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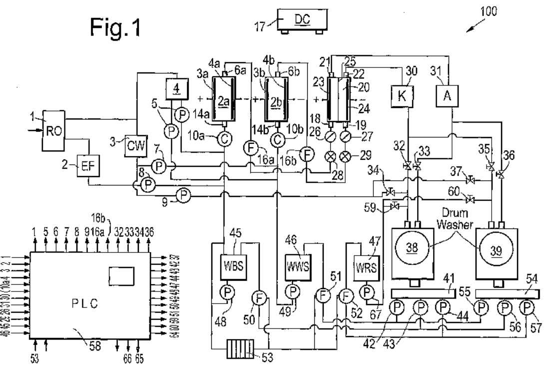
Fig.1



(57) Abstract: The present invention provides a computer-controlled laundering method comprising: (i) providing at least one catholyte solution and at least one anolyte solution from at least one electrolysis apparatus to a washing apparatus; and (ii) laundering at least one item in a first laundering process in said washing apparatus, the first laundering process comprising: d) a washing step in at least a first solution comprising said at least one catholyte solution thereby generating a waste catholyte solution; e) a bleaching/disinfecting step in a second solution comprising said at least one anolyte thereby generating a waste anolyte solution; and f) a rinsing step in a rinsing solution thereby generating a waste rinsing solution;to provide a substantially clean item wherein at least one of the pH and oxidation-reduction potential (ORP) of the catholyte fed to said washing step or the anolyte fed to said bleaching/disinfecting step is substantially continuously monitored to maintain at least one of the pH and ORP in at least one of said steps at least in part by controlling the amount of at least one of the catholyte and anolyte respectively introduced into each of said steps; and (iii) recycling at least one of said waste catholyte solution and said waste anolyte solution via said at least one electrolysis apparatus to said washing apparatus to allow at least partial reuse of said at least one of said waste catholyte solution and said waste anolyte solution in a second or subsequent laundering process.

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SYSTEMS AND METHODS FOR LAUNDERING WITH RECYCLING

FIELD OF INVENTION

This invention relates to systems and methods for laundering, in particular with regard to industrial laundering employing solution mixtures produced from electrochemical processes and recycling of the solutions. This invention can be implemented in the food industry, agriculture, meat industry etc. with minor modification of collection points of waste solution mixtures from electrochemical processes

BACKGROUND OF THE INVENTION

Current laundering processes use a large amount of energy, are fairly slow, and use detergents, bleaching agents and softeners which are not environmentally desirable.

Known fabric washing methods depend upon many inefficient technologies which could be improved, such as by reducing the electrical or fuel energy consumption. Additionally, a large amount of water is required for current washing processes, as approximately 10 to 30 liters of water used for the entire laundering process of 1 kg. of soiled fabrics. Furthermore, the cycle time of a domestic/commercial washing machine process is 60 to 90 minutes, and worst of all, the soiled fabrics are not thoroughly cleansed by the process.

Currently, washed fabrics contain approximately 2% of the initial detergent, which remains entrained within the fabric, as well as 2 to 5% of the original dirt, which remains in the washed fabric.

The detergents, softeners, bleaches and other chemicals used in the washing process are typically released into the environment. Additionally, byproducts of these chemicals may also be released into the environment.

Some prior art solutions toward improving the apparatus and method of washing fabrics have used ozone, which is a gas at room temperature. By adding ozone to water, an oxidizing agent is produced which enables the washing of fabrics in water without detergents. However, maintaining the stability over time of the ozone content in the water has proven difficult and has led to increased use of electrolytically produced oxidants in washing solutions.

One such apparatus is disclosed in United States Patent No. 4,319,973 to Porta Augusta. This invention relates to a method for washing and bleaching textiles. The method is carried out by means of an aqueous wash bath containing a detergent substantially free of a bleaching agent. The process is characterized in that the bleaching is performed by incorporating into the wash bath an aqueous alkaline oxidizing solution containing in particular hydrogen peroxide ions, which was produced electrolytically, immediately before its addition to the wash bath, by reducing oxygen at a cathode in an alkaline medium.

A similar invention is disclosed in Certificate of Authorship No. SU 1687684 to A. Pulavsky et al. This invention relates to processes and systems for machine washing. The method is carried out by passing washing solution, which has been electrolytically treated in a cathode chamber of diaphragm electrolyzer, prior to washing through a washing reservoir. The washing solution is treated to attain pH level of from 10.0 to 11.5 and Oxidation Redaction Potential of from -600 to -800 mV. Additionally, oxygen is injected into the washing solution before completion of the washing process.

Further prior art solutions towards improving the apparatus and method of washing fabrics have focused on developing an apparatus that can produce treated water with an elevated oxidation reduction potential of the treated water and an elevated amount of hypochlorite, wherein detergent is not required in the treated water for the washing of fabrics, thereby eliminating the previously identified drawbacks related to using detergent in wash water for fabrics.

One such apparatus is disclosed in United States Patent No. 6,841,058 to Culvey et al., which describes a redox bipolar cell in a fabric washing machine utilizing tap water with a low oxidation reduction potential. This system produces charged wash water by an electrochemical reaction to elevate the oxidation reduction potential of the wash water in order to remove contaminants from soiled fabrics thereby forming charged waste water, without the use of a detergent.

This invention has many drawbacks, such as not being able to provide fully cleaned laundry since the use of an oxidizing mixture for laundering is ineffective. This necessitates the use of many additives, such as enzymes, optical brightener, softener, deodorant etc. Furthermore, the redox potential sensor described therein cannot measure the laundering solution in real-time inside the tub where fabric or clothes are being laundered.

Another invention is disclosed in United States Patent No. 5,928,490, to Sweeney, which discloses an improved laundry treatment system comprising a washer which is connected to used water discharge to a tank for filtration and recirculation back to the washer, a tank containing water for making up losses in the wash cycle, and an electrolytic cell therein comprising an enclosed compartment.

The electrolytic cell comprises an enclosed compartment containing an anode and a cathode supported on the outside and inside respectively of an opening in the wall of the compartment open to the surrounding liquid when the compartment is immersed in the water in the tank for producing mixed oxidants dissolved in the make up water for oxidizing deleterious components, without damaging the fabric that are being washed.

United State Patent Application No. 2004/0172985, to Mamiya Haruo et al., discloses an electric washing machine which performs a washing process with the use of electrolyzed water. When the level of supplied water reaches an electrolyzing water level which is lower than a washing water level, energizing of an electrolyzing device is activated. At this time, air is supplied into an electrolyzing chamber by an air pump, so that water in the electrolyzing chamber is caused to flow, thereby assisting efficient electrolysis of the water. The water thus electrolyzed has an enhanced cleaning capability thereby improving the washing performance of the washing machine.

United States Patent Application 2006028874 to van Kralingen et al., describes a peroxide generating device and method. The peroxide generating device for application in an automatic fabric washing machine comprises an electrochemical cell for the production of peroxide from tap water and air, and a pH modifying device for the production of acidic and alkaline water, thereby enabling washing of the fabric articles without the need for added chemicals and improved fabric care, due to the separate dosing of peroxide.

The idea of laundering only by mixing oxidants, without any detergents is disclosed in the patents hereinabove. However, the methods therein are limited in practice. From theoretical point of view, utilization of mixed oxidants or utilization of hypochlorous compound, such as sodium hydroxide (NaOH) or hypochlorous acid (HOCl), provides only for bleaching and disinfecting, but not for laundering/washing because these compounds are effective only in neutral, weakly acid and weakly alkaline solutions (and not in strongly alkaline solutions required for washing). The equilibrium equation of such solutions may be written:

$$NaOCl + H_2O \leftrightarrow NaOH + HOCl \leftrightarrow Na^+ + OH^- + H^+ + OCl^- \quad (1)$$

As is well known, the laundering process is performed in three sequential steps:

a) washing step in an alkaline medium (pH = 10.0 – 12.0, ORP = -700 ...-900 mV);

b) bleaching and disinfection step in an acid medium (pH = 2.0 – 4.0, ORP = 800 – 1,200 mV); and

c) rinsing, neutralization and softening step in a neutral medium (pH = 6 – 8, ORP = 400...- 200 mV).

Step a) can only proceed efficiently in a highly alkaline medium/solution with above mentioned parameters of pH and ORP, such that the following saponification reaction occurs:

R1-COO-R2 (Fatty acid) + NaOH (Sodium hydroxide) ↔
R1-COO-Na (Soap) + R2-OH (Glycerol) (2)

This reaction allows the soap to soften the water, decompose fatty acids, neutralize amino acids and proteins and remove decomposed substances from linen.

Step b) takes place in an acid medium with above mentioned parameters of pH and ORP, a chloramination reaction occurs, in accordance with following equation:

R-CHNH_2COO-OH (Amino acid) + HOCl (Hypochlorous acid) ↔
R-CClNH_2COO-OH (Chloramine) + H2O (Water) (3)

This reaction allows bleaching and disinfection to occur, with decomposition of amino acids, proteins, any kinds of dye-stuffs etc.

Step c) occurs in neutral weakly acid or weakly alkaline medium with above mentioned parameters of pH and ORP, a neutralization reaction in accordance with next equation may occur:

R-CHNH_2COO-OH (Amino acid) + NaOH (Sodium hydroxide) ↔
R-CHNH_2COO-ONa (Salt) + H_2O (Water) (4)

or

$R\text{-}CHNH_2COO\text{-}OH$ (Amino acid) + $NaOCl$ (Sodium hypochlorite) $\leftrightarrow$
$R\text{-}CHNH_2COO\text{-}ONa$ (Salt) + $HOCl$ (Acid) (5)

It should be understood that one cannot achieve an efficient saponification reaction in a weakly acid or weakly alkaline medium (solution), such as using mixed oxidants without detergent, per the prior art patents. These prior art processes allow for a good bleaching effect, but reactions products, such as salts, decomposed proteins, fats and other residual soil may still remain in the fabrics. This has been confirmed by laboratory analyses.

United States Patent No. 6,132,572, to Kim, describes an electrolyzer apparatus including anode and cathode units that are alternately arranged in a sandwich type fashion separated from each other by ion exchange membranes. Two inlet streams of water introduced into the apparatus wherein one water stream is routed through the anode sections and the other water stream is routed through the cathode sections, and resulting in two treated water outlet streams, with the anode stream being highly acidic and the cathode stream being highly alkaline that cumulates in an elevated oxidation reduction electric potential ranging from-900 to +1180 mV. This device has several drawbacks, namely: air plugging in the chamber until it does not function properly, and b) the washing effect (washing quality) is estimated on a basis of reflection factors from dirty and clean fabrics and do not take in consideration the amount of residual dirt in the fabric.

Another device is disclosed in United States Patent Application No.2002/023847 to Natsume Shinichi. This invention provides a cleansing and sterilizing apparatus for cleaning embodiments such as dishes, medical devices, clothing, etc. The apparatus comprises an electrolysis chamber that uses an ion exchange membrane to separate a cathode section from an anode section of the chamber. Tap water is injected into cathode section and saltwater is injected into the anode section. Electrolysis in the anode section of the electrolysis chamber forms acidic water and HOCl, which has antibacterial and disinfectant properties. In addition, electrolysis in the cathode section of the electrolysis chamber forms alkaline water and sodium hydroxide (NaOH), which has cleansing and reducing properties.

The alkaline water and sodium hydroxide is then pumped out of the electrolysis chamber sprayed on embodiments to be cleansed, such as medical devices (endoscopes, dialysis equipment), dishes, etc. After cleansing, the items may then be optionally sprayed with the acidic water and HOCl to sterilize or disinfect the items. In alternative embodiments of the apparatus, the ion exchange membrane includes an anion exchange membrane, a cation exchange membrane, and a neutral membrane. In another embodiment of the invention, the electrolysis chamber does not include an ion exchange membrane, thereby reducing costs of manufacturing and using the invention.

There is thus still a need to provide an energy-efficient and cheap, environmentally friendly and user-friendly quick washing process and method.

