Keywords:

Startup projects: Scientific and technical support; Power management;

Book in 2 parts

Part 1 - Field of the invention. The present invention generally relates to the field of electrochemical water purification systems. More specifically, the invention relates to power control for 10 electrically driven water purification apparatuses.

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POWER CONTROL FOR AN ELECTRICALLY POWERED WATER TREATMENT APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to the field of electrochemical water treatment system. More specifically, the invention relates ot a power control for an electrically powered water treatment apparatus.

Description of Related Art

Electrochemical treatment of water was practiced in the early 1900's, see, e.g., Hinkson, U.S. Pat. No. 820,113 (1906). However, this technology fell into disuse, and in recent texts the only electrical water purification apparatus mentioned is electrodialysis equipment involving membranes, primarily for desalination applications. See, e.g., Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse (McGraw Hill 2003), at 1131-34. The present invention reflects the inventor's work in using modern tools, methods and scientific knowledge to advance the state of the art in this field.

SUMMARY OF THE INVENTION

The invention provides a complete electrochemical water purification system. The complete configuration of this system, including alternative embodiments, is described at length.

One embodiment of this system includes apower control for an electrically powered water treatment apparatus having electrode cells. The power control comprises:

a master power supply unit having a control input;

aslave power supply unit having acontrol input;

a current sensor adapted ot measure the electrical current flowing through the cells of the water treatment apparatus;

a voltage sensor adapted to measure the voltage applied to the cells of the water treatment apparatus;

a PLC having inputs from said current sensor and said voltage sensor and outputs for said master and slave power supply units; and

wherein, said PLC is programmed so as to be able to maximize the electrical power applied ot hte cells

without overheating.

Other aspects and advantages of the present invention wil be apparent from reading the detailed description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic representation of the motion of streams of impure water and their synchronization.

Fig. 2 si a schematic cross-section view of a W2W electrochemical reactor body of the present invention.

Fig. 2' si aslight revision of Fig. 2.

Fig. 3 is a perspective schematic sectional view of a W2W electrochemical reactor body of the present invention.

Fig. 3' si a slight revision of Fig. .3

Fig. 4 is a perspective view of a W2W electrochemical reactor with two electrode cell cassettes and the associated electrodes.

Fig. 8 is a general scheme of one embodiment of a W2W system of the present invention.

Fig. 9 is a schematic cross-section view of one embodiment of a W2W electrochemical reactor of the present invention.

Fig. 10 shows an electrode cell cassette and its associated pair of oppositely charged electrodes of the present invention in three different views.

Fig. 1 is aperspective view of two electrode cell cassettes and their associated pair of oppositely charged electrodes of the present invention.

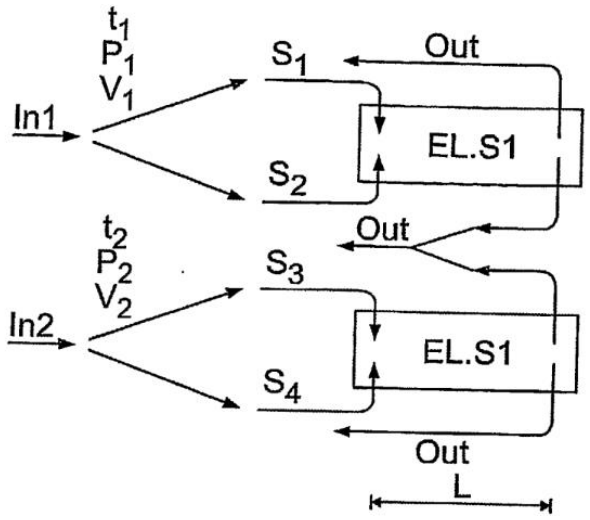
Fig. 5 is an exploded view of one embodiment of electrode cell cassette and the associate electrodes of hte present invention.

Fig. 6 shows the self-sealing construction of electrode cells of hte present invention in two cross-section views.

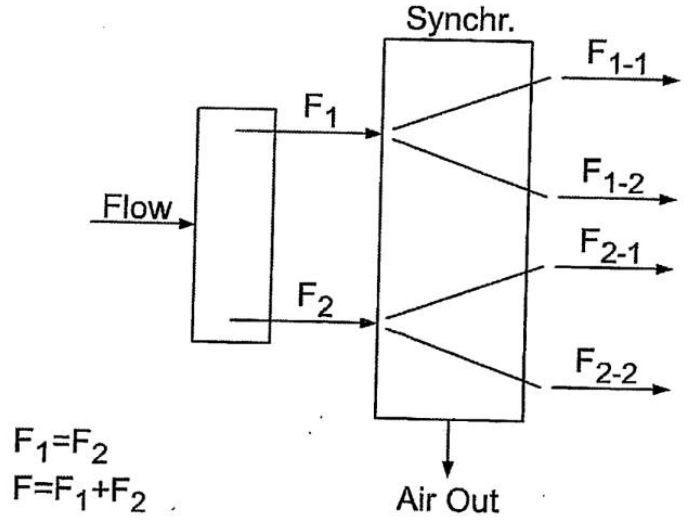
Fig. 7is abasic water flow chart of aW2W system.

Fig. 8 is a general scheme of one embodiment of a W2W system of the present invention.

Fig. 9 is a schematic cross-section view of one embodiment of a W2W electrochemical reactor of the present invention.



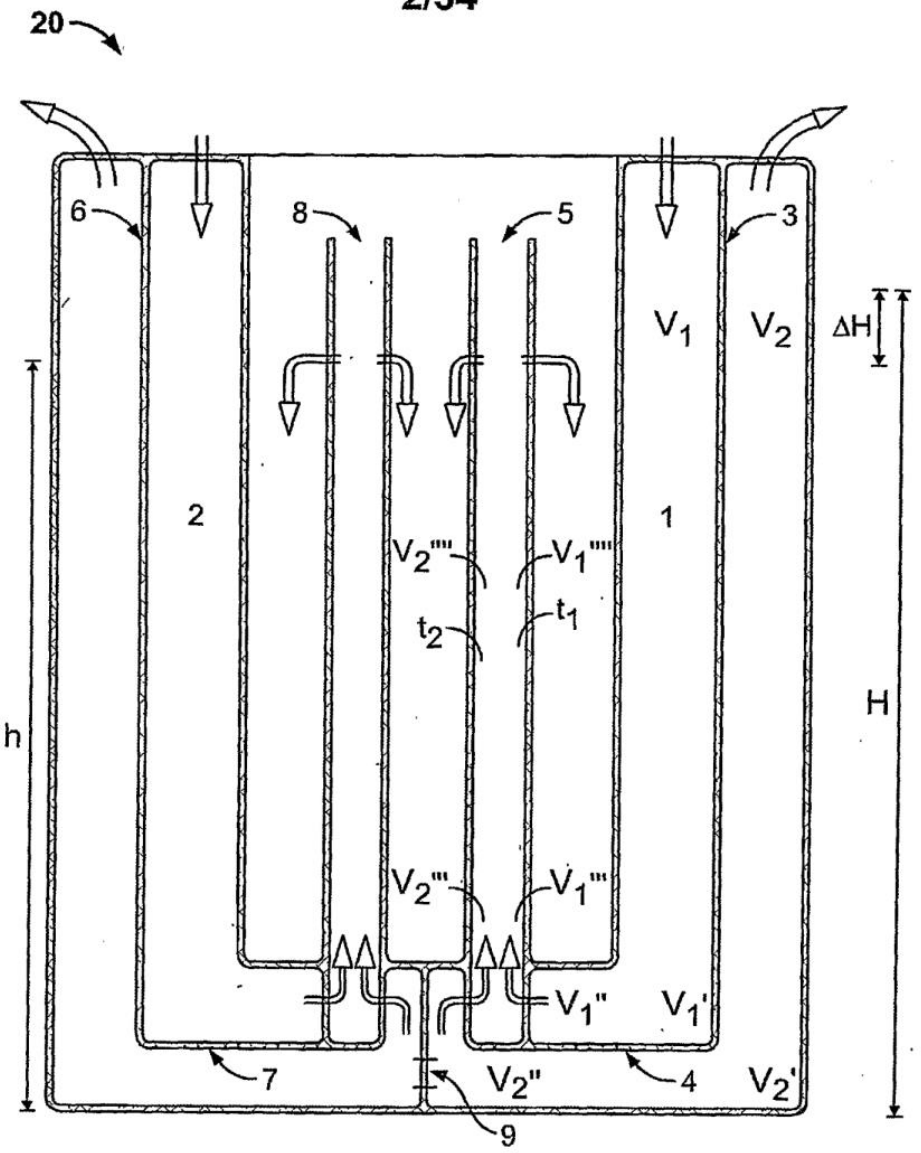
L/V=T(Const) for S_1; S_2; S_3; S_4
In Sells S -S Time-Cost. for All Streams



$F_1=F_2$
$F=F_1+F_2$

$F_{1-1}=F_{1-2}=F_{2-1}=F_{2-2}=F/4$

FIG. 1



$H-h=\Delta H_1$
$H_1-h=\Delta H_2$
$\Delta H_1=\Delta H_2$
$V_1=V_2$
$t_1=t_2$

FIG. 2

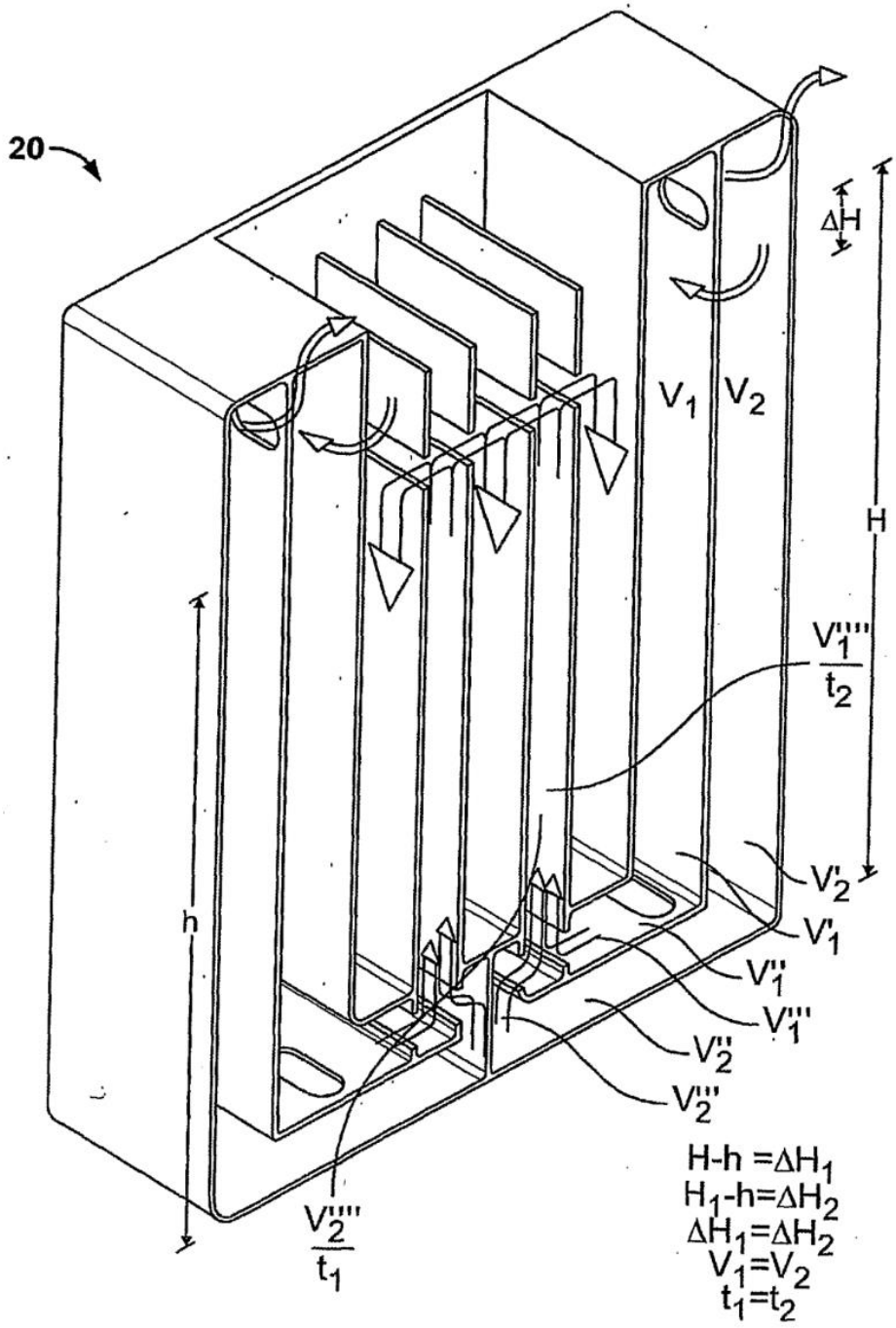


FIG. 3

SUBSTITUTE SHEET (RULE 26)

