG. 5, and thus the circuit 50 obtains "No" answer at step 605 and proceeds to step 610 to determine whether the start switch 72 is turned on. If the operator has not turned on the start switch 72, the circuit 50 obtains "No" answer at step 610 and proceeds to step 695 to finish this routine tentatively.

Under this stage, when the operator turns on the start switch 72, the electric control circuit 50 obtains "Yes" answer at step 610 and proceeds to step 615 to set flag "G" at "1". It then proceeds to step 620 to increase the value in the timer T by "1". Note that the value in the timer T is set at "0" at step 520 shown in FIG. 5 executed when the start switch 72 was turned off. Subsequently, the circuit 50 determines whether the value in the timer T becomes larger than a predetermined value T0 at step 625. Since the value in the timer T has been just started to be increased at this point of time, the electric

control circuit 50 obtains "No" answer at step 625 and proceeds to step 695 to finish this routine tentatively.

When the circuit 50 executes this routine next time, since flag "G" was set at "1" at step 615 executed previously, it proceeds to step 620 from step 605 directly to increase the value in the timer T. Accordingly, since the value in the timer T indicates a lapse of time after the system starts to produce electrolyzed water, the circuit 50 obtains "Yes" answer at step 625 (value in the timer T > the predetermined time period T₀) when the predetermined time period passes and proceeds to step 630 to set flag "F", which is used to prohibit the feedback control, at "0". As a result, when the circuit 50 executes routine shown in FIG. 3, it obtains "Yes" answer at step 315 which follows steps of 300, 205 and 240 and proceeds to step 245 to start to carry out the feedback control.

According to the second modified embodiment described above, the feedback control for the flow amount P is enforced to start at a lapse of the predetermined time period T₀ by setting Flag F at "0". Therefore, even in the rare case where the measured current I does not increase large enough to start the feedback control, the circuit 50 can obtain "Yes" answer at step 315 to start the feedback control. Accordingly, it can be avoided that the system can not produce desired electrolyzed water because the feedback control is not started. Note that, the timing that the measured current I becomes larger than the reference value I₀ usually occurs before the timing that the value in the timer T becomes larger than the time period T₀. In other words, the time period T₀ is defined to be larger than the period within which the measured current I becomes larger than the reference value I₀ in most cases. That is, it is inferred that the measured current I will not exceed the reference value I₀ if it is not larger than the reference value I₀ at the lapse of the time period T₀. This is why the second modified embodiment sets the flag "F" at "0" when the time period T₀

has passed.

Hereinafter, a third modified embodiment of the second embodiment will be described with reference to FIGs. 3 and 7. The routine shown in FIG. 7 is one that is inserted between the route that the circuit 50 follows when it obtains "No" answer at step 320 until it proceeds to step 395 (see "A" and "B" circled in FIG. 3) in order to enforce to start the feedback control for the flow amount P discharged by the pump 60 when the maximum change amount per second in the measured current I (i.e. maximum change rate of the measured current) is smaller than a predetermined reference value.

More concretely, when the electric control circuit 50 obtains "No" answer at step 320 in FIG. 3 since the measured current I does not exceed the reference value $I(T)$, it proceeds to step 710 to store ten (10) measured current I (ten data of measured current I detected). That is, the value stored in the RAM $I(n+1)$ is transferred to the value in the RAM $I(n)$ where " n " is a positive integer number from one(1) to nine(9), for instance, the content in the $I1$ is replaced by the content in the $I2$, and the present measured current I (instant measured current I) is stored in the RAM $I10$. The circuit 50, then, searches the maximum value $IMAX$ among values of $I1$ to $I10$ at step 715 and minimum value $IMIN$ among values of $I1$ to $I10$ at step 720. Subsequently, the circuit 50 calculate the difference D between the maximum value $IMAX$ and the minimum value $IMIN$ as a change rate of the conductivity of the diluted brine at step 725 and proceeds to step 730 to determine whether the difference D is smaller than the predetermined reference value $D0$. If the circuit obtains "Yes" answer, it proceeds to step 735 to set the flag " F " at "0" in order to start the feedback control. That is, the circuit 50 is enforced to obtain "Yes" answer at step 315 in FIG. 3 and to start the feedback control at step 245.

