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Systems and methods for managing fluid and suction in electrosurgical systems

Abstract

Aspects of the present disclosure include control systems of an electrosurgical system for managing the flow of fluid, such as saline, and rates of aspiration or suction, in response to various states of conditions at a surgical site. The control system(s) may monitor and adjust to impedance at the surgical site, temperature of the surgical tissue, and/or RF current of electrodes, and may account for certain undesirable conditions, such as the electrodes sticking. The control systems may include various automatic sensing scenarios, while also allowing for several manual conditions.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
2366274	12/1944	Luth et al.	N/A	N/A
2458152	12/1948	Eakins	N/A	N/A
2510693	12/1949	Green	N/A	N/A
2736960	12/1955	Armstrong	N/A	N/A
2849788	12/1957	Creek	N/A	N/A
2867039	12/1958	Zach	N/A	N/A
3015961	12/1961	Roney	N/A	N/A
3043309	12/1961	McCarthy	N/A	N/A
3166971	12/1964	Stoecker	N/A	N/A
3358676	12/1966	Frei et al.	N/A	N/A
3525912	12/1969	Wallin	N/A	N/A
3526219	12/1969	Balamuth	N/A	N/A
3580841	12/1970	Cadotte et al.	N/A	N/A
3614484	12/1970	Shoh	N/A	N/A
3636943	12/1971	Balamuth	N/A	N/A

3703651	12/1971	Blowers	N/A	N/A
3710399	12/1972	Hurst	N/A	N/A
3776238	12/1972	Peyman et al.	N/A	N/A
3777760	12/1972	Essner	N/A	N/A
3805787	12/1973	Banko	N/A	N/A
3862630	12/1974	Balamuth	N/A	N/A
3900823	12/1974	Sokal et al.	N/A	N/A
3906217	12/1974	Lackore	N/A	N/A
3918442	12/1974	Nikolaev et al.	N/A	N/A
3946738	12/1975	Newton et al.	N/A	N/A
3955859	12/1975	Stella et al.	N/A	N/A
3956826	12/1975	Perdreaux, Jr.	N/A	N/A
3988535	12/1975	Hickman et al.	N/A	N/A
4005714	12/1976	Hiltebrandt	N/A	N/A
4034762	12/1976	Cosens et al.	N/A	N/A
4047136	12/1976	Satto	N/A	N/A
4058126	12/1976	Leveen	N/A	N/A
4063561	12/1976	McKenna	N/A	N/A
4099192	12/1977	Aizawa et al.	N/A	N/A
4156187	12/1978	Murry et al.	N/A	N/A
4188927	12/1979	Harris	N/A	N/A
4200106	12/1979	Douvas et al.	N/A	N/A
4203430	12/1979	Takahashi	N/A	N/A
4220154	12/1979	Semm	N/A	N/A
4237441	12/1979	van Konynenburg et al.	N/A	N/A
4278077	12/1980	Mizumoto	N/A	N/A
4281785	12/1980	Brooks	N/A	N/A
4304987	12/1980	van Konynenburg	N/A	N/A
4314559	12/1981	Allen	N/A	N/A
4384584	12/1982	Chen	N/A	N/A
4445063	12/1983	Smith	N/A	N/A
4463759	12/1983	Garito et al.	N/A	N/A
4491132	12/1984	Aikins	N/A	N/A
4492231	12/1984	Auth	N/A	N/A
4535773	12/1984	Yoon	N/A	N/A
4545926	12/1984	Fouts, Jr. et al.	N/A	N/A
4550870	12/1984	Krumme et al.	N/A	N/A
4582236	12/1985	Hirose	N/A	N/A
4585282	12/1985	Bosley	N/A	N/A
4597390	12/1985	Mulhollan et al.	N/A	N/A
4617927	12/1985	Manes	N/A	N/A
4633874	12/1986	Chow et al.	N/A	N/A
4634420	12/1986	Spinosa et al.	N/A	N/A
4640279	12/1986	Beard	N/A	N/A
4655746	12/1986	Daniels et al.	N/A	N/A
4671287	12/1986	Fiddian-Green	N/A	N/A
4708127	12/1986	Abdelghani	N/A	N/A
4735603	12/1987	Goodson et al.	N/A	N/A
4761871	12/1987	O'Connor et al.	N/A	N/A