Table 1: Results of Comparative Tests of Various Cassettes

Source	Connec-tion	Cassette type	Water through-put	Cur-rent	Vol-tage	Power	pH			Conduc-tivity			Cu mg/l			Date
A/V			l/h	A	V	kW	In-put	An-ode	Ca-thode	Input	An-ode	Ca-thode	Input	An-ode	Ca-thode	
50/50	Parallel	Anode Al Cathode Al No Mem-brane	2000	96	25	2.496	8.5	8.5	9	1380	1470	1340	75 - 37.6	25 - 2	37.5 - 12.5	4.02
30/100	Parallel	Anode Al Cathode Al No Mem-brane	2000	56	24	1.344	9	8.5	9	1385	1390	1370	60 - 30	30 - 15	40 - 30	4.02
50/60	Parallel	Anode Steel Cathode Steel No Mem-brane	2000	96	24	2.304	8.5	8.5	9	1497	1510	1345	50 - 30	37.5 - 20	40 - 25	4.02
30/100	Parallel	Anode Steel Cathode Steel No Mem-brane	2000	56	14	0.784	8.5	8.5	9	1520	1540	1412	37.5 - 30	25 - 20	25 - 20	4.02
50/60	Parallel	Anode Ti Cathode Ti No Mem-brane	2000	96	29	2.784	9	9	9.5	1670	1725	1625	70 - 53	45 - 15	65 - 25	7.02
30/100	Parallel	Anode Ti Cathode Ti No Mem-brane	2000	56	21	1.176	9	9	9.5	1655	1566	1566	60 - 30	50 - 18	60 - 37.5	7.02

Fig. 10 shows an electrode cell cassette and its associated pair of oppositely
30
charged electrodes of the present invention in three different views.

Fig. 1 is aperspective view of two electrode cell cassettes and their associated pair of oppositely charged electrodes of the present invention.

Fig. 12 is another perspective view of two electrode cell cassettes and their
associated pair of oppositely charged electrodes of hte present invention. Fig. 13 is a schematic diagram showing how the water flows through
electrodes of the present invention.

Fig. 41 is a general scheme of one embodiment of a W2W system with
automatically controllable power supplies.

Fig. 51 is a schematic diagram of the automatically controllable power
supplies in Fig. 14.

Fig. 16 si a schematic diagram of power supplies connected ni series and their connections to a PLC.

Fig. 17 si another schematic diagram of power supplies connected ni series. Fig. 18 is a schematic diagram of power supplies connected ni parallel and
their connections to a PLC.

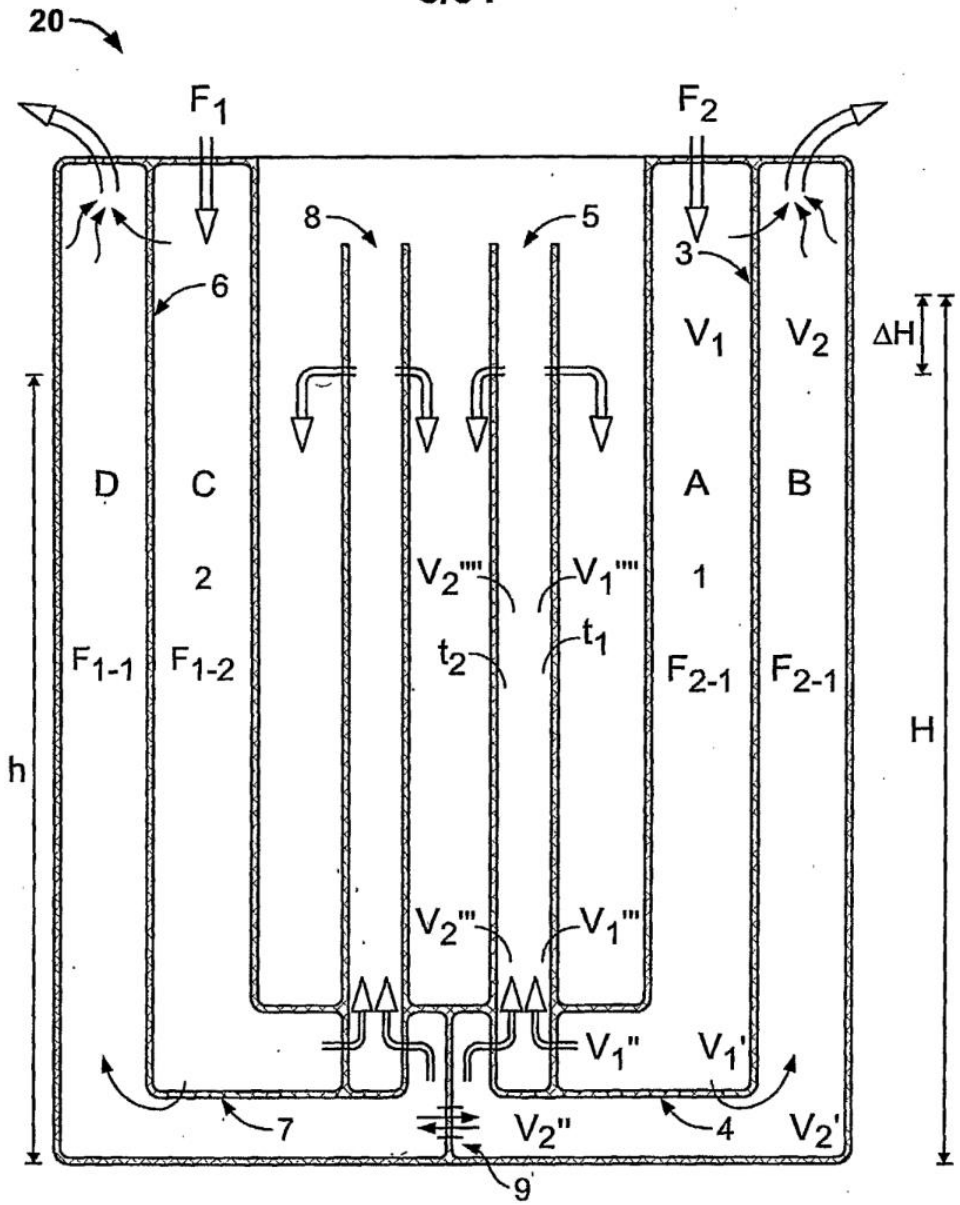
Fig. 19 is another schematic diagram of power supplies connected in parallel. Fig. 20 is a schematic diagram of power supplies connected in pseudo parallel
and their connections to a PLC.

Fig. 21 is a schematic diagram of a control board interface of the present
invention.

Fig. 2 is a schematic diagram of a W2W system of hte present invention. Fig. 23 is a schematic diagram of a W2W system with a water sampling plan,
ni which Arefers ot atapping point for inspection of water included ni the W2W system, Brefers ot a tapping point for inspection of water coming out of the reactor (katholyte), C refers to a tapping point for inspection of water coming out of the reactor (anolyte), and D refers ot a tapping point for inspection of water coming out of the W2W system.

Fig. 24 is aschematic diagram ofaW2W system with awater flow path indicated, ni which 1 refers to an electrochemical reactor, 2 refers to sedimentation containers, 3refers ot abuffer tank, and 4refers ot apreliminary tank.

Fig. 25 is a schematic diagram of a W2W system with another water sampling plan, in which Arefers to a tapping point for inspection of water included in the W2W system, B refers to a tapping point for inspection of water included in the reactor, Cl refers to a tapping point for inspection of water coming out of the reactor (katholyte), C2 refers to a tapping point for inspection of water coming out of the 3
filters in 50 micron and sedimentation containers, D1 refers to a tapping point for



$H-h=\Delta H_1$
$H_1-h=\Delta H_2$
$\Delta H_1=\Delta H_2$
$V_1=V_2$
$t_1=t_2$

FIG. 2'

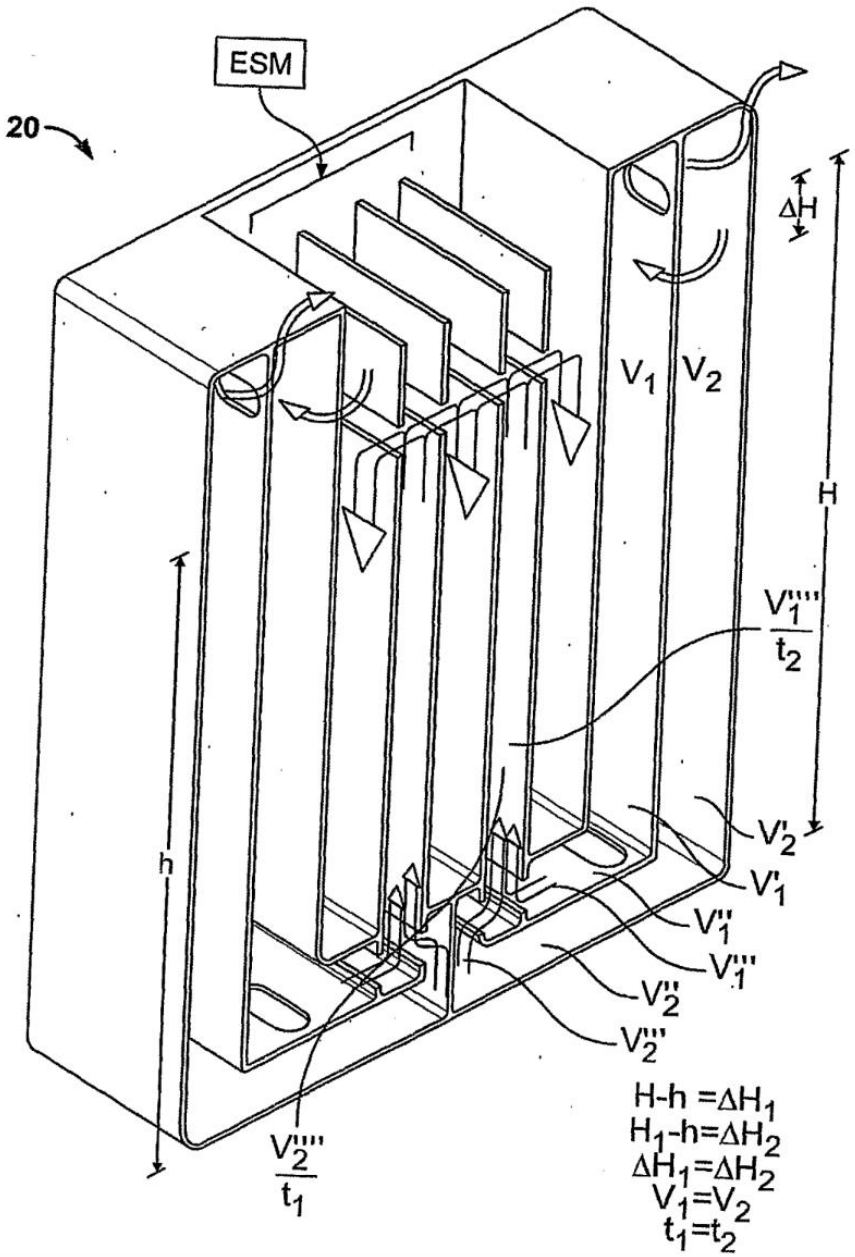

ESM
20
ΔH
H
h
V1
V2
V''''1/t2
V'2
V'1
V''1
V'''1
V''2
V''''2
V''''2/t1
H-h =ΔH1
H1-h=ΔH2
ΔH1=ΔH2
V1=V2
t1=t2

FIG. 3'