According to the third modified embodiment described above,

when the difference D mentioned above becomes smaller than the reference value D_0 (that is, when the change rate in the measured current I during a certain time period is small), the feedback control for the flow amount P discharged by the pump 60 is started, since it is proper to infer that the measured current I will not exceed the reference value $I(T)=I_0$ any more. By means described above, just like the first or the second modified embodiment, it can be avoided that the system can not produce desired electrolyzed water because the feedback control is not started, in the rare case where the measured current I does not increase large enough to start the feedback control because of changes in pressure of the raw water from the external source of water or in density of brine stored in the storage tank 40. Note that, the number of the measured current I stored in the RAM is not necessarily ten(10), i.e. I1-I10, but the number can be determined according to the execution interval of the routine shown in FIG.7.

It is preferable that initial values of I1 to I10 are set appropriately in the initial routine (not shown) executed immediately after the start switch 72 is turned on so that the circuit 50 does not obtain "Yes" answer at step 730 since the current data of I1 to I10 has not been obtained for a certain period immediately after the system starts to produce electrolyzed water. Alternatively, the program may be designed not to execute step 730 until all values of I1 to I10 are obtained properly. More concretely, it is preferable that the circuit 50 adopts a timer just like one shown in FIG. 6 to measure the lapse of time after the system starts the production of the electrolyzed water, and a new step, at which the circuit 50 is enforced to proceed to step 730 after the value in the timer becomes larger than a predetermined time period and to proceed to "B" shown in FIG. 7 when the value in the timer is smaller than the predetermined time period.

In the first and second embodiments described above, it is also

preferable that the memorized value RS is defined to be a average value or a weighted integral of the measured current I obtained in the routine currently executed as well as in the routine previously executed in order to stabilize the value RS. More concretely, when the stored value obtained in the presently executed routine is defined to be the value RS_n, the value RS_n can be calculated by the equation " $RS_n = \alpha \cdot P_n + (1 - \alpha) \cdot RS_{n-1}$ ", where the P_n is the flow amount P discharged by the pump 60 in the presently executed routine, RS_{n-1} is the stored value which was obtained in the routine previously executed as R_n, and α is a predetermined value between "0" and "1".

Although the embodiments described above commence to renew the memorized value RS immediately after the feedback control is started, the renewal of the memorized value RS may be delayed until a predetermined time period passes after the feedback control was started to obtain more stable memorized value RS. It should be noted that, in this way of renewal of the memorized value RS, since there is a possibility that the stored value has not been obtained yet even after the system has already started to produce electrolyzed water more than twice after the power supply switch had been turned on, the step 255 should be modified into the step at which the circuit 50 determines whether the memorized value RS has been already renewed after the power supply switch had been turned on, and the circuit 50 is enforced to proceed to step 230 when the answer at the modified step is "No" to set the initial flow amount P at R0, or to step 305 if the answer at the modified step is "Yes" to set the initial flow amount P at value f(RS).

In the embodiments described above, it is also preferable that the system adopts a fluid pump of the type driven by each pulse of pulse train signals from the circuit 50, just like used in the third embodiment described hereinafter, as the fluid pump 60.

Hereinafter, a third embodiment in accordance with the

present invention will be described in detail with reference to the drawings shown in FIGs. 12 to 15. The third embodiment is substantially the same as the first and the second embodiment described above except for the program (routine) to be executed by the electric control circuit 50.

The pump adopted in this third embodiment is so called a pulse driven pump which discharges the saturated brine to mix it with raw water by reciprocal movement of the diaphragm which is moved by attractive force generated by an activated solenoid by a pulse signal. The amount discharged by the pump per one cycle is constant.

More concretely, the pump shown in FIG. 12 includes a pump housing 61 which contains a pump chamber 63 formed by a diaphragm 62, one way valve 65 which allows stream from intake opening 64 to the pump chamber 63 only, and one way valve which allows stream from the pump chamber 63 to discharge opening 66 only. A plunger 68 is connected to the diaphragm 62 and is biased toward the pump chamber 63 (to the left in FIG. 12) by the diaphragm 62 as well as a spring (not shown), on the other hand, it moves in reverse direction against the pump chamber 63 (to the right in FIG. 12) by the force generated when the solenoid 69 is activated by a pulse from the electric control circuit 50 which functions as a pulse generator.

