

Exhibit 21



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Field et al.

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(54) **METHOD AND APPARATUS FOR GENERATING, APPLYING AND NEUTRALIZING AN ELECTROCHEMICALLY ACTIVATED LIQUID**

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 (52) **U.S. Cl.** **205/746**; 205/701; 205/755; 205/756; 205/757; 205/498
 (58) **Field of Classification Search** 205/498-505, 205/701, 746, 755, 756, 757
 See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,859,195 A	1/1975	Williams	204/272
3,897,320 A	7/1975	Cook, Jr.	204/95
3,933,614 A	1/1976	Bunn, Jr.	204/266
4,099,489 A	7/1978	Bradley	123/3
4,108,052 A	8/1978	Cunningham	99/275
4,121,543 A	10/1978	Hicks, Jr. et al.	123/3
4,154,578 A	5/1979	Bane	8/137
4,244,079 A	1/1981	Bane	15/321
4,324,635 A	4/1982	Sweeney	204/266
4,374,711 A	2/1983	Ogawa	204/98
4,405,418 A	9/1983	Takemura	204/95
4,502,929 A	3/1985	Stewart et al.	204/147
4,603,167 A	7/1986	Mahalek et al.	524/706

(Continued)

FOREIGN PATENT DOCUMENTS

AU 732602 4/2001

(Continued)

OTHER PUBLICATIONS

Aoki et al., Wafer Treatment Using Electrolysis-Ionized Water, 1994, Jpn. J. Appl. Phys. vol. 33, pp. 5686-5689.*

(Continued)

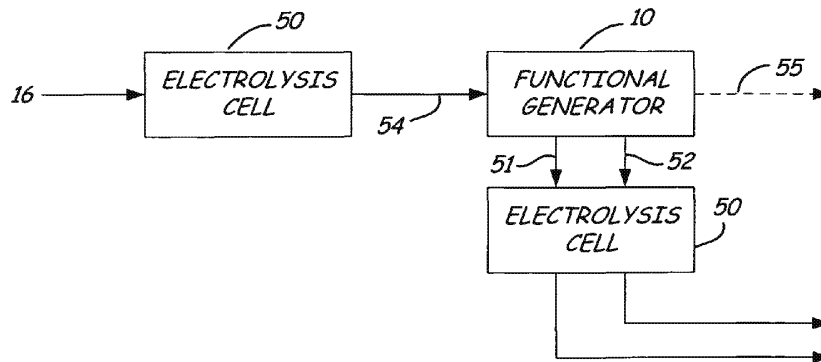
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(57) **ABSTRACT**

A method and apparatus are provided for receiving a cleaning liquid having a pH in a range between pH6-pH8 and an oxidation reduction potential (ORP) between ± 50 mV. The liquid is converted into an anolyte liquid and a catholyte liquid having respective pHs outside of the range between pH6-pH8 and having respective ORPs outside the range between ± 50 mV. The anolyte and catholyte liquids are applied to a surface, wherein the anolyte and catholyte liquids are, for example, in a combined state on the surface and substantially neutralize to a pH between pH6-pH8 and an ORP between ± 50 mV within one minute of the time at which the anolyte and catholyte liquids are converted.