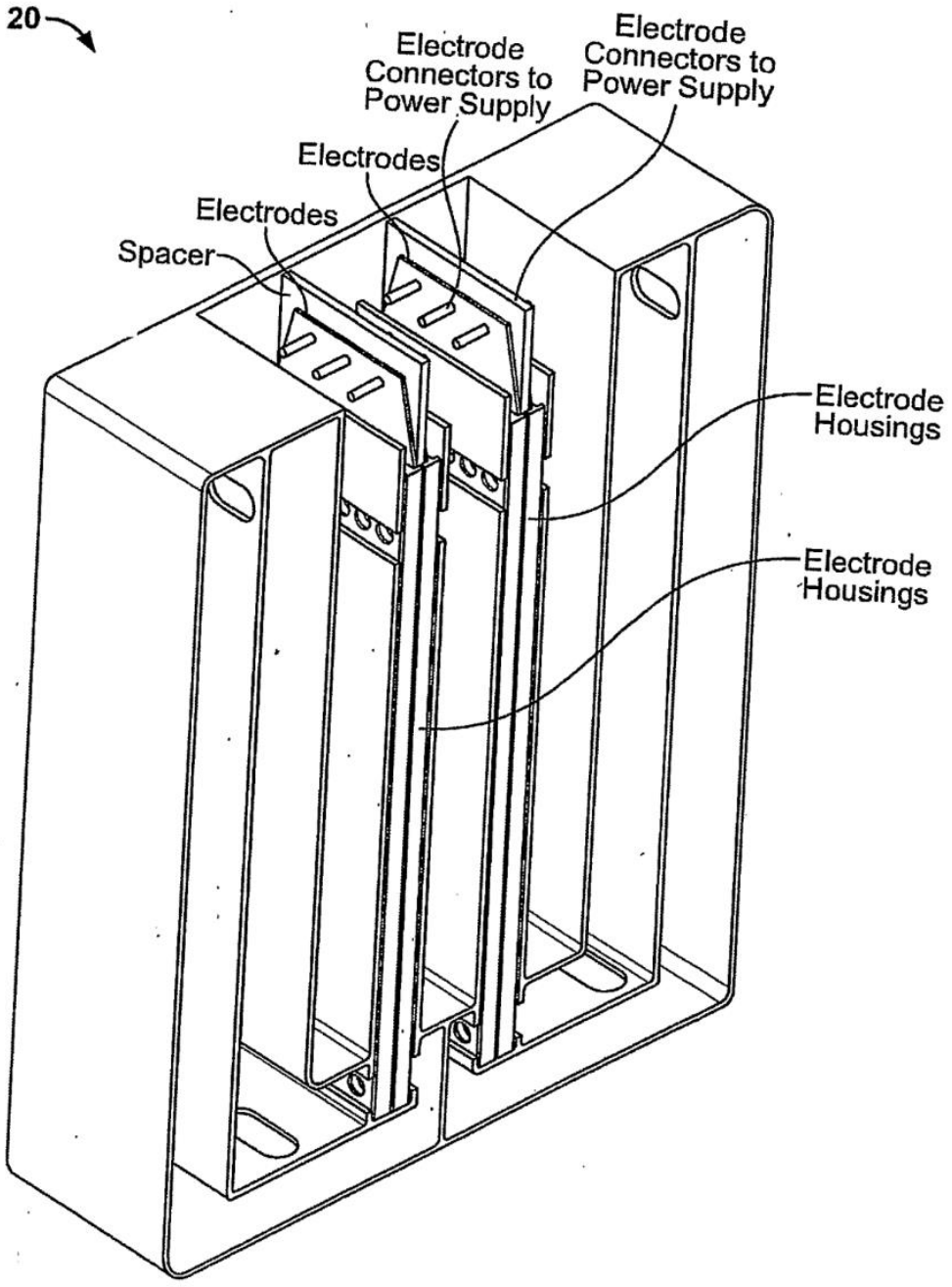

20
Electrode Connectors to Power Supply
Electrode Connectors to Power Supply
Electrodes
Electrodes
Spacer
Electrode Housings
Electrode Housings

FIG. 4

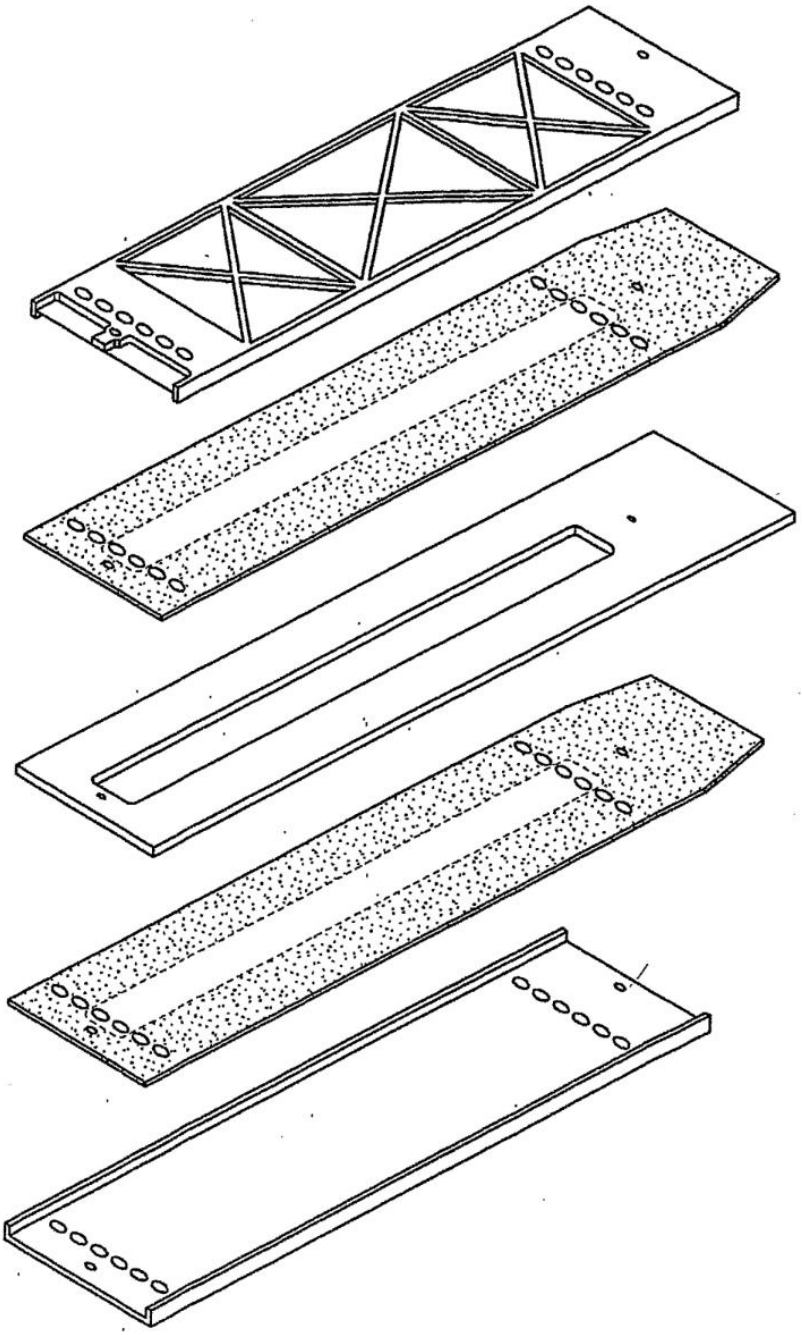


FIG. 5

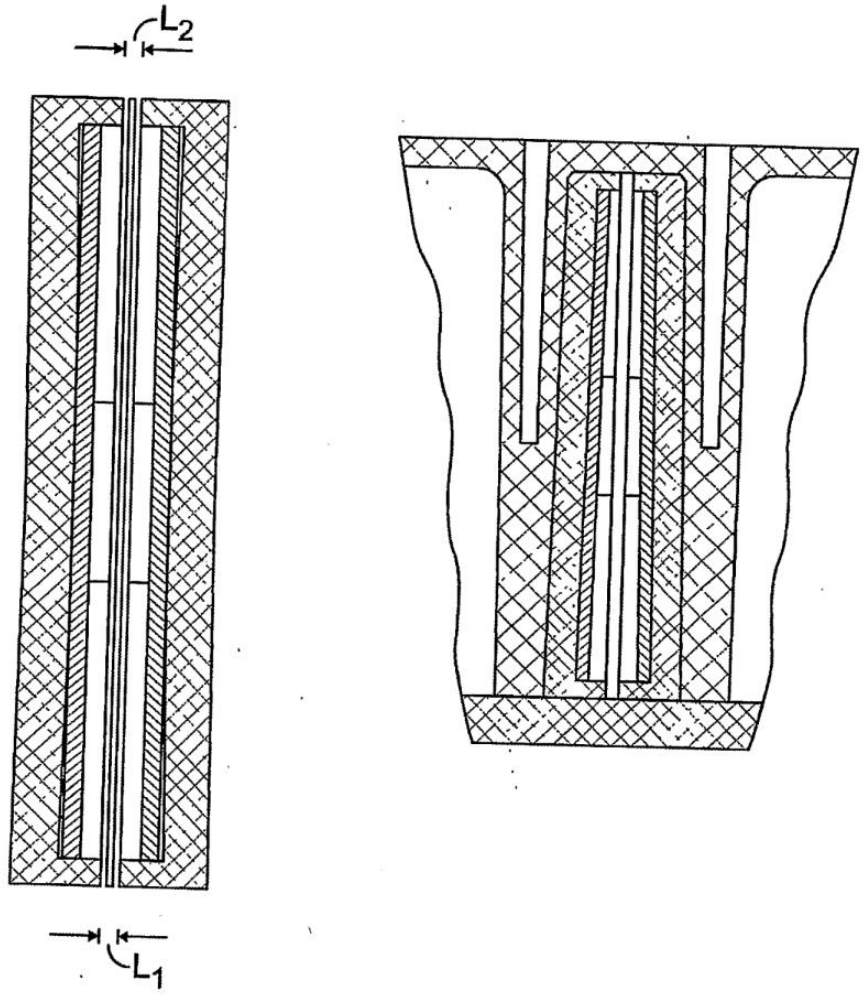
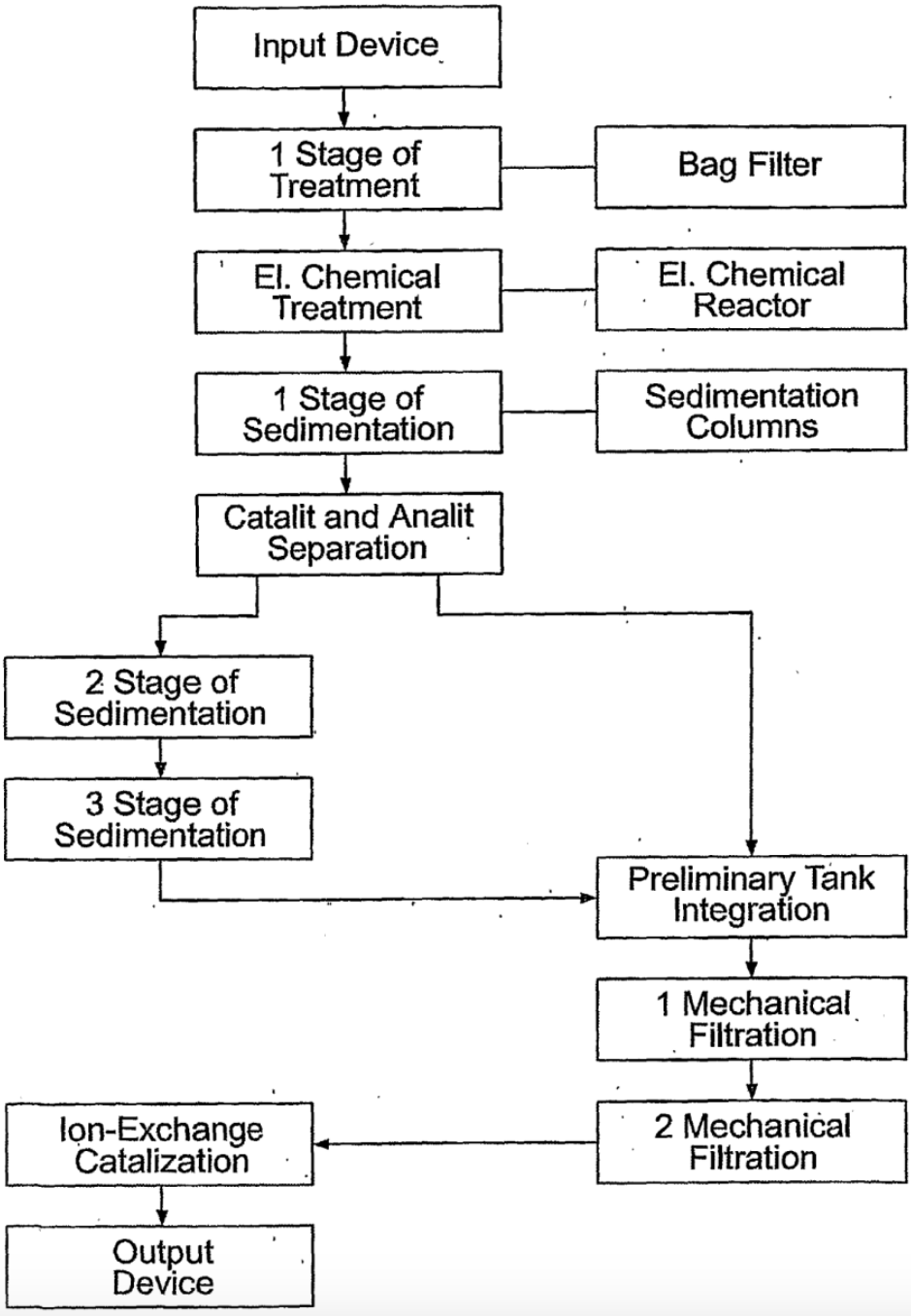