With structure described above, the pump 60 reciprocates the diaphragm 62 in accordance with the repetition of activation of the solenoid 69 (i.e. pulse train signal) to suck the saturated brine from the storage tank 40 and discharge the brine into the brine supply pipe P6 to mix it with raw water. That is, the pump 60 discharges constant amount of the saturated brine in accordance with the reciprocal movement of the diaphragm 62 every time the solenoid 69 receives the pulse signal. Therefore, it can vary its discharge amount per a unit time (i.e. flow amount) to adjust the density of the diluted brine.

Hereinafter, operation of the third embodiment of the electrolyzed water production system will be described. The electric control circuit 50 starts to execute routine shown in FIG.13 from the step 1300, and proceeds to step 1305 to detect whether or not the state of the start switch 72 is changed from the "off" state to the "on" state. Accordingly, when the operator has not turned on the start switch 72, the circuit 50 obtains "No" answer at step 1305 and proceeds to step 1330 to detect whether the state of the start switch 72 is changed from the "on" state to the "off" state. At this point of time, since the start switch 72 remains at "off" state, the circuit 50 obtains "No" answer at step 1330, and it proceeds to 1395 to finish this routine tentatively.

When the operator turns on the start switch 72 to produce electrolyzed water, the circuit 50 obtains "Yes" answer at step 1305 and proceeds to step 1310. The circuit 50 opens the water supply valve 27 to commence to supply the electrolytic cell 20 with raw water at step 1310 and applies the constant voltage between the electrodes 24 and 25 at step 1315.

Subsequently, the circuit 50 proceeds to step 1320 to set a pump drive signal S for the pump 60, explained afterwards, at the initial value R0 and proceeds to step 1325. At step 1325, the circuit 50 sets pulse interval ST, also explained later, at "1" to provide the solenoid 69 with the first pulse signal and value in the counter N, later explained, at "0". Then, the circuit 50 proceeds to step 1395 to finish this routine tentatively. With the operation described above, the production of the electrolyzed water is started.

A control method to drive the pump 60 will be described with reference to routine shown in FIG.15, a pump driving routine. Note that the routine shown in FIG.15 is executed by the circuit 50 at a shorter interval than the interval at which the routine shown in FIG.13 is executed. First, the circuit 50 starts the routine shown in

FIG. 15 with the step 1500 and proceeds to step 1510 to increase value in timer T by "1", then proceeds to 1520 to compare the value in the timer T with the pulse interval ST. Since the value in the timer is set at "0" immediately after the pulse signal is provided (generated) at step 1540 described later or when the state of the start switch 72 is changed from "on" state to "off" state (see step 1350 in FIG. 13), the circuit 50 obtains "No" answer at step 1520 and proceeds to step 1595 to finish this routine tentatively.

The value in the timer T increases and becomes larger than the pulse interval ST when a certain time period has passed, since the circuit repeats steps 1500, 1510, 1520 and 1595. When the value in the timer N becomes larger than the pulse interval ST, the circuit 50 obtains "Yes" answer at step 1520 and proceeds to step 1530 to generate a pulse signal which is a high level signal for a predetermined time period (i.e. the pulse width is 10 m sec.), and provide the solenoid 69 with the generated pulse signal to discharge the saturated brine from the discharge opening 66 of the pump 60. Subsequently, the circuit 50 sets the value in the timer T at "0" at step 1540 and proceeds to step 1550 to set the pulse interval ST used in the step 1520 at a value which is inversely proportional to the drive signal S for the pump 60 (i.e. A/S ; "A" is constant positive number), and then proceeds to step 1595 to finish this routine tentatively.

It should be noted that the circuit 50 obtains "Yes" answer at step 1520 when the circuit executes the step 1520 for the first time after the system started to produce electrolyzed water because the pulse interval ST is set at "1" at step 1325 shown in the FIG. 13 and therefore proceeds to step 1530 to generate the pulse signal immediately. It is also noted that the pulse interval ST corresponds to the value $R0$ (e.g. $ST=A/S=A/R0$), because the drive signal S is set at the value $R0$ at step 1320 shown in FIG. 13, and the signal S remains the same (i.e. $A/R0$) until the drive signal S is altered.

According to operation described above, the circuit 50 provides the solenoid 69 with a pulse signal having high level (Hi) signal for the predetermined time period at a time interval in accordance with the pump drive signal S, i.e. inversely proportional to the pump drive signal S (A/S), and the diaphragm 62 moves in accordance with the pulse signal to mix the saturated water with the raw water. Therefore, as the drive signal S becomes larger, the pump 60 is driven at higher speed and the discharge amount per a unit time of the saturated brine to be mixed by the pump 60 becomes larger.