19 Claims, 17 Drawing Sheets



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US 8,025,787 B2

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U.S. PATENT DOCUMENTS

4,630,167	A	12/1986	Huggins	361/213
4,663,091	A	5/1987	Seo	261/72.1
4,670,113	A	6/1987	Lewis	204/80
4,676,882	A	6/1987	Okazaki	204/260
4,687,558	A	8/1987	Justice et al.	204/59
4,705,191	A	11/1987	Irtzel et al.	222/80
4,810,344	A	3/1989	Okazaki	204/228
4,832,230	A	5/1989	Janowitz	222/80
4,875,988	A	10/1989	Aragon	204/265
5,186,860	A	2/1993	Joyce, Jr. et al.	252/500
5,292,406	A	3/1994	Wanngard et al.	204/95
5,316,646	A	5/1994	Arai	204/306
5,320,718	A	6/1994	Molter et al.	204/101
5,378,339	A	1/1995	Aoki et al.	204/260
5,536,389	A	7/1996	La Naur et al.	205/688
5,590,439	A	1/1997	Alazet	15/320
5,632,870	A	5/1997	Kuchеров	204/241
5,665,212	A	9/1997	Zhong et al.	304/297
5,733,434	A *	3/1998	Harada et al.	205/746
5,762,779	A *	6/1998	Shiramizu et al.	205/746
5,766,438	A	6/1998	Ishibashi et al.	204/520
5,779,891	A	7/1998	Andelman	210/198.2
5,815,869	A	10/1998	Hopkins	8/158
5,824,200	A	10/1998	Kitajima et al.	204/265
5,858,201	A	1/1999	Otsuka et al.	205/701
5,858,202	A	1/1999	Nakamura	205/746
5,928,505	A	7/1999	Inakagata et al.	210/91
5,931,859	A	8/1999	Burke	607/66
5,997,717	A	12/1999	Miyashita et al.	205/466
6,016,973	A	1/2000	Thompson et al.	239/304
6,032,655	A	3/2000	Kavonius	123/538
6,059,941	A	5/2000	Bryson et al.	204/263
6,088,211	A	7/2000	Pitel	361/212
6,101,671	A	8/2000	Wright et al.	15/365
6,110,353	A	8/2000	Hough	205/701
6,132,572	A	10/2000	Kim	204/253
6,200,434	B1	3/2001	Shinjo et al.	204/230.2
6,231,747	B1	5/2001	Fukuzuka et al.	205/500
6,315,886	B1	11/2001	Zappi et al.	205/701
6,375,827	B1	4/2002	Kurosu et al.	205/687
6,379,628	B2	4/2002	de Jong et al.	422/186.04
6,425,958	B1	7/2002	Giddings et al.	134/21
6,488,016	B2	12/2002	Kavonius	123/538
6,502,766	B1	1/2003	Streutker et al.	239/332
6,585,827	B2	7/2003	Field et al.	134/6
6,638,364	B2	10/2003	Harkins et al.	134/21
6,652,719	B1	11/2003	Tseng	204/257
6,689,262	B2	2/2004	Senkiw	204/278.5
6,703,785	B2	3/2004	Aiki et al.	315/111.81
6,719,891	B2	4/2004	Ruhr et al.	205/500
6,735,812	B2	5/2004	Hekman et al.	15/320
6,842,940	B2	1/2005	Christopher et al.	15/320
6,855,233	B2	2/2005	Sawada	204/263
6,878,287	B1	4/2005	Marais	210/748
6,921,743	B2	7/2005	Scheper et al.	510/220
6,926,819	B2	8/2005	Nakamura et al.	205/701
6,964,739	B2	11/2005	Boyd et al.	210/167
6,974,561	B1	12/2005	Thomason	422/186.29
7,008,523	B2	3/2006	Herrington	205/701
7,011,739	B2	3/2006	Harkins et al.	205/701
7,059,013	B2	6/2006	Wydra et al.	15/345
7,156,962	B2	1/2007	Koizumi et al.	204/292
7,160,472	B2	1/2007	Van Vliet et al.	201/748
7,226,542	B2	6/2007	Zemel et al.	210/748
7,238,272	B2	7/2007	Sano	205/701
2001/0002500	A1	6/2001	Kasen et al.	15/320
2001/0034922	A1	11/2001	Ko	15/320
2002/0023847	A1	2/2002	Natsume	205/687
2002/0027070	A1	3/2002	Oyokota et al.	204/257
2002/0032141	A1	3/2002	Harkins	510/253
2002/0074237	A1	6/2002	Takesako et al.	205/628
2002/0112314	A1	8/2002	Harkins	15/321
2002/0185423	A1	12/2002	Boyd et al.	210/167
2003/0001439	A1	1/2003	Schur	310/11
2003/0062068	A1	4/2003	Ko et al.	134/28
2003/0070919	A1	4/2003	Gilmore	204/275.1
2003/0102270	A1	6/2003	Schoeberl	210/748
2003/0159230	A1	8/2003	Oh	15/320