SUMMARY OF THE INVENTION

The current invention is directed to systems and methods for laundering soiled items without detergents and with low water consumption. In sharp contrast to prior art processes in which the quantity of water used for one kg of linen is from 10 to 30 liters, the method of the current invention uses 0.5 to 3.0 liters of water per 1kg of linen.

Additionally, the system and method of the present invention result in energy and fuel savings of about 85 – 90%.

Some embodiments of the present invention are directed to a laundering process and a method with recycling of process solutions.

In particular, at least one of anolyte and catholyte solutions are recycled.

The ratio of the fresh anolyte to recycled anolyte ranges from 1:3 to 1:10.

The ratio of the fresh catholyte to recycled catholyte ranges from 1:3 to 1:10.

The present invention has been made in consideration of the aforementioned problems of the related prior art and seeks to provide a laundering process having at least one closed-loop recycling system for separate treatment of each kind of laundry waste water.

Additionally, the recycling system of the present invention is based upon electrochemical methods, which allow for a reduction in water consumption of 90 – 95% down to around 0.5 – 3.0 liter of water for 1kg of laundering linen.

A significant saving in energy sources (such as oil, gas, electrical energy etc.), of 85-90% relative to prior art processes from 0.15 – 0.25- KW/kg linen to 0.02 – 0. 1KW/kg linen.

A further saving in cycle time is around 30-90% of prior art cycle times from 30 – 90 min. to 8 – 20 min.

A significant saving in consumption of detergents of about 90 – 95%, down to around of 0.5 – 1.0 g. of detergent for 1 kg. very dirty linen is also provided with an average savings of about 93 – 96% of all kinds of linen, including linen for hotels, hospitals, restaurants, and domestic linen etc.

It is therefore one of the objects of the present invention to provide an improved treatment of laundry waste water by separate electrochemical treatment of washing solution, bleaching-disinfecting solutions and rinsing solution. Such treatment of the solutions retains up to around 95% of their properties without a requirement of an external supply of energy and chemicals.

According to one aspect of the present invention, there is provided an improved treatment of washing solutions by multi-stage electrochemical treatment comprising the following steps:

- collecting waste washing solution from one or more washers
- filtering waste washing solution in a self-cleaning filter
- treating filtered waste washing solution in a membrane-less electrolyzer
- filtering waste washing solution after treatment in the membrane-less electrolyzer in a self-cleaning filter
- treating of filtered waste washing solution in a membrane electrolyzer with simultaneous catholyte production
- filtering catholyte in a self-cleaning filter and collecting said filtered catholyte in a catholyte tank
- collecting effluents from said self-cleaning filter to a filter-press,
- treating effluents in the filter-press and returning filtered solution to an inlet of a membrane-less electrolyzer for washing solution treatment.

Another aspect of the present invention is to provide an improved treatment of bleaching-disinfecting solutions by multi-stage electrochemical treatment comprising the following steps:

- collecting of waste bleaching- disinfecting solution from washers
- filtering waste bleaching- disinfecting solution in a self-cleaning filter
- treatment of filtered waste bleaching- disinfecting solution in membrane-less electrolyzer

- filtering of waste bleaching- disinfecting solution after treatment in a membrane-less electrolyzer in a self-cleaning filter
- treatment of filtered waste bleaching- disinfecting solution in a membrane electrolyzer with simultaneous anolyte production
- filtering of anolyte by self-cleaning filter and its collection in anolyte tank

Yet another aspect of the present invention provides a catholyte chamber of membrane electrolyzer having two simultaneous functions- namely laundry waste washing water treatment and catholyte production.

A further aspect of the present invention is to provide an anolyte chamber of membrane electrolyzer having two simultaneous functions, namely laundry waste bleaching-disinfecting water treatment and anolyte production.

An additional aspect of the present invention provides a clean water from a reverse osmosis (RO) device to provide additional feed water for catholyte production to prevent scaling of the electrolyzer cathodes.

A further aspect of the present invention provides an effluent from an RO device to provide additional feed water for anolyte production.

A significant advance of the present invention is that the use of two electrolyzer units in series, particularly with a second unit comprising a membrane enables production of a catholyte having a higher pH than that obtainable from a comparable prior art systems.

The computer-controlled laundering system of the present invention includes a system, substantially as shown in the figures.

The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures so that it may be more fully understood.

With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is a simplified diagram of an industrial drum washing system with a solution recycle, in accordance with some embodiments of the present invention;

Fig. 2 is a simplified diagram of an industrial tunnel washing system with a solution recycle in accordance with some embodiments of the present invention;

Fig. 3 is a simplified flowchart of a method for performing a first laundering process, in accordance with some embodiments of the present invention;

Fig. 4 is a simplified flowchart showing sub-steps of step 310 of Fig. 3;

Fig. 5 is a simplified flowchart of a method for catholyte recycling of a laundering step in accordance with some embodiments of the present invention;

Fig. 6 is a simplified flowchart of a method for anolyte recycling of a laundering process, in accordance with some embodiments of the present invention; and

Fig. 7 is a simplified flowchart of a method for rinse solution recycling of a laundering process, in accordance with some embodiments of the present invention.

Identical reference numerals refer to similar or identical parts in different figures.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Some embodiments of the present invention are directed to systems and methods for laundering fabrics in processes wherein the pH and ORP levels are kept substantially constant over a long period of time. More particularly, in all of the three steps: a) washing/laundering, b) disinfecting and bleaching and c) rinsing, the solution compositions are retained within strict parameter regimes by means of adding tap water, catholyte or anolyte and additives, responsive to a detected change in the solution composition in the washing machine.

Some embodiments of the present invention particularly relate to systems and methods for laundering fabrics in processes employing three recycling subsystems of waste solutions, namely, a) a washing/laundering (catholyte) recycle, b) a disinfecting and bleaching (anolyte) recycle and c) a rinse solution recycle.

More particularly, the waste solutions from all three laundering steps: a) washing/laundering, b) disinfecting and bleaching and c) rinsing, are collected separately and recycling thereof is implemented by three separate recycles simultaneously.

Fig.1 is a simplified diagram of an industrial washing recycle system 100 having a drum washing machine or washer 41 or 42 in accordance with some embodiments of the present invention.

Fig. 2 is a simplified diagram of an industrial tunnel washing recycle system 100 comprising a tunnel washer 67, in accordance with some embodiments of the present invention.

The present invention provides laundering waste solution collection and recycling from drum washing machines 41, 42 (Fig. 1) and/or from a tunnel washing machine 67 (Fig. 2) by continuous collection of the washing waste solution, bleaching – disinfection waste solution and rinsing waste solution followed by their separate and simultaneous recycling.

The set up and control of the waste laundering solutions recycling from drum washer 41, 42 (Fig. 1) and tunnel washer 67 (Fig. 2) are very similar. Identical reference numerals refer to similar or identical parts in different figures and the following description refers to both Fig. 1 and Fig. 2.

Waste washing solution from drum washer 41 or 42 is collected in reception tank 53 or 54 and by pump 55 or 58 is fed to a filter, such as a self-cleaning filter 50. Thereafter it is fed from said filter and collected in an intermediate holding tank for waste washing solution (WWS) 44. Pump 47 pumps the filtered WWS from tank 44 and directs it to a conductivity meter sensor 10b and thereafter to inlet 14b of membrane-less electrolyzer 2b. There, clean water (CW) is fed from clean water tank 3 from RO device 1 by pump 7 and salt water from tank 4 by metering pump 5 for salt water.

Conductivity meter sensor 10b constantly monitors the conductivity (EC) level of a replenished catholyte solution. A PLC 74 and metering pump 5 are employed to retain the correct quantity and quality of the replenished catholyte solution within predetermined process limits, such that the conductivity is between 1 and 15 mS, the flow rate into the electrolytic membrane-less electrolyzer apparatus 2b is between 2 and 50 l/min.

Membraneless electrolyzer apparatus 2b comprises a housing, an anode 3b and a cathode 4b, an inlet nozzle 14b and an outlet nozzle 6b. The anode is preferably constructed from a titanium substrate with an MMO coating from RuO_2 and IrO_2. The cathode is preferably constructed from titanium. The housing and electrodes can be round or flat, but, in any case, a distance between anode and cathode is generally from 3 to 20 mm.

The aqueous solution in the processing chamber of membrane-less electrolyzer 2b is subject to an electric current from anode 3b and cathode 4b, which are both connected to a DC supplier 17, and the current passes through the processing chamber such that electrochemical reactions occur at the anode and cathode. Ions generated at the anode are cations and chemical agents, such as, but not limited to HOCl, HCl, Cl_2, H^+, HO_2, H_3O+, Na^+, and K^+. At the cathode, the following types of anions are generated OH^-, $H_3O_2^-$, NO_3^-, CO_3^{2-}, SO_4^{2-}, ClO^-. These cations and anions may react together in one or more neutralization reactions resulting in non-treated aqueous solution and reactions products such as NaOCl, NaOH, KOH, H_2O, HOCl etc. with pH about of from 8.0 to 9.0 at outlet nozzle 6b of membrane-less apparatus exit.

After passing through the membrane-less apparatus 2b, the resultant aqueous solution and reactions products are fed into a self-cleaning filter 16b and then through control cock 29 and flow-meter 27 to catholyte chamber of membrane electrolyzer apparatus 20 as described hereinbelow.

Membrane electrolyzer apparatus 20 comprises a housing, an anode 23, a cathode 24, a membrane 25, inlet nozzles 18 for anode and 19 for cathode chambers and outlet nozzles 21 for anode and 22 for cathode chambers, The anode is constructed from a titanium substrate with an MMO coating of RuO_2 and IrO_2.

Electrochemical reactions occur at the anode and at the cathode. However, apparatus 20 has a membrane 25 disposed between the anode and cathode chambers. Thus, the neutralization reactions occurring in apparatus 2b, cannot occur herein due to their separation by the membrane. Thus, electrochemical reaction products accumulate in their respective chambers and exit the chambers through outlet nozzle 21 for anode chamber and outlet nozzle 22 for cathode chamber of membrane electrolyzer 20 to catholyte tank 30 and anolyte tank 31.

A predetermined feed rate of catholyte from catholyte tank 30 is fed to washer 41 and 42 through electric cock 32 and 35 together with CW through electric cock 34 and 37and additives (not shown on Fig.1 and Fig.2) into an inner drum of drum washer 41 and 42. This effects the formation of a mixed catholyte solution or washing solution. After the washing stage a waste washing (catholyte) solution is pumped out into receptor 53 and 54 and the waste washing solution is recycled.

The same recycling principal is used to recycle the bleaching – disinfecting solution. After the bleaching disinfecting step is performed in the washer, the waste (anolyte) bleaching-disinfecting solution is fed into receptor 53 and 54.. Pump 56 and 59 pumps the solution through a self–cleaning filter 49 to a tank 43 for waste bleaching – disinfecting solution (WBS) collection. Pump 46 feeds the filtered solution from tank 43 to membrane-less electrolyzer 2a. Additionally RO device 1 and tank 2 of effluent and pump 8 supply the effluent, in addition to filtered waste bleaching – disinfecting solution. Further additions are made via metering pump 40 for salt water from tank 4.

Typically the filtered solution passes via a conductivity meter sensor 10a and then into inlet 14a of membrane-less electrolyzer 2a. Thereafter, the resultant anolyte solution from the membrane–less electrolyzer 2a is pumped into a filter, such as a self–cleaning filter 16a. Control cock 28 and flow-meter 26 regulate the flow of anolyte from filter 16a to an anode chamber of membrane electrolyzer 20 via an inlet 18 to anolyte holding tank 31.

There is a simpler recycling cycle for the waste rinsing solution, which includes only receptors 53 and 54 of the waste rinsing solution, a pump 57 and 60, which pumps the waste rinse solution via a self – cleaning filter 51 to a holding tank 45 for filtered waste rinsing solution (WRS). Thereafter, a pump 48 feeds the solution from tank 45 back to the drum washer as an additive solution to the washing step to the washing solution which include tap water, catholyte, filtered waste rinsing solution and additives.