A feedback control for the pump drive signal S (a control for the pulse interval ST of the pulse train by the feedback operation) will be described hereinafter. It should be noted that the circuit 50 executes routine shown in FIG.14 every one(1) second, while the circuit 50 repeats steps 1300, 1305, 1330 and 1395 shown in FIG.13.

More concretely, the circuit 50 adds "1" to the value in the counter N at step 1405. The value in the counter N is used when the measured current I (corresponding to a detected conductivity of the diluted brine given to the electrolytic cell 20) is stored as I1 to I3, described later. The circuit 50 then proceeds to step 1410 to input the current across the electrodes 24 and 25 as the measured current I through the AD converter and proceeds to step 1415 to determine whether the value in the counter N is three(3).

Since the value in the counter N is set at "0" at step 1325 shown in FIG.13 when the start switch 72 is turned on, the value becomes "1" at step 1405. Thus, the circuit 50 obtains "No" answer at step 1415 and proceeds to step 1425 to determine whether the value in the counter N is one(1). The circuit 50 obtains "Yes" answer at step 1425 and proceeds to step 1430 to store the measured current I obtained at the previous step 1410 as I1 in the memory of the microprocessor, and proceeds to step 1495 to finish this routine tentatively.

At the lapse of one second from the timing above, the circuit 50 resumes to execute the routine shown in Fig 14 and makes the value in the counter N two(2) at step 1405. Then the circuit 50 proceeds to step 1410 to input new (present) measured current I and proceed to steps of 1415 and 1425. At this time, the circuit 50 obtains "No" answers at both steps of 1415 and 1425, it proceeds to step 1435 to store the measured current I obtained at step 1410 as I₂ and finishes this routine.

At a lapse of another second, the circuit makes the value in the counter N three(3) at step 1405 and proceeds to step 1410 to input new (present) measured current I. The circuit 50, then, proceeds to step 1415 and obtains "Yes" answer this time, proceeds to 1420 to set the value in the counter N at zero(0).

The circuit 50 proceeds to 1440 after the execution of step 1420 to store measured current I obtained at step 1410 as I₃, and proceeds to step 1445 to calculate an arithmetic mean (an average) of I₁, I₂ and I₃ that have been stored, and then set a average measured current I_{AVE} at the calculated arithmetic mean indicative of average conductivity of the diluted brine. Then the circuit 50 proceeds to 1450. It should be noted that the data I₁, I₂ correspond to the plural data on conductivity previously detected (obtained) at the first predetermined interval, i.e. one second, and the I₃ corresponds to the data on conductivity newly detected.

Step 1450 is for performing the feedback control for the flow amount P discharged by the pump 60 to obtain the diluted brine which has the optimal conductivity. Therefore, the circuit 50 sets the drive signal S at the value calculated by adding value proportional to the difference obtained by subtracting the average measured current I_{AVE} from the target value I₀ ($K \cdot (I_0 - I_{AVE})$, "K" is positive constant number) to the instant drive signal S indicative of the present flow amount P, and proceeds to step 1495 to finish this routine tentatively.

Accordingly, the circuit 50 increases the drive signal S if the average measured current IAVE is smaller than the target current value I0 to increase the flow amount P to be discharged by the pump 60 by shortening the pulse interval of the pulse train ST, whereas the circuit 50 decreases the drive signal S if the average measured current IAVE is larger than the target current value I0 to decrease the flow amount P to be discharged by the pump 60 by lengthen the pulse interval of the pulse train ST. By the operation above, the feedback control is performed. As is understood from above description, the measured current is newly detected again repetitively every one (1) second, and the average measured current IAVE as well as the pump drive signal S is renewed when the value in the counter N becomes three, i.e. every three(3) seconds.

Since the circuit 50 continuously executes the routine shown in FIG.13 at the predetermined interval, when the operator turns off the start switch 72 to stop producing electrolyzed water, the circuit 50 obtains "No" answer at step 1305 and proceeds to step 1330 to determine whether the state of the start switch 72 was changed from "on" state to "off" state. Under this condition, the circuit 50 obtains "Yes" answer at step 1330 and proceeds to steps 1335 to 1345 to execute necessary steps to stop producing electrolyzed water. More concretely, the circuit 50 closes the water supply valve 27 to stop supplying raw water at step 1335, stops applying voltage between the electrodes 24 and 25, and stop operation of the pump 60 (i.e. stop generating pulse train) at step 1345. Subsequently, the circuit 50 proceeds to step 1350 to set the value in the timer T at "0" used in the pump driving routine described above and proceeds to step 1395 to finish this routine tentatively.