FIG. 6


Input Device
1 Stage of Treatment
Bag Filter
El. Chemical Treatment
El. Chemical Reactor
1 Stage of Sedimentation
Sedimentation Columns
Catalit and Analit Separation
2 Stage of Sedimentation
3 Stage of Sedimentation
Preliminary Tank Integration
1 Mechanical Filtration
2 Mechanical Filtration
Ion-Exchange Catalization
Output Device

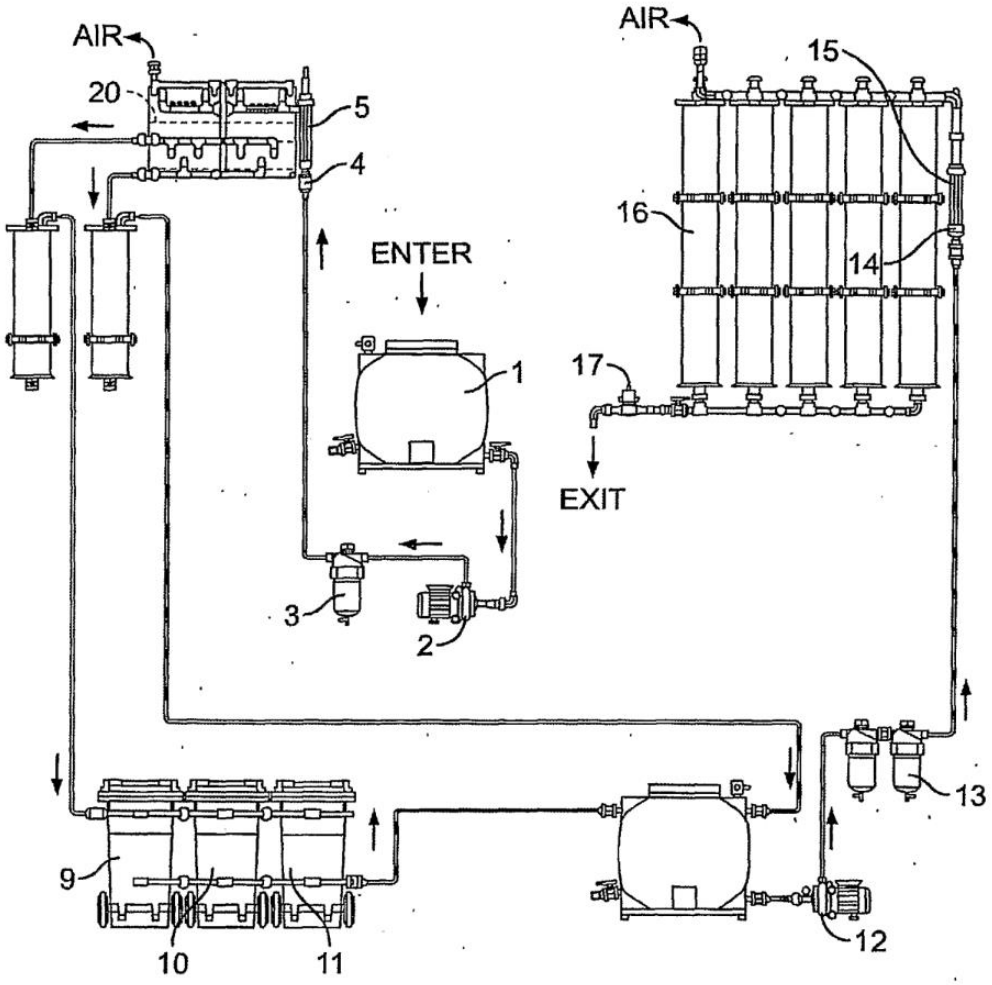


FIG. 8

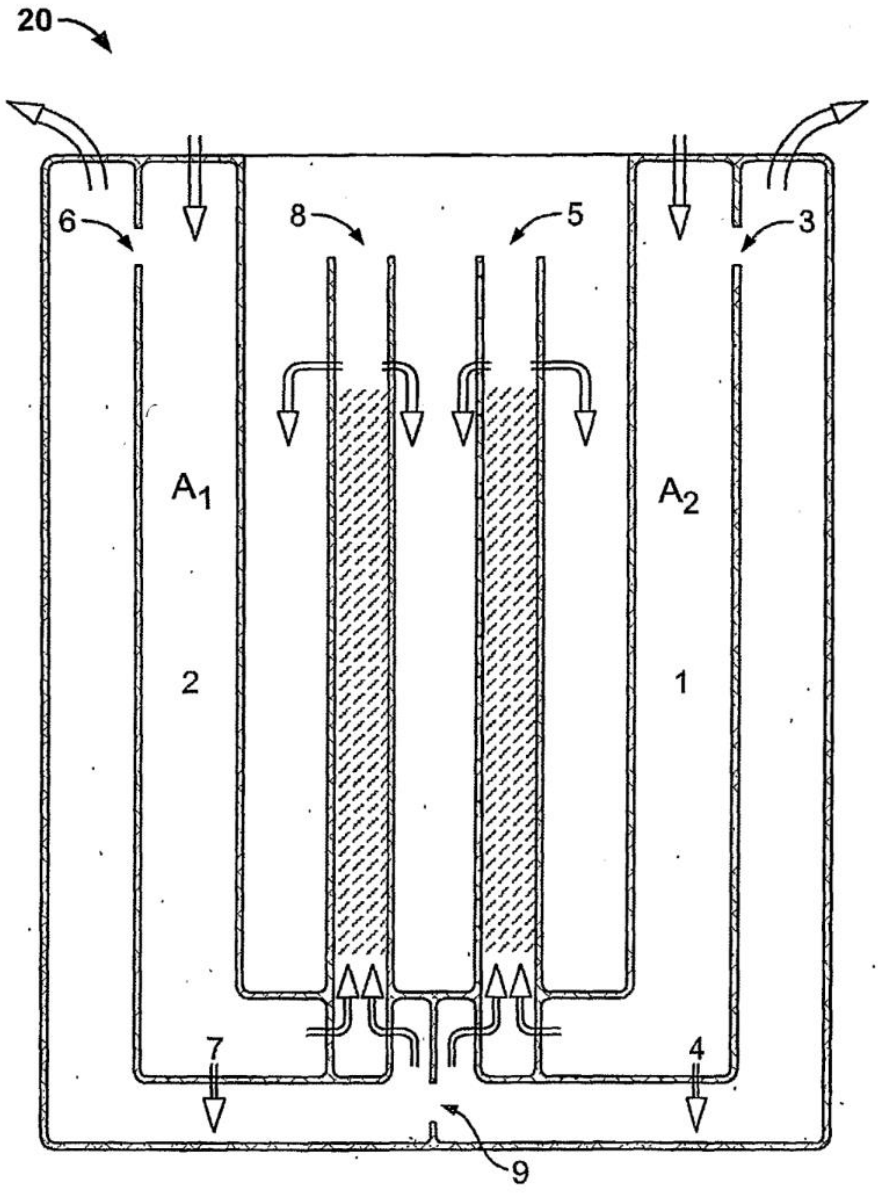


FIG. 9

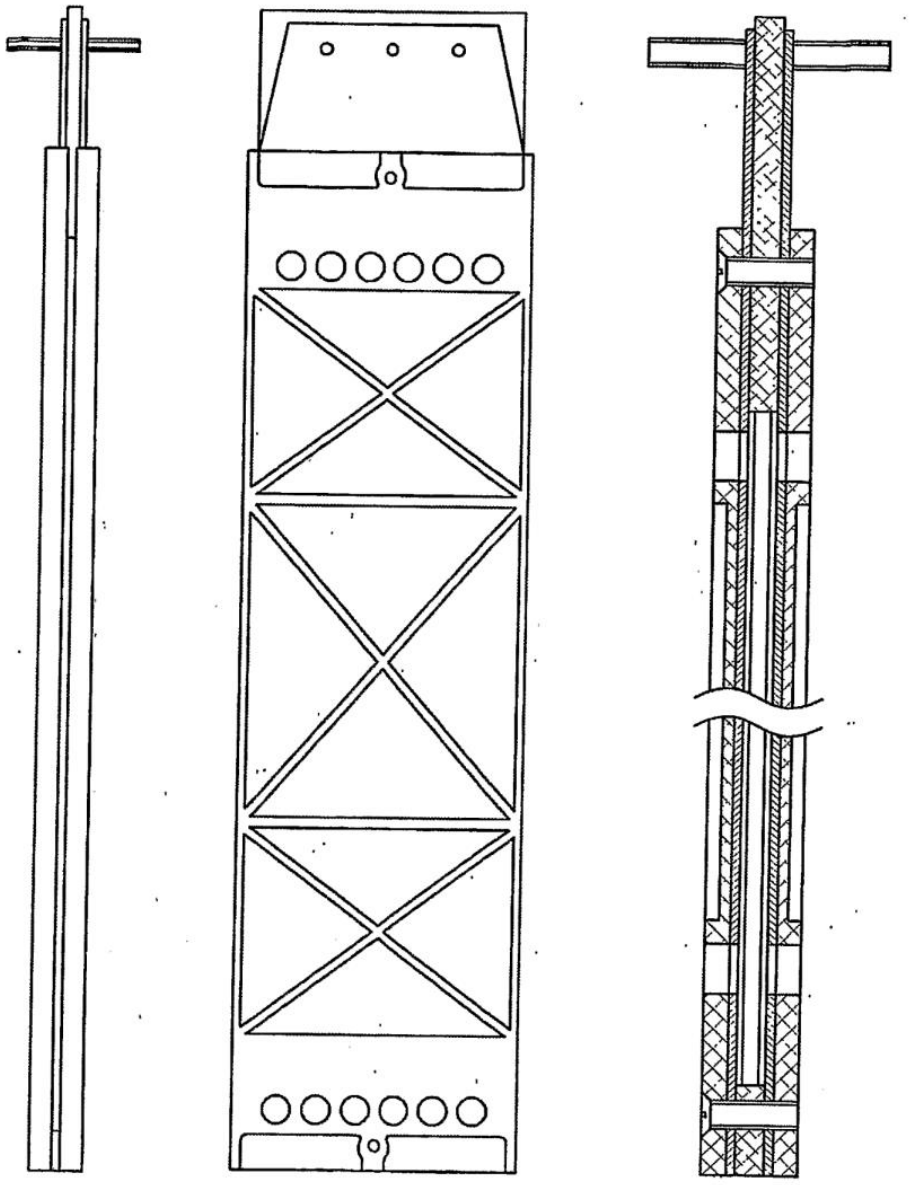


FIG. 10

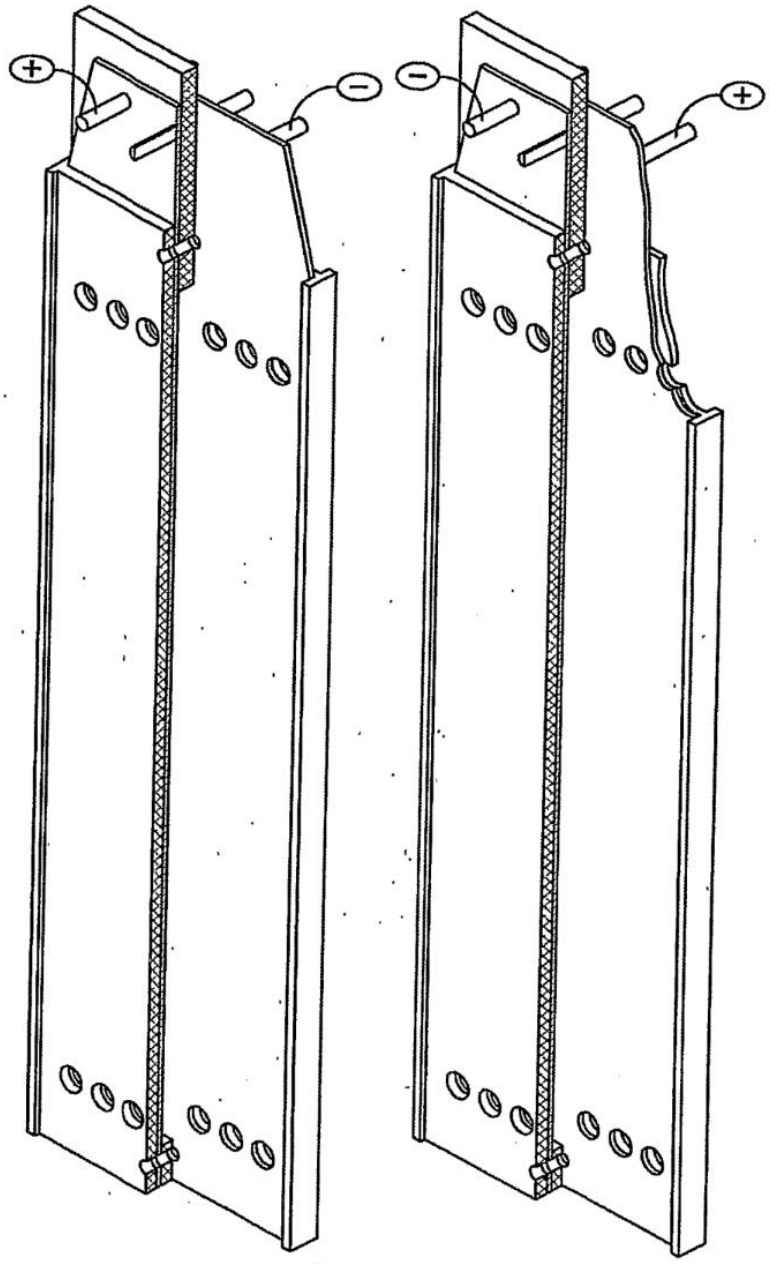


FIG. 11

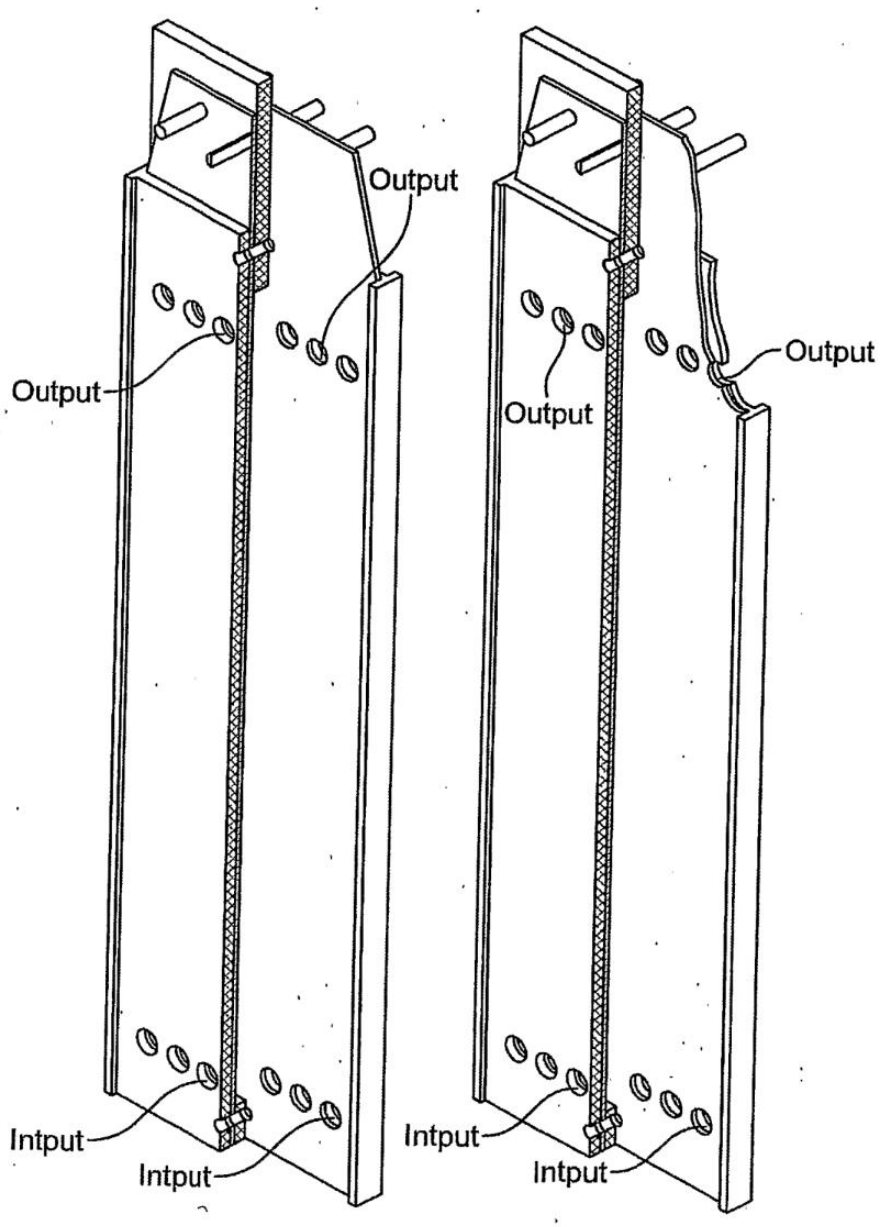


FIG. 12

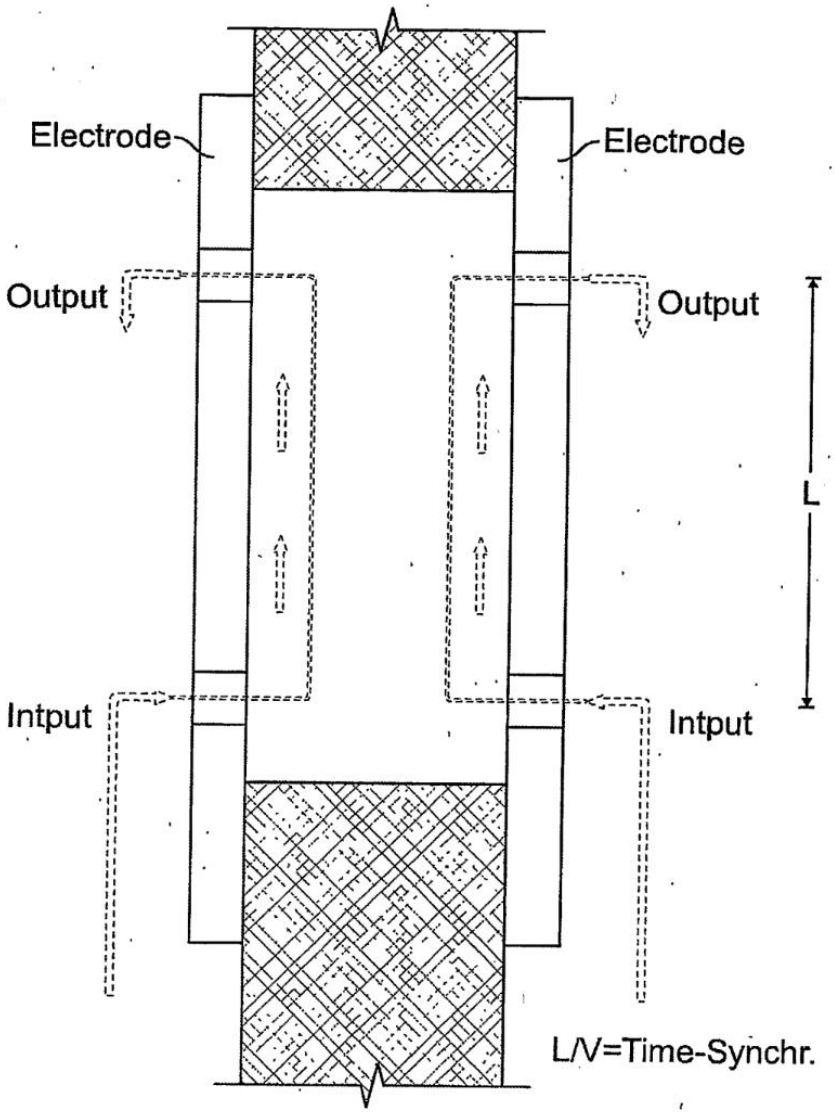

Electrode
Electrode
Output
Output
L
Intput
Intput
L/V=Time-Synchr.

FIG. 13

inspection of water coming out of the reactor (anolyte), D2 refers ot a tapping point for inspection of water coming out of the reactor (anolyte) on an input in intermediate
container after filter ni 50 micron, Erefers ot a tapping point for inspection of water flowing through the columns with ionic-exchange resin, and F refers to a tapping
point for inspection of water coming out of the W2W system.

Fig. 26 is a schematic diagram of a W2W electrochemical reactor and its connections to power supplies and a mechanical filter, in which VS stands for voltage senor, and CS stands for current senor.

Fig. 27 is a schematic diagram showing power supplies connected in parallel and electrodes connected in parallel.

Fig. 28 is a schematic diagram showing power supplies connected in parallel and electrodes connected in series.

Fig. 29 is a schematic diagram showing power supplies connected ni series and electrodes connected in parallel.

Fig. 30 is a schematic diagram showing power supplies connected ni series and electrodes connected in series.

Fig. 13 is aschematic diagram of one embodiment of avoltage sensor/stabilizer and its connection to a PLC.

Fig. 32 is aschematic diagram of one embodiment of acurrent sensor/stabilizer and its connection to a PLC.

DETAILED DESCRIPTION OF THE INVENTION

The disclosure and description of the currently active Mey Rechavam PCT International Patent Application No. PCT/IL02/00911, filed Nov. 14, 2002, entitled: "WASTEWATER TREATMENT SYSTEM", taking priority from U.S. Provisional

Patent Application No. 60/387,585, filed June 12, 2002, is incorporated herein by reference. The cited Mey Rechavam PCT patent application illustratively describes ni detail the design, construction, and implementation, of the electrochemical reactor, pre-treatment sub-systems, and post-treatment sub-systems, without any direct of indirect description of synchronous and/or synergistic design, construction, and/or operation, of the electrochemical reactor for providing stable and synchronous electrochemical process and hydrodynamic flow conditions.

The present disclosure and description of the Mey Rechavam (W2W7M, invention, hereinafter, also equivalently referred ot as the Mey Rechavam (W2W)

invention, or as the Mey Rechavam (W2W) electrochemical reactor, or as the W2W system, or as hte Mey Rechavam (W2W) water treatment/purification/regeneration system, si arranged and presented in four main parts. Part 1 is a general introduction and overall description of the W2W system. Part 2 is an illustrative detailed