The same recycling cycles are used by laundering with a tunnel washer, but in this case, there is a separate receptor 68 for waste washing solution, receptor 69 for waste bleaching – disinfecting solution and receptor 70 for waste rinsing solution..

Self – cleaning filters are released from sludge by back flash after a certain predetermined time and sludge is directed to a filter press 52, where it is filtered. The liquid phase is then directed as an additive to the waste bleaching – disinfecting solution to the inlet of membrane – less electrolyzer 2a.

Tap water is fed to RO device 1 and is divided into two streams: a) one to the clean water (CW) tank 3 and salt tank 4 and the other b) to the effluent (EF) tank 2. CW from tank 3 fed also to inlet of membrane – less electrolyzer 2b as an addition solution to the recycled washing solution to replenish water removed with laundered linen and is also passed to the drum and tunnel washers.

Effluent solution (EF) is passed from tank 2 and fed to the inlet of membrane–less electrolyzer 2a as an additive to recycling bleaching-disinfecting solution in place of water, which was removed with the laundered linen.

A salt tank 4 is filled with CW and salt (from time to time) for saline water formation, which is further fed by metering pump 5 and 40 to inlet nozzle 14a and 14b of membrane-less electrolyzers 2a and 2b. The quantity of saline water is regulated by EC meter sensors 10a and 10b.

It should be understood that the methods of the present invention allow for optimized washing/laundering processes in comparison to prior art processes. Some of the advantages include, but are not limited to:

- minimal quantities of utilized water relative to standard processes
- no requirement for detergent
- no environmental problems due to release of detergents
- no detergents traces in clean clothes
- energy saving - less or no requirement to heat water
- shorter washing cycles – saving in electricity and labor
- minimal quantities of additives relative to standard processes

Another notable improvement of the present invention over the prior art is the gathering and recycling of three main waste laundering solutions - waste washing solutions, waste bleaching – disinfecting solution and waste rinsing solution. This feature is implemented simultaneously via at least one line for waste washing solution recycling and at least one line for waste bleaching - disinfecting solution recycling and at least one line for waste rinsing solution recycling. By such a recycling system, the anion-containing waste washing solution cannot be in contact with the cation-containing waste bleaching – disinfecting solution and therefore neutralization reactions cannot occur. Thus, both the washing and bleaching – disinfecting solutions retain above 65 – 85% of their properties over time.

It should be noted that the result of retention of the properties of the above mentioned solutions, leads to a significant reduction in all kinds of energy consumption (fuel, electricity) and labor cost for regeneration them to the required working level.

Yet another advantage of the present invention over the prior art is the use of two electrolytic stages (2a, 20) in both lines for recycling (waste washing solution and bleaching – disinfecting solution) by consecutively passing waste laundering solutions through first membrane-less electrolysis apparatus 2a or 2b and thereafter the two above mentioned solutions are passed simultaneously through anode and cathode chambers of the membrane electrolysis apparatus 20, having a membrane between the anode and cathode chambers.

In the two membrane-less electrolyzers 2a and 2b, similar processes take place, but with different solutions. In membrane-less electrolyzer 2a the feed waste bleaching – disinfecting solution is processed. The solution has a pH of from 3.0 to 6.0. Membrane–less electrolyzer 2b is fed with waste washing solution having a pH of from 9.0 to 11.0. Thus, in electrolyzer 2a, there prevails a reduction reaction at the cathode, in which azo- and nitro compounds are reduced to amino compounds, with further oxidation to CO_2, NH_2 and H_2O. Parts of the reduced products are oxidized to insoluble compounds and precipitate. In electrolyzer 2a, there prevails an oxidation reaction at the anode and destruction of dye and organic contaminants.

Yet another advantage of the present invention over the prior art is the use of membrane electrolyzer 20 which regenerates waste washing solution to catholyte, provided with the required level of pH and ORP. Additionally the bleaching – disinfecting solution is converted to anolyte having the required level of pH and ORP. These processes use significantly less energy relative to prior art processes.

A further advantage of the present invention over the prior art is the use of a reverse osmosis apparatus, which is configured to supply purified water back to membrane-less electrolyzer 2b from the recycle line of waste washing solution.

Effluent from the RO device is recycled to the membrane-less electrolyzer 2a from the recycle line for waste bleaching - disinfecting solution. Thus, the effluent of the RO device effluent is re-used in the laundering process and is not discarded.

An additional advantage of the present invention over the prior art is the use of a membrane electrolyzer with an anion exchange membrane, which prevents the membrane thereof from clogging up with precipitates such as calcium and magnesium carbonates.

In especially preferred embodiment of the present invention, the present invention achieves pH and ORP stability within a drum washing machine 41 and 42 (Fig. 1) and/or within a tunnel washing machine 67 (Fig. 2) by providing at least periodical and preferably constant monitoring of washing, bleaching and disinfection solutions parameters and immediately correcting any of the parameters upon deviation thereof from an upper and a lower limit.

The set up and control of the drum washer 41 and 42 (Fig. 1) and tunnel washer 67 (Fig. 3) are very similar. Identical reference numerals refer to similar or identical parts in different figures and the following description refers to both Fig. 1 and Fig. 2.

Tap water is fed to RO device 1 and divided into two streams: a) one to the clean water (CW) tank 3 and salt tank 4 and the other b) to effluent (EF) tank 2. CW from tank 3 fed also to inlet of membrane – less electrolyzer 2b as addition to recycling washing solution in return for water, which was take off by laundered linen and also to drum and tunnel washers.

EF from tank 2 fed to inlet of membrane – less electrolyzer 2a as addition to recycling bleaching - disinfecting solution in return for water, which was take off by laundered linen.

A salt tank 4 is filled with CW and salt (from time to time) for saline water formation, which is further fed by metering pump 5 and 40 to inlet nozzle 14a and 14b of membrane-less electrolyzers 2a and 2b. Amount of saline water is regulated by EC meter sensors 10a and 10b.

Membrane-less electrolysis apparatus 2a comprises a housing, an anode 3a and a cathode 4a, an inlet nozzle 14a and an outlet nozzle 6a. The anode constructed from a titanium substrate with an MMO coating from RuO_2 and IrO_2 in an equal ratio (1:1). The housing and electrodes can be round or flat, but, in any case, a distance between anode and cathode is generally from 3 to 20 mm.

A conductivity meter sensor 10a is set at the end of an inlet nozzle 14a to the membrane-less apparatus 2a. The sensor measure the quantity of saline water entering apparatus 2a and transmits this data to PLC 74. The aqueous solution in the processing chamber of membrane-less apparatus 2a is subject to an electric current from anode 3a and cathode 4a, which are both connected to a DC supplier 17, and the current passes through the processing chamber such that electrochemical reactions occur at the anode and cathode. Ions generated at the anode are cations and chemical agents, such as, but not limited to HOCl, HCl, Cl_2, H^+, HO_2, H_3O+, Na^+, and K^+. At the cathode, the following types of anions are generated OH^-, $H_3O_2^-$, NO_3^-, CO_3^{2-}, SO_4^{2-}, ClO^-. These cations and anions may react together in one or more neutralization reactions resulting in non-treated aqueous solution and reactions products such as NaOCl, NaOH, KOH, H_2O, HOCl etc. with pH about of from 8.0 to 9.0 at outlet nozzle 6a of membrane-less apparatus exit.

After passing through the membrane-less apparatus 2a, the resultant aqueous solution and reactions products are fed into membrane apparatus 20 as described above. Membrane electrolysis apparatus 20 comprises a housing, an anode 23, a cathode 24, a membrane 25, inlet nozzles 18, 19 for anode and cathode chambers and outlet nozzles 21, 22 for anode and cathode chambers, The anode is constructed from a titanium substrate with MMO coating of RuO_2 and IrO_2 in an equal ratio (1:1) and the cathode is uncoated titanium. The cross section ratio of the outlet nozzles 21, 22 to cross-section of the inlet nozzles 18, 19 is 2:1.

Electrochemical reactions occur at the anode and at the cathode. However, apparatus 20 has a membrane disposed between the anode and cathode chambers. Thus, the neutralization reactions occurring in apparatus 2a 2b, cannot occur herein due to their separation by the membrane. Thus, electrochemical reaction products accumulate in their respective chambers and exit the chambers through outlet nozzles 21, 22 of membrane apparatus 20 to catholyte tank 30 and anolyte tank 31.

As described above the pH level of the catholyte in tank 30 is typically in the range of 11.3 to 12.5 and ORP to Platinum, relative to Ag/AgCl, in the range of from -650 to -920 mV. The pH level of the anolyte in tank 31 is typically in the range of from 1.7 to 2.4, and ORP to Platinum, relative to Ag/AgCl, of from +800 to +1200 mV.

The anolyte and catholyte produced are for use in the laundering process in drum washer 41 and 42. Additives may also be added to the drum washer to improve the laundering quality, thus a solution of washing enzymes known in the art, such as lipases. Another additive used in the art is a grease remover (any kind of solvent), an optical brightener, a softener, one or more fragrances or odorants (Additives holding tanks, pumps, piping etc do not shown on Fig.1 and Fig.2) .

All the aforementioned and not shown tanks for additives are connected to drum washer 41 and 42 (in Fig. 1) or to tunnel washer – CBW 67 (Fig. 2). All solutions are fed to the respective washers either by gravitation, per tank 30 for catholyte and tank 31 for anolyte and electric valves 32, 33, 34, 35, 36, 37, 38, 39, 61, 62, 63, 64, 65, 66 or by pumps.

Referring further to Fig. 1, by laundering with drum washer 41 or 42 in a washing phase, the catholyte from tank 30 is used with additives such as grease remover, enzyme, optical brightener and CW by means of electrical valve 34 and 37. The required pH level of the washing solution in this phase is controlled by a time control of electrical valves 32, 34 and of electrical valves for the introduction of additives (not shown in Fig.1 and Fig.2) which is based on a response to the readings from pH sensors 77 and 78.

In a bleaching and disinfecting phase, anolyte is added from tank 31, using time control of electrical valve 33 and 36 and CW is added by means of electrical valve 75 and 76, which is based on a response to the readings from pH sensors 77 and 78..

The required pH level of the rinsing solution is maintained in this phase by time control of electrical valves 32, 34 and 35, 37 which is established on basis of pH measurements from pH sensors 77 and 78.

It should be emphasized that in prior art washing systems the pH level in a drum washer was not normally monitored since the only pH sensor was disposed externally to the drum washer.

Turning now to Fig. 2, it should be noted that in laundering with a CBW – tunnel washer 67, there are three different laundering zones:

1) a washing/laundering zone with a highly alkaline pH level;

2) a bleaching- disinfecting zone with a low and acidic pH level; and

3) a rinsing zone with neutral or alkaline pH level.

The three zones are periodically and preferably continuously controlled by three respective pH sensors 79, 80 and 81.

In the washing zone, the washing solution used is the catholyte from tank 30 by means of electrical valve 61 with the addition of additives such as grease remover, enzyme and optical brightener (tanks and electrical valves of additives are not shown on Fig.2). CW water is added by means of electrical valve 62. The required pH level of the washing solution to this zone is effected by time control of electrical valve 61 and pump 73, which is established by measurements from pH sensor 79.

In the bleaching and disinfecting zone, anolyte is used as a bleaching and disinfecting solution, and is received from tank 31. CW is added to this zone by means of electrical valve 63.

The required pH level of the bleaching and disinfecting solution is supplied by time control of electrical valves 64, which is established on the basis of pH measurements from pH sensor 80.

In the rinsing zone, the required pH level of the rinsing solution is supplied to this zone by activation of electrical valves 65 and 66, which, in turn are fed signals on the basis of pH measurements from pH sensor 81.

All laundering operations with either the drum washer 41 or 42 or CBW – tunnel washer 67 are controlled by means of a controller, exemplified herein by, but not limited to Programmable Logic Controller (PLC) 74. Any other computer control system of the art could be used in place of PLC 74. PLC 74 has inputs (1, 2, 3, 4, 10a, 10b, 30, 31, 26, 29, 45, 46, 77, 78, 79, 80, 81) and outputs (1, 5, 6, 7, 8, 9,16a, 16b, 32, 33, 34, 353, 36, 37, 38, 39, 46, 47, 48, 51, 52, 53, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 71, 72 and 73).

