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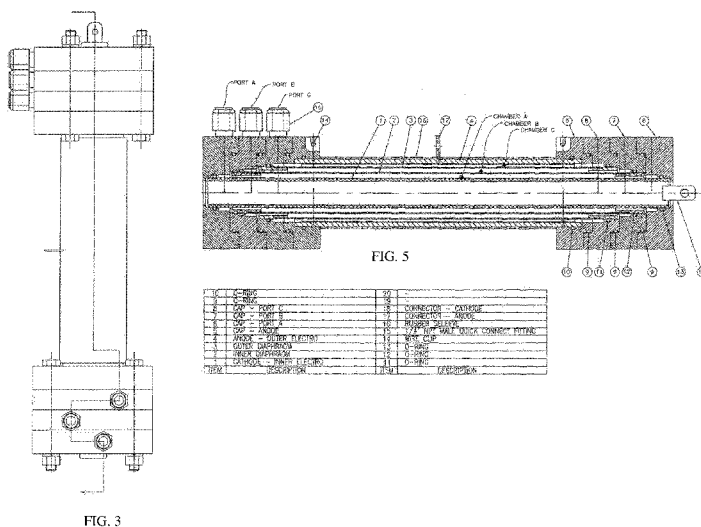
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(54) Title: DUAL DIAPHRAGM ELECTROLYSIS CELL ASSEMBLY AND METHOD FOR GENERATING A CLEANING SOLUTION WITHOUT ANY SALT RESIDUES AND SIMULTANEOUSLY GENERATING A SANITIZING SOLUTION HAVING A PREDETERMINED LEVEL OF AVAILABLE FREE CHLORINE AND PH



(57) Abstract: An electrolysis cell assembly to produce diluted Sodium Hydroxide solutions NaOH and diluted Hypochlorous Acid HOCl solutions having cleaning and sanitizing properties. The electrolysis cell consists of two insulating end pieces for a cylindrical electrolysis cell comprising at least two cylindrical electrodes with two cylindrical ion selective membranes arranged co-axially between them. The method of producing different volumes and concentrations of diluted NaOH solutions and diluted HOCl solutions comprises recirculating an aqueous sodium chloride or potassium chloride solution into the middle chamber of the cylindrical electrolytic cell and feeding softened filtered water into the cathode chamber and into the anode chamber of the cylindrical electrolysis cell.

DUAL DIAPHRAGM ELECTROLYSIS CELL ASSEMBLY AND METHOD FOR GENERATING A CLEANING SOLUTION WITHOUT ANY SALT RESIDUES AND SIMULTANEOUSLY GENERATING A SANITIZING SOLUTION HAVING A PREDETERMINED LEVEL OF AVAILABLE FREE CHLORINE AND PH

5 FIELD OF THE INVENTION

The present invention relates to a cylindrical electrolysis cell assembly for producing simultaneously a diluted Sodium Hydroxide and diluted Hypochlorous Acid solution for usage as cleaning and sanitizing solutions
10 by electrolysis of an aqueous saline solution. The method comprising a cathode chamber, an electrolyte chamber and an anode chamber separated by two cylindrical ion-selective permeable exchange membranes to prevent presence of salt residues in the cleaning and
15 sanitizing solutions and whereas pH and free available chlorine content of the sanitizing solution can be altered.

BACKGROUND OF THE INVENTION

Electrolysis cells are used for the production
20 of cleaning and sanitizing solutions from brine. Also, electrolysis cells are used to produce a sanitizing solution to disinfect water or other media. Many types of electrolysis cells exist for these purposes. The basic feature of these cells is two concentrically
25 disposed cylindrical electrodes with a separator dividing the space between the two electrodes to define anode and cathode compartments. An electrolyte, such as brine, is passed through the anode and cathode compartments, separately or successively. When brine is
30 electrolyzed in this way, under suitable conditions, it can produce a cleaning and sanitizing solution of high strength and long shelf life, which is ecologically and human friendly.

Typically an electrolyte solution is passed through the anode and cathode chambers separately to produce a diluted Hypochlorous Acid solution as a sanitizing solution and a diluted Sodium Hydroxide solution as a cleaning solution. Alternatively, neutral sanitizing solutions can be produced when an electrolyte is passed through the anode and cathode chambers successively.

Typically, in a cylindrical electrolysis assembly, the separator is a porous diaphragm made of a permeable ceramic material. Typically, in a plate electrolysis assembly, the separator is an ion-exchange membrane made of a cation or anion material on a polymer impregnated cloth. The ion-exchange membrane permits the diffusion of electrolytes between the anode and cathode but retard the migration of electrolysis products at the anode and cathode from diffusing to each other reverting back to starting material or undesired side products. The diaphragm permits the diffusion of electrolytes between the anode and cathode but only retard the migration of electrolysis products at the anode and cathode from diffusing to each other reverting back to starting material or undesired side products when the pressure differential between the anode and cathode chamber facilitates this.

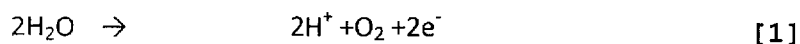
Acidic sanitizing solutions are generated by passing saline through an electrolytic cell comprising an anode chamber, a cathode chamber, and a separator. The result contains free available chlorine (FAC) in the form of a mixture of oxidizing species, predominantly hypochlorous Acid (HOCl) and sodium hypochlorite, and is characterized by its pH, FAC content, conductivity, osmolarity and redox potential.

Such reactive species have a finite life and so, while the pH, conductivity and osmolarity of the solution will usually stay constant over time, its biocide efficacy will decrease with age. Electrolysis cells either
 5 comprise cylindrical electrodes plus one cylindrical ceramic diaphragm or electrolysis cells comprise plate electrodes plus one ion permeable sheet of membrane as separator.

Usage of porous, insoluble ion permeable
 10 ceramic diaphragms between the electrodes have been described for more than 100 years as, for example, that described in U.S. Patent No. 590,826. U.S. Patent No. 914,856 and U.S. Patent No. 1,035,133 describe a cell which permits the flow of electrolyte solutions
 15 separately through the anode and cathode compartments using concentric cylindrical electrodes with a porous or ion permeable diaphragm.

In the cell shown in FIG. 1, the following electrolysis reactions take place.

20 At the Anode:



At the Cathode:



25

These reactions increase the oxygen concentration in the anode solution and the hydrogen concentration in the cathode solution, while leaving the essential properties of electrolytic water unchanged.

30 Further, migration of hydrogen ions formed on the anode toward the cathode is limited, and then the electrolysis reaction [3] takes place in addition to the reaction [1] and [2] :



This reaction suggests that the pH of cathode water tends to shift to the alkaline region. Hydrogen ions formed in the anode chamber in the reaction [1] remain partly in that chamber. In the two-chamber cell shown in FIG. 1 the anode solution, therefore, is likely to be charged with the hydrogen ions, while the cathode water is charged with hydroxide ions. In other words, the charged water produced using electrolysis cell shown in FIG. 1 may not be suitable for the surface cleaning such as glass, mirrors, metals or treatment of semiconductors or resins.

In order to enhance the cleaning or surface treatment efficacy, anode water is required to be more oxidative and/or acidic and cathode water is required to be more reductive and/or alkaline. However, the electrolysis cell shown in FIG. 1 is difficult to produce the effective solutions.

Some plate electrolysis assemblies are designed to solve the problem mentioned above, where a middle chamber is added between the anode chamber and the cathode chamber divided by two separators and whereas the middle chamber is filled with ion-exchange resin as a solid electrolyte and whereas the anode and cathode have holes and are closely attached to the separators. US patent application 10/629,165 describes a three chamber plate electrolysis cell utilizing two ion permeable sheets of membrane to divide middle chamber from anode and cathode chamber whereas the anode and cathode have holes and are closely attached to the ion-exchange membranes.

These three-chamber plate electrolysis cell assemblies utilizing anion and cation selective membranes have the following merits over two chamber cylindrical electrolysis cell assemblies. Reductive

species such as dissolved hydrogen gas produced in the cathode chamber are likely to migrate into the anode chamber through the diaphragm when utilizing a two chamber cell, such as described in U.S. Patent No 5 7,374,645, U.S. Patent No 7,691,249 or in U.S. Patent No 7,828,942. However, the middle chamber in the three-chamber cell and the usage of ion-exchange membranes control the diffusion of reductive species from the cathode chamber to the anode chamber and then the more 10 strongly oxidative anode water can be obtained.

Another merit of a three chamber cell is the fact that no electrolyte is fed into the anode and cathode chamber. Although efficiency of two chamber electrolysis cells has been significantly improved, not 15 all electrolytes that pass the cathode chamber are converted into Sodium Hydroxide. Likewise, not all electrolytes that pass the anode chamber are converted into Hypochlorous Acid and/or Hypochlorite Ion.

As a result, both the cleaning and sanitizing 20 solutions generated in a two cell electrolysis cell contain salt residues. Presence of salt in both the cleaning and sanitizing solutions limit its usage for surface treatment, as salt is corrosive, streaks the surface, and leaves deposits on the surface. As a 25 result, most cleaning and sanitizing procedures include an extra rinse with potable water.

Having described the benefits of producing cleaning and sanitizing solutions in a three-chamber plate cell assembly over a two-chamber cylindrical cell 30 assembly, the three-chamber plate cell assembly has several constructional disadvantages compared to the two-chamber cylindrical cell assembly.

Ion-exchange resin need to be replaced periodically, which is not only costly, but labor intensive.

Ion-exchange membranes are made of cloth
5 impregnated with ion-selective material. Though some cloth is reinforced the strength to the ion-exchange membrane is limited, depends on the surface size it needs to cover and tension placed over the membrane.

In a plate electrolysis cell, Ion-exchange
10 membranes are subject to a pressure-differential that will push on the ion-exchange membrane cloth and expand the space in one chamber at the expense of the space in the other chamber. Over time due to temperature, fluctuating pressures and aging, the tension of the ion-
15 exchange cloth will reduce. Moreover, ion-exchange membrane cloth is known to expand over its lifetime and causes the ion-exchange membrane cloth to become wobbling. An Ion permeable sheet of membrane is not very dimensionally stable.

20 In order to economically produce a cleaning and sanitizing solution, the volume and pressure in the cathode and anode chamber is higher than the pressure in the middle chamber whereas a brine solution is simply circulated. In the three-chamber cell shown in FIG. 2,
25 the ion-exchange resin somehow prevent both ion-exchange membrane cloths to restrict the flow of electrolyte in the middle-chamber. However, In US patent application 10/629,165 both Ion-exchange membrane cloths can easily expand and restrict the flow of electrolyte in the
30 middle chamber. For this reason in a plate cell assembly, the flow rate of water to the anode and cathode is often restricted.

Another disadvantage of mentioned three-chamber plate electrolysis cell assembly is the fact

that the electrodes are closely attached to the ion-exchange membranes. As these ion-exchange membrane cloths extend in size and become wobbly, they touch the electrodes and thus compromise their function to selectively allow ions to migrate through the membrane. As electrodes are hot, any contact with the ion-exchange membrane may burn holes in the cloth and thus allow impurities to migrate through the ion-exchange membrane. In several plate cell assemblies an insulating sheet is placed between the ion-exchange membrane cloth and the electrodes to reduce the risk of burning holes in the ion-exchange membranes.

Also, though in theory it appears to be easy to replace ion-exchange resin and ion-exchange membranes in plate electrolysis cell assemblies, in practicality it is difficult to maintain a leak-free construction, as these plate electrolysis cell assemblies are 'sandwiched' together whereas gaskets between the sections of the plate electrolysis cell assembly must prevent a leak-proof seal. At the same time these gaskets must keep the same distance between the electrodes, ion-exchange membranes and insulating sheets, the spaces that define the anode chamber, the middle chamber and the cathode chamber that need to remain the same, as different distances between the membranes, electrodes changes the dimension and volume of the different chambers; this may effect the produced cleaning and sanitizing solutions. Thus, it is important that the plate sections are compressed together in such way that the ion-exchange membranes, the insulating sheet and the electrodes are exactly positioned in its place and whereas an even force should be applied on the gaskets all around the plate cell assembly to obtain a leak-free seal and whereas one should be careful not to

over compress certain sections or sides of the plate cell assembly in order not to change the internal spaces of the chambers.

Finally, the flow in a plate electrolysis cell assembly is turbulent, whereas in some corners of the chambers there exist stagnant flow.

The three-chamber cylindrical cell shown in FIG. 3 is designed to solve the problems of plate three-chamber cells mentioned above, whereas in a more robust cylindrical cell assembly, a middle chamber is added between the anode chamber and the cathode chamber.

Although the above addition of a middle chamber seems obvious, it required significant changes in the construction of a cylindrical cell assembly.

The core of the present invention lies in the construction of cylindrical ion-exchange membranes which are dimensionally stable and which can be easily replaced, constructing a cylindrical electrolysis cell assembly that can be quickly, easily and leak-free re-assembled to replace ion-exchange membrane tubes multiple times.

When evaluating recent two-chamber cylindrical electrolysis cells as described in U.S. Patent No 7,374,645, U.S. Patent No 7,691,249 or in U.S. Patent No 7,828,942, it becomes clear that none of these cylindrical cell assemblies were constructed with the possibility to utilize an ion-exchange membrane as separator between the anode and cathode chamber.

U.S. Patent No 7,374,645, U.S. Patent No 7,691,249 and U.S. Patent No 7,828,942 clearly describe the usage of a ceramic diaphragm as separator for the same reason as described in U.S. Patent No. 914,856 and U.S. Patent No. 1,035,133; all cylindrical cell assemblies rely on the structural strength of the

ceramic material once assembled in a cylindrical cell assembly. When evaluating U.S. Patent No 7,374,645 and U.S. Patent No 7,691,249, both inventions are aimed to resolve the issue of breakage of the fragile ceramic diaphragm during assembling whereas in U.S. Patent No 7,691,249 glue or a sealant is used to provide a permanent leak-free seal between the end-cap sections, the electrodes and the diaphragm or whereas as described in U.S. Patent No 7,374,645 the end-cap sections, the electrodes and diaphragm are compressed together without any imposition of torque or compressive stress on the ceramic material.

It is known that it is economically not feasible to produce ceramic diaphragm tubes that are 100% round, have an even wall-thickness or even (inside) diameter throughout the length of the ceramic diaphragm tube. Assembling a ceramic diaphragm tube in a cylindrical cell requires machining and is time consuming, as the ceramic tube ends needs to be exactly at length and 100% round to form a leak-free seal with the o-ring. Edges of the ceramic tubes can easily chip off during machining and inserting the ceramic tube inside the cylindrical cell assembly. Assembling two ceramic diaphragm tubes with different diameters and lengths concentrically around each other would require more machining, more time and becomes a skillfull craft, economically not feasible.