description of hte structure, function, and operation, of main and alternative embodiments, and components thereof, of the W2W system. Part 3 is a detailed description of exemplary "actual" practice and applications, and analysis of results obtained therefrom, of the W2W system. Part 4 is a detailed description of how the power control of the present invention synchronizes the power supply to a W2W electrochemical reactor.

Brief Product Description

Proprietary integrated, scalable, adaptive, and modular, systems and equipment, and technical support services thereof, for treating/purifying/regenerating commercial types and quantities of impure flowable water. Based on separating and removing inorganic and/or organic impurities (e.g., metals, sulfates, phosphates, oils, and grease) from the impure water flowing through, and interacting with electrodes housed in, at least two electrode cells specially designed and constructed for providing stable and synchronous electrochemical process and hydrodynamic flow conditions. Efficient and cost effective design and operation of an energy supply mechanism including a pair of synchronously connected and operative power supply units, for synchronously energizing the electrodes which oxidize and reduce components in the contacting flowing water. Generated oxidized/reduced water components complex impurities ni the flowing water via mechanisms involving coagulation and precipitation, thereby forming impurity complexes removable, for example, by sedimentation, from the flowing water. Automated and computerized, including automatic process and feedback control equipment, procedures, and software.

Part 1--General Introduction and Overall Description

Following is a general introduction and overall description of the Mey Rechavam (W2W) water treatment/purification/regeneration system.

The Mey Rechavam (W2W) invention relates to the general field of water treatment/purification/regeneration, and more particularly, ot a method, device, and system, for treating/purifying/regenerating commercial types and quantities of impure flowable water.

The W2W invention features a variety of synchronized and synergistically interrelated electrochemical and hydrodynamical properties, characteristics, behavior, and phenomena, which are new (non-

anticipated) and inventive (not obviously derived from prior art inventions in the field of water treatment/purification/regeneration. Structure and operation of the W2W invention, and components thereof, are designed, constructed, and implemented, using conventional engineering techniques, equipment, and materials, based on well known established physical, chemical, and associated mathematical, theories, laws, and considerations. The W2W invention corresponds to a novel and unique synchronized and synergistic model of a non-linear system, influenced by continuously occurring fluctuations of primary system parameters relating ot the flowing water being treated, that is, concentration of chemical components ni the flowing water and conductivity of the flowing water.

In view of the fact that the W2W invention for purifying impure flowable water must handle fluctuating conditions, it therefore includes provisions for mitigating "selective instabilities" characteristic of most ecological technologies.
This si accomplished vai mechanisms of "organic" or "natural" order, which as part of the described invention for regeneration of impure flowable water, provide the capability of synchronizing and synergistically interrelating electrochemical and hydrodynamical properties, characteristics, behavior, and phenomena.