Typically, the PLC will have several different programs for corresponding washing programs for different types and quantities of clothes.

Reference is now made to Fig. 3, which is a simplified flowchart 300 of a method for performing a first laundering step, in accordance with some embodiments of the present invention.

In a first step, 310 catholyte and anolyte solutions are prepared in one or more electrolytic stages. Further details of this step are described with reference to Fig. 4 hereinbelow.

In a washing or laundering step 320, soiled, dirty or stained clothes are placed in the washer, such as drum washer 41 or 42 (Fig. 1) or tunnel washer 67 (Fig.2). CW is fed from via a water pipeline and valves 34, 37, 75, 76, 62, 63, 66 to the drum washers 41 and 42 or to the CBW 67..

Catholyte from tank 30 is fed and mixed with the water such that the resultant solution is a washing solution of pH from 10.8 to 11.8 and ORP to Platinum, relative to Ag/AgCl, of from – 600 to -900 mV. Typically, the washing solution comprises the catholyte in combination with tap water and additives, wherein the pH of the catholyte is from 11.3 to 12.5 and the ORP of said catholyte to Platinum, relative to Ag/AgCl, is from -650 to -920 mV.

The additives added to the washing stage are grease remover, enzyme, optical brightener and CW The required pH level of the washing solution in this phase is controlled by time control of electrical valves 32, 34, 35, 37, 61, 65, which is based on a response to the readings from pH sensor 77, 78, 79, 80 and 81.

Typically, the ratio of the water: catholyte is 1 : 1.

Typically the quantities of additives used are 20 – 30%, which are 70% less than the requirements of prior art processes.

The washing step is performed under controlled and maintained pH and ORP. For example, if the pH of the washing solution drops from 11.5 to 10.8, pH sensor 77 measures the *in situ* pH of the washing solution in the washer and the PLC receives signals from the pH sensor and sends a signal back to valve 32 which allows more catholyte to feed into the washer and the pH is raised.

According to some embodiments, the pH and ORP are set to a set-point and the PLC adds one or more of an additive, water, catholyte and anolyte responsive to the pH change.

Typically the washing stage takes 2 to 10 minutes and is performed at a temperature of 17 to 40 ^{o}C.

According to some embodiments, at least one of a drain and a spin step is performed in the drum washer 41 or 42 to evacuate the spent washing solution prior to the next step. The wet clothes remain in the drum washer for all steps in flowchart 300.

According to some embodiments, at least one drain step is performed in the tunnel washer 67 to evacuate the spent washing solution prior to the next step. However, the wet clothes are passed from the washing zone to the next zone (disinfect and bleach zone) prior to the starting of the next step.

In a disinfect and bleach step 330, a bleaching and disinfection solution is added to the washer, having a pH of from 2.1 to 2.5 and ORP to Platinum, relative to Ag/AgCl, of from +750 to +1160 mV. The bleaching and disinfection solution comprises the anolyte from tank 31 in combination with tap water.

Typically the pH of the anolyte ranges from 1.7 to 2.4 and/or ORP to Platinum, relative to Ag/AgCl, of from +800 to +1200 mV.

Typically the disinfecting and bleaching step takes 2 - 8 minutes and is performed at a temperature of 17 - 40°C.

According to some embodiments, at least one of a drain and a spin step is performed in the drum washer 41 or 42 to evacuate the spent disinfect and bleach solution prior to the next step. The wet clothes remain in the drum washer for all steps in flowchart 300.

According to some embodiments, at least one drain step is performed in the tunnel washer 67 to evacuate the spent disinfect and bleach solution prior to the next step. However, the wet clothes are passed from the disinfect and bleach zone to the next zone (rinse zone) prior to the starting of the next step.

In a rinse and soften step 340, a rinsing solution is passed into the washer, wherein said rinsing solution comprises CW from tank by pump 8 and electrical valve 34, catholyte through electrical valve 32 and softener (softener tank and valve is not shown on Fig.1 and Fig.2). Commercial softeners used according to this invention. Typically the quantities of softener and other additives used are 20 – 30%, which are 70% less than the requirements of prior art processes.

The rinsing step may include several rinse, drain and spin sub-steps as are known in the art.

Typically the rinse and soften step takes 1 - 3 minutes and is performed at a temperature of 17 to 40 °C.

Thus steps 310-340 take from 8 to 18 minutes in the drum washer and from 10 to 24 minutes in the tunnel washer as function of the tunnel construction.

An optional drying step may be performed after step 340, which is performed at 80 -120 °C over a time of 3 - 18 minutes. This drying step is much shorter than the drying steps of the prior art. Without being bound or limited to any theory, this may be because the surface tension of the catholyte is much less than that of tap water and thus is energetically less bound to the fabrics or clothes after the rinsing step.

Reference is now made to Fig. 4, which is a simplified flowchart 400 showing sub-steps of step 310 of Fig. 3.

In a reverse osmosis step 410, tap water is fed into a reverse-osmosis module 1. The tap water typically has the following properties: pH=5.0 - 9.0, hardness= 60 – 180 ppm, conductivity = 0.1 – 1.5 mS. The reverse osmosis module provides reverse osmosis water having the following properties: pH= 6.5, hardness= 0 – 2 ppm, conductivity = 10 -15 μS. The function of the reverse osmosis step is to clean the tap water from Ca and Mg.

In a first electrolysis step 420, one or more of tap water and reverse osmosis water from step 410 are fed via pumps 7 and 8 into apparatus 2a and 2b. Salts added to the water from salt tank 4 such that the resultant saline solution comprises NaCl at a concentration of from 0.5 to2.5 g/l and KNO_3 at a concentration of from 0.5 to 2.5 g/l. A current is passed between the electrodes (anode and cathode) 3a, 3b, 4a, 4b such that electrochemical reactions occur. Ions generated at the anode are cations and chemical agents, such as, but not limited to HOCl, HCl, Cl_2, H^+, HO_2, H_3O+, Na^+, and K^+. At the cathode, the following types of anions are generated OH^-, $H_3O_2^-$, NO_3^-, CO_3^{2-}, SO_4^{2-}, ClO^-. These cations and anions may react together in one or more neutralization reactions resulting in an aqueous solution, comprising reactions products such as NaOCl, NaOH, KOH, H_2O, HOCl etc., with a pH about of from 8.0 to 9.0 at outlet nozzle 6 of membrane-less apparatus exit.

In a second electrolysis step 430, a membrane electrolysis step is performed. The aqueous solution from nozzle 6a and 6b in step 420 is fed into apparatus 20.

A current is applied and an anolyte and catholyte solution form at anode 23 and cathode 24 respectively. As described hereinabove, the pH level of the resultant catholyte is typically in the range of 11.3 to 12.5 and ORP to Platinum, relative to Ag/AgCl, in the range of from -650 to -920 mV. The pH level of the resultant anolyte is typically in the range of from 1.7 to 2.4, and ORP to Platinum, relative to Ag/AgCl, of from +800 to +1200 mV.

It should be understood that the methods of the present invention allow for optimized washing/laundering processes in comparison to prior art processes. Some of the advantages include, but are not limited to:

- cleaner clothes- highly efficient washing cycle
- no requirement for detergent-check
- no environmental problems due to release of detergents
- no environmental problems due to release of NaCl, Cl2, RCl etc.
- no environmental problems due to release of waste water with high or low PH and ORP level
- no detergents traces in clean clothes
- energy saving-less or no requirement to heat water
- shorter washing cycles
- shorter energy-saving drying cycles
- smaller quantities of additives relative to standard processes
- reproducible cycles due to maintained parameter control
- washing cycle parameters matched to type and quantity of clothes

Very dirty clothes, such as hospital blood-stained laundry may require enzymes to denature blood proteins. Prior art processes for such laundry needed to be carried out at a pH of 8.6, with a working temperature to 50 °C. Furthermore, in prior art processes for bleaching such blood-soiled clothes, it was necessary to use both a chemical bleacher and an optical brightener at a pH of 9.6 and a working temperature of from 60 to 90 °C. However, according to the present invention, the prior art process can be replaced by the washing/laundering step 320 with the addition of the required enzymes and optical brightener in the catholyte solution at temperature of about 30 or 35 °C (taking into account higher catalytic ability of catholyte).

Mineral grease can be removed by adding any kind of solvent at a pH of 10.0 as an additive to the catholyte solution in step 320.

Fabric softening can be achieved in several different ways, according to some embodiments of the present invention:

a) the catholyte may be added to water at ratio of from 1:9 to 9:1 and the resultant catholyte solution may be used as a rinsing medium;

b) a softener may be added to an anolyte solution at pH of 3.5 in a quantity of 3 to 5 fold less in comparison to regular washing.

c) Additives may be added to the membrane electrolysis apparatus 12 in a quantity of from 7 to 10 fold less compared to regular washing.

Another notable improvement of the present invention over the prior art is the combination of NaCl and KNO_3 salts in the electrolysis process. Such combination of salts in a concentration of from 0.5 to 2.5 g/l produced a sufficient amount of chloric oxidants (Cl_2, HCl), chloric – oxygen oxidants (HOCl) and oxygen oxidants (O_2, H_2O_2, HO_2, HO^{3+} etc.), necessary for stain elimination (bleaching) of any specific disinfectants, e.g. as ALCOXIDINE (skin disinfectant).

Yet another advantage of the present invention over the prior art is the reduction in drying time of clothes washed according to the method of the present invention. This has been verified experimentally and may be due to the fact that the surface tension of the catholyte is only $36x10^{-3}$ N/m relative to tap water $72x10^{-3}$ N/m.

Yet another advantage of the present invention over the prior art is the use of two electrolytic stages (2a, 2b and 20), thus producing the anolyte and catholyte by consecutively passing saline water through first the membrane-less electrolysis apparatus 2a wherein there is precipitation of Ca and Mg carbonates. Thereafter the solution is passed through the anode and cathode chambers of the membrane electrolysis apparatus 20, having a membrane between the anode and cathode chambers. This arrangement allows for a decrease in the quantity of carbonate precipitation on the cathode of membrane electrolysis apparatus 20, thus improving quality of Electrochemically Activated Water and extending the operating time of apparatus 20.

Another functional advantage of the two stage electrolytic cell arrangement is that the pH level of the catholyte from the membrane electrolysis apparatus is significantly higher (11.3 to 12.5) than that of a one-stage process (8-9).

A structural advantage of the electrolysis apparatus of the present invention is in the use of an anode coating comprising RuO_2 and IrO_2 in a ratio of approximately 1:1. This anode coating allows production of chloric oxidants, chloric

– oxygen oxidants and oxygen oxidants by various reactions from NaCl and KNO_3, the salts used in the electrolysis process.

Another structural advantage of the electrolysis apparatus of the present invention is that membrane electrolysis apparatus 20 is constructed such that the ratio of the inlet cross-section nozzle to outlet nozzles is 1:2, and this, in turn, provides protection to the inlet piping from hydraulic shock, due to gases generated from the electrolytic reactions. This arrangement also provides a freer exit of the catholyte and the anolyte to their respective storage tank 30, 31.

Reference is now made to Fig. 5, which is a simplified flowchart 500 of a method for catholyte recycling of a second laundering process in accordance with some embodiments of the present invention.

A second washing process 510 typically takes place in a drum washing system 100 of Fig. 1 or in a tunnel washing system 200 of Fig. 2. In preferred embodiments of the present invention, these systems comprise at least one membrane-less and one membrane electrolytic apparatus 2a, 2b and 20 respectively.

The second washing process step 510 is performed on soiled linen or other soiled articles.

The first washing process depletes certain chemicals from the catholyte solution in which the first washing process is performed and thus a replenished catholyte solution 584 is used in step 510 to perform the second and any further washing steps. The method for forming solution 584 will be explained further hereinbelow.

As stated, the washing step may be performed in drum washers 41, 42 of Fig. 1 or tunnel washer 67 of Fig. 2.