Only the creation and utilization of ion-exchange membrane tube as described in this invention, made it possible to create a three-compartment cell for producing a diluted Sodium Hydroxide and a diluted Hypochlorous Acid suitable for cleaning and sanitation.

Attached drawings Fig. 16a and Fig. 16b show the ion-exchange membrane tubes manufactured and utilized in this invention.

An ion-exchange membrane tube is constructed using a Cation and Anion material made of either polymer impregnated cloth or reinforcing media of some kind; or an extruded or otherwise processed polymer, combined with suitable molded or otherwise fabricated attachment mechanisms and can be assembled in a cylindrical electrolysis cell in order to electrolyze water, electrolyte or other applicable liquids.

The inner membrane material(s) can be wrapped or coextruded in order to create an ion-exchange membrane of single or multiple layers of similar or dissimilar materials in order to create a liquid, once electrolyzed, having certain distinctive properties.

Said membrane material can be wrapped in any of several ways including, but not limited to: single wrap cylinder, multiple wrap cylinder, diagonally wrapped cylinders, etc.. This cylindrical wraps can be of any geometric shape, including, but not limited to circular, oval, square, hexagon, or even tetrahedral.

Fig. 16a and Fig.16b show a bushing that is inserted at both ends of the ion-exchange membrane tube and a collar that is pushed over the outer diameter of the ion-exchange membrane tube to lock the tube-end onto the bushing. The usage of the bushing and/or collar is optional. The bushing is manufactured conically so that it screws into the tube end. This gives a solid seal between the bushing and the ion-exchange membrane tube. Optionally, on the outside of the bushing, some glue or sealant can be added to form a leakfree seal between the bushing and the ion-exchange membrane tube.

When the Ion-exchange membrane tube needs to be replaced, the bushings may be recovered, provided no glue or other cement is used. The ion-selective tubular membrane is disposed.

5 Alternatively, a skeleton tube made of Polyvinyl Chloride (PVC) is used, as can be seen on Fig. 17. A cation or anion ion-exchange membrane sheet can be tightly wrapped around the skeleton tube in various patterns whereas one sheet end is glued on to the
10 skeleton tube, wrapped around and glued on top of the ion-exchange membrane sheet. Optionally, one or more collars can be pushed over the ion-exchange membrane tube (and thus over the skeleton tube) to help to hold the ion-exchange membrane sheet wrapped around the
15 skeleton tube. Alternatively the ion-exchange membrane sheet end can be glued to the inside of the skeleton tube, then rolled whereas the other end of the sheet is glued on top of the inside wrapped sheet, thus creating a good seal and a leak-free ion-selective membrane tube.

20 The ion-exchange membrane tubes are typically made in advance. The ion-exchange membrane sheet is soaked to extent its surface prior to gluing it onto the skeleton tube. As glue, a waterproof Polyurethane glue that requires the surfaces to be damp to get activated
25 is used. Once glued, the sheets are clamped for several hours. Once dried the ion-exchange membrane tubes are tested to ensure they are leak-proof and its, wall-thickness, length and diameters meet the specifications. When ion-selective exchange membrane sheet dries they
30 shrink, thus increasing the tension; therefore they are stored in a saline solution, prior to assembling into the electrolysis cell.

This invention resolves the deposits of salt and thus allows for cleaning and sanitation of surfaces without additional rinsing.

This invention resolves the structural weaknesses of plate electrolysis cells minimizing the torsion of ion-exchange membrane cloth by constructing a sturdy dimensionally stable ion-exchange membrane tube, enabling a high laminar flow rate through the anode and cathode chambers preventing stagnant water, avoiding ion-exchange membrane cloth to expand and make contact with electrodes thus securing integrity and improving lifetime of the ion-exchange membranes whereas the unique cylindrical cell assembly enable frequent and easy leak-free replacement of cation and anion ion-exchange membrane tubes without the possibility to reduce the spaces of the chambers by compressing the cell sections together.

This invention resolves the limitation of cylindrical electrolysis cells of utilizing porous or permeable ceramic diaphragms by constructing a sturdy ion-exchange membrane tube, enabling to selectively reject anions or cations not having to rely on a certain pressure differential between the anode and cathode chambers to prevent migration of undesired ions occurs utilizing a porous or ion-permeable diaphragm.

This invention resolves assembling issues related to machining, handling and assembling fragile ceramic ion-permeable diaphragm and facilitate easy periodic replacement of pre-constructed sturdy unbreakable ion-exchange membrane tubes having either a bushing on either end or are tightly wrapped around a skeleton tube of which outer diameter is 100% round and fits the inner diameter of the end-cap section to form a leak-free seal using an o-ring.

This invention resolves the dimensional issues related with the manufacture of the ceramic diaphragm, as length, wall-thickness and diameter of the pre-constructed ion-exchange membrane tube can be better and
5 more precisely controlled than casting, drying firing, machining ceramic diaphragms, thus making it possible to utilize and assemble two ion-exchange membrane tubes coaxially within each other to create a middle chamber.

SUMMARY OF THE INVENTION

10 The invention is directed to a cylindrical dual diaphragm electrolysis cell assembly comprising a cathode chamber, electrolyte chamber, and an anode chamber. The present invention provides an insulating end piece for a cylindrical electrolysis cell of the
15 type comprising at least two cylindrical electrodes arranged coaxially one within the other with two cylindrical ion-exchange membranes arranged coaxially between them.

Softened filtered water passed through the
20 cathode chamber functions as cleaning agent for all surfaces, fabrics, textiles, and carpets. Softened filtered water passed through the anode chamber functions as sanitizing agent for all hard surfaces.

Anodic electrolysis of softened water produces
25 hydrogen ions, where no anion is present as counter ion, unlike acidic solutions prepared by adding acid such as hydrochloric acid or sulfuric acid. The anode water produced by electrolyzing softened water exhibits that the solution is charged. Moreover, the hydrogen ion by
30 itself is an electron acceptor and so exhibits one of oxidizing species. So, the oxidation-reduction potential of anode water tends to shift to noble side. In other words, the redox sensor indicates a plus value. During

cathodic electrolysis of softened water is reduced at the cathode. This occurs because water is more easily reduced than are sodium ions. Cathodic electrolysis alters the H^+/OH^- balance around the cathode making the
5 solution more basic and the oxidation reduction potential of cathode becomes negative.

When the two-chamber cylindrical cell depicted in FIG. 1 is used, the cathode water is not necessarily suitable for actual cleaning or a surface treatment
10 without rinsing the surface with distilled, RO or tap water. The anode water is not necessarily suitable for sanitizing hard surfaces without rinsing the surface afterwards with distilled, RO or tap water. So improving the electrolysis cell is very important to
15 apply to actual use.

When the three-chamber plate cell depicted in FIG. 2 is used, the periodic replacement of the ion-exchange membrane sheets cause issues with regard to leakage, space and applying an even amount of force
20 while compressing the sections of the plate cell assembly. Moreover, a plate cell design does not enable a high laminar flow rate of water in the anode and cathode chamber, as the Ion-exchange membrane sheet is dimensionally unstable and expand with changes in
25 pressure differential restricting the flow in one of the chambers or touch the electrodes that are mounted directly next the Ion-exchange membranes causing damages and shortened lifetime of the cloth thus increase periodic replacement of the ion-exchange membrane. So
30 improving the electrolysis cell is very important to apply to actual use.

The main factor for producing effective cleaning and sanitizing agents is the construction and assembly of a sturdy dimensionally stable easy to

replace ion-exchange membrane tube in a cylindrical electrolysis cell assembly that facilitate two Ion-exchange membrane tubes of different length and diameter coaxially mounted within each other creating a middle
5 chamber for circulation of electrolyte.

Other important factors for producing effective cleaning and sanitizing agents is the use of ion-selective materials for creating selective anion and cation Ion-exchange membrane tubes.

10 Further factors for producing effective cleaning and sanitizing agents are an apparent current density (current (A)/apparent area of whole electrode (cm.sup.2), a fluid velocity along the electrode surface, and a true current density (effective current
15 density=current (A)/true area of the electrode (cm.sup.2)). As the fluid velocity increases, the hydrogen ions and other electrolytic species produced on the electrode surface migrate faster.

Various different sanitizing solutions can be
20 produced in the electrolysis cells of the present invention, depending on the various flow patterns through the cell of the present invention. For example, the softened water can be fed to the anode and cathode chambers separately and the electrolyzed solutions can
25 then be collected from each of these chambers separately.

Alternatively, the softened water can be fed through the cathode and anode chamber successively. Other factors which can be used to vary the sanitizing
30 solution include the voltage applied to the electrodes, the electrical power absorbed, the electrode coating and physical size of the electrode, the shape of the electrodes and distances between them and the spacing and material of the Ion-exchange membrane. The Ion-

exchange membrane material is an important feature since it affects the mobility of ions passing between the electrodes.

An objective of the invention is to provide a
5 cylindrical electrolytic cell than can produce a constant quality of diluted Sodium Hydroxide and simultaneously a constant quality diluted Hypochlorous Acid whereas the separators pre-constructed made of are anion and cation selective Ion-exchange membrane sheet
10 and can be easily replaced.

Another objective of the invention is to disclose a method and apparatus that can prevent the presence of salt residues in cleaning and sanitizing solutions whereas pH and free available chlorine content
15 of the sanitizing solution can be altered.

Another objective of the invention is to improve cleanliness, as the cleaning solutions produced by the electrolytic cell are effective for cleaning all surfaces by removing fine particles or the like
20 wherefrom and sanitizing solutions produced by the electrolytic cell are effective for sanitizing all hard surfaces by oxidation of micro-organism and viruses.

Yet another objective of the invention is to
25 produce cleaning and sanitizing solutions that are also effective for cleaning and sanitizing resins or the like, in particular resins for beverage, dairy, and even medical devices.

Yet still another objective of the invention
30 is to produce cleaning and sanitizing solutions wherein no special chemical remains after cleaning and sanitizing.

Other objectives and further advantages and benefits associated with this invention will be apparent

to those skilled in the art from the description, examples and claims which follow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 (prior art) is a view of a two chamber
5 cylindrical electrolysis cell as described in e.g. in
U.S. Patent No 7,374,645, U.S. Patent No 7,691,249, U.S.
Patent No 7,828,942, or in U.S. Patent No 8,002,955.

FIG. 2 (prior art) is a view of a three
chamber plate electrolysis cell as described in
10 US2004/0020787.

FIG. 3 is a view of a three-chamber
cylindrical electrolysis cell assembly using two ion-
exchange membrane tubes to create a middle chamber
whereas electrolyte is circulated.

15 FIG. 4 (prior art) is a view of a typical
cylindrical two-chamber electrolysis cell assembly cut
in a plane on the center axis between the port to one
electrode compartment in one end cap and the port to the
other electrode compartment in the other end cap.

20 FIG. 5 is a view of a three-chamber
cylindrical electrolysis cell assembly cut in a plane on
the center axis between the port to one electrode
compartment in one end cap and the port to the other
electrode compartment in the other end cap.

25 FIG. 6a is a view of the outer electrode
wherein a groove is manufactured that facilitates a
stainless steel clip.

FIG. 6b is a view of the stainless steel clip
that mounts the end-cap on the outer electrode.

30 FIG. 7 (prior art) is a view of a one section
end piece from the side into which the tubes of a
cylindrical two chamber electrolysis cell would be
inserted.

FIG. 8 (prior art) is a view of a one section end plug with only the inserted tubes cut in a plane of the center axis.

FIG. 9 is a view of a multiple section end piece from the side into which the tubes of a cylindrical three chamber electrolysis cell would be inserted.

FIG. 10 is a view of a multiple section end piece from the top of a cylindrical three chamber electrolysis cell.

FIG. 11 (prior art) is a view of typical flow patterns in a two chamber electrolysis cell.

FIG. 12 is a view of flow patterns in a three chamber electrolysis cell.

FIG. 13 (prior art) is a view of alternative flow patterns in a two chamber electrolysis cell.

FIG. 14 is a view of alternative flow patterns in a three chamber electrolysis cell.

FIG. 15 is a view of the brine reservoir and peristaltic pump to circulate the electrolyte.

FIG. 16A is a view of an inner ion-selective membrane tube.

FIG. 16B is a view of an outer ion-selective membrane tube.

FIG. 17 is a view of a skeleton on which anion or cation material made of either polymer impregnated cloth or reinforced media of some kind can be wrapped around.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to the construction of an optimized cylindrical electrolysis cell that produces a cleaning solution and simultaneously a sanitizing solution. The diluted Sodium

Hydroxide solution is more alkaline, contains no salt residues and, therefore, the solutions can be used to clean any surface without rinsing the surface afterwards with distilled, RO water or tap water. The diluted
5 Hypochlorous Acid solution contains no salt residues and its free available chlorine content as well as pH can be adjusted. As a result, surfaces can be effectively sanitized using a sanitizing solution which pH and free available chlorine is 'tailored' to sanitize a certain
10 surface taking into account chlorine consumption and in line with various sanitizing procedures as set by regulatory agencies such as the FDA, EPA, USDA and CDC. Certain surfaces require a more acidic sanitizer whereas other surfaces are damaged by the acid nature of the
15 sanitizer. In these cases, a more neutral pH Hypochlorous Acid is preferred. Also, the absence of salt residues allows the use of the sanitizing solution on any surface without rinsing the surface with distilled, RO or tap water.

20 The three chamber electrolysis cell is illustrated in FIG. 3 and FIG. 5, where a cylindrical electrode [1] is positioned within a cylindrical cation ion-exchange membrane tube [2] which is positioned within a second cylindrical anion ion-exchange membrane
25 tube [3], where the anion ion-exchange membrane tube [3] is positioned within a second cylindrical electrode [4] by the use of two end pieces [99] which consist of a tube cap [6], port A cap [7], port B cap [8] and port C cap [9].

30 The design of the four sections of the end piece [99] permits the orientation and sealing of the entire assembly [100]. Tube cap [6] seals the outer electrode [4] with the end piece [99] using an O-ring [12]. The tube cap [6] is compressed or screwed on the

outer electrode [4]. In case the tube cap [6] is screwed on the outer electrode [4], the outer electrode tube-ends have a male thread that fits a female thread manufactured in the tube cap [6].