An important goal of the W2W invention is based on comprehensive and well-founded principles of synchronization and synergetics as applicable to the technology of complex processing of impure flowable water. The W2W invention addresses the task of setting up an effective, mobile, adaptive, self-sufficient device (electrochemical and hydrodynamically stable reactor) as part of a larger overall system for regenerating impure flowable water. The effectiveness of the offered technical solution is due to:

-The low level of energy input required for the process.

--The low level of unproductive energy losses during a technological cycle of the process.

-The possibility of combining and synchronizing at the same time certain energy-consuming autonomous technological tasks, such as electric dissolution of the anode (the electro-coagulating element) and forming at the same time a space of highly concentrated oxidizers.

-Reduction of the process duration, by precisely synchronizing the cycle time with the interaction between the technological stages of the process.

-Stabilization and synchronization of process rates, concentrations, energy inputs and time factors.

-High level of reproducibility and technical standardization of the process. Mobility of the proposed solution is due ot the following:

--Minimized construction.

-Modular construction, with fully synchronized modules.

--Flexible interaction scheme between modules, possibility of synchronized change of additional processing, allowing operation of facilities during the transition time.

The proposed technical solution is adaptable in that:

-Synchronous automatic variation of the energy supply parameters of the process, upon change of conditions and initial characteristics of the process, such as 15 change of the conductivity of the aqueous solution.

-Modular, stand-alone system, made up of identical, energy conversion and energy-producing units, synchronously operating to supply energy for the process.

A- system of feedback sensors, supplying signals used ot stabilize and synchronize the process parameters.

-Synchronously combining various operations in the treating/purifying/regeneration of impure flowable water so as to obtain the best possible result.

-Deriving from the process separate traditional results, such as pH corrections.

The self-sufficiency of the proposed solution consists in that there is:

A- ful cycle of technological operations and transitions synchronized in all parameters among themselves, thus providing the ultimate regulation required. -Fuly autonomous system for processing various different types of sources and supplies of impure flowable water.

The main advantages offered by the W2W invention for treating/purifying/regenerating impure flowable water are due to the realization of the various fundamental characteristics of the W2W invention, and hte folowing structural and technological advances:

-Effectively stimulating co-sedimentation (multi-sedimentation) when the impure water contains metals and other materials, enabling their sedimentation under
fundamentally different conditions.
-Effective stimulation of co-sedimentation without significant change of the
acidity or alkalinity of the water.
-Carrying out at the same time hydroxidation as wel as electro-coagulation,
without expenditure of energy and time.
--Effectively processing, via treating/purifying/regenerating, impure flowable
water sources within a short space of time, permitting ot speed up the operation of automatic production lines.
-Obtaining indirect data on the variation of readily-sensed parameters of operation of the system elements ni treating/purifying/regenerating, impure flowable water sources using feedback to gather information on the quality of the treated/purified/regenerated water.
-Speeding up automatic control systems.
-Speeding up flexible automated technological modules and complexes. -Adaptation to the treatment/purification/regeneration of impure flowable
water having very low conductivity, for example, 1- 5 micro-Siemens.
-Achieving two-fold increase in the parameters of electric current or voltage,
without additional expenditure of energy, by facilitating electrochemical processing in the system, by changing one parameter without changing the other parameter.
-Remote control of the system, along with controlling process parameters and eliminating imbalance ni the electrochemical and hydrodynamic parameters of the system.
-Autonomous local shutdown of the system and remote operation, without actuating treatment/purification/regeneration of the already treated/purified/regenerated flowing water, for closed-cycle recirculation of the water.
-Rapid change of hte technological regime of system operation, automatically synchronizing the operation of sources of direct electric current and the hydrodynamic part of the system with an arbitrary change in configuration, and according to the character of interaction between system components.
--Integrating the W2W invention into larger scale systems and processes, for example, reverse osmosis systems, ultra-filtration systems, etc.

Associated advantages obtainable due to specific advanced characteristics of parts of the W2W system for treating/purifying/regenerating impure flowable water:
--Indication of the presence of at least two synchronously acting sources of direct current.
-Series connection and voltage doubling relative to the maximum needed for a given conductivity of impure flowable water. Aconsequence of this is the increase of concentration of oxidizing and reducing agents at the output and as a result, leading ot a higher percentage of hydroxides ni the exiting treated/purified/regenerated water.
-Paralel connection and doubling of the current, relative ot the maximum current required for a given conductivity of the impure flowable water. As a result, there is higher concentration of oxidizing and reducing agents at the output, leading to a higher quality of sedimentation of hydroxy compounds ni the treated/purified/regenerated water.
-For parallel connection, there is achieving effective coagulation at high
current regime - pu ot acurent density of about 4A/dm,' enabling dissolution of na aluminum electrode to achieve twice the effective rate of reaction, compared to conventional electro-coagulation reaction rates (current density roughly 1to 2A/đm').
-For parallel connection, there is setting up electrolytic extraction of precious metals from the impure flowable water at the stabilization stage of hydrodynamic parameters, as the water passes between the electrodes in the electrode cells of the electrochemical reactor.
-The W2W invention is applicable to treating/purifying seawater.
-There is the capability of on-line monitoring. During signal of disturbance of the synchronous regime, there si an automatic signal indicating system irregularity, folowed yb automatic return ot hte synchronous regime, along with an automatic signal informing of return to normal operating regime.
-Maintaining the quality of the treatment/purification/regeneration process output, while having a two-fold reduction in power relative to using a single energy source providing a larger power ot the electrochemical reactor electrodes.
-Indication of the presence of common cathodic and anodic sections ni inter- electrode spaces inside the electrode cells.
--Higher intensity of the electrical field strength in the inter-electrode spaces. -Reduced resistance to the water flowing through the inter-electrode spaces. -Higher concentration of generated oxidizing and reducing agents.

Table 2: Results of Comparative Tests of Various Cassettes

Source	Connection	Cassette type	Water throughput	Current	Voltage	Power	pH			Conductivity			Cu mg/l			Date
A/V			l/h	A	V	kW	Input	Anode	Cathode	Input	Anode	Cathode	Input	Anode	Cathode	
50/60	Parallel	Anode Al Cathode Al With Membrane	2000	35	120	4.32	9	9	9.5	1819	1815	1755	75 - 37.5	67.5 - 20	67.5 - 37.5	5.02
30/100	Parallel	Anode Al Cathode Al With Membrane	2000	52	65	4.42	9	8.5	9	1520	1565	1432	67.5 - 25	37.5 - 25	50 - 20	4.02
30/100	Parallel	Anode Steel Cathode Steel No Membrane	2000	52	65	4.42	9	9	9.5	1795	1602	1743	75 - 37.5	37.5 - 30	67.5 - 30	5.02
30/100	Parallel	Anode Al Cathode Al With Membrane	2000	50	55	4.25	9	9	9.5	1750	1013	1764	35 - 30	50 - 20	50 - 20	5.02

-Prevention of hte shedding or release of salts from the cathode. -Avoidance of retention of anode scale ni the anode section of the
electrochemical reactor.
-Facilitated utilization of system characteristics.
--Increased service life of the electrodes, ni particular, and of hte electrode cells, in general.
-Reduction of the loss of electric energy, due to the reduced resistance in inter-electrode space.
-Asymmetric configuration of the working surfaces of the electrodes.
-Use of electrodes of varying thickness, which is important for increasing hte
thickness of anodes, thereby increasing electrode service life.
--Performing electro-coagulation at the same time as performing electro-
oxidation and/or an electro-reduction reaction.
-Synchronously changing the effective active surface of the electrodes, and to the same extent on both cathode and anode.
-Unhindered division, into two equal parts, of the water flowing into or out of the inter-electrode space.
-Reduction of hydraulic resistance ot the flowing water, for carrying out the process without requiring assistance of extra pressure ni the inter-electrode space. 20
-Increasing the cross-sectional area between each pair of two electrodes, thereby increasing the rate of water flowing between the inter-electrode space,
translating ot increasing performance of the electrode cells, and therefore, of the electrochemical reactor.
-Increase of cross-sectional area (theoretical input) of the electrode cells, enabling higher input of water flowing through the electrode cells, and through the electrochemical reactor.
--Increased throughput capacity of the electrode cells and of the electrochemical reactor.
According ot the result of experimental studies of the system, a highly significant advantage of the W2W invention si the twofold power reduction supplied
ot the electrodes, compared ot prior art versions of energy conservation. As a consequence thereof, there is:
-Avoidance of formation of solid salts, or scaling, at the cathode surface.

-Avoidance of passivation or deactivation of electrodes (anode and/or cathode).

- Avoidance of unmitigated or total destruction of electrodes (anode and/or cathode).
-Avoidance of overheating electrodes (anode and/or cathode). -Reduction of size of the power sources of the electrodes (anode and/or
cathode).
-Reduction of the installed power of the power sources and a lower electrical
safety threshold.
The W2W invention for regenerating aqueous solutions is designed,
constructed, and implemented, using the principle of dynamic symmetry. Dynamic symmetry is defined as "the coordination of al non-stationary system states and the stabilization of al transitions among system states possessing different energies", as stated ni the Encyclopedia of Physics, p. 683, published by the Great Russian Encyclopedia, Moscow, 1999.

In general, the terms "synchronous" and "synchronization" are defined by, and
refer to, actions, devices, systems, and/or processes, taking place or occurring, moving, and/or operating, at same time and/or at the same rate, for example, by having identical periods and/or phase. Moreover, the term "synchronize" si defined by, and refers to, causing actions, devices, systems, and/or processes, to occur at the same time and/or at the same rate; ot be simultaneous; ot move and/or operate ni unison.

Herein, with respect ot the present invention, a special form of synchronization is used. As defined in the same Encyclopedia of Physios, p. 687, and as defined and described ni "Synchronization of Dynamical Systems" by II. Blechman, Moscow, 1968, with particular reference ot electronics applications, synchronization refers to the special situation when "the working parameters of two direct current sources are such, that one of the sources (the synchronization master) acts on the other (the synchronized slave) by feedback regulation". For the present invention, the operating regime under dynamic symmetry of states for the system consists of two direct current sources, whereby all synchronizing parameters are taken to correspond in real time to the parameters of the synchronization master source. For the present invention, for example, as illustrated in Figs. 16-20, the operating regime under dynamic symmetry of states (conditions) for the water treatment system is determined by at least two direct current sources (power supply units), whereby al synchronizing parameters are taken ot correspond in real time to the parameters of the synchronization master source.

The W2W invention features integrated, scalable, adaptive, and modular, sub- systems and equipment, for treating/purifying/regenerating commercial types and quantities of impure flowable water. A main aspect of the W2W invention is based
on separating and removing inorganic and/or organic impurities (e.g., metals, sulfates,
phosphates, oils, and grease) from the impure water flowing through, and interacting with electrodes housed in, at least two electrode cells of an electrochemical reactor
specially designed and constructed for providing stable and synchronous electrochemical process and hydrodynamic flow conditions. The W2W invention features efficient and cost effective design and operation of an energy supply mechanism including a pair of synchronously connected and operative power supply units, for synchronously energizing the electrodes which oxidize and reduce components in the contacting flowing water. Generated oxidized/reduced water components complex impurities ni the flowing water via mechanisms involving coagulation and precipitation, thereby forming impurity complexes removable, for example, by sedimentation, from the flowing water. The W2W system is fuly

automated and computerized, including automatic process control, feedforward control, and feedback control, equipment, procedures, and software.

Operation of the specially designed and constructed electrochemical reactor is initiated and maintained by two interrelated power sources (generators) which
considerably differ ni power. This is due ot the fact that the first regulation (calibration) of voltage is carried out on the first source (the synchronization master), during which time the second source (the synchronized slave) remains ni standby (starting pause). This means that the instantaneous power of the first source being calibrated will momentarily exceed the power of the second source. A detailed scientific explanation of the synchronization of two coupled systems is provided ni
hte aforementioned cited Encyclopedia of Physics, p. 687. nI this situation, hte first source, having an instantaneous high output power, plays the role of the synchronizing master, while the second source which is momentarily weaker, plays the role of the synchronized slave.

