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(54) Title: APPARATUS FOR DECONTAMINATION AND DISINFECTION OF AQUEOUS SOLUTIONS

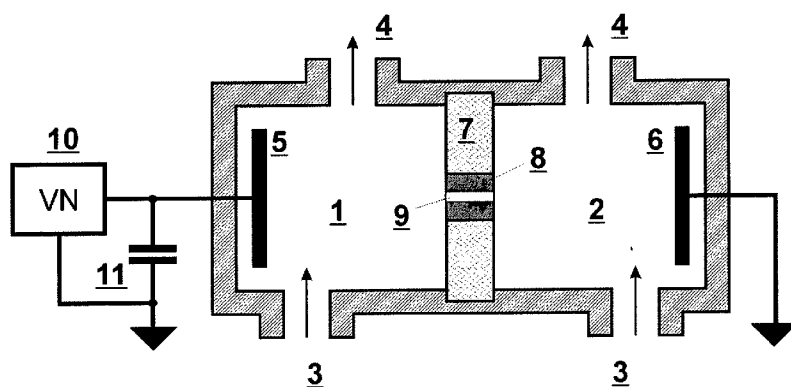


Fig. 1

(57) Abstract: Apparatus for decontamination and disinfection of aqueous solutions consists of two separated chambers (1,2) that are filled and circulated with aqueous solution. Electrodes (5,6), one grounded and second connected to the high voltage DC source, are placed in chambers (1,2). Chambers (1,2) are connected through a connecting hole (9) of the finite length. Electrical discharge is created in the connecting hole (9) between electrodes (5,6) and generates chemically active species, which expand into the water flowing through the apparatus. Due to action of primary chemical and physical processes initiated by the discharge and subsequent secondary chemical processes taking place in an aqueous solution present in the chambers (1,2) water treated by this apparatus is decontaminated and disinfected.

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## Apparatus for decontamination and disinfection of aqueous solutions

### Technical field

The present invention relates to an apparatus for purification and treatment of water.

### Background art

Methods of water purification and treatment by means of electrical discharges are based on generation of non-equilibrium plasma that initiates in water various physical and chemical processes such as generation of chemically active species (e.g. hydroxyl radicals, ozone, hydrogen peroxide), ultraviolet light, high-pressure shockwaves and strong electrical field. These physical and chemical processes are capable to inactivate or degrade various microorganisms and chemical compounds dissolved in water. Electrical discharges are generated either directly in the water or in the gas phase in close proximity to the liquid surface or in both phases simultaneously. To generate electrical discharge in water a very high-localized electric field is needed for electrical breakdown of water. To accomplish this apparatuses with electrode systems producing a highly non-uniform electric field (e.g. point-plate, diaphragm) charged by high voltage pulsed power systems are often used to generate electrical discharge in water. However, from technological and application point of view the need of pulsed high voltage brings cost and complexity disadvantages of these systems. In addition, only small volume of discharge is generated by such types of electrode configurations, i.e. a zone in which chemically active species are generated by the discharge and interact with the treated water, that limits the efficiency of these systems. To overcome this limitation, device using porous ceramic-coated metal electrodes was recently developed (Czech patent No. 281566) that generates large volume multichannel pulsed high voltage discharge in water and, thus, significantly enhances the active zone of the discharge in water. Consequently, several studies have been published about pinhole (diaphragm) discharge systems. These systems are charged by DC voltage and the discharge is generated in small hole(s) of very thin dielectric sheet placed between the electrodes in water. However, use of such system is limited due to a small volume of generated active zone and wear problems associated with the pinhole in the diaphragm layer that permit deposition only low applied power.

### Disclosure of the invention

The present invention seeks to solve these problems by providing an improved apparatus for decontamination and disinfection of aqueous solutions. A key of the invention is based on the principle, that DC current between electrodes flows in water through relatively small connecting hole placed between two reactor chambers filled with water. By proper choosing of connecting hole dimensions (its length and diameter) it is possible to establish in the connecting hole an electrical current of sufficient density needed for evaporation of small amount of liquid. Created inhomogeneity allows electrical breakdown of water and an initiation of electrical discharge inside of the connecting hole.