2003/0159231	A1	8/2003	Oh	15/320
2003/0159233	A1	8/2003	Oh	15/321
2003/0164306	A1	9/2003	Senkiw	205/633
2003/0213505	A1	11/2003	Price et al.	134/25.2
2004/0011665	A1	1/2004	Koizumi et al.	205/626
2004/0012913	A1	1/2004	Andelman	361/503
2004/0037737	A1	2/2004	Marais et al.	422/28
2004/0069611	A1	4/2004	MacGregor	204/157.15
2004/0112763	A1	6/2004	Itoh et al.	205/746
2004/0166019	A1	8/2004	Schultheiss	422/22
2004/0168933	A1	9/2004	Inoue	205/746
2004/0226123	A1	11/2004	Policicchio et al.	15/115
2004/0250323	A1	12/2004	Arai et al.	D32/1
2004/0256247	A1	12/2004	Carson et al.	205/688
2005/0121334	A1	6/2005	Sumita	205/628
2005/0126928	A1	6/2005	Hung et al.	205/746
2005/0136520	A1	6/2005	Kinley et al.	435/155
2005/0139239	A1	6/2005	Prae	134/34
2005/0139808	A1	6/2005	Alimi	252/187.26
2005/0194261	A1	9/2005	Hadia	205/701
2005/0244556	A1	11/2005	Karren	426/335
2006/0037869	A1	2/2006	Mitchke	205/701
2006/0076248	A1	4/2006	Kindred	205/743
2006/0162735	A1	7/2006	Thiebaut	132/200
2006/0169575	A1	8/2006	Sumita	204/164
2006/0231503	A1	10/2006	Flettner	210/748
2006/0263240	A1	11/2006	Hopkins	422/28
2006/0280664	A1	12/2006	Huang et al.	422/292
2007/0023273	A1	2/2007	Kitaori et al.	204/164
2007/0037267	A1	2/2007	Lewis et al.	435/161
2007/0141434	A1	6/2007	Joshi et al.	429/34
2007/0170072	A1	7/2007	Shyu	205/701
2007/0186367	A1	8/2007	Field et al.	15/320
2007/0186368	A1	8/2007	Field et al.	15/320
2007/0186957	A1	8/2007	Field et al.	134/18
2007/0186958	A1	8/2007	Field et al.	134/21
2007/0187263	A1	8/2007	Field et al.	205/742
2008/0264778	A1	10/2008	Joshi et al.	204/232
2009/0008268	A1	1/2009	Salathe et al.	205/746
2009/0127128	A1	5/2009	Kitaori et al.	205/464
2009/0162505	A1	6/2009	Kriebel et al.	426/335
2009/0184186	A1	7/2009	Suda et al.	239/690
2009/0235481	A1	9/2009	Gosebruch et al.	15/320
2010/0189805	A1	7/2010	Saefkow et al.	424/600
2010/0192987	A1	8/2010	Steffen	134/34

FOREIGN PATENT DOCUMENTS

CN	1440711	9/2003
CN	1845877	10/2006
CN	200977495	11/2007
DE	2951993	7/1981
DE	8430251	6/1984
DE	4406320	8/1995
DE	19752174	7/1998
DE	20210562	10/2002
DE	202004010572	11/2004
DE	202007005471	6/2007
DE	202007004181	8/2007
DE	102007017502	10/2008
EP	0041373	12/1981
EP	0104345	4/1984
EP	0199493	10/1986
EP	0438902	7/1991
EP	0636581	2/1995
EP	0663176	7/1995
EP	0672623	9/1995
EP	0740329	10/1996
EP	0761235	3/1997
EP	1000554	5/2000
EP	1008662	6/2000
EP	1162176	12/2001
EP	1188719	3/2002
EP	1293481	3/2003
EP	1308421	5/2003
EP	1065170	1/2004
EP	1386995	2/2004
EP	1309519	9/2004
EP	1533041	5/2005
EP	1671560	6/2006