This second washing step 510 is typically performed under conditions similar or identical to first washing step 320 of Fig. 3.

Replenished catholyte solution 584 is normally of a pH from 10.8 to 11.8 and an ORP to Platinum, relative to Ag/AgCl, of from – 600 to -900 mV. Typically, the washing solution comprises the catholyte in combination with tap water and additives, wherein the pH of the catholyte is from 11.3 to 12.5 and the ORP of said catholyte to Platinum, relative to Ag/AgCl, is from -650 to -920 mV.

The additives added to the second washing stage are grease remover , enzyme, optical brightener and CW by means of electrical valve 34 or 37 or 62. The required pH level of the washing solution in this phase is controlled by time control of electrical valves 32, 35, and 61, which is based on a response to the readings from pH sensor 77, 78 and 79.

The washing step is performed under controlled and maintained pH and ORP. For example, if the pH of the washing solution drops from 11.5 to 10.8, pH sensor 77 measures the *in situ* pH of the washing solution in the washer and the PLC receives signals from the pH sensor and sends a signal back to valve 32 which allows more catholyte to feed into the washer and the pH is raised.

Typically this washing step 510 takes 2 to 10 minutes and is performed at a temperature of 17 to 40 °C. Other sub-steps such as draining and spinning may be performed as described hereinabove with respect to step 320 (Fig. 3).

After the washing step 510, waste catholyte solution may be passed into a holding tank or may be directly filtered in a filtering step 520 and solids and/or sludge 525 is removed there from. Typically, the filter 50 (Fig. 1) used is a self-cleansing filter such as model 2"TAF-500H, Amiad Filtrarion Systems, CA, employing a 80 μm filter.

A filtered waste catholyte stream 524 is fed to a holding tank, such as holding tank 44 (Fig. 1). The stream 524 may be held in holding step 530 for 1 to 24 hours.

At this stage, the filtered waste catholyte 524 may be mixed with water, additives and salt solution.

Alternatively, after holding, a filtered waste catholyte stream 534 may be fed to a membrane-less electrolysis apparatus, such as apparatus 2b (Fig. 1) and water 542 and salt solution 546 may be added at the entry thereto or in the chamber thereof. Whatever the procedure, the waste catholyte stream is replenished with water and salt solution using pH and ORP control such that these properties of solution 534, after replenishment, fall within predetermined limits. The resultant replenished mixed catholyte solution 534 may have, for example, a pH range of between 8 and 1 and its OPR may be in the range of ORP to Platinum, relative to Ag/AgCl, of from – 500 to -850 mV (verify).

In a membrane-less electrolysis step 540, electrolysis is performed to solution 534 under conditions similar or identical to the conditions for performing step 420 of Fig. 4.

A catholyte solution 544 forms having the following properties: a pH range of between 8-11.5 and its ORP may be in the range of – 500 to 860 mV of Platinum, relative to Ag/AgCl.

Catholyte solution 544 may be filtered in a filtration step 550 employing a filter 2"TAF-500H, Amiad Filtrarion Systems, CA, employing a 80 μm filter.and waste sludge or solids 555 may be discarded. According to some embodiments, this step may not be performed.

A resultant filtered catholyte solution 554 is fed into a membrane electrolytic apparatus 20 for a second electrolytic step 560. This step may be performed under similar or identical conditions of step 430 of Fig. 4 hereinabove. The resultant catholyte solution 564 forms. Catholyte solution 564 typically has the following properties: pH level of the resultant catholyte is typically in the range of 11.3 to 12.5 and ORP to Platinum, relative to Ag/AgCl, in the range of from -650 to -920 mV.

Catholyte solution 564 is fed into a holding tank and when required a stream thereof 574 is mixed in a mixing step 580 with water 582 and additives 586. The additives added to the washing stage may be, for example, grease remover, enzyme , optical brightener and CW by means of electrical valve 34 or 37 or 62. The required pH level of the washing solution in this phase is controlled by time control of electrical valves 32, 35 and 62, which is based on a response to the readings from pH sensor 77, 78 or 79.

Typically, the ratio of the water: catholyte is 1 : 1.

Typically the quantities of additives used are 20 – 30%, which are 70% less than the requirements of prior art processes.

The resultant replenished catholyte solution (or washing solution) 584 may then be fed into the next washing step 510.

Reference is now made to Fig. 6, which is a simplified flowchart 600 of a method for anolyte recycling of a second or subsequent bleaching/disinfecting process, in accordance with some embodiments of the present invention.

After a first laundering cycle has been performed, which may be similar, dissimilar or identical to that of bleaching and disinfecting step step 330 of flowchart 300 of Fig. 3, a waste anolyte is produced.

A second bleaching/disinfecting process 610 typically takes place in a drum washing system 100 of Fig. 1 or in a tunnel washing system 200 of Fig. 2. In preferred embodiments of the present invention, these systems comprise at least one membrane-less and one membrane electrolytic apparatus 2a, 2b and 20 respectively.

The second bleaching/disinfecting step 510 is performed on soiled linen or other soiled articles after the second washing step.

The first bleaching/disinfecting process depletes certain chemicals from the anolyte solution in which the first bleaching/disinfecting process is performed and thus a replenished anolyte solution 684 is used in step 610 to perform the second and any further bleaching/disinfecting steps. The method for forming solution 684 will be explained further hereinbelow.

Bleaching/disinfecting step 684 may be performed in drum washers 41 or 42 of Fig. 1 or tunnel washer 67 of Fig. 2.

This second bleaching/disinfecting step 620 is typically performed under conditions similar or identical to first washing step 330 of Fig. 3.

Replenished anolyte solution 684 is normally of a pH in the range of from 1.7 to 2.4, and ORP to Platinum, relative to Ag/AgCl, of from +800 to +1200 mV.

In step 610, a bleaching and disinfection solution is added to the washer, having a pH of from 2.1 to 2.5 and ORP to Platinum, relative to Ag/AgCl, of from +750 to +1160 mV. The bleaching and disinfection solution typically comprises the anolyte from tank 31 in combination with tap water.

Typically the pH of the anolyte ranges from 1.7 to 2.4 and/or ORP to Platinum, relative to Ag/AgCl, of from +800 to +1200 mV.

Typically the disinfecting and bleaching step takes 2 - 8 minutes and is performed at a temperature of 17 - 40°C.

The additives added to the second washing stage are grease remover, enzyme, optical brightener and CW by means of electrical valve 75, 76 or 63. The required pH level of the washing solution in this phase is controlled by time control of electrical valves 33, 36 or 64,, which is based on a response to the readings from pH sensor 77, 78 or 79.

Other sub-steps such as draining and spinning may be performed as described hereinabove with respect to step 330 (Fig. 3).

After the bleaching/disinfecting step 610, waste anolyte solution 614 may be passed into a holding tank 43 or may be directly filtered in a filtering step 620 and solids and/or sludge 625 is removed therefrom. Typically, a filter 49 (Fig. 1) is used is a self-cleansing filter such as model 2"TAF-500H, Amiad Filtrarion Systems, CA, employing a 80 μm filter.

A filtered waste anolyte stream 624 is fed to a holding tank, such as holding tank 43 (Fig. 1). The stream 624 may be held in holding step 630 for 1 to 24 hours.

At this stage, the filtered waste anolyte 624 may be mixed with water, additives and salt solution.

Alternatively, after holding, a filtered waste anolyte stream 634 may be fed to a membrane-less electrolysis apparatus, such as apparatus 2a (Fig. 1) and effluent 646 and salt solution 648 may be added at the entry thereto or in the chamber thereof. Whatever the procedure, the waste anolyte stream is replenished with effluent and salt solution using pH and ORP control such that these properties of solution 634 after replenishment fall within predetermined limits. The resultant replenished mixed anolyte solution 634 may have, for example, a pH range of between 2.5 to 3.8 and/or ORP to Platinum, relative to Ag/AgCl, of from +600 to +850 mV.

In a membrane-less electrolysis step 640, electrolysis is performed to solution 634 under conditions similar or identical to the conditions for performing step 420 of Fig. 4.

An anolyte solution 644 forms having the following properties: a pH range of between 3-5 and its ORP may be in the range of – 400 to 600 mV of Platinum, relative to Ag/AgCl.

Anolyte solution 644 may be filtered in a filtration step 650 employing a filter (give details) and waste sludge or solids 655 may be discarded. According to some embodiments, this step may not be performed.

A resultant filtered anolyte solution 654 is fed into a membrane electrolytic apparatus 20 for a second electrolytic step 660. This step may be performed under similar or identical conditions of step 430 of (Fig. 4) hereinabove. The resultant anolyte solution 664 forms. Anolyte solution 664 typically has the following properties: pH level of the resultant anolyte is typically in the range of 1.7 to 2.4 and/or ORP to Platinum, relative to Ag/AgCl, of from +800 to +1200 mV.

Anolyte solution 664 is fed into a holding tank 31 and when required a stream thereof 674 is mixed in a mixing step 680 with CW 682 and additives 686.

The resultant replenished anolyte solution (or washing solution) 684 may then be fed into the next washing step 610.

Fig. 7 is a simplified flowchart 700 of a method for rinse solution recycling of a second laundering process, in accordance with some embodiments of the present invention.

After a laundering process is performed in accordance, for example with the steps of Fig. 3, and in particular, with respect to step 340, a waste rinse solution is formed 714. The rinse solution may be filtered in a filtering step 720. Solids or sludge 725 may be discarded and a filtered waste rinse solution may then be mixed in a mixing step 730 with CW 732, a catholyte solution 736 and additives, such as softeners 738. A resultant replenished rinse solution 734 is formed which may be used in a second and/or subsequent rinsing step(s) 710.

It should be understood that the steps of flowcharts 500, 600 and 700 may be repeated for one or more consecutive laundry cycles. These cycles may be performed immediately one after the other or there may be time gaps in between the cycles, during which the solutions are held in the appropriate holding tanks.

It should also be understood that the processes of flowcharts 500, 600 and 700 may be taking place simultaneously in a synchronized or non-synchronized manner.

DEFINITIONS

As used herein, the following terms are defined as follows:

ECA - Electrochemical Activation – it is electrolysis of all kinds of liquids with small amount of salts for producing electrochemically activated (energetically exited) liquids such as anolyte and catholyte by applying a voltage of from 5V to 100,000V in accordance with liquids characteristics.

EAW - Electrochemically Activated Water - electrochemically activated (energetically exited) liquids such as anolyte and catholyte

ECAC - Electrochemical Activator – a certain type of electrolyzer for the production of anolyte and catholyte

Anolyte – a cation containing liquid after treatment in ECAC;

Catholyte – an anion containing liquid after treatment in ECAC

Anode chamber – a half-cell of the activator wherein anolyte is produced;

Cathode chamber – a half-cell of the activator wherein catholyte is produced;

ORP – Oxidation-Redaction Potential.

PLC – Programmable Logic Controller.

EC – Electro-Conductivity of a liquid.

RO – Reverse Osmosis

CW – Clean Water

EF – Effluent

WWS – Waste Washing Solution

WBS – Waste Bleaching Solution

WRS – Waste Rinsing Solution

CBW – Continuous Batch Washer

The references cited herein teach many principles that are applicable to the present invention. Therefore the full contents of these publications are incorporated by reference herein where appropriate for teachings of additional or alternative details, features and/or technical background.

It is to be understood that the invention is not limited in its application to the details set forth in the description contained herein or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Those skilled in the art will readily appreciate that various modifications and changes can be applied to the embodiments of the invention as hereinbefore described without departing from its scope, defined in and by the appended claims.

It will also be understood that the invention further contemplates a machine-readable memory tangibly embodying a program of instructions executable by the machine for executing the method of the invention.