5 In case the tube cap [6] is compressed on the outer electrode [4], the outer electrode tube ends have a groove [30] manufactured that fits a stainless steel clip [14]. Once the tube cap [6] is compressed on the outer electrode [4], the stainless steel clip [14] is
10 pushed through an aperture manufactured in the tube cap [6] into the groove [30] to lock the tubecap [6] onto the outer electrode [7]. A huge benefit of using a groove and stainless steel clip [14] is the fact that the face of the bottom end pieces [99] can be easily
15 line-up with the face of the upper end pieces [99] whereas when screwing the tube cap [6] onto the outer electrode [4] the tube caps [6] cannot be tightened totally, if both faced are to be lined up.

 Port A cap [7] features port A for direction
20 of the flow of softened water through port A ending in fittings [17] into the chamber A defined by the spaces between the anode [4] and the anion ion-exchange membrane [3] and out of chamber A through port A ending in fittings [17] of the opposite port A cap [6].

25 Port B cap [8] features port B for direction of the flow of saturated brine through port B ending in fittings [17] into chamber B defined by the spaces between the cation ion-exchange membrane [2] or anion ion-exchange membrane [3] and out of chamber B through
30 port B ending in fittings [17] of the opposite port B cap [8].

 Port C cap [9] features port C for direction of the flow of softened water through port C ending in fittings [17] into chamber C defined by the spaces

between the inner electrode [1] and the cation ion-exchange membrane [2] and out of chamber C through port C ending in fittings [17] of the opposite port C cap [9].

5 The four sections of end piece [99] are compressed on each other using 0-rings [13] to seal the section on each other.

 The tube cap [6] is either compressed or screwed on the outer electrode [4]. Port A cap [7] is
10 pressed on the tube cap [6] whereas the tube cap [6] facilitated a groove for an 0-ring [13] and whereas port A cap [7] is pressed on the tube cap [6]. Port B cap [8] is pressed on port A cap [7] whereas the port A cap [7] facilitated a groove for an 0-ring [13] and whereas
15 the Port B cap [8] is pressed on port A cap [7]. Port C cap [8] is pressed on port B cap [7] whereas port B cap [7] facilitated a groove for an 0-ring [13] and whereas port C cap [8] is pressed on port B cap [7].

 The tube cap [6], port A cap [7], port B cap
20 [8] and port C cap [8] are bolted together using three or four stainless steel bolts [18], washers [19] and nuts [20]. In each section of the end piece [99], there are three or four holes [21] to facilitate the stainless steel bolts [18], washers [19] and nuts [20]. The seal
25 between each section of the end piece [99] is achieved by compressing the sections of the end piece [99] onto each other, in a manner such that the compressive force can be applied slowly and smoothly without the introduction of torque such that a reliable seal is
30 produced between each section of the end piece [99] as well with the ion-Exchange membrane tubes [2] and [3].

 Either of the electrodes [1] and [4] can act as the anode with the other acting as the cathode. The choice can be made by considerations of the ease of

manufacture or requirements of the nature of the electrolysis process to be performed which can favor the anode or cathode chamber preferentially being the outer chamber. These considerations include the desired
5 spacing between the electrodes and the Ion-exchange membranes, the desired space between the ion-exchange membranes [2] and [3] and the relative volume requirements for the balance of flows of the electrolyte solution in chamber B and the softened
10 water in chamber A and chamber C.

The inner electrode cathode [1] and outer electrode anode [4] tubes are constructed of an electrically conductive material, preferably titanium.

The metal electrode tubes are coated with a
15 mixed metal oxide on the face of the tube directed toward the Ion-exchange membranes [2] and [3]. The metals of the two electrodes can be titanium or stainless steel. Both metals can be coated with a mixed metal oxide. The cathode can be an uncoated metal, but
20 the anode has to be a mixed metal oxide coated metal. A preferred arrangement has the outside electrode tube [4] as the anode internally coated with a mixed metal oxide and the inner electrode tube [1] as the cathode and not coated.

25 The outer electrode [4] is shown in FIG. 2 with an electrical connector [10] welded to the outside of the outer electrode [4] tube. The inner electrode [1] has an electrical connector [11] on its end that is part of the inner electrode [1] and extends out of the
30 outside of the upper end piece [89]. Although not necessary for the function of the assembly, the outside of the outer electrode [4] is insulated by a rubber sleeve [5] that is heat-shrunk over the outer electrode [4] and cut to length. Another option is to glue an

insulating sheath [5] or tube on the outside of the outer electrode [4].

In a preferred embodiment, the outer anion ion-exchange membrane tube and the inner cation ion-exchange membrane tube are pre-constructed and made from polymer ion-selective membrane sheet. The thickness of the Ion-exchange membrane tube can vary over a broad range depending on the application the electrolysis cell assembly [100].

10 The relative diameter of the outer electrode [4], inner electrode [1], Ion-exchange membranes [2] and [3] can vary within the single requirement that outer electrode [4] must be of greater diameter than Ion-exchange membrane tube [3], the diameter of Ion-exchange
15 membrane tube [3] greater than Ion-exchange membrane tube [2] and the diameter of Ion-exchange membrane tube [3] greater than the inner electrode tube [4]. The actual diameters can vary depending upon the desired features of the electrolysis cell assembly [100]. To
20 this end the diameters can be varied to optimize the rate of electrolysis, rate of flow through the cell assembly, and other needs of the system to which the assembly will be used. Likewise, the relative length of the electrodes [1] and [4] and Ion-exchange membrane
25 tubes [2] and [3] can vary within the single requirement of this embodiment that the outer electrode tube [4] must be shorter than Ion-exchange membrane tube [3] Ion-exchange membrane tube [3] shorter than Ion-exchange membrane tube [2] and Ion-exchange membrane
30 tube [2] shorter than inner electrode [1]. The lengths of the electrodes [1] and [4] and the length of the Ion-exchange membrane tubes [2] and [3] can be determined by factors such as ease of construction and geometries to

optimize the performance of the electrolysis cell assembly in the system in which it is to perform.

The upper and lower end pieces [99] are interchangeable and constructed of an insulating material, preferably Polyvinyl Chloride. Each end piece [99] consist of four sections, the tube cap [6], Port A cap [7], Port B cap [8] and port C cap [9].

The upper and lower end pieces [99] have an inlet fitting connected to a tube that passes tangentially through a specific section of the upper and lower end pieces [99] to communicate with the cathode chamber through an aperture. The upper and lower end pieces [99] respectively have an inlet fitting and an outlet fitting connected to a tube that passes tangentially through a specific section of the upper and lower end pieces [99] to communicate with the anode chamber through an aperture.

The upper and lower end pieces [99] respectively have an inlet and outlet fitting connected to a pipe that passes through a specific section of the upper and lower end pieces to communicate with the middle chamber through an aperture.

The four sections of the end piece [99] can be formed by molding or machining. Ports [17] are for introduction or exit of softened water to chamber A and to chamber C. Port [17] is for the introduction and exit of electrolyte to chamber B. All sections of the end piece [99] consist of three or more holes to accept three or more stainless steel bolts [18], washers [19] and nuts [20] by which the four sections of the end piece [99] are compressed together.

Three sections [6], [7] and [9] of the end piece [99] have a groove to facilitate O-ring [13] to form the seals between the end piece sections. When the

tube cap [6] is screwed or compressed on the outer electrode [4] using the stainless clip [14], then three or four pairs of stainless steel bolts [18], washers [19] and nuts [20] are used and the three or four bolts
5 provide the structural integrity of the assembly [100].

Two holes [22] with female thread are made in the tube cap [6] at both opposite sides. This allows mounting the assembly [100] on a plate or bracket. This
10 plate or bracket may be a plastic or stainless steel as long as the metal is insulated from one or both of the electrodes. A preferred fabrication of a mounting plate or bracket is a machined sheet of Polyvinyl Chloride, which is commercially available as PVC.

15 One critical feature of the end piece [99] is that the inside diameter of all sections of the end piece [99] closely match the outside diameters of the four tubes [1], [2], [3] and [4] so that the o-rings [12], [14], [15] and [16] form a good seal between the
20 sections. When screwing or compressing the tube cap [6] on the outer electrode [4] using the stainless steel clip [14] and when the other sections of the end piece [99] are compressed on each other, it is important that the O-rings [12], [14], [15] and [16] form a good seal
25 between the tubes [1], [2], [3] and [4] and the four end caps [6], [7], [8] and [9] as well form a good seal between the four sections themselves using O-ring [13]. The Ion-exchange membrane tubes [2] and [3] require the use of O-rings [14] and [15] to form the seal such that
30 whilst assembling, the Ion-exchange membrane tubes slide over the end cap to form a good seal. It is necessary that, upon assembly, the length of the cell assembly [100] is defined by the length imposed by the outer electrode tube [4]. The Ion-exchange membrane tubes [2]

and [3] must be long enough to seal at both ends by O-rings [14] and [15] even if one end of the Ion-exchange membrane tubes [2] and [3] is resting on Port B cap [8] and Port C cap [9].

5 A second critical feature of the end caps [99] is the presence of three ports. Port A begins at fitting [17] on an outside surface of Port A [7] permits the flow of softened water through chamber A defined by the inside of the outer electrode tube [4] and the outside of diaphragm [3] as illustrated in FIG. 2 and FIG. 4. 10 Port C begins at fitting [17] on an outside surface of Port C cap [9] and permits the flow of softened water through chamber C defined by the inside of Ion-exchange membrane tube [2] and the outside of inner electrode [1] 15 as illustrated in FIG. 2 and FIG. 4. Port B begins at the fitting [17] on an outside surface of port B cap [8] and permits the flow of an electrolyte solution through chamber B defined by the inside of Ion-exchange membrane tube [3] and the outside Ion-exchange membrane 20 tube [2], as illustrated in FIG. 2 and FIG. 3. The outside of port A, port B and port C is a fitting [17] which accepts a tube for introduction or exit of a fluid to the cell assembly [100].

 These fittings [17] can be a compression 25 fitting, as is illustrated in FIG. 2 and FIG. 4, or it can be a hose barb or some other coupling which is appropriate for the system within which the electrolysis cell assembly [100] is to function. The orientation of the ports is necessary to promote a tight spiral flow 30 around the inner electrode tube [1], Ion-exchange membrane tubes [2] and [3] between the spaces in chamber A, chamber B and chamber C.

 The end pieces [99] can have other configurations as long as the configuration permits for

the sealing of the assembly where the compressive force is imposed upon the outer electrode [4] and no significant compressive force is required imposed on Ion-exchange membrane tubes [2] and [3]. The different
5 types of end pieces [99] can be combined in any combination as long as the appropriate lengths of tubing are chosen and as long as the sections of the end piece [99] can be sealed together by compression. While the preferred end piece [99] has been illustrated and
10 described, it will be clear that the invention is not so limited. Modifications, changes, variations, substitutions and equivalents will occur to those skilled in the art without departing from the spirit and scope of the present invention as described in the
15 claims.

A critical feature of this invention is the construction of the ion-selective membrane tubes.

A Cation and Anion material made of either polymer impregnated cloth or reinforcing media of some
20 kind; or an extruded or otherwise processed polymer, combined with suitable molded or otherwise fabricated attachment mechanisms, can be used in conjunction with a suitable shell in order to process electrolyzed water or other applicable liquids.

25 The inner membrane material(s) can be wrapped or coextruded in order to create an ionic cell membrane of single or multiple layers of similar or dissimilar materials in order to create a liquid, once electrolyzed, having certain distinctive properties.

30 The membrane material can be wrapped in any of several ways including, but not limited to: single wrap cylinder, multiple wrap cylinder, diagonally wrapped cylinders, etc. This cylindrical wraps can be of any

geometric shape, including, but not limited to circular, oval, square, hexagon, or even tetrahedral.

In a typical wrapping, an ion-exchange membrane tube has been created out of two dissimilar materials and wrapped at a 20 degree angle and subsequently, or coincidentally, bonded together. This is an example of cylinder that is circular in design. The bonding of these layers of fabric/polymer can be achieved by any of a number of acceptable methods including, but not limited to: adhesive bonding, dielectric bonding, vibrational welding, ultrasonic welding or any of a variety of other thermal and chemical bonding techniques.

These bonds can be lineal, circular or spiral in order to achieve the maximum strength longevity of the membrane itself. Once the membrane itself is constructed, the membrane can be bonded to a set of pre-fabricated end caps to assist in the subsequent assembly of the ionic cell. These end caps are typically, but not uniquely made by any of the various thermoplastic or thermoset polymer methods such as injection molding, compression molding, machining, etc.

These end caps are then bonded to the membrane materials with any of the above mentioned, or other, methods of bonding dissimilar materials together.

Optionally, a protective collar, of similar material to the membrane cap, can be placed over the membrane material and subsequently bonding all 3 components together into one functional tube.

Another critical feature of this invention is the construction of the brine reservoir [98] and the usage of a pump [23] to circulate an electrolyte from the brine reservoir [98] through chamber B to the brine reservoir [98] as shown in FIG.

13. The brine reservoir [98] is preferably manufactured from a transparent plastic tube [24] and two end pieces [25] and [26] made of Polyvinyl Chloride, which is commercially available as PVC. The transparent tube [24] is glued between end piece [25] and end piece [26]. End piece [25] has a male thread that allows screwing a cap [27] on top of end piece [25]. End piece [25] has also a port [28] whereas through fitting [17] a tube can be connected for the exit of the electrolyte to chamber B. End piece [26] has a port [29] on the bottom of end piece [26] whereas through fitting [17] a tube can be connected for the inlet of softened water. End piece [26] has another port [30] on the bottom of end piece [26] with valve [31]. Opening valve [31] allows drainage of the electrolyte from the brine reservoir [98]. Ports [29] and [30] have been constructed in such a way that the aperture of ports [29] and [30] is located at the side and above the brine fill line. This feature is important for two reasons. Firstly, when granular salt is added to the brine container [98] by opening cap [26], no salt can enter into ports [29] and [30] as the apertures are located at the side of these elevated ports [29] and [30]. Secondly, when opening valve [31], only the electrolyte is drained and the brine reservoir [98] remains filled with granular salt that is collected at the bottom of the brine reservoir [98] on top of end piece [26]. End piece [26] has a third port [32] on the bottom of end piece [26] whereas through a fitting [17] a tube can be connected for the inlet of electrolyte from the pump [23]. Port [32] has been constructed in such a way that the aperture of port [31] is located under the brine fill line. This feature is important for two reasons. Firstly, when granular salt is added to the brine container [98] by opening cap

[27], no salt can enter into port [31] as the inlet is located at the side of the port [31]. Secondly, the electrolyte from the pump is circulated through a brine layer that saturates the electrolyte. The electrolyte
5 is circulated through pump [23] which is preferably a peristaltic pump with a variable pump-speed and which has two fittings [17] to connect a tube from the brine reservoir [98] to the pump [23] and from the pump [23] to the cell assembly [100]. The brine concentration can
10 be adjusted by adding granular salt and softened water into the brine reservoir [98]. The electrolyte is preferably made by adding granular sodium chloride into the brine reservoir [98] by opening cap [27]. Besides granular sodium chloride, granular potassium chloride
15 can be used. The electrolyte is preferably a saturated aqueous brine solution.