Table 3: Test Bench Results

Cassette type	Water flow	Current	Voltage	Power	pH			Conduc-tivity			Cu mg/l			Date
	l/h	A	V	kW	In put	An-ode	Ca-thode	Input	An-ode	Ca-thode	Input	An-ode	Ca-thode	
Anode Al Cathode Al With Membrane	2000	36	120	4.32	9	9	9.5	1819	1815	1755	75* - 37.5**	67.5 - 20	67.5 - 37.5	5.02
Anode Al Cathode Al With Membrane	2000	52	85	4.42	9	8.5	9	1520	1565	1432	67.5 - 25	37.5 - 25	50 - 20	4.02
Anode Al Cathode SS With Membrane	2000	52	85	4.42	9	9	9.5	1795	1802	1743	75 - 37.5	67.5 - 30	67.5 - 30	5.02
Anode Al Cathode SS With Membrane	2000	50	85	4.25	9	9	9.5	1780	1813	1764	75 - 30	50 - 20	50 - 25	5.02

* - total copper concentration

** - copper concentration after filtration

After the starting calibration of the voltage of the first source, in relation ot the conductivity of the flowing water during calibration, the second source starts running an identical regime. Since both sources run ni a "stabilized voltage" regime, during
operation of the W2W invention, upon change of conductivity of the flowing water being treated/purified/regenerated, the master source reduces its output voltage and
the second source steps up its voltage. The application of the herein defined and
described synchronization principle leads ot a non-linear system with continuously occurring fluctuations of primary system parameters relating to the water being treated/purified/regenerated, that is, concentration of chemical components in the water and conductivity of the water, ni a steady engineering regime, and provides stable operation under all energy conditions, and a general energetic balance of the system for treating/purifying/regenerating an impure water source.

Part 2-Structure, Function, and Operation

The following is an illustrative detailed description of the structure, function,
and operation, of main and alternative embodiments, and components thereof, of the Mey Rechavam (WW) water treatment/purification/regeneration system.

Hetero-coagulation

Installation into hte water treatment/purification/regeneration electrochemical
reactor of electrode cells having anodes made of aluminum or pure iron, leads to an effect whereby the basic process of generating oxidizing and reducing agents ni the stream of water is complemented by anodic debris which is a coagulant. This facilitates the process associated with the necessary separation of disperse phase substances from hte dispersing medium. This "coagulation threshold" rises rather rapidly. nI most cases, the flowing impure water contains various salts of polyvalent metals, which are hydrolyzed ot produce colloidal hydroxides. This stimulates hte process of hetero-coagulation, and often basic coagulation as wel. In hetero- coagulation, various disperse systems reciprocally coagulate with one another, resulting ni particles of one disperse phase adhering ot those of another phase. Hetero-coagulation increases upon mutual mixing of segregating salts with variously loaded particle surfaces, since ionic type of electrostatic forces among them lead to mutual attraction, and not repulsion, of the particles.

Brownian motion kinetics of coagulation of colloidal systems determines hte needed contact time of the flowing water contacting the electrodes, and the flow through hte cells ni the inter-electrode space, so that the number of independent unrelated units is diminished by half, giving rise ot a "coagulation threshold" contact time expressed ni the following form, as described by the "Theory of Smoluchovski",

n= viscosity of the medium; =k Boltzmann's Constant;
T = the absolute temperature (K);
no = initial particle concentration;
a = the so-called coefficient of coagulation slowdown. In the absence of an energy barrier, that is, at high current densities, which for the present invention is about 4A/dm', whereby a= 1; ni the presence of an energy barrier, a<1.
The time of stay ni an electrode cel within the inter-electrode space ni a
system having athroughput of 1m / hour is about 3seconds. During this period of
time, the entire volume of the water flowing through the electrode cell experiences the action of a space-coagulating network. For a sample of water passing through the electrode cel for approximately 0.2 - 0.6 second, after exiting from the inter-electrode space, whether from the anode or from the cathode, the volumetric weight of the water sample characterizes the initial turbidity, that is, the segregated disperse medium (precipitate). The unstructured sediment phase deposited in the course of between about 1and 2minutes passes into the structured sedimented phase and the consolidated precipitate layer.
The candelabra (in particular, menorah) -like labyrinth configuration or shape of the electrochemical reactor used in the W2W system, provides a synchronized electrochemically active and hydrodynamically stable environment for separating impurities from the flowing water. To obtain optimum conditions for hydrodynamic synchronization of al parallel streams of the flowing water, the electrochemical reactor body of the electrode cell is filled by a labyrinth ni the form of a "menorah". This structure makes possible the following:

-Disposing the electrochemical reactor horizontally as wel as vertically.

-Stabilizing the dynamic flow of all streams without additional energy expenditure.

-Synchronizing all entering streams for each of the electrode cells. -Synchronizing the motion of parallel streams ni the inter-electrode space.

ni Chemical Encyclopedia, vol. 2, p. 817, published by the Soviet Encyclopedia,
Moscow, 1990:
=t 3n/[4kTna],
where t = the time in which the number of independent unrelated units is halved;

The motion of streams of the impure water and their synchronization is schematically shown on

Fig. 1, and the "menorah"-like labyrinth is schematically
shown on Fig. 2. The flowing water si directed into two equal parallel streams, inl and in2 (Fig. 1). Streams in and in2 are driven by apressure in arange of between
about 1.2 ot 1.5 bars. As shown in Fig. 2, ni electrochemical reactor 20, channelsi and 2are provided with openings 3and 4facing towards aworking chamber 5, while openings 6 and 7 face the working chamber 8. Working chamber 5 and working chamber 8 are joined to the channels adjacent to channels 1 and 2, respectively. The channels of the two working chambers are interconnected by way of an opening 9. Since operation of chambers 5 and 8 proceeds in an absolutely identical, that
is, synchronous, manner, it si possible ot consider the hydrodynamic balance for only one of them. The flow in channel 1 comes out through opening 4 in the adjacent channel and reaches the level AH, whereby on account of the presence of openings 3 and 4, this level is identical in both channels, and continues upwards ot come out through the channels into working chambers 5and 8. The difference AH for the two channels is the same, and is maintained in a synchronous regime, whereby opening 3 stabilizes this regime, allowing passage of air out of both channels.
In electrochemical reactor 20, absolute working symmetry is obtained between channels 1 and 2, and the adjacent channels (Fig. 2). Due ot the presence of opening 9 and AH being symmetrical for both channels, the flow speed in the two identical parts is the same and symmetrical for all channels adjacent to one of the working chambers 5 and 8. This symmetry permits synchronization of the flow speed at all stages of motion of the water flowing throughout the labyrinth, and thus permits synchronizing the transit time of corresponding symmetrical parts (Fig. 1). This circumstance permits the electrochemical reactor to be considered as a synchronized tandem electrode cell, internally connected ot provide hydrodynamic synchronization of the electrode cells. This also permits the drawing of electric energy from two synchronized power sources.

Fig. 3 is a schematic diagram illustrating a perspective view of the menorah- like labyrinth configuration or shape of the electrochemical reactor 20 used in the W2W system, illustrated in Fig 2. Fig. 4 is a schematic diagram illustrating a perspective view of the electrode cells as part of the electrochemical reactor 20 used in the W2W system.

Main Structural Characteristics of the Electrochemical Reactor
-Construction of the electrochemical reactor body labyrinth in the form of a
"menorah", as illustrated in Figs. 2 and .4

--Hydraulic connection between adjacent channels of the labyrinth.
5
-Geometric and hydraulic symmetry between homologous elements of the electrochemical reactor body labyrinth.
--Provision within the electrochemical reactor body for two electrode cells, identical ni al structural and technological parameters.
-Trapezoidal cross-section of the electrode cells in the case of plane-parallel electrodes (as a variant) with parallel active working surfaces, for example, as illustrated in Fig. 5.
-Self-sealing construction of the electrode cells, for example, as illustrated in Fig. 6.
-Composite electrochemical reactor body.
-Other spatial position of the body (as a variant). -Other form of the electrode cross-section (as variant).
-Co-axial tubular electrodes (as variant).
-Two independent, identical, sources of direct electric current, synchronized
in all basic parameters.
-Symmetric position (as variant) of the active working surfaces in the
electrode cells.
-Asymmetric position (as variant) of the active working surfaces in the
electrode cells.
--Different combination of the cross-section of the inter-electrode space.
--Combined cathodic and anodic space ni the cavity of the inter-electrode volume of the electrode cels (as variant).
-Communicating zones, connected by adjacent symmetrical channels ni the electrochemical reactor body labyrinth.
-Empirical relationship between the area of the communicating zones and the cross-sectional area of the inter-electrode space:
Sc.z. = Si.e.s.,
where Sc.z. is the area of the communicating zones, and Si-es. is the area of the inter- electrode space.

Empirical Parameters

Area of inter-electrode space is on the order of about 600 mm'. Width of the
active working surface of the electrodes is on the order of about 100mm. Area of electrode cross-section si on hte order of about 20 mm?. Preferred electrode

materials are stainless steel, titanium, aluminum, iron, or carbon-carbon. Main Technological Characteristics of the Electrochemical Reactor

-Stabilization and even distribution of the flowing water at the input to the electrochemical reactor.

-Gravitational stabilization and synchronization of streams of aqueous 10 solution at the input to the inter-electrode space in the electrode cells.

-Synchronous passage of streams of aqueous solution through the inter- electrode space ni crossing magnetic lines of force of the electric field at high voltage between active working surfaces of the electrodes.

-Current supply by two synchronized, equivalent, identical sources of direct electric current, with doubling of one output parameter, current or voltage, by means 15 of their synchronization in series or ni parallel connection with hydrodynamic stabilization of the water flowing through the electrode cells.

-Simultaneous parallel action by the technique of generating oxidizing and reducing agents and the technique of electrically assisted dissolution (saturation 20 volume of coagulant ions), using a single energy supply mechanism operative with two synchronized power supplies.

-Separate output of catolyte and anolyte (as variant).

-Sedimentation ni sedimentation tanks, using hydrophobic enhancers and using hydrophobic sedimentation threads, for the purpose of increasing rate of 25 sedimentation as a function of time.

Description of Operation of the W2W System

The W2W system for water treatment/purification/regeneration is applicable ot industrial waste water as wel as sewage. The treated/purified/regenerated water si of a quality permitting reuse ni technological cycles. Water 30 treatment/purification/regeneration is performed by using an electrochemical method, whereby a direct voltage si applied across neighboring electrodes, resulting ni the generation of alkalis (on the anode) and acids (on the cathode). Since water contains various pollutants and impurities, these enter into chemical reaction with the electrochemically generated alkalis and acids.

Chemical reactions taking place in flowing water immediately adjacent to the electrodes are considered as redox reactions. Electrolysis thus consists of a reduction reaction at the cathode and an oxidation reaction at the anode. A metallic anode may

be (a) non-dissolving and only acting as an electron transfer site during electrolysis, or
(b) dissolving (active), whereby ti is oxidized upon electrolysis. The redox activity of the electric current in many cases reinforces chemical oxidation and reduction
reactions.
Examination of the tables of standard electrode metals shows the following: 1. Metal cations, for example, Cut?, Hg*2, Ag*, Pt*2, ... , and Pt*", having a
standard electrode potential greater than that of hydrogen, during electrolysis are
completely dissolved either at and/or by the anode, and are deposited in metal form onto the cathode.
.2 Metal cations, for example, Lit, Na*, K*...,..., and Nit?, down ot Al*, having a standard electrode potential less than that of hydrogen, during electrolysis, remain attached to the anode without dispersing among the water molecules.
3. Metal cations, for example, Mnt, Znt, Cr*, and Fet, having astandard electrode potential less than that of hydrogen, and greater than that of aluminum, during electrolysis, deposit onto the cathode, and become dispersed among hte water molecules.
Cations of such substances are readily dispersed around the cathode, representing high positive potential. Reactions going on at the anode depend on the
physical and chemical characteristics of the electrolyte, as wel as on the anode material. Products detached from the electrodes may be involved ni chemical reactions among themselves.

In electrolysis, the quantitative relationships between the transported substance and the current passing through the electrolyte are expressed by Faraday's First and Second laws:
First law - the quantity of substance detached from an electrode si directly proportional to the electric charge transported between the electrodes.

Second law - the quantity of substance detached from an electrode upon
transport of one unit of electric charge si directly proportional ot hte chemical equivalent of the substance.

It follows from Faraday's laws that to detach a mass G of substance equal to 1 equivalent Erequires atransport across the electrodes of 96,487 coulombs of electric

charge. This constant is known as Faraday's constant. Thus, G = EIT/96487, where I is the current strength, Tis the duration of the electrolysis.