As described above, the third embodiment on the electrolyzed water production system in accordance with the present invention obtains the average measured current IAVE of the three (plural) data

consisting of the measured current I indicative of the present conductivity, i.e. I_3 , and the measured current I detected in the routine executed previously as well as in the routine executed before the previous execution of the routine, i.e. I_2 and I_3 . The system also calculates the pump drive signal S for the pump 60 in such a manner that the average measured current I_{AVE} becomes equal to the target value I_0 , and generates the pulse train having the pulse interval ST which corresponds to the pump drive signal S .

Accordingly, even if the circuit 50 detects the measured current I which is larger than the average value of the measured current I for a certain period of time because the timing when the circuit 50 obtains the measured current I happens to fall on the timing when a certain portion of the diluted brine having high density because of the saturated brine discharged by the pump 60 reaches the electrolytic cell 20, the circuit 50 uses, instead of the measured current I just detected, the average measured current I_{AVE} obtained based on not only the measured current I just detected but the measured current I detected at the successively previous timings for the feedback control. Thus, the system can decrease the fluctuation of the density of the diluted brine stemming from the detection timing of the measured current I and can produce desired electrolyzed water having a stable property.

Hereinafter, a fourth embodiment in accordance with the present invention will be described. The system of the fourth embodiment is different from the system of the third embodiment in that the fourth embodiment substitutes routine shown in FIG.16 for the routine shown in FIG. 14. In operation, the fourth embodiment is different from the third embodiment in that the third embodiment uses the measured current $I(I_1)$ detected immediately after the calculation and the renewal of the pump drive signal S is performed for the successive calculation and the renewal of the average

measured current IAVE and the pump drive signal S, whereas the fourth embodiment uses the measured current I(I2) detected after the detection of the measured current I (I1) and the measured current I detected successively at a lapse of the predetermined interval after the detection of the measured current I(I2).

More concretely, the circuit 50 executes routine shown in FIG.16 at a lapse of one (1) second (i.e. every 1 second), as FIG. 14, and proceeds to steps 1605 and 1610 which is identical to steps 1405 and 1410 shown in the FIG.14 respectively to increase the value in the counter N by "1" and to detects (obtain) the measured current I at that present.

The value in the counter N becomes "1" by the execution of step 1605 when the step 1605 is executed immediately after the start switch 72 was turned on since the value in the counter N was set at "0" by the execution of the step 1325. Accordingly, the circuit 50 obtains "Yes" answer at step 1615 at which the circuit 50 determines whether the value in the counter N is "1" and proceeds to step 1695 to finish this routine tentatively without storing the measured current I.

At a lapse of one second, the circuit 50 executes the routine shown in FIG.16 and proceeds to step 1605 to set the value in the counter N at "2". It then proceeds to step 1610 to detect the measured current I again. The circuit 50, then, proceeds to step 1615, obtains "No" answer this time and proceeds to step 1620 to determine whether the value in the counter N is "4". The circuit 50 obtains "No" answer and proceeds to step 1625 to determine whether the value in the counter is "2". Since the value is "2" at this time, the circuit 50 proceeds to step 1630 to store the measured current I as I2 and proceeds to step 1695 to finish this routine tentatively.

Further, at a lapse of another one second, the circuit 50 starts the routine shown in FIG.16 from step 1600 and proceeds to step 1605 to increase the value in the counter N by "1". Thus the value in

the counter N becomes "3".

Then the circuit 50 again detects the measured current I at step 1610, and obtains "No" answers at the all steps of 1615, 1620 and 1625. Then, it proceeds to step 1635 to store the measured current I as I₃ and proceeds to step 1695 to finish this routine tentatively.

The circuit 50 increases the value in the counter N which then becomes "4" at step 1605 in the routine resumed another one second later, detects the measured current I at step 1610, obtains "No" answer at step 1615, obtains "Yes" answer at step 1620 and proceeds to step 1640 to set the value in the counter N at "0". Then the circuit 50 stores the measured current I as I₄ and proceeds to step 1650 to calculate an arithmetic mean of I₂, I₃ and I₄ and to store the mean as the average measured current I_{AVE}. Subsequently, the circuit 50 proceeds to step 1655 to calculate and renew the pump drive signal S, as steps 1450 shown in FIG. 14. From this time, the circuit 50 repeats operation described above to renew the pump drive signal S (i.e. carrying out the feedback control).