Formed electrical discharge generates chemically active substances that initiate a variety of chemical effects, which cause decontamination and disinfection of the aqueous solution flowing through the apparatus. Electrical discharge generated inside of the connecting hole strongly expands into the surrounding water and, thus, chemically active species generated by the discharge are transported also into the water outside of the discharge zone and they may initiate secondary chemical processes in relatively large volume of treated liquid. Expansion of the discharge leads to the termination of conditions required for existence of the discharge and to the interruption of the discharge current between electrodes. After the end of this process connecting hole begins to fill back with aqueous solutions and all process is repeated.

The present invention of the apparatus for decontamination and disinfection of aqueous solutions comprises of two separate chambers connected with at least one connecting hole, whereas in each chamber is at least one electrode and both chambers have inlet and outlet ports. One electrode or more electrodes in the first chamber is/are grounded and one or more electrodes in the second chamber is/are connected to the DC high voltage power supply. Connecting hole(s) is/are made in the diaphragm of the finite thickness, which separates chambers. In the case of independent chambers connecting hole(s) is/are made by tubing(s) connecting chambers. Electrodes may be made from graphite, stainless steel or other conductive material. Connecting hole(s) may be lined with ceramic material to enhance its/their wear resistance. High voltage capacitor may be connected in parallel to the DC power supply.

As described above in detail the present invention of the apparatus for decontamination and disinfection of aqueous solutions is characterized in that there is no need of a high voltage pulse power supply and the apparatus is operated by DC high voltage power

supply, which total costs are much lower than of the pulsed power supply; the apparatus is operated at the pulse regime although it is charged by DC power supply, pulses are generated by physical processes in the device; chemically active species generated by the discharge are expanded into relatively large volume of treated liquid, which provides higher efficiency of induced decontamination and disinfection effect caused by the apparatus of the present invention.

The apparatus provided according to the present invention eliminates the main limitations of currently existing electrical discharge systems that were proposed for water treatment applications. There is no need for complex and expensive high voltage pulse power supply to operate the present apparatus. Design of the apparatus allows deposition relatively high applied power into the discharge. Physical processes induced by the expansion of the discharge from the connecting hole into the surrounding water accelerate transport chemically active species generated by the discharge in the direction of connecting hole axis and their penetration into large volume of treated water.

### Drawings

Embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawing.

### Example of preparation

Two chambers 1, 2 provided with inlet 3 and outlet 4 ports are filled with aqueous solution and separated from each other by dielectric diaphragm 7. In one chamber 2 is placed grounded electrode 6, the electrode 5 in second chamber 1 is connected to the DC high voltage power source 10, and high voltage capacitor 11 is connected in parallel to the DC power source 10 to lower its output impedance. Chambers 1,2 are connected through a connecting hole 9, which is lined with ceramic material 8. Processes that were described in the section "Disclosure of the invention" lead to a periodic generation of an electrical discharge, which generates chemical active substances, whose next action to liquid, which cause decontamination and disinfection of the aqueous solution in chambers 1, 2.

Claims

1. Apparatus for decontamination and disinfection of aqueous solutions, the apparatus comprising two separate chambers (1,2), which are connected with at least one connecting hole (9), characterized in that, in each chamber (1,2) is at least one electrode (5,6), both chambers (1,2) have inlet (3) and outlet (4) ports, one electrode (6) or more electrodes (6) in the first chamber (2) is/are grounded and one or more electrodes (5) in the second chamber (1) is/are connected to the DC high voltage power supply (10).
2. Apparatus as claimed in Claim 1 characterized in that the connecting hole(s) (9) is/are made in the diaphragm (7) of the finite thickness, which separates chambers (1,2).
3. Apparatus as claimed in Claim 1 characterized in that the connecting hole(s) (9) is/are made by tubing(s) connecting chambers (1,2).
4. Apparatus as claimed in any one of Claims 1, 2 or 3 characterized in that the electrodes (5,6) are made from graphite.
5. Apparatus as claimed in any one of Claims 1, 2 or 3 characterized in that the electrodes (5,6) are made from stainless steel or other conductive material.
6. Apparatus as claimed in any one of Claims 1, 2 or 3 characterized in that the one of the electrodes (5,6) is made from graphite and the second electrode (5,6) is from conductive material.
7. Apparatus as claimed in any one of Claims 1, 4, 5 or 6 characterized in that the connecting hole(s) (9) is/are lined with ceramic material (8).
8. Apparatus as claimed in any one of Claims 1, 4, 5, 6 or 7 characterized in that the high voltage capacitor (11) is connected in parallel to the DC power supply (10).