WHAT IS CLAIMED IS:

1. A computer-controlled laundering method comprising:
   (i) providing at least one catholyte solution and at least one anolyte solution from at least one electrolysis apparatus to a washing apparatus; and
   (ii) laundering at least one item in a first laundering process in said washing apparatus, the first laundering process comprising:
      a) a washing step in at least a first solution comprising said at least one catholyte solution thereby generating a waste catholyte solution;
      b) a bleaching/disinfecting step in a second solution comprising said at least one anolyte thereby generating a waste anolyte solution; and
      c) a rinsing step in a rinsing solution thereby generating a waste rinsing solution;

   to provide a substantially clean item wherein at least one of the pH and oxidation-reduction potential (ORP) of the catholyte fed to said washing step or the anolyte fed to said bleaching/disinfecting step is substantially continuously monitored to maintain at least one of the pH and ORP in at least one of said steps at least in part by controlling the amount of at least one of the catholyte and anolyte respectively introduced into each of said steps; and
   (iii) recycling at least one of said waste catholyte solution and said waste anolyte solution via said at least one electrolysis apparatus to said washing apparatus to allow at least partial reuse of said at least one of said waste catholyte solution and said waste anolyte solution in a second or subsequent laundering process.
2. A computer-controlled laundering method according to claim 1, wherein said waste catholyte is recycled and said recycling step of said waste catholyte solution comprises:
   a. collecting said waste catholyte solution from said washing apparatus;
   b. filtering said waste catholyte solution to form a filtered waste catholyte solution;

c. mixing said filtered waste catholyte solution with at least one of water and a catholyte solution to form a mixed feed stream;
d. passing said mixed feed catholyte stream to said at least one electrolysis apparatus; and
e. electrolyzing said mixed feed catholyte stream in said at least one electrolysis apparatus to form at least one replenished catholyte solution.

3. A computer-controlled laundering method according to claim 2, wherein said electrolyzing step comprises:
   i. treating the mixed feed catholyte stream in a membrane-less electrolyzing step to form an electrolyzed catholyte stream; and
   ii. treating said electrolyzed catholyte stream in a membrane electrolyzing step to form said at least one replenished catholyte solution.
4. A computer-controlled laundering method according to claim 3, further comprising filtering the electrolyzed catholyte stream prior to step ii.
5. A computer-controlled laundering method according to claim 3, further comprising filtering said at least one replenished catholyte solution to form at least one filtered catholyte solution.
6. A computer-controlled laundering method according to claim 1, further comprising performing a washing step of said second or subsequent laundering process in a solution comprising said at least one filtered catholyte solution.
7. A computer-controlled laundering method according to claim 1, wherein said anolyte solution is recycled and said recycling step of said waste anolyte solution comprises:
   a. collecting said waste anolyte solution from said washing apparatus;
   b. filtering said waste anolyte solution to form a filtered waste anolyte solution;
   c. mixing said filtered waste anolyte solution with at least one of water, a reverse osmosis effluent and an anolyte solution to form a mixed feed anolyte stream;
   d. passing said mixed feed anolyte stream to an electrolysis apparatus; and

e. electrolyzing said mixed feed anolyte stream to form at least one replenished anolyte solution.

8. A computer-controlled laundering method according to claim 7, wherein said electrolyzing step comprises:

i. treating said mixed feed anolyte in a membrane-less electrolyzing step to form an electrolyzed anolyte stream; and

ii. treating said electrolyzed anolyte stream in a membrane electrolyzing step to form said at least one replenished anolyte solution.

9. A computer-controlled laundering method according to claim 8, further comprising filtering the electrolyzed anolyte stream prior to step ii.

10. A computer-controlled laundering method according to claim 8, further comprising filtering said at least one replenished anolyte solution to form at least one filtered anolyte solution.

11. A computer-controlled laundering method according to claim 10, further comprising performing a bleaching/disinfecting step of said second or subsequent laundering process in said at least one filtered anolyte solution.

12. A computer-controlled laundering method according to claim 3, wherein the replenished anolyte solution is provided at a pH value of from 1.3 to 3 and an ORP to Platinum, relative to Ag/AgCl, of from +500 to +1250 mV and the replenished catholyte solution is provided at a pH in the range of from 11 to 12.5 and an ORP to Platinum, relative to Ag/AgCl, of from -800 to -950mV.

13. A computer-controlled laundering method according to claim 1, wherein both said first laundering process and said second laundering process are performed in a washing apparatus selected from a drum washing apparatus and a tunnel washing apparatus.

14. A computer-controlled laundering method according to claim 13, wherein said laundering is performed in said tunnel washing apparatus in a washing zone, a bleaching – disinfecting zone and a rinsing zone.

15. A computer-controlled laundering method according to claim 14, wherein said washing step is performed in the washing zone.

16. A computer-controlled laundering method according to claim 2, wherein the pH of said replenished catholyte solution is maintained within a range of 11 to 12.5.

17. A computer-controlled laundering method according to claim 2, wherein an ORP of said replenished catholyte solution is maintained within a range of Platinum, relative to Ag/AgCl, of from -800 to -950mV.
18. A computer-controlled laundering method according to claim 14, wherein said bleaching/disinfecting step is performed in the bleaching – disinfecting zone.
19. A computer-controlled laundering method according to claim 2, wherein the pH of said replenished anolyte solution is maintained within a range of 1.3 to 3.
20. A computer-controlled laundering method according to claim 2, wherein said ORP of said replenished anolyte solution is maintained within a range of ORP to Platinum, relative to Ag/AgCl, of from +500 to +1250 mV.
21. A computer-controlled laundering method according to claim 14, wherein said rinsing step is performed in the rinsing zone.
22. A computer-controlled laundering method according to claim 1, wherein the pH of said rinsing solution is maintained within a range of 6.5 to 8.5.
23. A computer-controlled laundering method according to claim 1, wherein the ORP of said rinsing solution is maintained within a range of -150 to + 500 mV.
24. A computer-controlled laundering method according to claim 1, wherein said catholyte solution and said anolyte solution are produced by electrolysis of an aqueous solution comprising NaCl at a concentration of from 0.5 to2.5 g/l and KNO_3 at a concentration of from 0.5 to 2.5 g/l.
25. A computer-controlled laundering method according to claim 1, wherein the first solution further comprises at least one washing additive selected from: an enzyme, a grease remover and an optical brightener.
26. A computer-controlled laundering method according to claim 25, wherein said at least one washing additive improves at least one of a washing rate and a washing quality of the washing step.
27. A computer-controlled laundering method according to claim 3, wherein the rinsing step is carried out in a rinsing solution comprising the at least one replenished catholyte solution and tap water.

28. A computer-controlled laundering method according to claim 27 wherein the rinsing solution further comprises at least one rinse additive selected from a fabric softener and an odorant.

29. A computer-controlled laundering method according to claim 28, wherein said at least one rinse additive improves at least one of a rinsing rate and a rinsing quality of the rinsing step.

30. A computer-controlled laundering method according to claim 1, further comprising a drying step.

31. A computer-controlled laundering method according to claim 30, wherein the drying step time is reduced by up to 50% relative to a standard laundering process.

32. A computer-controlled laundering method according to claim 1, employing 0.5 to 3 liters of water per kg of linen.

33. A computer-controlled laundering method according to claim 1, employing 0.02 to 0.03 KW/kg linen.

34. A computer-controlled laundering method according to claim 1, employing a cycle time of from 8 to 20 min.

35. A computer-controlled laundering method according to claim 4, wherein said mixing step comprises employing a volumetric ratio of filtered waste catholyte solution with at least one of water and a catholyte solution of from 1 to 10.

36. A computer-controlled laundering method according to claim 7, wherein said mixing step comprises employing a volumetric ratio of said filtered waste anolyte solution with said at least one of water, a reverse osmosis effluent and an anolyte solution of from 1 to 10.

37. A computer-controlled laundering method according to claim 1, using washing additives in quantities of 20% to 50% relative to a standard laundering process.

38. A computer-controlled laundering method according to claim 27, wherein the rinse additives are used in quantities of 20% to 50% relative to a standard laundering process.

39. A computer-controlled laundering method according to claim 1, wherein said substantially clean item comprises less than 1.0 percent of the original

contaminant, said contaminant being selected from dirt, microorganisms, odor and stains.

40. A computer-controlled laundering method according to claim 1, substantially as described in the specification.

41. A computer-controlled laundering system comprising:
   (i) at least one electrolysis apparatus adapted to provide providing at least one catholyte solution and at least one anolyte solution;
   (ii) a washing apparatus adapted to receive said at least one catholyte solution and said at least one anolyte solution, the washing apparatus comprising at least one washing chamber with *in situ* controllers for maintaining the pH and oxidative-reduction potential (ORP) of said at least one catholyte solution and said at least one anolyte solution, and wherein said washing apparatus is adapted to produce a waste catholyte solution and a waste anolyte solution; and
   (iii) recycle apparatus for recycling said waste catholyte solution and said waste anolyte solution from said washing apparatus to said at least one electrolysis apparatus.

42. A computer-controlled laundering system according to claim 40, wherein said recycling apparatus for said waste catholyte solution comprises:
   a. collecting means for collecting said waste catholyte solution from said washing apparatus;
   b. at least one filter for filtering said waste catholyte solution to form a filtered waste catholyte solution;
   c. mixing means for mixing said filtered waste catholyte solution with at least one of water and a catholyte solution to form a mixed feed stream; and
   d. pumping means for passing said mixed feed catholyte stream to said at least one electrolysis apparatus.

43. A computer-controlled laundering system according to claim 40, wherein said recycling apparatus for said waste anolyte solution comprises:
   a. collecting means for collecting said waste anolyte solution from said washing apparatus;

b. at least one filter for filtering said waste anolyte solution to form a filtered waste anolyte solution;
c. mixing means for mixing said filtered waste anolyte solution with at least one of water and an anolyte solution to form a mixed feed stream; and
d. pumping means for passing said mixed feed anolyte stream to said at least one electrolysis apparatus.

44. A computer-controlled laundering system according to claim 41 or 42, wherein said at least one filter comprises at least one self-cleaning filter.

45. A computer-controlled laundering system according to claim 40, further comprising a filter press.

46. A computer-controlled laundering system according to claim 40, wherein said at least one electrolysis apparatus comprises a membrane-less electrolytic module and membrane electrolytic module.

47. A computer-controlled laundering system according to claim 40, wherein the at least one electrolysis apparatus is configured to produce an anolyte having a pH value of from 1.3 to 3 and an ORP to Platinum, relative to Ag/AgCl, of from +500 to +1250 mV and a catholyte having a pH in the range of from 11 to 12.5 and an ORP to Platinum, relative to Ag/AgCl, of from -800 to -950mV.

48. A computer-controlled laundering system according to claim 40, wherein said washing apparatus is selected from a drum washing apparatus and a tunnel washing apparatus.

49. A computer-controlled laundering system according to claim 47, wherein said tunnel washing apparatus comprises a washing zone, a bleaching – disinfecting zone and a rinsing zone.

50. A computer-controlled laundering system according to claim 48, wherein the washing zone is configured and operative to maintain a washing solution at a first pH and first ORP.

51. A computer-controlled laundering system according to claim 48, wherein the bleaching – disinfecting zone is configured and operative to maintain a disinfecting and bleaching solution at a second pH and second ORP.

52. A computer-controlled laundering system according to claim 48, wherein the rinsing zone is configured and operative to maintain a rinse solution at a third pH and third ORP.

53. A computer-controlled laundering system of claim 40, further comprising a reverse osmosis apparatus configured to supply purified water to said at least one electrolysis apparatus.
54. A computer-controlled laundering system according to claim 45, wherein the membrane electrolytic module comprises an cation exchange membrane.
55. A computer-controlled laundering system according to claim 45, wherein the membrane electrolytic module comprises an anion exchange membrane
56. A computer-controlled laundering system according to claim 53, wherein membrane electrolytic module comprises the ion exchange membrane disposed between at least one cell for collecting anolyte and at least one detached cell for collecting catholyte.
57. A computer-controlled laundering system according to claim 54, wherein the at least one anolyte cell is configured to provide anolyte of a pH value of from 1.3 to 3 and an ORP to platinum, relative to Ag/AgCl, of from +500 to +1250 mV.
58. A computer-controlled laundering system according to claim 54, wherein the at least one catholyte cell is configured to provide catholyte of a pH value of from 11 to 12.5 and an ORP to platinum, relative to Ag/AgCl, of from -800 to -950mV.
59. A computer-controlled laundering system according to claim 40, substantially as described in the figures.
60. A computer-controlled laundering system according to claim 40, substantially as described in the specification.
61. A computer-controlled laundering method according to claim 1, substantially as shown in the figures.