According to the fourth embodiment described above, the circuit 50 detects the measured current I at a first predetermined interval (i.e. one second), calculates a average measured current I_{AVE} at a second predetermined interval (i.e. four seconds), and renews the pump drive signal S. However, the circuit 50 does not store the measured current I which is detected immediately after the drive signal S is renewed (i.e. when the value in the counter N becomes "1" at step 1605). Therefore, the circuit 50 does not use the measured current I which is detected immediately after the drive signal S was renewed for the calculation of the average measured current I_{AVE} at step 1650. Thus, the circuit 50 is designed not to use the measured current I which is very unlikely to be effected by the result of the renewal of the pump drive signal S according to the average measured current I_{AVE}. Instead, the circuit 50 adopts the

measured current I obtained at or after a lapse of the third predetermined time interval (i.e. 2 seconds) for the calculation of the next average measured current I_{AVE} (i.e. the next drive signal S). As a result, the feedback control operation for the pump 60 becomes stable.

It should be noted that there is a small delay from the time that the pump drive signal S is renewed till the result of the renewal of the drive signal S appears as the actual flow amount discharged by the pump 60. That is, the time period between the timing of the renewal of the drive signal S and the timing of pulse generation to solenoid 69 of the pump 60 varies. Thus, the time period between the timing that the actual flow amount discharged by the pump 60 is effected by the renewed pump drive signal S and the timing that the measured current I is stored as I_2 varies.

This time delay is very short and can be ignored, however, it may be preferable to eliminate the effect caused by the delay. From this point of view, the following measures may be taken. That is, the program is designed in such a manner that the circuit 50 proceeds to the step 1600 shown in FIG.16 when the pump discharges the saturated brine based on the signal effected by the renewed pump drive signal S (i.e. at the timing of the generation of the pulse effected by the renewed pump drive signal S to the solenoid 69). Alternatively, the program is designed to have an additional timer which measures the time period from the timing when the pump 60 discharges the saturated brine based on the signal influenced by the renewed pump drive signal S , and to store the measured current I detected when the additional timer measures a predetermined constant time period as I_2 . The constant time is preferably defined to be equal to the time period in which the saturated brine takes to reach the electrolytic cell 20 from the pump 60.

As is understood from the above description, the measured

current I detected when the value in the counter N equals to a certain number, which is "1" in this embodiment described above, is not used for the calculation of the average measured current IAVE, but the certain number can be any number. That is, a determination on how many data on the measured current I, out of the measured current I successively detected during the time period from the renewal of the pump drive signal S according to the renewed average measured current IAVE to the next renewal of the pump drive signal S should not be used for the calculation for the next average measured current IAVE should be made based on the sampling timing of the measured current I or on the time period which is necessary for the brine from the pump 60 to reach the electrolytic cell 20.

Hereinafter, a fifth embodiment will be described. The electrolyzed water production system according to the fifth embodiment is different from the system of the third embodiment only in that the system of the fifth embodiment substitutes routine shown in FIG. 17 for the step 1445 in the routine shown in FIG. 14 the circuit 50 of third embodiment executes.

That is, the circuit 50 of the fifth embodiment stores measured current I as I1 to I3 every one second successively and proceeds to step 1710 from step 1440. At step 1710, the circuit 50 selects one out of I1, I2 and I3 which has the largest absolute deviation from the target value I0 and stores it as J1, selects one out of I1 to I3 which has the smallest absolute deviation from the target value I0 and store it as J3, and stores the rest as J2.

The circuit 50 determines whether a predetermined condition is satisfied after the start switch 72 was turned on at step 1720. The predetermined condition above can be the condition which indicates that it is time to give priority to stability of the control instead of response time of the system. For instance, it could be "when a predetermined time period has passed since the start switch 72 was

turned on", or could be "when the measured current I , for the first time, becomes larger than the reference value which may be the target value I_0 or may be the value being smaller than the target value by a certain amount".