Saturation of the electrolyte is ensured by circulating the electrolyte through the brine reservoir [98] that is filled with a certain minimum amount of
20 brine. The electrolyte is circulated from the bottom of the brine reservoir [98] through a layer of salt that is at the bottom of the brine reservoir [98].

This three chamber cylindrical electrolysis cell can be used with different flow patterns allowing
25 changing the volume of the cleaning and sanitizing solution, as well as the pH and free available chlorine content. A typical flow pattern permits approximately 30 to 70% of the softened water to pass the anode chamber and approximately 70 to 30% of the softened
30 water to pass the cathode chamber. The volume of softened water that passes the anode chamber or cathode chamber can be restricted by closing a valve which is mounted in the outlet tube of the anode chamber and the volume of softened water that passes the cathode chamber

can be restricted by closing a valve that is mounted in the outlet tube of the cathode chamber. An alternative flow pattern is a flow pattern whereas 100% of the softened water is passed through either the cathode chamber or anode chamber. Approximately 70 to 100% of the electrolyzed solution that either exits the cathode chamber or anode chamber is re-directed to the inlet of either the anode chamber or the cathode chamber whereas 0 to 30% of the electrolyzed liquid is collected in a Sodium Hydroxide storage container or drained as useful by-product. This alternative flow pattern whereas 70 to 100% of the electrolyzed solution is collected in a Hypochlorous Acid storage container is preferred when there is no or little usage of the by-product and whereas the volume of the main-product is maximized. A preferred alternative flow pattern is to pass softened water first through the cathode chamber, wherein the outlet tube is a tee mounted to allow approximately 20% of the diluted sodium hydroxide to flow to a storage tank and where approximately 80% of the diluted sodium hydroxide is re-entered in the anode chamber. The result of this preferred alternative flow pattern is that approximately 80% of the softened water has undergone cathodic electrolysis followed by anodic electrolysis to generate a neutral pH sanitizing solution. Re-entering more diluted Sodium Hydroxide into the anode chamber will increase the pH of the diluted Hypochlorous Acid and re-entering less diluted Sodium Hydroxide will reduce the pH of the diluted Hypochlorous Acid. The volume of the diluted Sodium Hydroxide that enters the anode chamber is regulated by a valve that is mounted in the outlet tube of the cathode chamber between the tee and the Sodium Hydroxide storage container.

In the preferred embodiment, by utilizing polymer ion-selective membranes a pressure differential in the chambers will not affect ion exchanges thereby eliminating contamination of the cleaning or sanitizing solutions. The softened water in the cathode chamber is enriched with OH^- ions giving the softened water a high pH and therefore cleaning properties. The electrolyte is rejected by the cation ion-exchange membrane. The softened water in the anode chamber is enriched with Cl^- ions giving the softened water a low pH and sanitizing properties. The electrolyte is rejected by the anion ion-exchange membrane. By using ion-exchange membrane tubes made of ion-selective membrane sheets in this manner, surfaces where either the cleaning or sanitizing solutions are applied do not need to be rinsed of residual contaminants.

In an alternative embodiment, the anode chamber and the cathode chamber are separated from each other by at least one ion-exchange membranes constructed and arranged for generating a diluted Hypochlorous Acid sanitizing solution with a pH between 4.5 and 7.5, an ORP of +800 to +1200mV and a free available chlorine content between 10 to 1000ppm. The ion-exchange membranes simultaneously generate a dilute Sodium Hydroxide (NaOH) cleaning solution with a pH between 9.5 and 12.5 and an ORP of -500 to -1000mV.

One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objectives and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments, methods, procedures and techniques described herein are presently representative of the preferred embodiments, are intended to be exemplary and are not intended as limitations on the scope. Changes

therein and other uses will occur to those skilled in the art which are encompassed within the spirit of the invention and are defined by the scope of the appended claims. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications of the described modes for carrying out the invention which are obvious to those skilled in the art are intended to be within the scope of the following claims.

CLAIMS

What is claimed is:

1. A method of making electrolyzed liquids utilizing an electrolysis cell comprising an outer cylindrical electrode separated from an inner cylindrical electrode by at least one cylindrical cation ion-exchange membrane and at least one anion ion-exchange membrane arranged coaxially one within the other to create a cathode chamber, an electrolyte chamber and an anode chamber wherein the outer cylindrical electrode is of greater diameter than the anion ion-exchange membrane proximal to the outer cylindrical electrode which is of a diameter greater than the cation ion-exchange membrane to the outer cylindrical electrode and the diameter of said cation ion-exchange membrane is greater than the inner cylindrical electrode; providing a pair of end pieces where the space between the inner tubular electrode and the cation ion-exchange membrane and the space between the anion ion-exchange membrane and the outer tubular electrode defines anode and cathode chambers; where the space between the anion or cation ion-exchange membrane defines the electrolyte chamber and where one of the electrodes functions as an anode and the other electrode functions as a cathode; providing a saturated brine solution to the electrolyte chamber of the electrolysis cell and providing softened water to the anode and cathode chamber applying a current across the electrodes, wherein each end piece provides a sealing engagement between four sections of the end piece and each of the cylindrical electrodes and the anion ion-exchange membrane and the cation ion-exchange membrane,

wherein the end piece has a lateral inlet through an outer wall thereof, said inlet being provided with a fitting for tangential feeding of the liquid to the inside of the end piece, and wherein three pairs of ports for entrance or exit of fluid are situated in an upper and a lower end piece, each comprising an external fitting for attachment of a hose or pipe, wherein said first pair of ports at opposite ends of said assembly internally addresses a space between said outer electrode tube and said anion ion-exchange membrane and said second pair of ports at opposite ends of said assembly internally addresses a space between

said cation ion-exchange membrane and said anion ion-exchange membrane and said third pair of ports at opposite ends of said assembly internally addresses a space between said inner electrode tube and said cation ion-exchange membrane.

2. The method of claim 1, wherein said outer anion ion-exchange membrane and the inner cation ion-exchange membrane are cylindrical polymer ion-exchange membranes.

3. The method of claim 1, wherein the Selective ion-exchange membrane material can be wrapped or coextruded in order to create a cylindrical ion-exchange membrane tube of single or multiple layers of similar or dissimilar materials.

4. The method of claim 1, wherein said Selective ion-exchange membrane material can be wrapped in any of several ways including, but not limited to: single wrap cylinder, multiple wrap cylinder, diagonally wrapped cylinders; said cylindrical wraps can be of any geometric shape, including, but not limited to circular, oval, square, hexagon, or even tetrahedral.

5. The method of claim 1, wherein said cylindrical ion-exchange membrane can be of any thickness, length and diameter by wrapping two similar or dissimilar polymer (perfluorinated) selective ion-exchange materials at a predetermined angle, whereby said selective ion-exchange materials bond together to form a cylindrical ion-exchange membrane with specific characteristics.

6. The method of claim 5, wherein the bonding of said layers of polymer or perfluorinated selective ion-exchange membrane material can be achieved by any of a number of acceptable methods including, but not limited to: adhesive bonding, dielectric bonding, vibrational welding, ultrasonic welding or any of a variety of other thermal and chemical bonding techniques, said bonds can be lineal, circular or spiral in order to achieve the maximum strength longevity of the membrane itself.

7. The method of claim 1, wherein said Ion-exchange membrane tube can be inserted to a set of pre-fabricated end pieces to assist in the subsequent assembly of cylindrical three-chamber cell assembly.

8. The method of claim 7, wherein a bushing constructed of Polyvinyl Chloride (PVC) is inserted at both ends of the cylindrical ion exchange membrane to seal said Ion-exchange membrane tube with said bushing.

9. The method of claim 7, wherein a collar made of Polyvinyl Chloride (PVC) is positioned over the tube ends of said Ion-exchange membrane tube, thereby creating a leak-free seal between said cylindrical ion-exchange membrane and said bushing.

10. The method of claim 2, wherein said selective ion-exchange membrane material wrapped around a skeleton made of Polyvinyl Chloride(PVC), thereby creating a cylindrical ion-exchange membrane tube of a single layer, wherein said tube ends of said skeleton constructed and arranged for insertion of said membrane in said end pieces of said cylindrical electrolysis cell.

11. The method according to claim 10, wherein said selective ion-exchange membrane material is coextruded, thereby creating a cylindrical ion-exchange membrane tube of a single layer, wherein said tube ends of said skeleton constructed and arranged for insertion of said membrane in said end pieces of said cylindrical electrolysis cell.

12. The method according to claim 1, wherein said anode and cathode, comprise a titanium base activated with a mixed metal oxide coating structure comprising ruthenium, iridium, titanium, tantalum , rhodium or mixtures thereof.

13. The method of claim 1, wherein said upper and lower end pieces comprise four stackable sections of complimentary topography with at least one seal forming feature at every interface between adjacent sections wherein said seal forming feature comprising a sealant, compressible ridge, a gasket, or an O-ring.

14. The method of claim 12, wherein the upper and lower end pieces comprise Polyvinyl Chloride, said gaskets or O-rings comprised of Ethylene Propylene, Nitrile, Fluorocarbon or combination of a plastic and a rubber.

15. The method of claim 1, wherein an electrolyte is circulated through the electrolyte chamber is a sodium chloride solution or a potassium chloride solution.

16. The method of claim 1, wherein the electrolyte is saturated by circulating the electrolyte through an intermediate chamber lined with sodium chloride or potassium chloride and where the intermediate chamber can be opened to fill the reservoir with granular sodium chloride or granular potassium chloride and whereas the intermediate chamber is an external brine reservoir and not part of the cylindrical electrolysis cell.

17. The method of claim 15, whereas the electrolyte is saturated by circulating said electrolyte between the middle chamber and the brine reservoir using a variable speed peristaltic pump and where said pump being in communication with the reservoir through a main feed line made from a flexible and resilient material and to the middle chamber.

18. The method of claim 15, whereas the intermediate chamber is pressurized with softened water and whereas the electrolyte in intermediate chamber can be drained by opening a valve.

19. The method of claim 1, wherein the method further comprises, isolating an alkaline cleaning liquid having a negative redox potential ranging from 600 to 1200 mV, a pH ranging from 9-12 and 10-100 ppm of OH⁺.

20. The method of claim 1, wherein the method further comprises, isolating an acidic sanitizing solution having a positive redox potential ranging from 600 to 1200 mV, a pH ranging from 2-5 and 10-100 ppm of HOCl⁻.

21. The method of claim 1, wherein a portion of the liquid exiting the cathode chamber is fed into the anode chamber and another portion collected in a storage tank or drained.

22. The method of claim 1, wherein a part of a diluted Sodium Hydroxide solution NaOH is fed successively through the anode chamber to produce a more neutral pH Hypochlorous Acid solution HOCl.

23. The method of claim 1, wherein softened water is supplied to both the anode chamber and cathode chamber at a lower end piece of the electrolysis cell and cleaning solutions NaOH and usable non residue forming sanitizing solutions HOCl are obtained from an upper end piece of the cell.

24. The method of claim 1, wherein the cathode chamber comprises an inlet fitting connected to a tube that passes tangentially through a specific section of the lower end piece to communicate with the cathode chamber through an aperture and wherein the anode chamber comprises an inlet fitting connected to a tube that passes tangentially through a specific section of the lower end piece to communicate with the anode chamber through an aperture.

25. The method of claim 22, wherein a specific section of the lower end piece comprises an inlet fitting connected to a pipe that passes through the specific section of the lower end piece to communicate with the middle chamber through an aperture.

26. The method of claim 1, wherein the cathode chamber comprises an outlet fitting connected to a tube that passes tangentially through a specific section of

the upper end piece to communicate with the cathode chamber through an aperture and wherein the anode chamber comprises an outlet fitting connected to a tube that passes tangentially through a specific section of the upper end piece to communicate with the cathode chamber through an aperture.

27. The method of claim 25, wherein a specific section of the upper end piece comprises an outlet fitting connected to a pipe that passes through a specific section of the upper end piece to communicate with the middle chamber through an aperture.

28. The method of claim 1, wherein said ports address said spaces through said end pieces or through said electrode tubes adjacent to the site of insertion of said electrode tubes into said end pieces.

29. The method of claim 1, wherein the electrolyte is circulated in the middle chamber and fed into the cathode chamber wherein softened water in the cathode chamber is enriched with OH^+ ions giving the softened water a high pH and cleaning properties and said electrolyte is rejected by the cation ion-selective membrane; and softened water is fed into the anode chamber wherein softened water in the anode chamber is enriched with Cl^- ions giving the softened water a low pH and sanitizing properties and the electrolyte is rejected by said anion ion-selective membrane rejects; whereby the generated cleaning and sanitizing solutions will not create salt residues on surfaces.

30. A method of making electrolyzed liquids using an electrolysis cell comprising a cylindrical ion-exchange membrane having a cation or anion material made of either polymer or a perfluorinated impregnated cloth

or reinforcing media of some kind; or an extruded or otherwise processed polymer, combined with suitable molded or otherwise fabricated attachment mechanisms, constructed and arranged to operate in conjunction with a suitable shell in a cylindrical electrolysis cell having an anode chamber, a cathode chamber, said anode chamber and said cathode chamber are separated from each other by at least one ion-exchange membranes constructed and arranged for generating a diluted Hypochlorous Acid sanitizing solution with a pH between 4.5 and 7.5, an ORP of +800 to +1200mV and a free available chlorine content between 10 to 1000ppm, said ion-exchange membranes simultaneously generate a dilute Sodium Hydroxide (NaOH) cleaning solution with a pH between 9.5 and 12.5 and an ORP of -500 to -1000mV.