TC00016872

US 8,025,787 B2

Page 3

EP	1741676	1/2007	WO	2007031779	3/2007
EP	1754804	2/2007	WO	2007093395	8/2007
EP	1903128	3/2008	WO	2007095072	8/2007
EP	1932809	6/2008	WO	2007095074	8/2007
EP	1941912	7/2008	WO	2007138363	12/2007
EP	1978142	10/2008	WO	2007142693	12/2007
EP	2050378	4/2009	WO	2007145058	12/2007
EP	2078700	7/2009	WO	2007145385	12/2007
EP	2100623	9/2009	WO	2008032544	3/2008
EP	2103244	9/2009	WO	2008061546	5/2008
EP	2168604	3/2010	WO	2008131389	10/2008
FR	2381835	9/1978	WO	2009011841	1/2009
FR	2909370	6/2008	WO	2009039674	4/2009
GB	611819	11/1948	WO	2009040407	4/2009
GB	2149423	11/1983	WO	2009046563	4/2009
GB	2141738	1/1985	WO	2009067838	6/2009
GB	2298858	9/1996	WO	2010055108	5/2010
GB	2381187	4/2003			
GB	2393737	4/2004			
JP	62023663	2/1987			
JP	1111483	4/1989			
JP	03-157188	7/1991			
JP	7233493	5/1995			
JP	07263391	10/1995			
JP	08112574	5/1996			
JP	09-075427	3/1997			
JP	1997-174054	7/1997			
JP	11090442	9/1997			
JP	10057282	3/1998			
JP	11010159	1/1999			
JP	2000-079393	3/2000			
JP	2002-102856	4/2002			
JP	2002-186969	7/2002			
JP	2003-062573	3/2003			
JP	2003-181338	7/2003			
JP	2003-261190	9/2003			
JP	2003-3266073	9/2003			
JP	2003-334557	11/2003			
JP	2004-073914	3/2004			
JP	2004-129954	4/2004			
JP	2004-148108	5/2004			
JP	2004-148109	5/2004			
JP	2005-535783	11/2005			
JP	2006-036341	9/2006			
JP	2007-000402	1/2007			
JP	2007-136356	6/2007			
JP	2007-239041	9/2007			
KR	2001-0096847	11/2001			
KR	2002-0025023	11/2003			
KR	2006-0007369	1/2006			
KR	100599229	7/2006			
KR	2009-0123297	12/2009			
NL	1012257	12/2000			
WO	8606098	10/1986			
WO	WO 98/18723	5/1998			
WO	9846874	10/1998			
WO	9908719	2/1999			
WO	9963843	12/1999			
WO	0015561	3/2000			
WO	0118279	3/2001			
WO	0214228	2/2002			
WO	02066382	8/2002			
WO	02102716	12/2002			
WO	03009920	2/2003			
WO	03022444	3/2003			
WO	03040038	5/2003			
WO	2004015172	2/2004			
WO	2004079051	9/2004			
WO	2004079051	9/2004			
WO	2004106242	12/2004			
WO	2004108607	12/2004			
WO	2005014058	2/2005			
WO	2005020780	3/2005			
WO	2005079468	9/2005			
WO	2005093129	10/2005			
WO	2005094904	10/2005			
WO	2005097350	10/2005			
WO	2005012186	2/2006			
WO	2006124805	11/2006			

OTHER PUBLICATIONS

"Fast-Foam Scrubbing Technology, The Safe Scrubbing Alternative, T5-Parts Manual," Tennant Company, www.tennantco.com, 2006.

"Fast-Foam Scrubbing Technology, The Safe Scrubbing Alternative, T5-Scrubber-Dryer Operator Manual," Tennant Company, www.tennantco.com, 2006.

"ECO Smarte-The Best Multiple Mineral Technology for Problem Well Water; The Best Chemical Reduction System for City Water Complete Bacteria and Scale Control," ECOsmarte® Planet Friendly, Inc., <http://www.ecosmarte.com/sciencesummary.html>, 1994, pp. 1-13.