The circuit 50 obtains "No" answer at step 1720 since the predetermined condition is not satisfied immediately after the system has started producing the electrolyzed water and proceeds to step 1730 to calculate a weighted integral IAVE (weighted average) for improving the response time of the feedback control. More concretely, the circuit 50 calculates the weighted integral by multiplying J_1 , J_2 and J_3 by " $m_1/(m_1+m_2+m_3)$ " where " m_1 " is the largest coefficient among m_1 , m_2 and m_3 and " $m_1+m_2+m_3=1$ ", by " $m_2/(m_1+m_2+m_3)$ " where " m_2 " is smaller than " m_1 " but larger than " m_3 ", and by " $m_3/(m_1+m_2+m_3)$ " where " m_3 " is the smaller than " m_2 " respectively, then store the weighted integral as the average measured current IAVE, and then proceeds to step 1450.

The circuit 50 calculates the pump drive signal S at step 1450 shown in FIG.14. That is, it renews the pump drive signal S by adding value which is proportional to value obtained by subtracting the average measured current IAVE from the target value I_0 to the present pump drive signal S at step 1450. The circuit 50, just like the fourth embodiment, executes the routine shown in FIG.15, and generates pulse signal sent to the solenoid 69 at a time interval in accordance with the pump drive signal S .

When the predetermined condition described above is satisfied, the circuit 50 obtains "Yes" answer at step 1720 and proceeds to step 1740 to calculates the weighted integral IAVE for improving the response time of the feedback control. That is, the circuit 50 calculates the weighted integral IAVE by multiplying J_1 , J_2 , and J_3 by " $k_1/(k_1+k_2+k_3)$ " where " k_1 " is the smallest coefficient among k_1 , k_2 and k_3 and " $(k_1+k_2+k_3)=1$ ", by " k_2 " which is larger

than "k1" but smaller than "k3" and by "k3" which is the larger than "k2" respectively. The circuit 50 sets the average measured current IAVE at the weighted integral just calculated. It then proceeds to step 1450 shown in FIG.14 to obtain the pump drive signal S, as described above, and generates the pulse train of which period is in accordance with the pump drive signal S by executing the routine shown in FIG.15.

With operation described above, the system according to the fifth embodiment, the average measured current IAVE is set at the value for the improving (shortening) the response time during the measured current I (the conductivity of the diluted brine) is small compared to the target value I0 and therefore the difference D between the average measured current IAVE and the target value I0 becomes large. As a result, the time required to produce the electrolyzed water having the desired property after the system is activated to start the electrolyzed water becomes short, because the system increases the pump drive signal S more rapidly.

On the other hand, when the flow amount of the saturated brine becomes substantially equal to the optimal value (i.e. when the property of the electrolyzed water produced becomes stable), the system obtains the weighted integral of the measured current I to make the difference D smaller. As a result, the system can continuously produce the electrolyzed water having the desired property with stability, because the feedback control becomes stable (i.e. the flow amount of the saturated brine P does not change easily).

It should be noted that the various modified embodiments can be adopted with respect to the third, the fourth and the fifth embodiments described above. For instance, although the pulse signal used in these embodiments is the signal having the square-wave, it can be any signal that causes the pump to discharge intermittently, such as sign-wave signal and chop-wave signal.

It should be also noted that the pulse interval ST is set at the value inversely proportional to the pump drive signal S, however, any conversion from the pump drive signal S to the pulse interval ST can be adopted as long as the conversion changes the signal S into the interval ST in such a manner that the interval ST becomes smaller as the signal S becomes larger.

As is understood from above description on the embodiments in accordance with the present invention, the feedback control for the flow amount P discharged by the pump 60 can be defined as the feedback control for the amount of the saturated brine (i.e. the additive to help electrolyze the water) mixed with the raw water or the feedback control for the density of the diluted water supplied to the cell 20 because the flow amount of the raw water in the diluted water supplied to the cell 20 is substantially constant.

**WHAT IS CLAIMED IS:**

1. An electrolyzed water production system having a brine storage tank arranged to store saturated brine of predetermined concentration, brine supply means for supplying the saturated brine from said storage tank for mixing with raw water supplied from a source of raw water and an electrolytic cell arranged to be supplied with diluted brine prepared by a mixture of the raw water and saturated water for producing electrolyzed water,

wherein an electric control apparatus for the electrolyzed water production system comprises:

detection means for detecting the conductivity of the diluted brine supplied to said electrolytic cell;

feedback control means for controlling operation of said brine supply means in such a manner that the conductivity of the diluted brine detected by said detection means is adjusted to a predetermined target value;

memory means for memorizing an amount of saturated brine mixed with the raw water in operation of said brine supply means under control of said feedback control means and

initial control means for controlling operation of said brine supply means in such a manner that a supply amount of saturated brine mixed with the raw water is adjusted on a basis of the instant amount of saturated brine memorized in said memory means during previous operation of said brine supply means under control of said feedback control means when said electrolytic cell is activated to start production of the electrolyzed water.