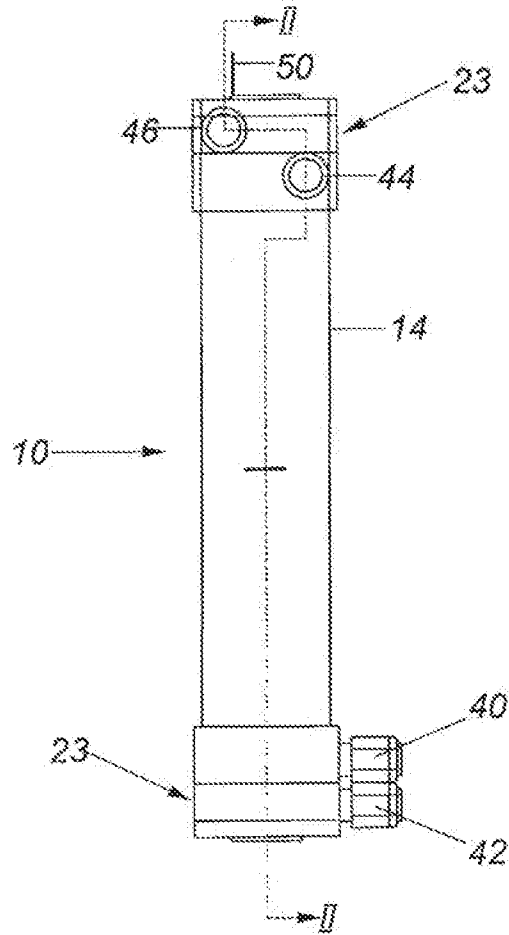


FIG. 1
(PRIOR ART)

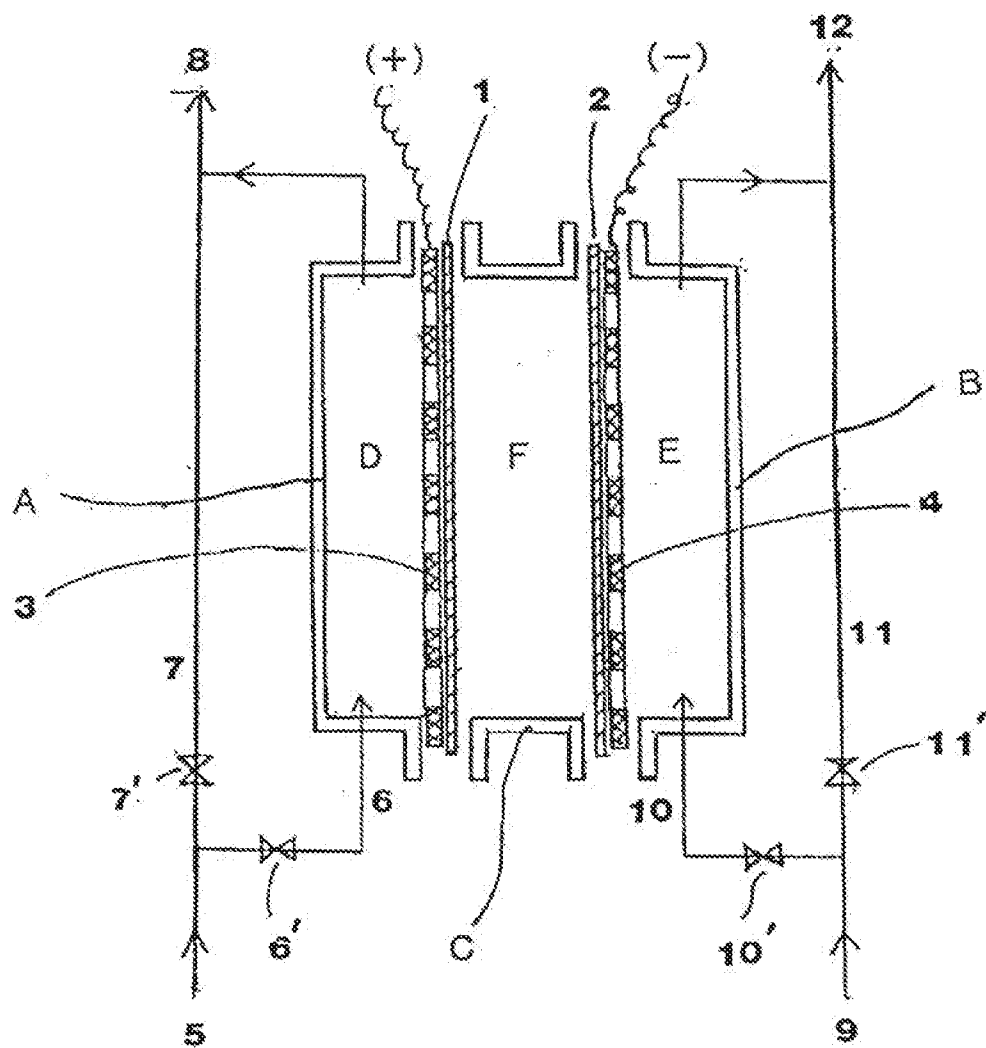


FIG. 2
(PRIOR ART)

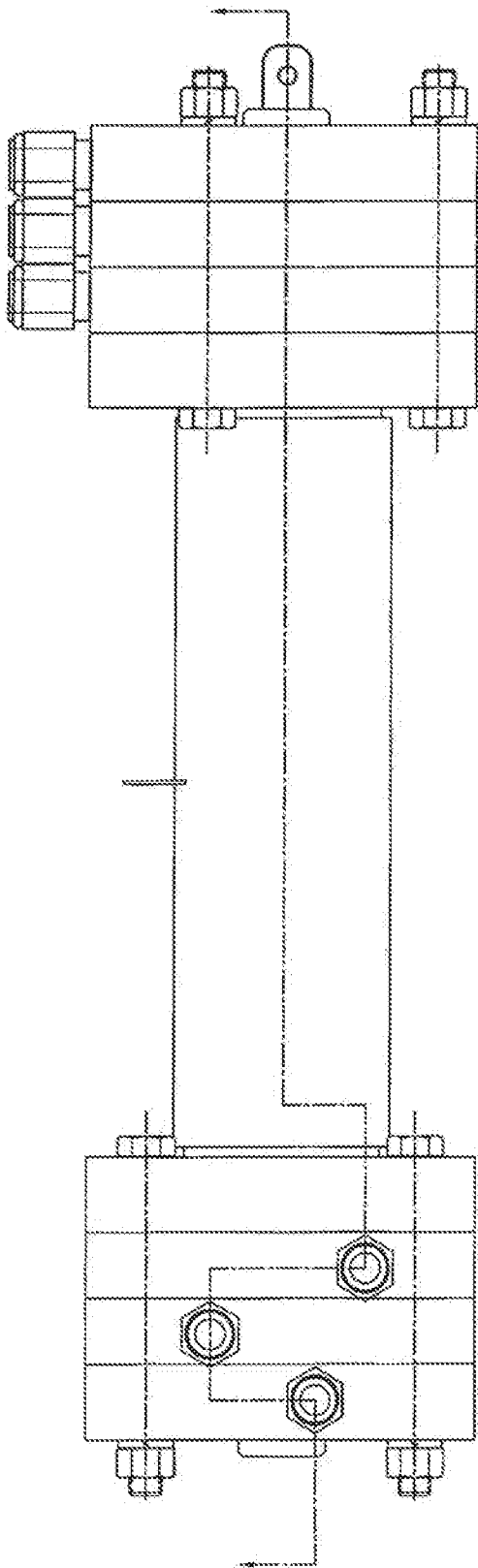


FIG. 3

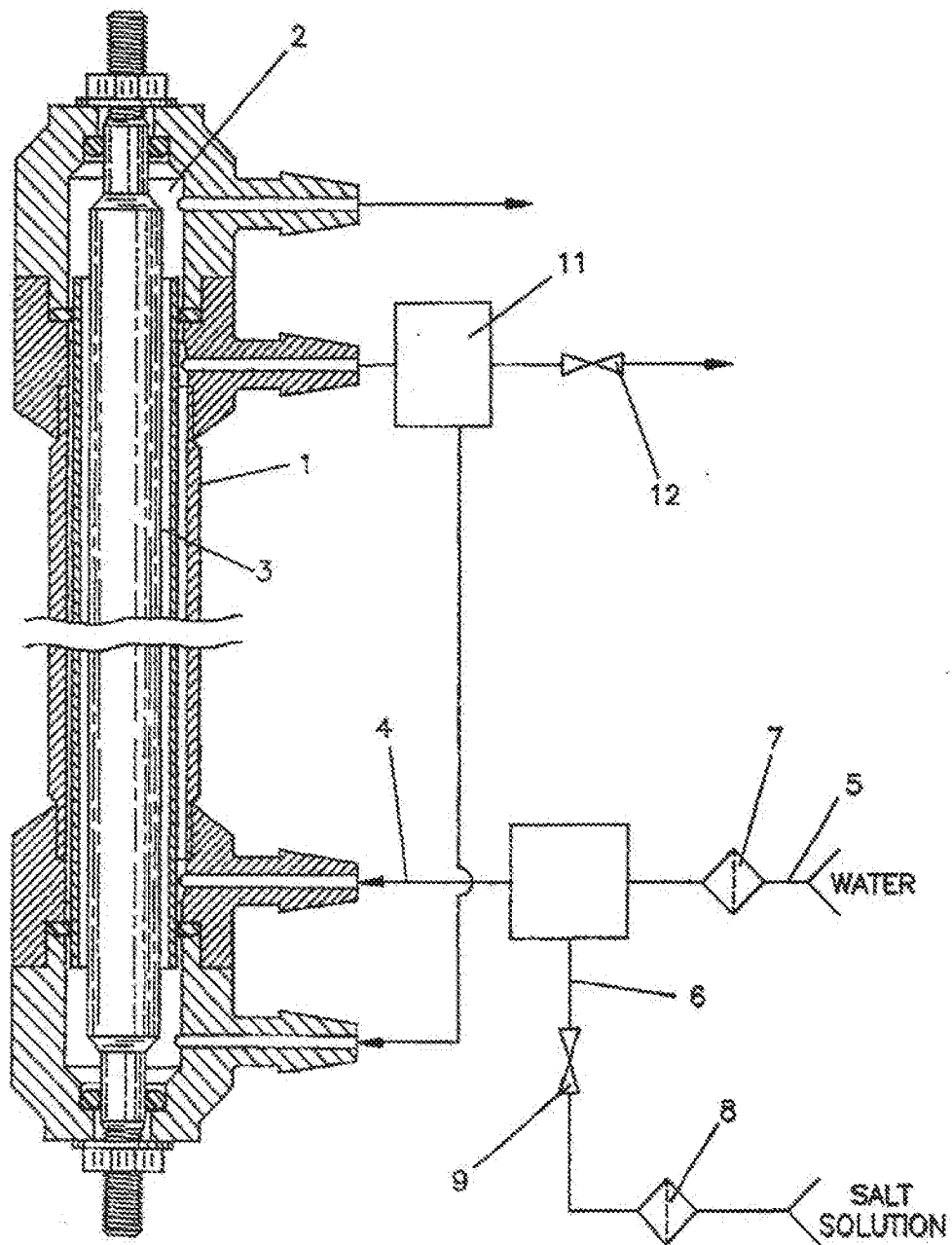


FIG. 4
(PRIOR ART)

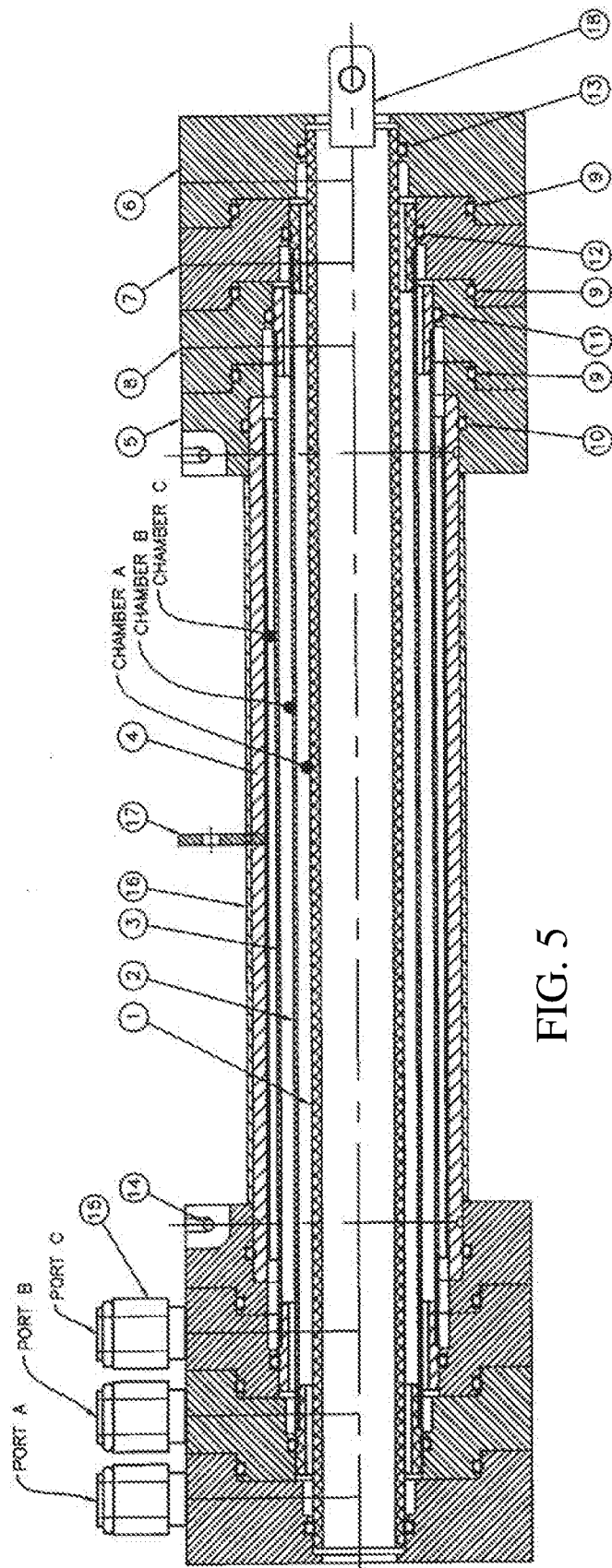


FIG. 5

ITEM	DESCRIPTION	ITEM	DESCRIPTION
10	O-RING	20	-
9	O-RING	19	-
8	CAP -- PORT C	18	CONNECTOR -- CATHODE
7	CAP -- PORT B	17	CONNECTOR -- ANODE
6	CAP -- PORT A	16	RUBBER SLEEVE
5	CAP -- ANODE	15	1/4" NPT MALE QUICK CONNECT FITTING
4	ANODE -- OUTER ELECTRO	14	WIRE CLIP
3	OUTER DIAPHRAGM	13	O-RING
2	INNER DIAPHRAGM	12	O-RING
1	CATHODE -- INNER ELECTRO	11	O-RING

- ① ALL COATING REMOVAL, SURFACE PREPARATION, TI-FACING AND/OR COATING PROCEDURES TO BE DONE ON SURFACES INDICATED AS ACTIVE.
- ② DO NO SCRATCH SURFACES TO BE COATED DURING WELDING, MACHINING OR HANDLING.
- ③ COAT I.D. MACHINED O.D. ENDS, AND TUBE END FACES PER MMO COATING 5-8 MICRONS THICK.