"Krebs Engineers® Products," 2006 Krebs Engineers, <http://www.krebs.com/about.php/> and <http://www.krebs.com/products/php/product/20/CycloClean%AE+Modules>, 2006, pp. 1-3.

"The Oxygenator Livelier Bait-Healthier fish," Aqua Innovations, Inc., aquainnovationsinc.com, published prior to Jan. 19, 2007, pp. 1-2.

"JP102 Water Cell," Emco Tech Co., LTD. of Goyang-City Kyungki-Do, South Korea, Oct. 18, 2006, pp. 1.

Mary Jones, "Richfield-Based EcoSmarte has Perfected a Natural and Profitable-Approach to Water Purification," Minnesota Technology, Inside Technology and Manufacturing Business, Fall 2005, pp. 1-3.

Restriction Requirement from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,385, dated Dec. 9, 2009.

Final Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,390, dated Jan. 11, 2010.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,378, dated Jan. 14, 2010.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,385, dated Jan. 29, 2010.

English Translation of Chinese Office Action for Corresponding Chinese Patent Application No. 200780005069.8 dated Jan. 8, 2010. Written Opinion dated Jul. 23, 2007 from counterpart foreign application No. PCT/US2007/003443 filed Feb. 8, 2007.

International Preliminary Report on Patentability dated May 5, 2008 from counterpart foreign application No. PCT/US2007/003443 filed Feb. 8, 2007.

Bluhm, Hans J. et al., "Disruption and Destruction of Biological Cells Using Strong Pulsed Electric Fields" Nachrichten, Karlsruhe, DE, vol. 3, Jan. 1, 2005, pp. 105-110.

Final Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,378, dated Jul. 2, 2010.

Notice of Allowance from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,385, dated Jul. 14, 2010.

Chinese Office Action with English Translation dated Jun. 9, 2010 for corresponding Chinese Application No. 200780010434.8, filed Feb. 8, 2007.

JP-HC15022149.

"Conductive Polymers: Evaluation of Industrial Applications" Synthetic Metals, 55-57 (1993) 3623-3631 S. Roth et al.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,390, dated Jan. 19, 2007.

TC00016873

US 8,025,787 B2

Page 4

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,359, dated Mar. 19, 2009.

Restriction Requirement from the United States Patent and Trademark Office for Appl. No. 11/655,390, dated Apr. 10, 2009.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,390, dated Jul. 16, 2009.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,359, dated Nov. 13, 2009.

Notice of Allowance from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,390, dated Jan. 6, 2011.

Office Action from the United States Patent and Trademark Office for U.S. Appl. 11/655,390, dated Jul. 19, 2010.

Restriction/Election Requirement from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,365, dated Aug. 17, 2010.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,359, dated Aug. 18, 2010.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,378, dated Sep. 9, 2010.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,360, dated Sep. 30, 2010.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 12/122,350, dated Sep. 30, 2010.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,310, dated Oct. 1, 2010.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,389, dated Oct. 1, 2010.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,365, dated Dec. 3, 2010.

Final Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,378, dated Jan. 25, 2011.

Office Action from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,359, dated Feb. 3, 2011.

Notice of Allowance from the United States Patent and Trademark Office for U.S. Appl. No. 12/122,350, dated Mar. 16, 2011.

Notice of Allowance from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,389, dated Mar. 17, 2011.

Notice of Allowance from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,360, dated Mar. 18, 2011.

Notice of Allowance from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,310, dated Mar. 23, 2011.

English Translation of Japanese Office Action dated May 25, 2011 for corresponding Japanese Application No. 2008-554350.

Notice of Allowability from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,378, dated Apr. 28, 2011.

Notice of Allowance from the United States Patent and Trademark Office for U.S. Appl. No. 11/655,378, dated May 10, 2011.

English Translation of Japanese Office Action dated Jun. 17, 2011 for Japanese Patent Application No. 2008-554363.

English Translation of Japanese Office Action dated May 31, 2011 for Japanese Patent Application No. 2008/554377.

* cited by examiner

TC00016874

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