2. An electrolyzed water production system as recited in Claim 1, wherein said initial control means is designed to control operation of said brine supply means in such a manner that the supply

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amount of saturated brine mixed with the raw water is decreased in a predetermined amount less than that of saturated brine memorized in said memory means.

3. An electrolyzed water production system as recited in Claim 1, wherein said initial control supply means is designed to delay operation of said brine supply means under control of said feedback control means until the conductivity of the diluted brine detected by said detection means becomes larger than a predetermined reference value.

4. An electrolyzed water production system as recited in Claim 3, wherein the reference value is defined by the target value of said feedback control means.

5. An electrolyzed water production system as recited in Claim 3, wherein the reference value is defined to be decreased in accordance with lapse of time after said electrolytic cell is activated to start production of the electrolyzed water.

6. An electrolyzed water production system as recited in Claim 1, wherein said initial control means is designed to operate said brine supply means under control of said feedback control means after lapse of a predetermined time when said electrolytic cell was activated to start production of the electrolyzed water.

7. An electrolyzed water production system as recited in Claim 1, wherein said initial control means is designed to operate said brine supply means under control of said feedback control means after change rate of the conductivity of the diluted brine detected by said detection means decreased less than a predetermined reference

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value.

8. An electrolyzed water production system as recited in Claim 1, wherein said brine supply means is in the form of a fluid pump of the type driven by each pulse of pulse train signals applied thereto, and wherein said detection means comprises means for detecting the conductivity of the diluted brine at a first predetermined time interval and calculation means for calculating an average value of the conductivity detected at the first predetermined time interval.

9. An electrolyzed water production system having a brine storage tank arranged to store saturated brine of predetermined concentration, a fluid pump of the type driven by each pulse of pulse train signals applied thereto from pulse signal generator to supply a predetermined amount of saturated brine from said brine storage tank for mixing with raw water supplied from a source of raw water, and an electrolytic cell arranged to be supplied with the diluted brine prepared by a mixture of the saturated brine and raw water for producing electrolyzed water,

wherein an electric control apparatus for the production system comprises:

detection means for detecting the conductivity of diluted brine supplied to said electrolytic cell at a first predetermined time interval;

calculation means for calculating an average value of the conductivity successively detected by said detection means in sequence; and

pulse control means for adjusting a period of the pulse train signals applied from said pulse signal generator in accordance with a difference between the calculated average value of the conductivity

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and a predetermined target value so that the average conductivity becomes substantially equal to the target value.

10. An electrolyzed water production system as recited in Claim 9, wherein said pulse control means is designed to adjust the period of the pulse train signals at a second predetermined time interval more than the first predetermined time interval, and wherein said calculation means is designed to calculate the average value of the conductivity on a basis of plural data on conductivity detected by the detection means plural times at the first predetermined time interval during said second predetermined time interval except several data on conductivity detected successively by the detection means immediately after the said pulse control means adjusts said period of the pulse train signals.

11. An electrolyzed water production system as recited in Claim 9, wherein said calculation means is designed to weight the conductivity with a value which becomes larger as a difference between the conductivity detected by said detection means and the target value becomes larger for calculating a weighted integral of the conductivity.

12. An electrolyzed water production system as recited in Claim 9, wherein said calculation means is designed to weight the conductivity with a value which becomes smaller as a difference between the conductivity detected by said detection means and the target value becomes larger for calculating a weighted integral of the conductivity.

13. An electrolyzed water production system as recited in Claim 9, wherein said calculation means is designed to weight the

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conductivity with a value which becomes larger as a difference between the conductivity detected by said detection means and the target value becomes larger until a predetermined condition is satisfied after said electrolytic cell was activated to start production of electrolyzed water and to weight the conductivity with a value which becomes smaller as a difference between the conductivity detected by said detection means and the target value becomes larger after the predetermined condition is satisfied.

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