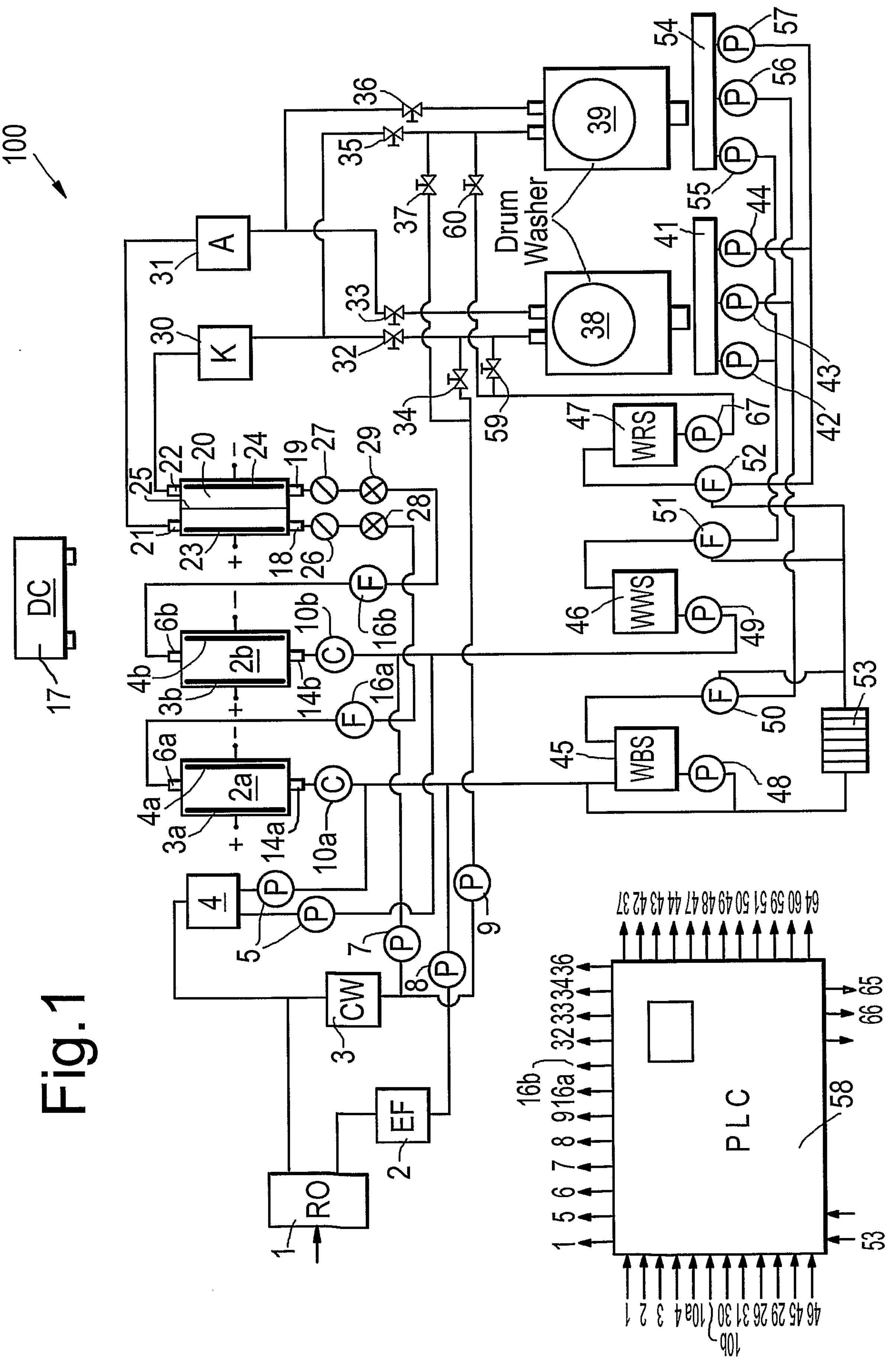


Fig.1

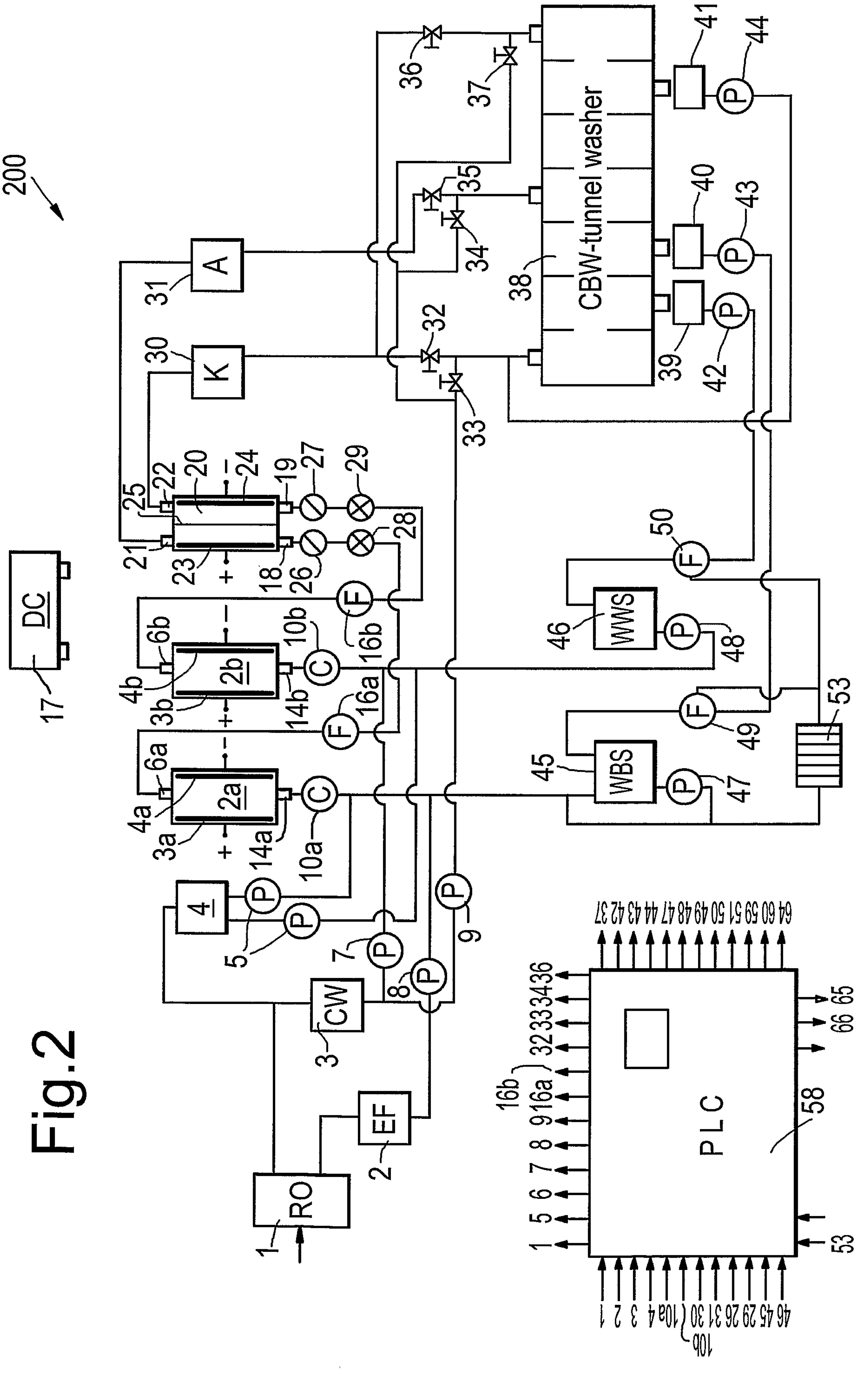
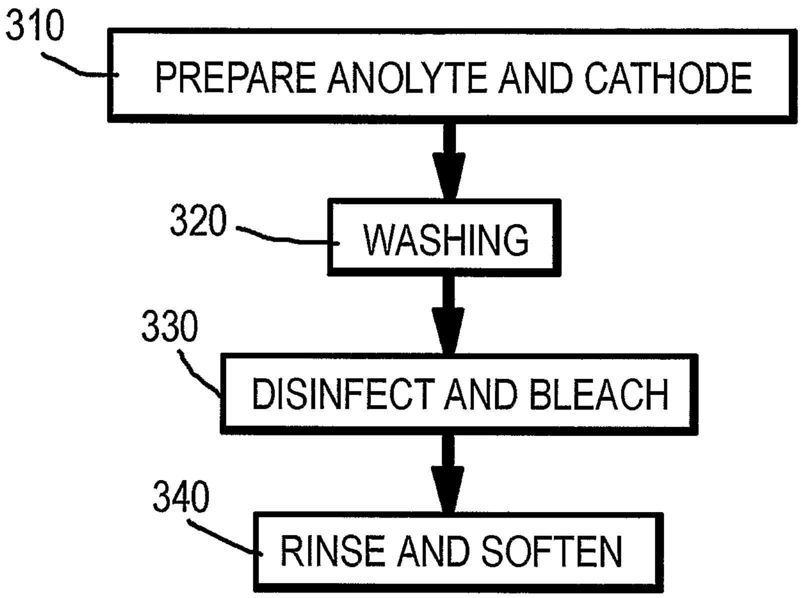


Fig.2

Fig.3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320
WASHING
330
DISINFECT AND BLEACH
340
RINSE AND SOFTEN