Typically, the electrochemical reactor of the W2W water treatment/purification/regeneration system can process contaminated water, which is fed into the electrochemical reactor, having the following physical and chemical properties, characteristics, and composition:

.1 pH from about 4 up to about 10.
2. Salt content up to about 2000 mg/l.
3. Total BOD (biological oxygen demand) up to about 150 mg/1.
4. Suspended particles not larger than about 0.7 mm, in a concentration of not
WO 2005/001164 PCT/US2004/016628
more than about 2% by volume of the contaminated water fed into the electrochemical reactor.
5. Typically,accordingotthesource,forexample,ametallicplatingprocess, of the contaminated water ot be treated by the W2W system, there is a dominant metallic ion contaminant, for example, copper ion ni water exiting from a copper plating process. The electrochemical reactor of the W2W system can process a maximum concentration of up to about 2000 mg/1 of the dominant metallic ion contaminant in the water fed into the electrochemical reactor. In cases where hexavalent chromium is the dominant metallic ion contaminant, the electrochemical reactor can process a maximum concentration of up to about 100 mg/l of hexavalent chromium in the input water.
6. Separate from, or in addition to, the contaminated water including a dominant metallic ion contaminant, the electrochemical reactor of the W2W system can process water containing a 'total' concentration of up to about 100 mg/1 of non
ferrous metal ions, for example, zinc, copper, nickel, cadmium, trivalent chromium, as long as the concentration of any one of such non-ferrous metal ions does not exceed about 30 mg/l. In the event that the total concentration of non-ferrous metal ions is higher than about 100 mg/l in the water fed into the electrochemical reactor, there is a need for reducing hte total concentration by subjecting hte input water ot a pre- treatment process (included as part of an overall configuration of the W2W system), prior to feeding the input water into the electrochemical reactor. The particular type of pre-treatment process si selected, ni part, according to the actual types and levels of contaminants ni the input water.

.7 In cases where the input water includes insoluble compounds, for example, salt hydroxy compounds, there is a need for decreasing the total concentration of such insoluble compounds as much as possible, for example, by using one or more pre- treatment processes (included as part of an overall configuration of the W2W system), prior to feeding the input water into the electrochemical reactor.

Any pre-treatment process, included as part of an overall configuration of the W2W system, used for the above indicated preliminary cleaning or pre-treatment of the input water before being fed into the electrochemical reactor is performed using reagents which are compatible with the downstream

electrochemical process taking place inside the electrode cells of the electrochemical reactor. For example, reagents used in any such pre-treatment process should not influence (by increasing or decreasing) the solubility in water of the electrodes, for example, aluminum or iron electrodes, operative ni the electrode cells of the electrochemical reactor.

The water treatment/purification/regeneration process does not need special reagents, and is controlled just by varying the electric parameters of the electrochemical reactor.

The facility power supply preferably consists of two sources. In case the impure water source is of high conductivity, the power sources wil be connected ni parallel, and in case the conductivity si low they wil be connected in series. Each power source operates in a voltage stabilized regime, using negative voltage feedback.

This recalls similar feedback of identical source operation under PLC (Programmable Logic Controller). An advantageous result of this solution is that no imbalance is involved at the output of the power sources, since the output current and voltage are kept identical.

The basic flow scheme of the W2W water treatment/purification/regeneration system si illustrated ni Fig. 7, along with reference ot an exemplary preferred embodiment illustrated in Fig. 8. Impure flowing water enters from a supply tank1 by way of avalve 2, descending along asystem pipeline through amechanical filter 3 to reach the electrochemical reactor 20. The throughput is determined by means of a control output valve 4at which an indicating output rotameter 5is provided.

Within the electrochemical reactor 20 electrochemical processes take place, which result ni the formation of certain hydroxy compounds of metals as wells as salts which exit hte electrochemical reactor 20 ni the form of smal floccules, after two cycles of the catalite and one cycle of the analite. These cycles are characterized by

reactions taking place ni electrochemical reactor 20, and in electrochemical reactor outlet tanks 7 and 8 within which the floccules are built up.

From the electrochemical reactor outlet tanks 7 and 8, the flowing water is directed ot the third phase of a vertical thin-walled sedimentation column 9. From sedimentation column 9, the clarified water passes through aregulator level vessel 10 into a reserve vessel 11. From that vessel, a water valve 12 allows passage of the 10 flowing water out through mechanical mesh filters 13 to ion-exchange filters 16. The throughput across ion-exchange filters 16 is determined by an output valve 14, and indicated by means of a rotameter 17.

In addition to the previous description, above, of the electrochemical reactor

20, as illustrated in Fig. 2, further details of the electrochemical reactor 6 (Fig. 8) are herein provided, with reference ot Fig. 9, a schematic diagram illustrating an exemplary preferred embodiment of the electrochemical reactor 20. For consistency and clarity, electrochemical reactor components and reference numbers thereof, shown ni Fig. 9, are the same as those shown in Fig. 2. As shown ni Fig. 9, hte electrochemical reactor 20 includes two working chambers 5and 8, each with its specific two electrode cel cassettes and their associated pair of oppositely charged electrodes, as previously illustrated ni Figs.4, 5, and 6, and illustrated herein, in Figs. 10, 11, and 12, made of the same or of different materials.

In order ot optimize the regime of operation of the electrochemical reactor 20, the construction represented ni Fig. 9 is specially designed and implemented for allowing estimation of the effectiveness of operation of the cassettes and of the electrolytic processes according to the electrical parameters which play a major part ni controlling the operating regime ni the inter-electrode gap and ni the cassette covers. Exemplary electrode dimensions are 100 mm x 320 mm, and the inter-electrode gap between them si 6 mm. Accordingly, the cross-sectional area through which the water flows is 100 x 6 = 600 mm?.

To estimate the character of the flow we make the following observations:

reactions taking place ni electrochemical reactor 20, and in electrochemical reactor outlet tanks 7 and 8 within which the floccules are built up.

From the electrochemical reactor outlet tanks 7 and 8, the flowing water is directed ot the third phase of a vertical thin-walled sedimentation column 9. From

5

sedimentation column 9, the clarified water passes through aregulator level vessel 10 into a reserve vessel 11. From that vessel, a water valve 12 allows passage of the

30

a. The flow temperature of the water across the gap is constant in the direction of the flow.

b. .c d.

Rate of gas evolution from the liquid is negligible.

The internal electrode surface has an insignificant roughness coefficient. No water is condensed in the course of operation.

In order ot determine the character of the liquid flow, we apply the criterion of the Reynolds number (Re), determined by the formula:

Re = [p V D] / п , (1)

where psi the liquid density, Vsi the velocity of flow, Dis the channel diameter, and n is the dynamic (=kinetic) viscosity.

For the specific case herein, whereby the cross-section through which the liquid flows is a right-angled channel, one arm of which being longer than the other arm by a factor of 16.5, the flowing water is considered as a streaming fluid through a narrow crack. In this case, the Reynolds number is determined by hte formula:

Re = [VL]/n, (2)

where Lis the channel characteristic dimension. In this case,hte gap width =6.00

mm. With reference to Fig. 13, for the flow of water through the electrode cassette, there is:
p= 1000 kg/m', and n = 0.01 × 10-68.
The W2W electrochemical reactor and system operate at impure water
throughput of Q= from 10. ot 30. m/'hour. Knowing the cross-sectional area Sot be
0.100 x0.006 m,' and hte number of electrode cassetes ni the electrochemical
reactor, the flow velocity, V, is determined according ot the formula:
V=Q/S 3600 0.006 =0.116 Qm/sec
(3)
Formulas (2) and (3) aer used for taking into account the value of the
Reynolds number and of the flow velocity, V, at various values of the water throughput, Q, as follows:

Qm's Vm/s
Re
0.5
1.0 1.5 2.0 0.116 0.174 0.232 73 160 1546
25. 30. 0.290 0.348 1933 2320

If the Reynolds number does not exceed a certain critical value, then hte flow behavior of hte water si laminar. If the Reynolds number exceeds a critical value, then hte flow behavior becomes turbulent. For smooth tubes and nonviscous fluids, the critical Reynolds number is around 2300. In other cases reported in the literature, the transition conditions occur at a critical Reynolds number of around 1700. It is noted that the initial temperature gradient at the level of the electrode cassettes, and the evolution of gas in the process of flow between the electrodes, ni the

electrochemical reactor, make the critical Reynolds number rather lower, affecting the onset of turbulent flow.
In the case where considerable control of water throughput is exercised, it is emphasized that upon exit of purified water at arate of at least 20. m/hour, hte flow 5
through the inter-electrode gap could become turbulent. For normal electrochemical reactions under conditions of improved ion diffusion assisted by the electric field,
ordinarily, the laminar flow regime is the rule rather than the exception. Automatic Feedforward and Feedback Control of the W2W System
For describing automatic feedforward and feedback control of the W2W
10 system, reference is made to Figs. 14 and 15. Automatic control of the W2W system
permits processing of impure water without intervention at the given production output. Impure water undergoing processing goes through the following stages: preliminary filtration 40, electrochemical treatment 31, sedimentation 41 and 42, point filtration 43 and ion exchange 44. The flow of water through

al treatment
15 stages is subject ot constant automatic control ot enable full and proper operation of al parts ni the hydrodynamic cycle with the one and only purpose of producing a proper output and avoiding "out-of-control" or "runaway" situations.
Automatic control of the W2W system is carried out by a programmable electronic controller. It is necessary ot use a lock-up configuration of the
20 hydrodynamic system. The basic system version operates as follows: the water ot be treated passes first into a system buffer tank 30, in which the water level si determined. The first buffer tank 30 is required in order to regulate the water flow from the demand tank and adjust it to the required flow rate through the system. The water level is determined by means of a level sensor 24, which establishes the
25 existence of any of three significant water levels ni the tank. The lowest level indicates the lowermost allowed water level in the tank and the minimum admissible
quant it y.
The power supply controller 1(Fig. 15) receives data on the water level as a
signal indicating whether first buffer tank 30 is empty and must be replenished. The 30
second level occurs between the low level and the top level. In this region, the controller 1 issues a command to undertake one of two possible processes, either replenish first bufer tank 03 by opening avalve 26, or empty first buffer tank 30
through the runout valve. The third level indicates top water level ni the tank, of

above it. The controler 1interprets this case by issuing asignal "tank ful" requiring closure of the filling valve.
Tank valve 26 from the first buffer tank 30 is the first valve in the basic version of the system. There is also a second release valve28 for a second buffer tank
27. Water enters second buffer tank 27 through electrochemical reactor 31 and sedimentation containers 41 and 42. The electrochemical reactor 31 receives power from a power source and control unit 29, but only when water enters the electrochemical reactor 31. The minimum sufficient water flow through the electrochemical reactor 31 which would operate power source and control unit 29 si triggered by a flow sensor 32. Flow sensor 32 is installed at the electrochemical reactor input where it senses incoming water. Other functions of flow sensor 32are additional control of the hydrodynamic chain, from the first buffer tank 30 down to the point where the flow sensor is installed.
Data control is performed as follows. fI a command is issued ot open the first 15
valve 26, a stream of water flows down through first valve 26, and fi this stream turns out ot eb improper, that is, there si a problem at the top part of the hydrodynamic chain, and the system is threatened by a potentially disorderly or unstable situation, then the second buffer tank 27 serves to adjust the water flow

after sedimentation 41 and 42, and regulates this flow after passing through various filters 43 and ion
20
exchange columns 44.
Random overfilling of the second buffer tank 27 is prevented by several measures. One of these is the preliminary indication of water flow entering the second buffer tank 27 and exiting that tank. This indication causes special measures to be taken for regulating the flow of water. Control of the water flow is carried out according to the readings of a flow meter 45. A preliminary indication of the water flow takes place when the water input into the second buffer tank 27 is 5 - 10% less than the water flow out of the second buffer tank 27. The second buffer tank 27 is provided with a level sensor 25, which serves for control of a second valve 28 and operates the second valve ni case of overfilling of the second buffer tank27. Such
30
overfilling may occur due to erroneous initial indication of water flow in the flow regulator or due to a failure causing water flow from the hydrodynamic part ot the second buffer tank 27. Therefore, lack of water level control at the second buffer tank
27 relative to the control of water level at the first buffer tank30 could give rise to overfilling, and in turn to shutoff of the first valve 26. Cancellation of the blocking of

CLAIMS
I claim:

1. A power control for an electrically powered water treatment apparatus having electrode cells, comprising:
a master power supply unit having a control input;
aslave power supply unit having acontrol input;
a current sensor adapted to measure the electrical current flowing through the cells of the water treatment apparatus;
a voltage sensor adapted to measure the voltage applied to the cells of the
10
power applied ot the cells without overheating.

15

2. The power control of claim 1, wherein the cells are driven in a series circuit.
water treatment apparatus;
a PLC having inputs from said current sensor and said voltage sensor and
outputs for said master and slave power supply units;
wherein, said PLC si programmed so as to eb able to maximize the electrical
power applied ot the cells without overheating.

3. The power control of claim 1, wherein the cels are driven ni a parallel circuit

4 The power control of claim 1, wherein the cells are driven in a psuedo- parallel circuit, wherein the cells are connected ni series and the current regulated so as to simulate parallel operation.