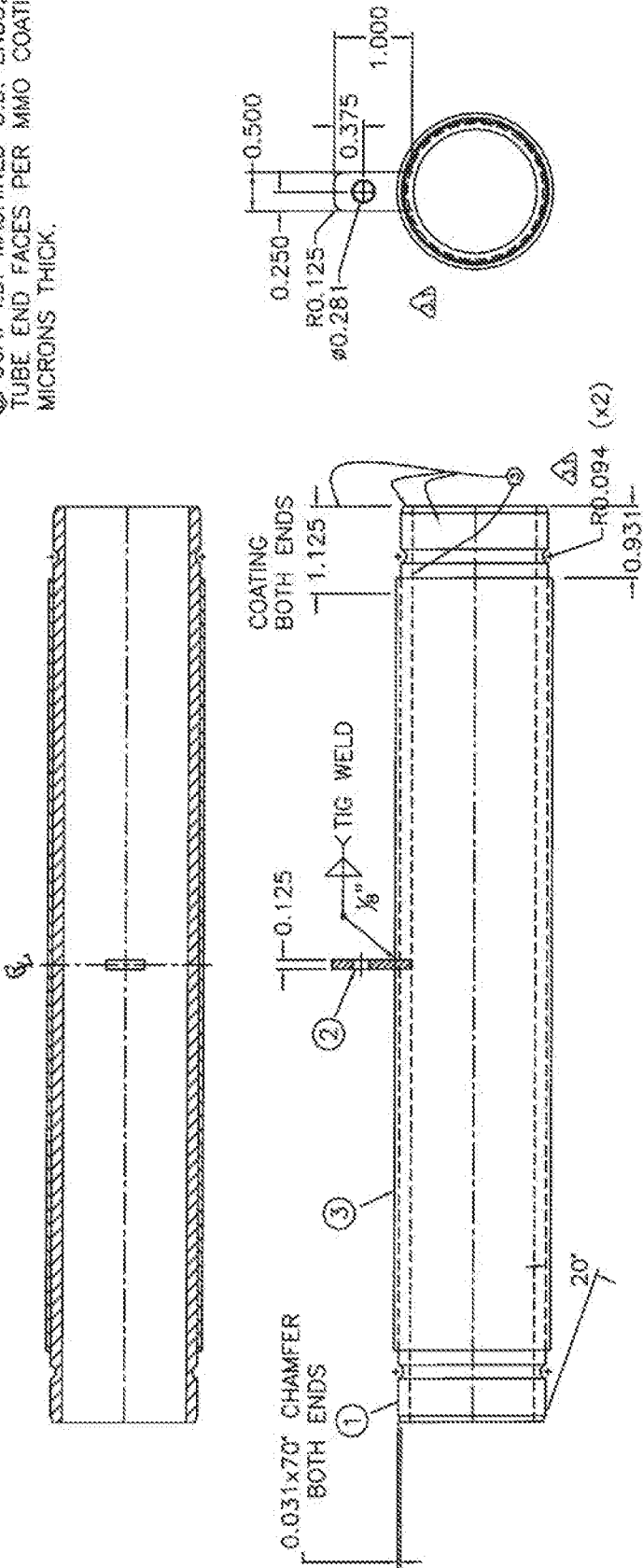


FIG. 6a

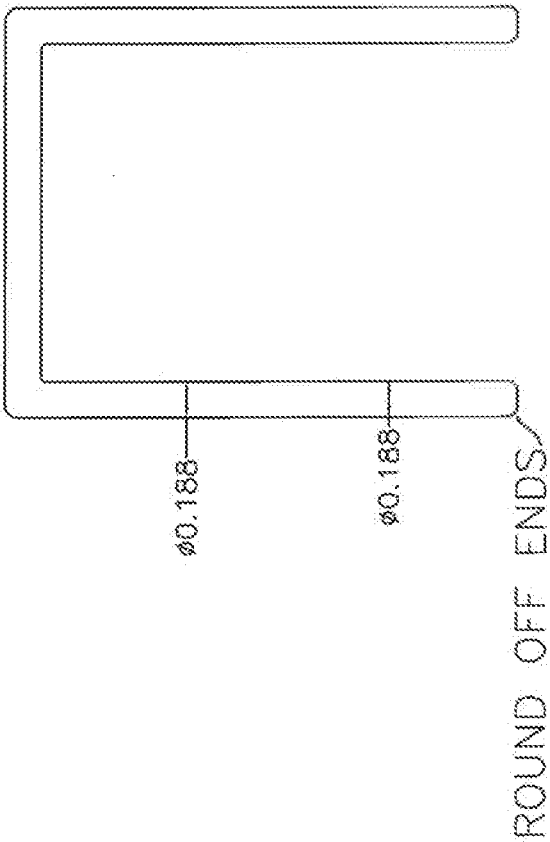


FIG 6b

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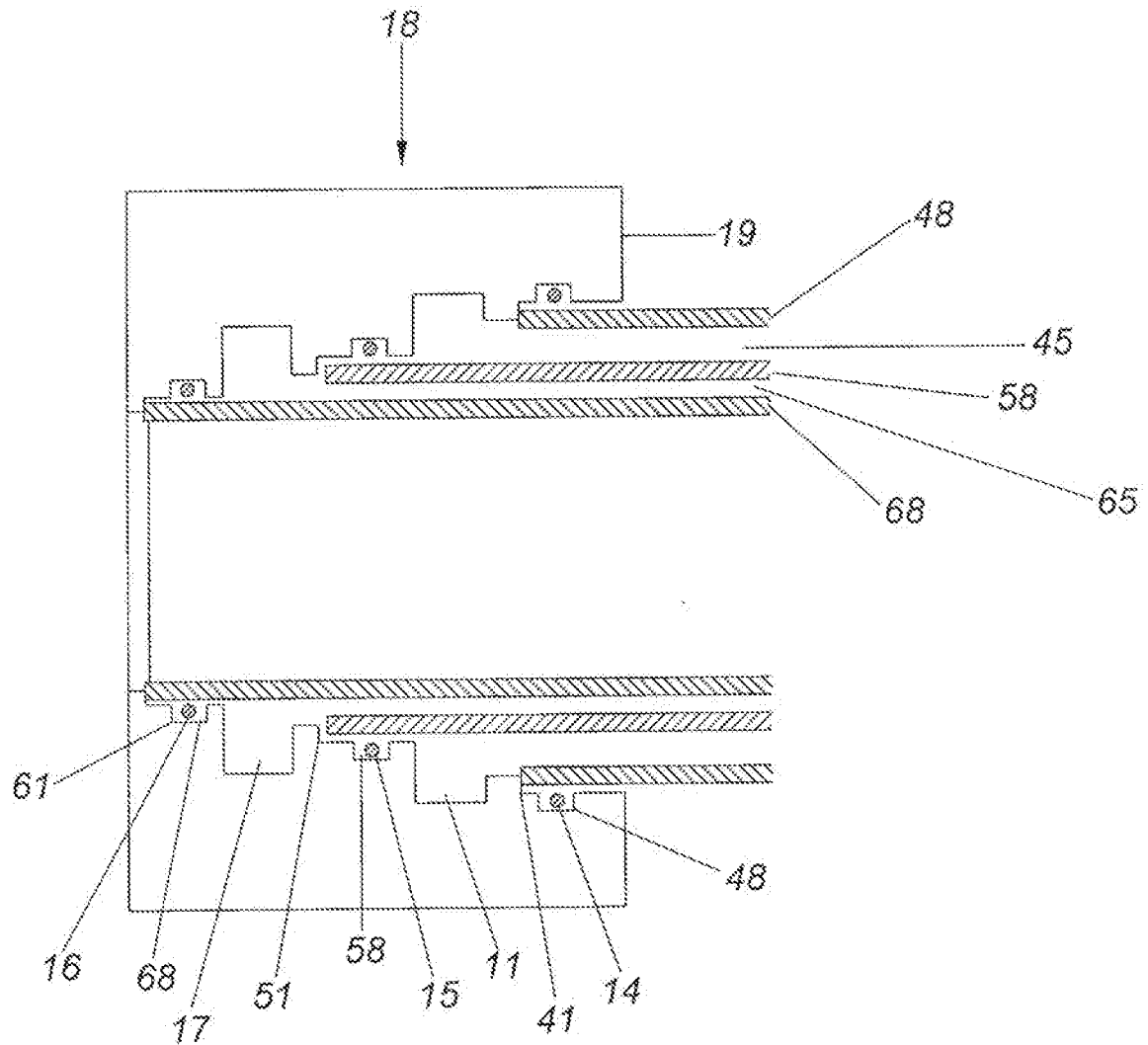


FIG. 7
(PRIOR ART)

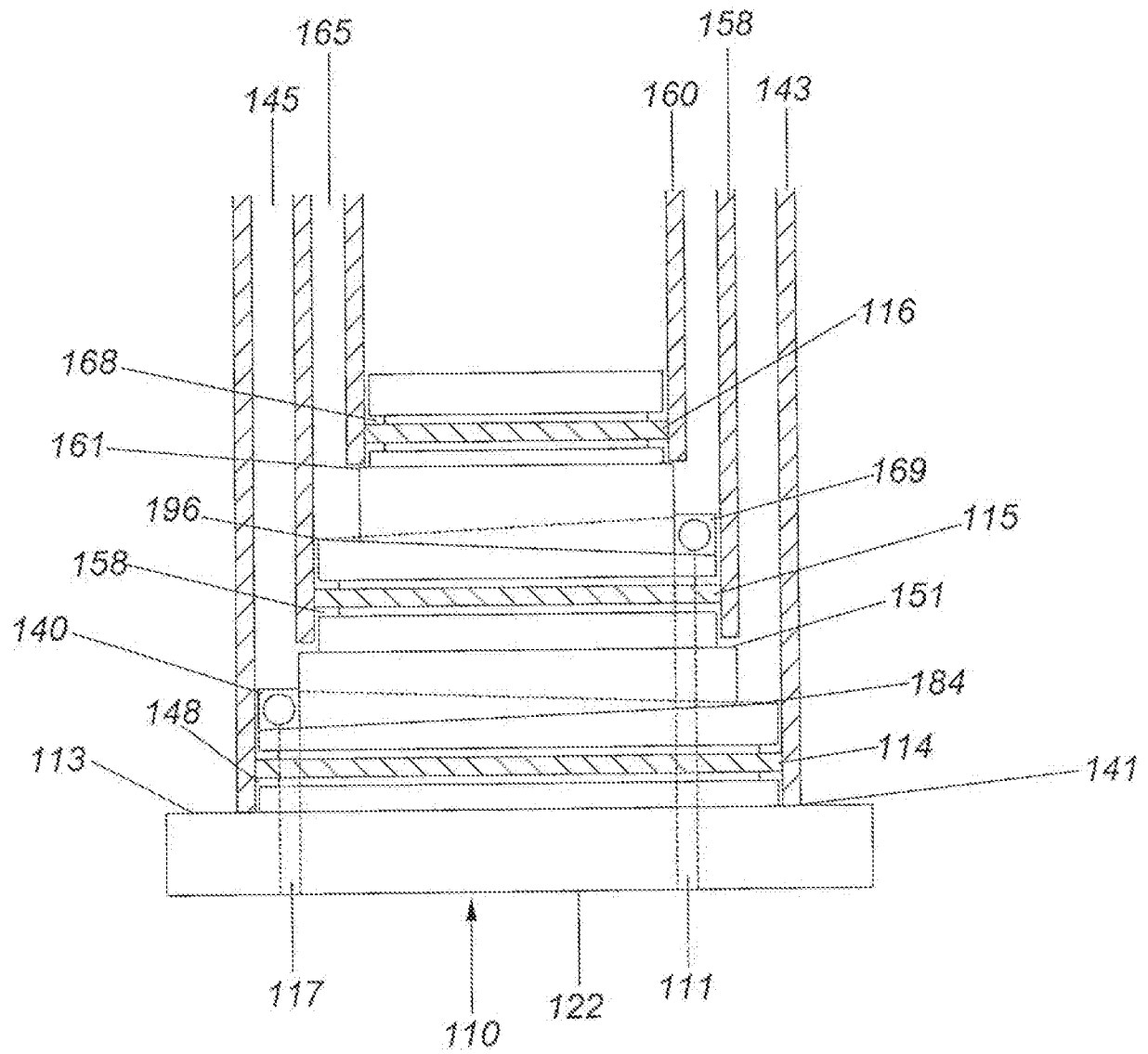


FIG. 8
(PRIOR ART)