Fig.4

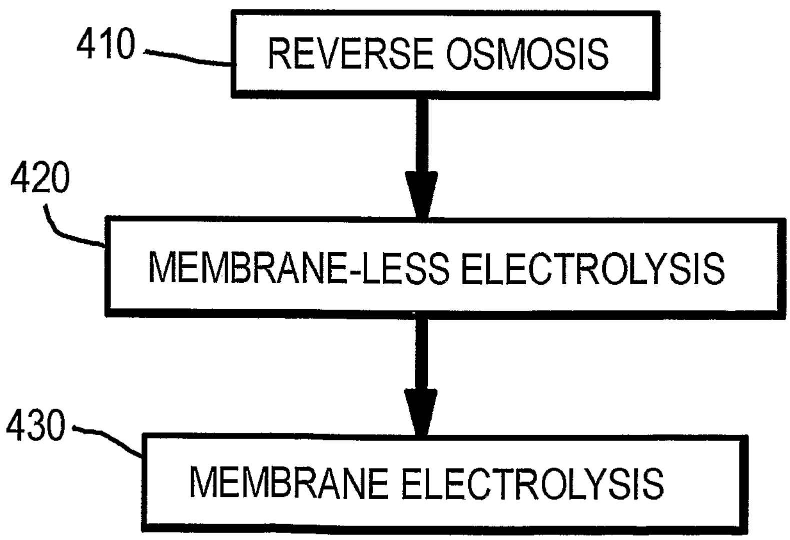
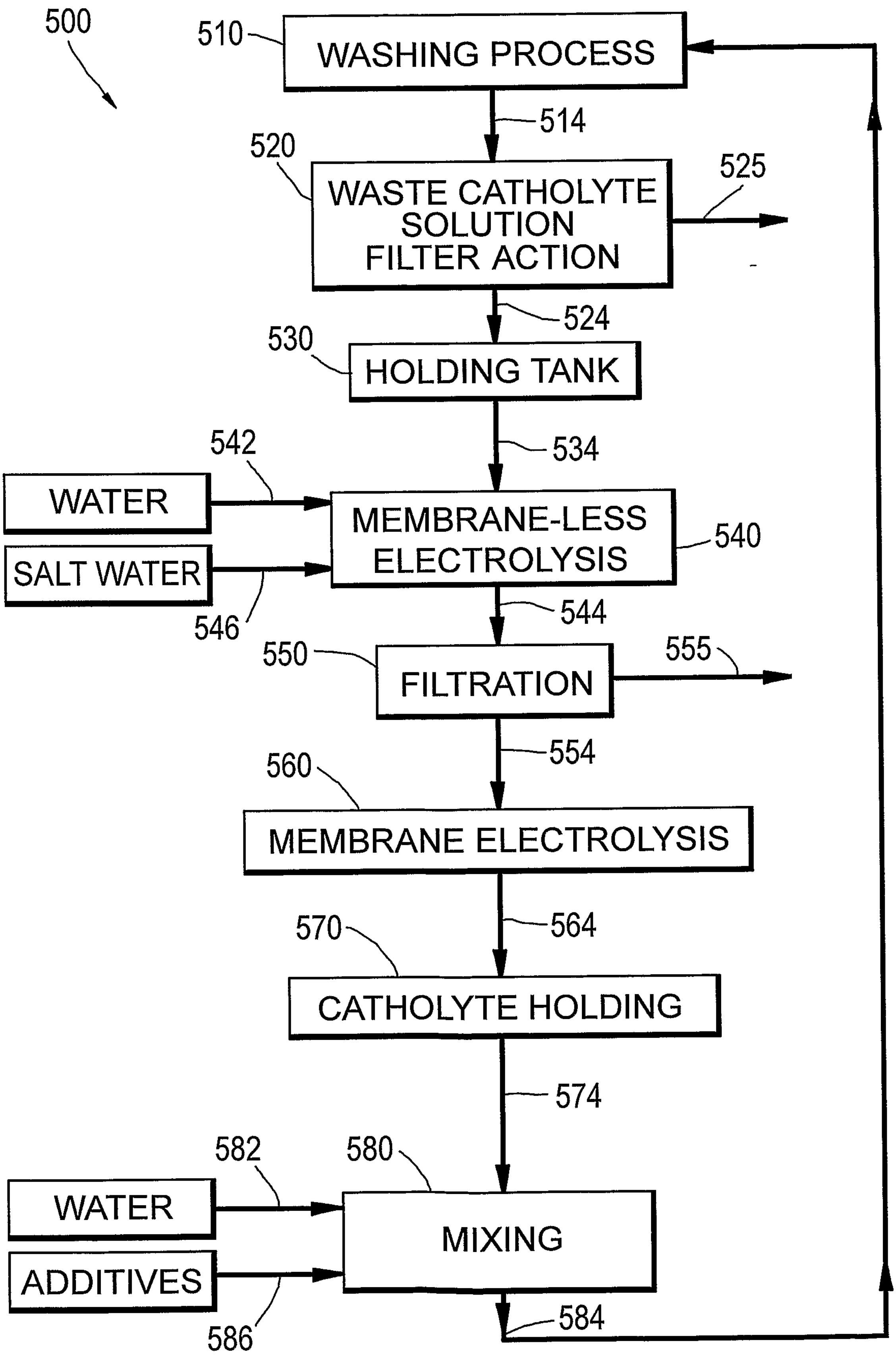

410
REVERSE OSMOSIS
420
MEMBRANE-LESS ELECTROLYSIS
430
MEMBRANE ELECTROLYSIS

Fig.5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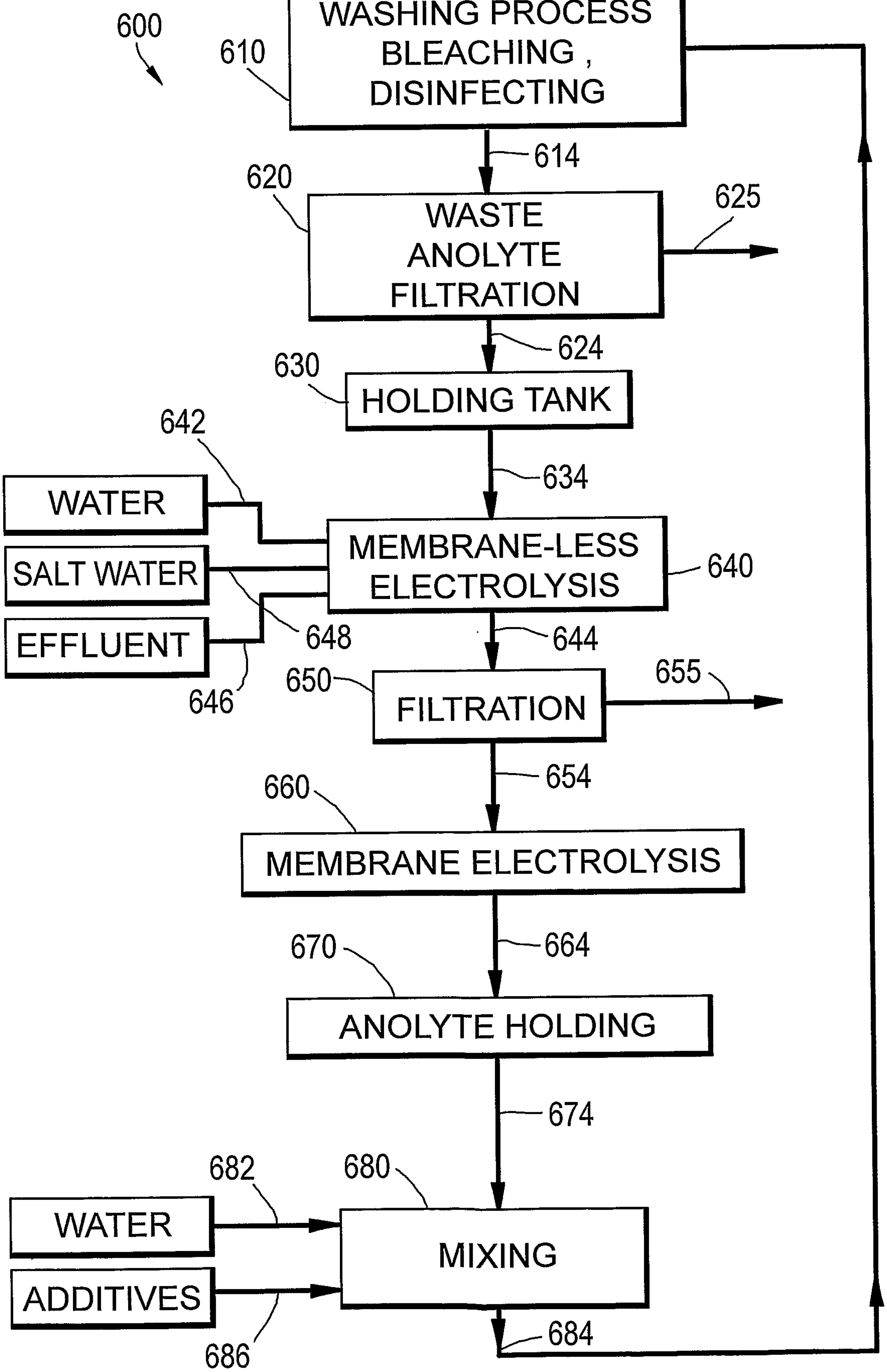
510
WASHING PROCESS
514
520
WASTE CATHOLYTE SOLUTION FILTER ACTION
525
524
530
HOLDING TANK
534
542
WATER
SALT WATER
MEMBRANE-LESS ELECTROLYSIS
540
546
544
550
FILTRATION
555
554
560
MEMBRANE ELECTROLYSIS
570
564
CATHOLYTE HOLDING
574
582
580
WATER
ADDITIVES
MIXING
586
584

Fig.6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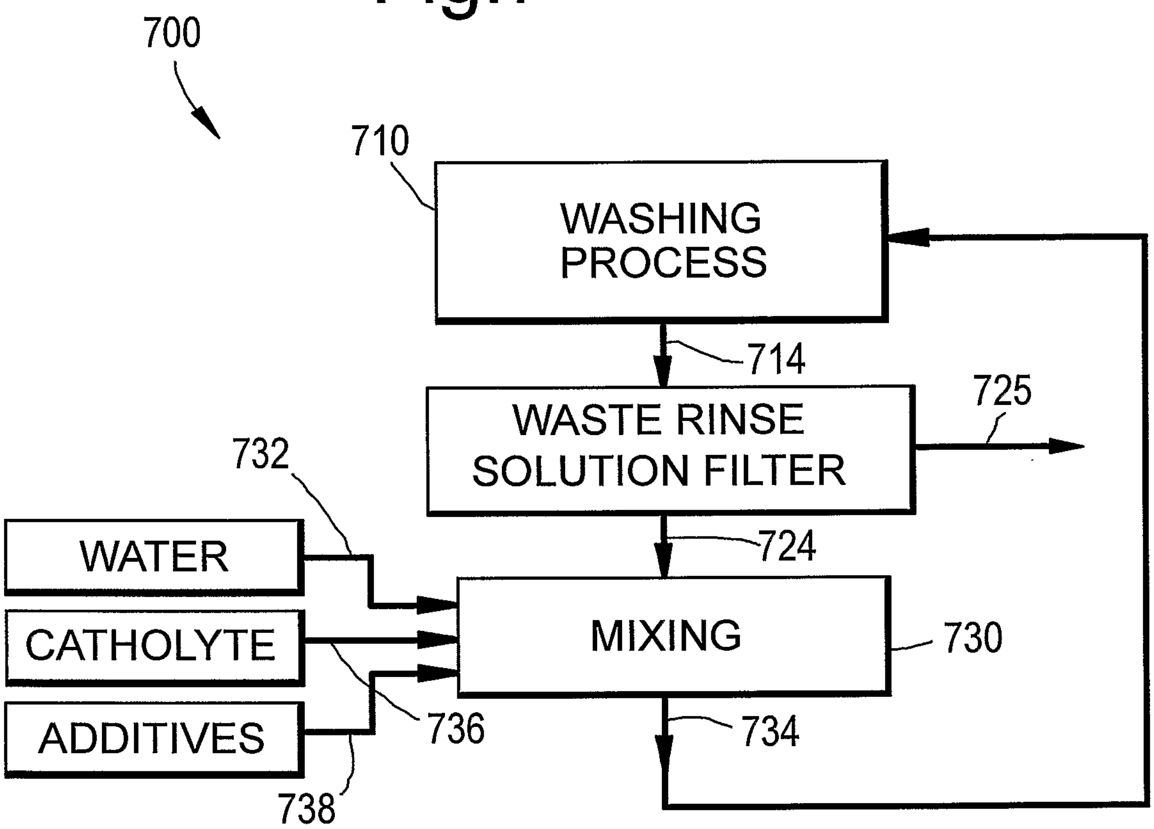
610
WASHING PROCESS
BLEACHING ,
DISINFECTING
614
620
WASTE
ANOLYTE
FILTRATION
625
624
630
HOLDING TANK
642
634
WATER
SALT WATER
EFFLUENT
MEMBRANE-LESS
ELECTROLYSIS
640
648
644
646
650
FILTRATION
655
654
660
MEMBRANE ELECTROLYSIS
670
664
ANOLYTE HOLDING
674
682
680
WATER
ADDITIVES
MIXING
686
684

Fig.7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710
WASHING PROCESS
714
WASTE RINSE SOLUTION FILTER
725
732
724
WATER
CATHOLYTE
ADDITIVES
MIXING
730
736
734
738

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2008/000785

A. CLASSIFICATION OF SUBJECT MATTER
INV. C02F1/467 D06F35/00 A47L15/42
ADD. A61L2/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C02F D06F A61L A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 02/079098 A (ELTEK SPA [IT]; GADINI CONSTANZO [IT]; FIORINI ANDREA [IT]) 10 October 2002 (2002-10-10) claims 1-76; figures 1-8	1-61
A	WO 2006/044951 A (PROCTER & GAMBLE [US]; VERNON PAUL JOHN EDWARD [US]; GLOGOWSKI MARK WI) 27 April 2006 (2006-04-27) paragraphs [0039], [0052]; claim 1	1-61
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 October 2008	28/10/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dupuis, Jean-Luc

2

International application No
PCT/IL2008/000785

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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