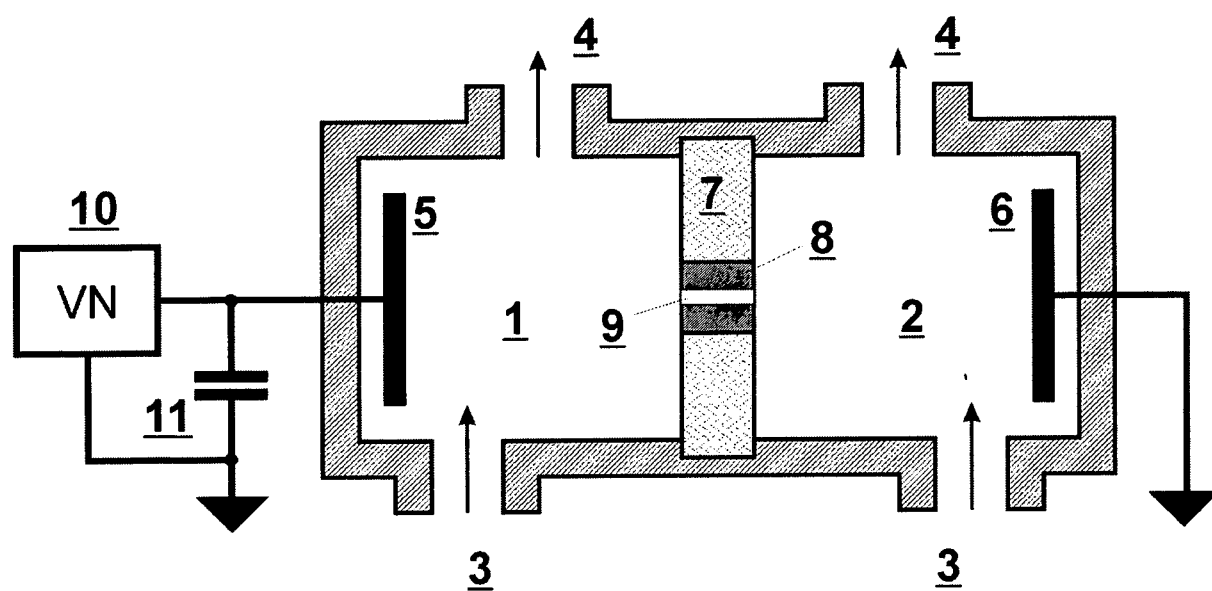


Fig. 1

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International application No

PCT/CZ2008/000103

## A. CLASSIFICATION OF SUBJECT MATTER

INV. C02F1/46 C02F1/461

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

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

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

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000 093972 A (SATO MASAYUKI; KOBE STEEL LTD) 4 April 2000 (2000-04-04) abstract; figures 1,2	1-8
Y	US 6 228 266 B1 (SHIM SOON YONG [KR]) 8 May 2001 (2001-05-08) column 5, line 16 - column 6, line 67; claims 1,8,9; figures 2,3A	1-8
Y	WO 02/098799 A (SPLITS TECHNOLOGIES LTD [GB]; ZADIRAKA YURI VLADIMIROVICH [GB]; BARKHU) 12 December 2002 (2002-12-12) page 16, line 31 - page 18, line 2; page 18, line 27 - page 20, line 15; claims 1,2,24; figures 1,2,5-7	1-8
A	JP 2001 058179 A (KOBE STEEL LTD) 6 March 2001 (2001-03-06) abstract; figure 1	1-8



Further documents are listed in the continuation of Box C.



See patent family annex.

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2000093972 A	04-04-2000	NONE	
US 6228266 B1	08-05-2001	CN 1207368 A DE 19830956 A1 GB 2328133 A JP 3236820 B2 JP 11070386 A	10-02-1999 14-01-1999 10-02-1999 10-12-2001 16-03-1999
WO 02098799 A	12-12-2002	NONE	
JP 2001058179 A	06-03-2001	NONE	