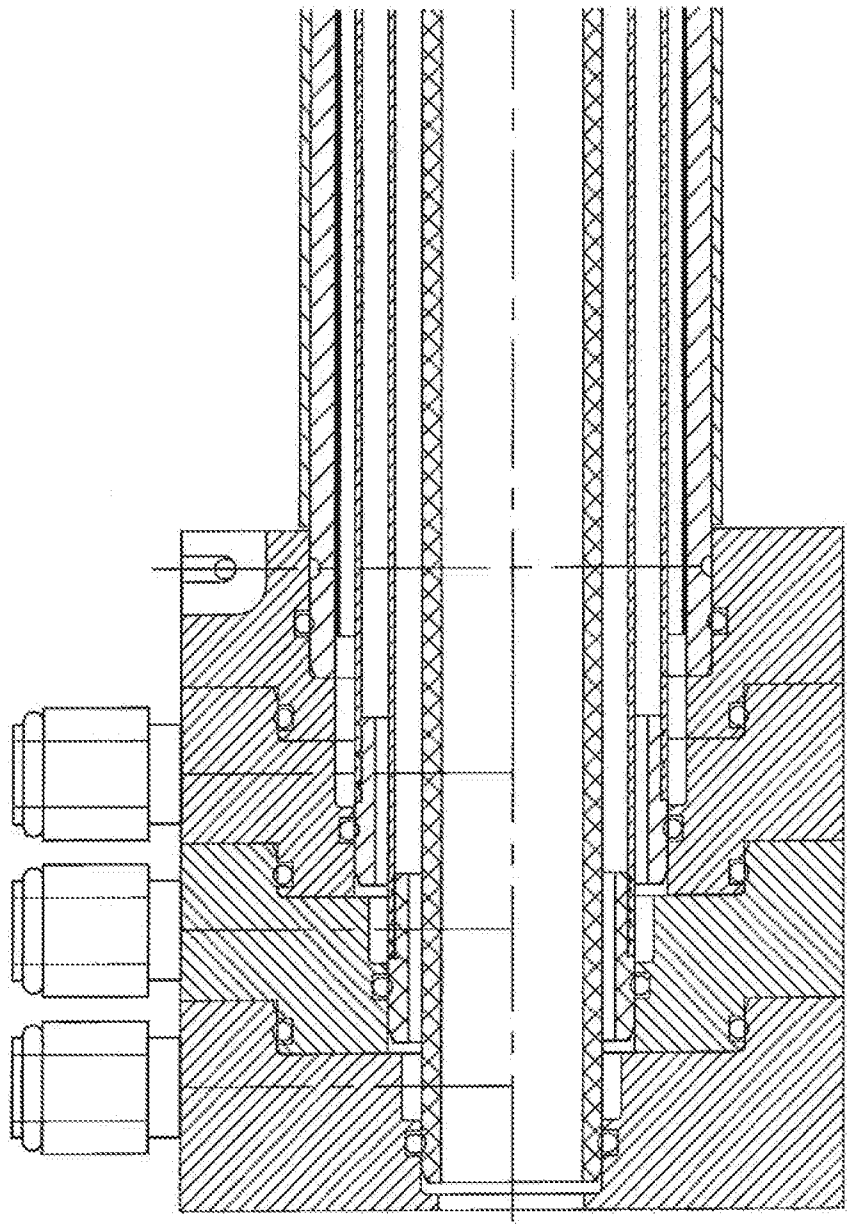


FIGURE 9

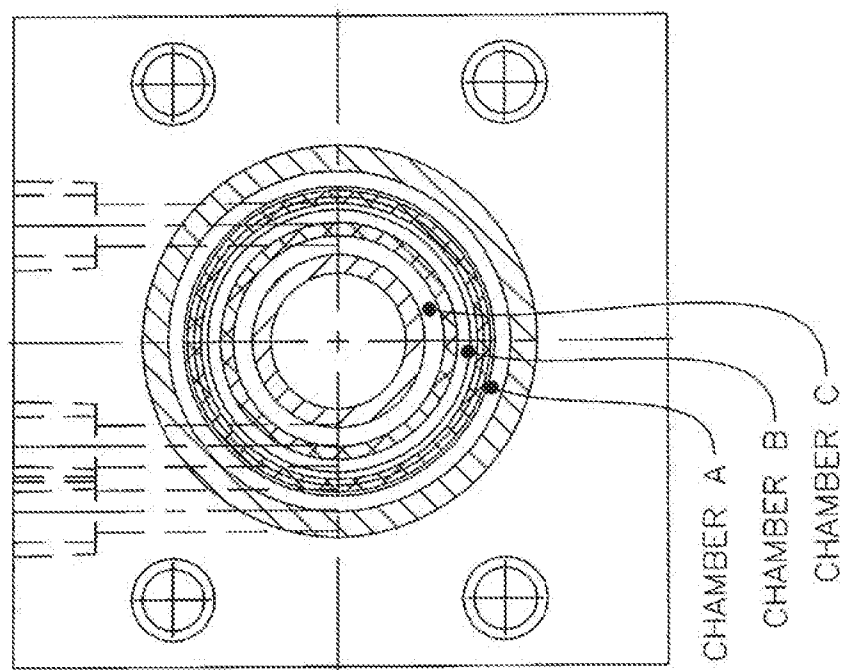


FIGURE 10

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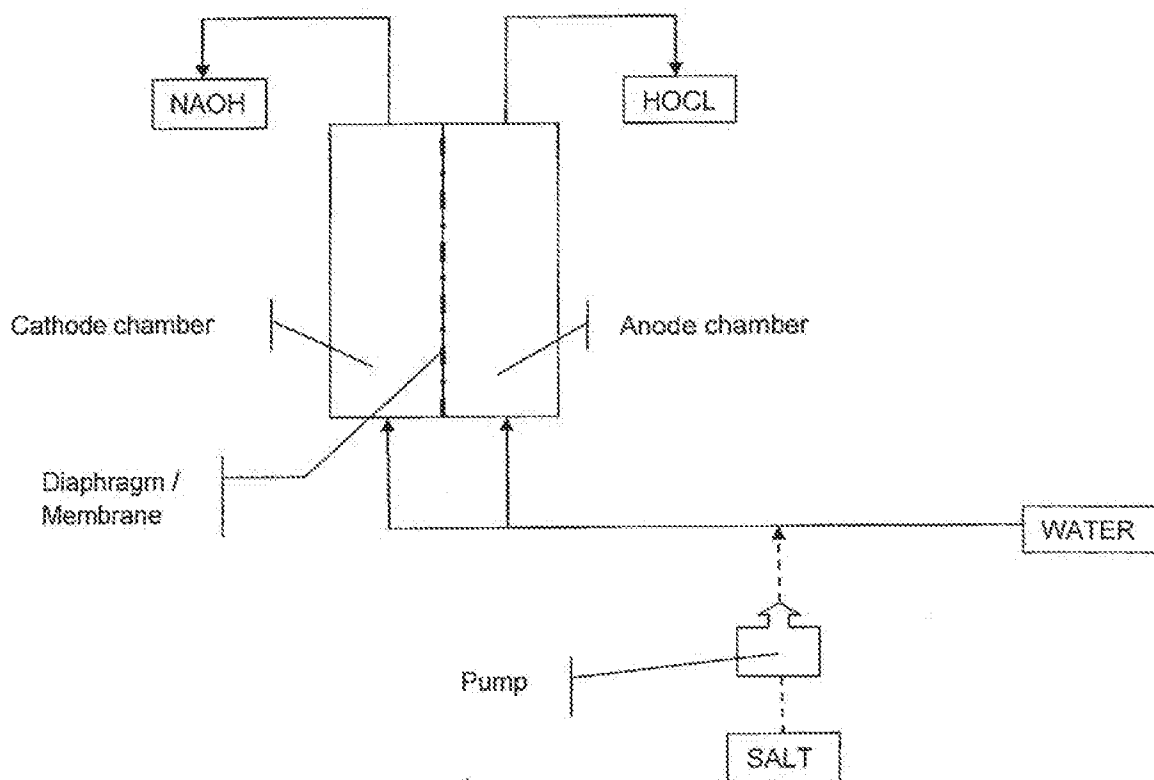


FIG. 11
(PRIOR ART)

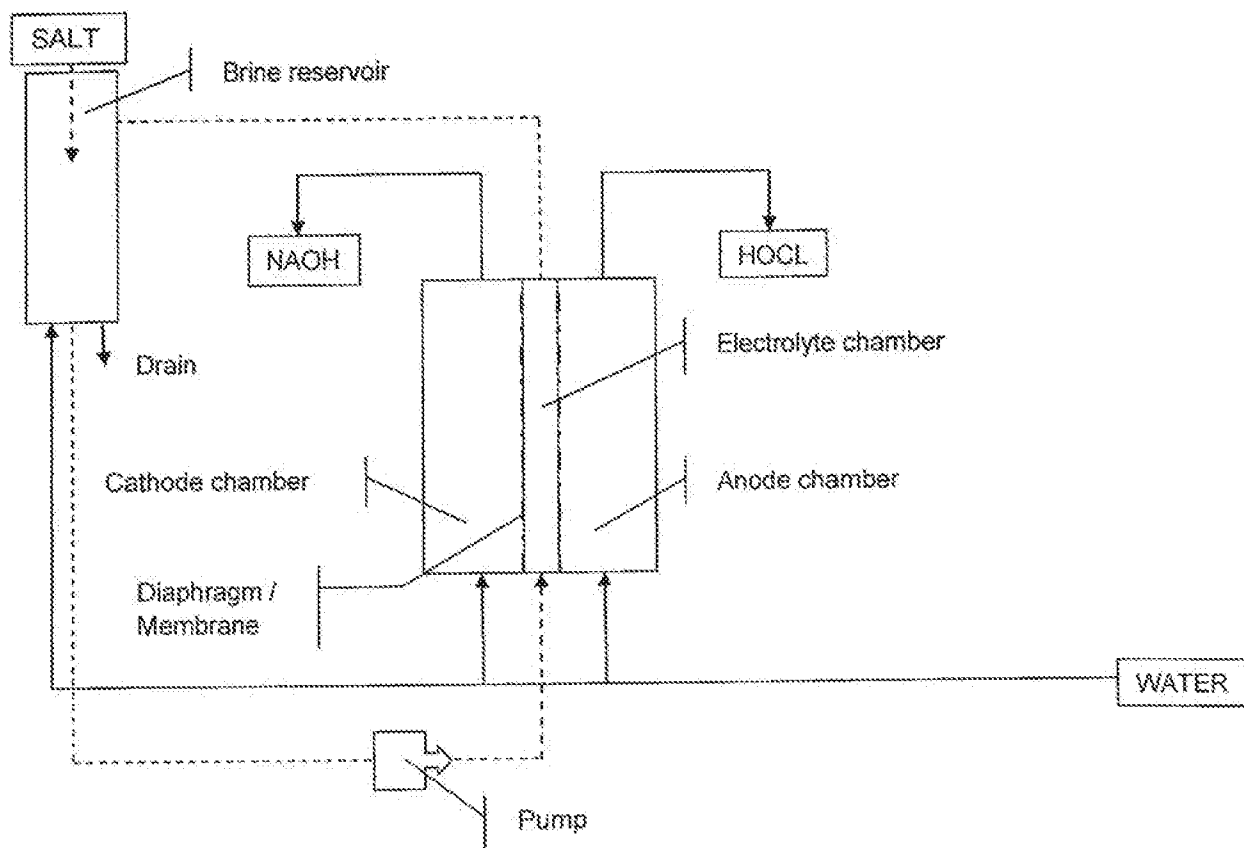


FIG. 12

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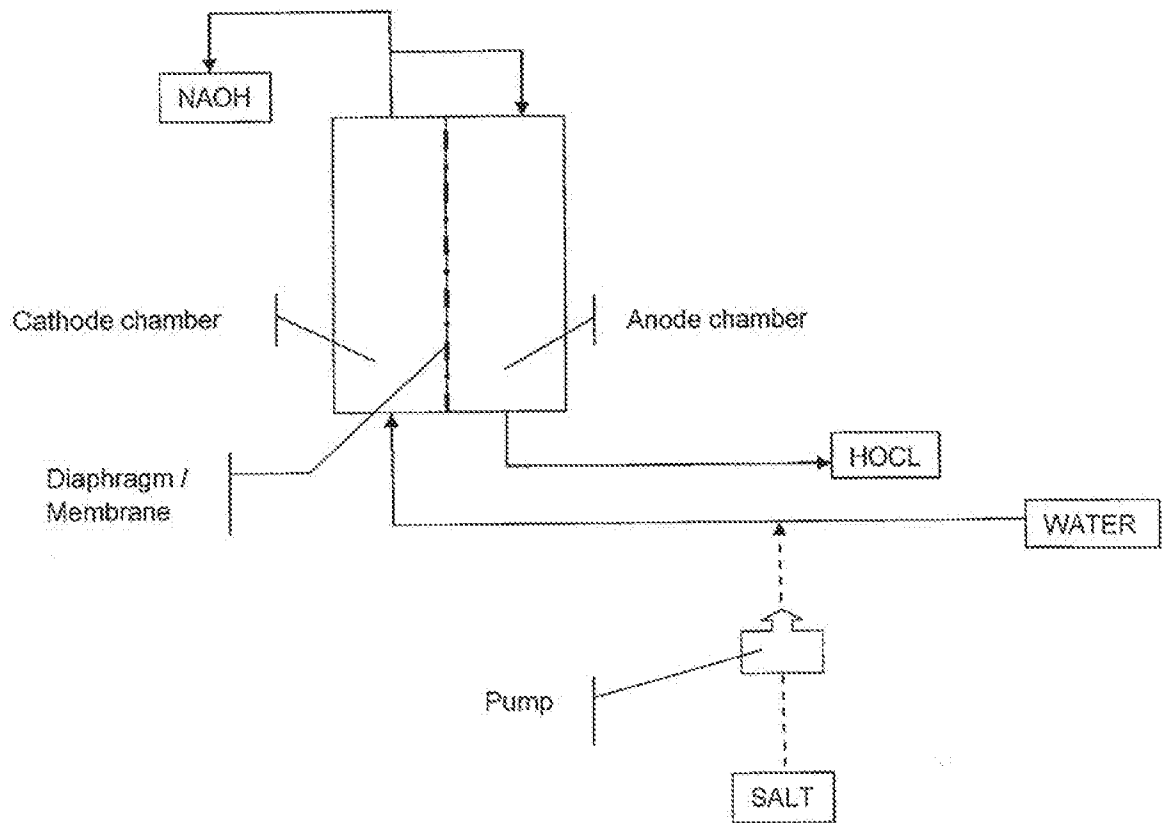


FIG. 13
(PRIOR ART)

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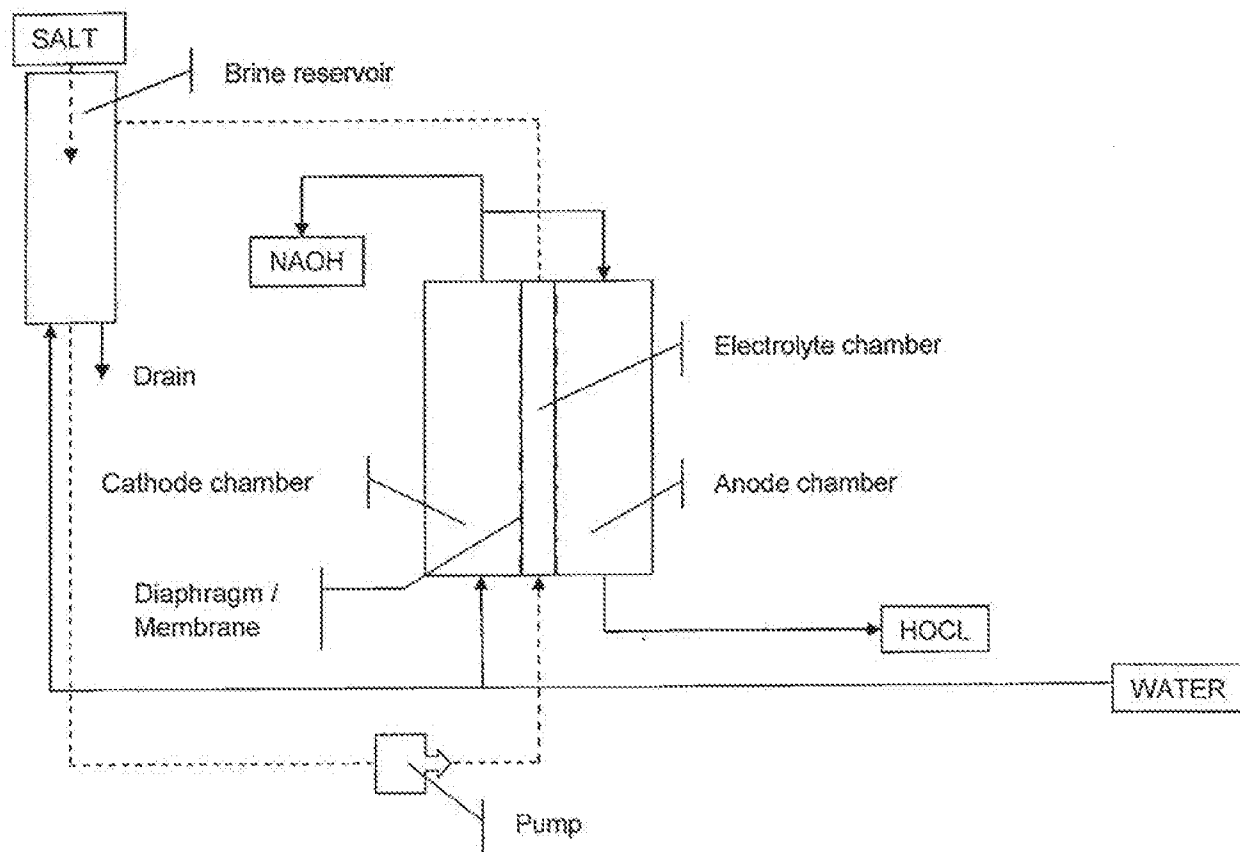


FIG. 14

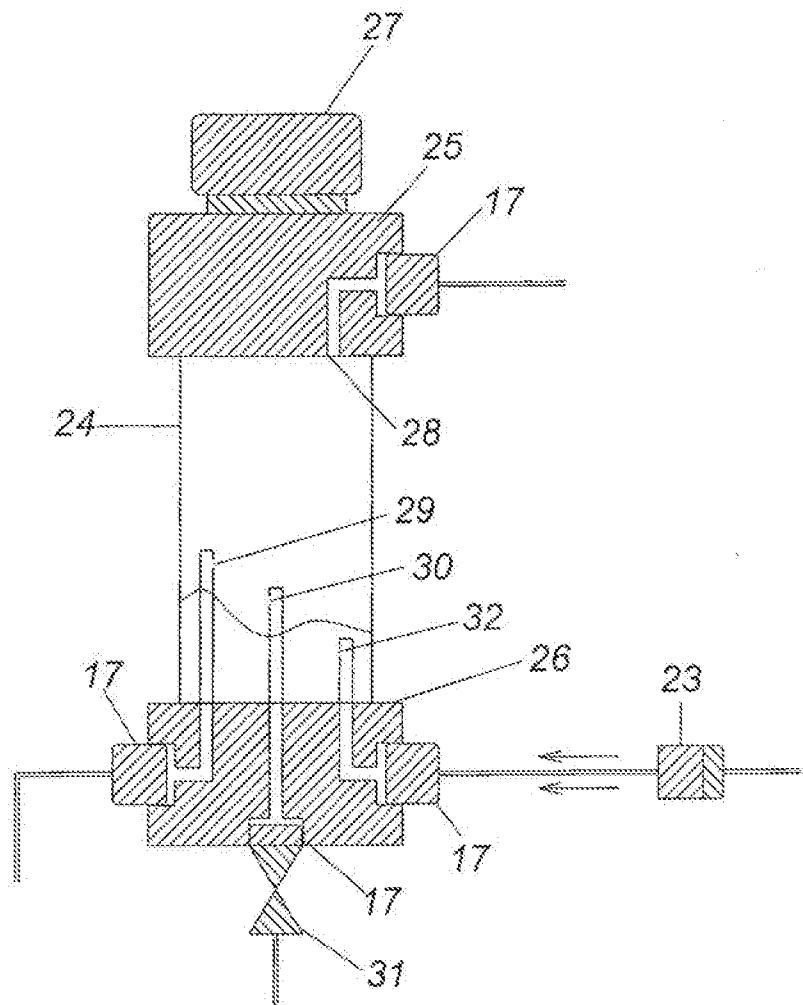


FIG. 15

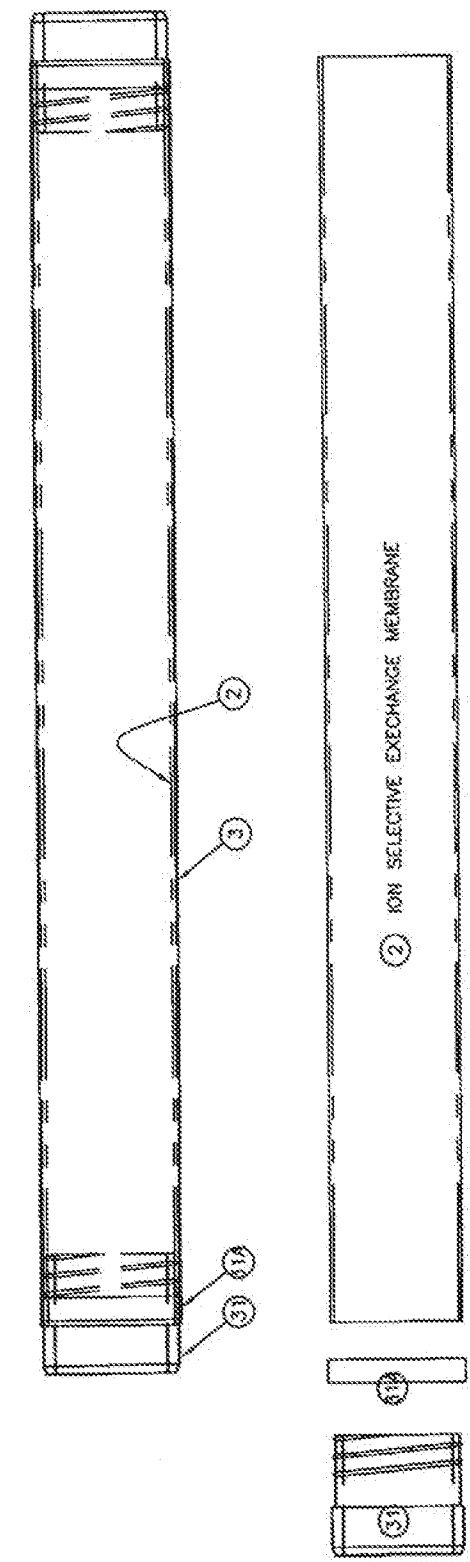


FIG. 16A

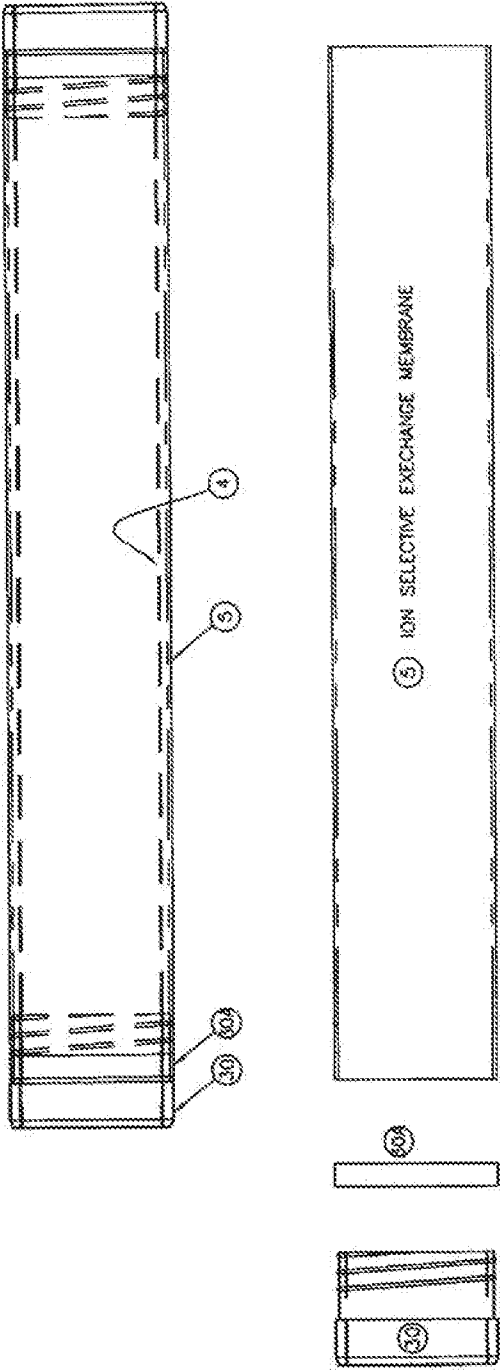


FIG. 16B

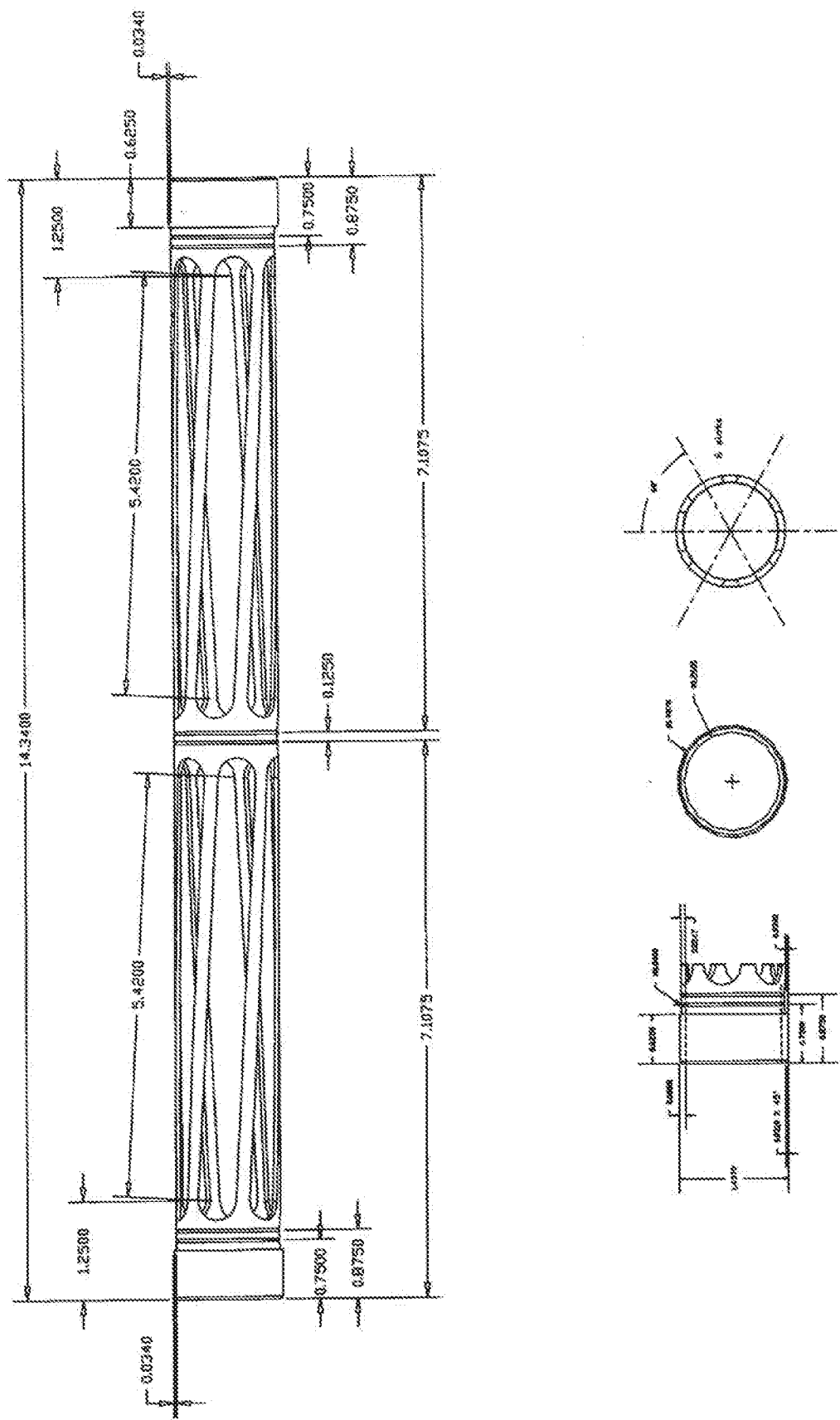


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/066794

A. CLASSIFICATION OF SUBJECT MATTER
INV. C02F1/461 C25B1/26 C25B9/08
ADD.

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 C25B

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/146473 A1 (LAMBERT RALPH A [US] ET AL) 13 June 2013 (2013-06-13) paragraph [0067]; claims; figure 4 -----	1-30
Y	US 6 527 940 B1 (SHIMAMUNE TAKAYUKI [JP] ET AL) 4 March 2003 (2003-03-04) claims; examples -----	1-30
Y	US 2013/146472 A1 (LAMBERT R A; SULLIVAN J B; VAN SCHAIK M) 13 June 2013 (2013-06-13) the whole document -----	1-30
Y	US 7 691 249 B2 (DALY JAMES [GB] ET AL) 6 April 2010 (2010-04-06) cited in the application claims; figures ----- -/--	1-30



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

3 March 2016

Date of mailing of the international search report

14/03/2016

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Authorized officer

Kurtulan Dogan, M

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2015/066794

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Information on patent family members

International application No

PCT/US2015/066794

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