4777951	12/1987	Cribier et al.	N/A	N/A
4797803	12/1988	Carroll	N/A	N/A
4798588	12/1988	Aillon	N/A	N/A
4802461	12/1988	Cho	N/A	N/A
4803506	12/1988	Diehl et al.	N/A	N/A
4830462	12/1988	Karny et al.	N/A	N/A
4832683	12/1988	Idemoto et al.	N/A	N/A
4838853	12/1988	Parisi	N/A	N/A
4849133	12/1988	Yoshida et al.	N/A	N/A
4850354	12/1988	McGurk-Burleson et al.	N/A	N/A
4860745	12/1988	Farin et al.	N/A	N/A
4865159	12/1988	Jamison	N/A	N/A
4878493	12/1988	Pasternak et al.	N/A	N/A
4880015	12/1988	Nierman	N/A	N/A
4896009	12/1989	Pawlowski	N/A	N/A
4910389	12/1989	Sherman et al.	N/A	N/A
4910633	12/1989	Quinn	N/A	N/A
4911148	12/1989	Sosnowski et al.	N/A	N/A
4919129	12/1989	Weber, Jr. et al.	N/A	N/A
4920978	12/1989	Colvin	N/A	N/A
4922902	12/1989	Wuchinich et al.	N/A	N/A
4936842	12/1989	D'Amelio et al.	N/A	N/A
4961738	12/1989	Mackin	N/A	N/A
4967670	12/1989	Morishita et al.	N/A	N/A
4981756	12/1990	Rhandhawa	N/A	N/A
5007919	12/1990	Silva et al.	N/A	N/A
5019075	12/1990	Spears et al.	N/A	N/A
5020514	12/1990	Heckele	N/A	N/A
5026387	12/1990	Thomas	N/A	N/A
5061269	12/1990	Muller	N/A	N/A
5093754	12/1991	Kawashima	N/A	N/A
5099216	12/1991	Pelrine	N/A	N/A
5099840	12/1991	Goble et al.	N/A	N/A
5104025	12/1991	Main et al.	N/A	N/A
5106538	12/1991	Barma et al.	N/A	N/A
5108383	12/1991	White	N/A	N/A
5112300	12/1991	Ureche	N/A	N/A
5123903	12/1991	Quaid et al.	N/A	N/A
5150102	12/1991	Takashima	N/A	N/A
5150272	12/1991	Danley et al.	N/A	N/A
5156633	12/1991	Smith	N/A	N/A
5160334	12/1991	Billings et al.	N/A	N/A
5162044	12/1991	Gahn et al.	N/A	N/A
5167725	12/1991	Clark et al.	N/A	N/A
D332660	12/1992	Rawson et al.	N/A	N/A
5176695	12/1992	Dulebohn	N/A	N/A
5184605	12/1992	Grzeszykowski	N/A	N/A
5188102	12/1992	Idemoto et al.	N/A	N/A
5190541	12/1992	Abele et al.	N/A	N/A

5196007	12/1992	Ellman et al.	N/A	N/A
5205459	12/1992	Brinkerhoff et al.	N/A	N/A
5205817	12/1992	Idemoto et al.	N/A	N/A
5209719	12/1992	Baruch et al.	N/A	N/A
5213569	12/1992	Davis	N/A	N/A
5217460	12/1992	Knoepfler	N/A	N/A
5221282	12/1992	Wuchinich	N/A	N/A
5226910	12/1992	Kajiyama et al.	N/A	N/A
5234428	12/1992	Kaufman	N/A	N/A
5241236	12/1992	Sasaki et al.	N/A	N/A
5253647	12/1992	Takahashi et al.	N/A	N/A
5254130	12/1992	Poncet et al.	N/A	N/A
5257988	12/1992	L'Esperance, Jr.	N/A	N/A
5258004	12/1992	Bales et al.	N/A	N/A
5258006	12/1992	Rydell et al.	N/A	N/A
5261922	12/1992	Hood	N/A	N/A
5263957	12/1992	Davison	N/A	N/A
5267091	12/1992	Chen	N/A	N/A
5282800	12/1993	Foshee et al.	N/A	N/A
5285945	12/1993	Brinkerhoff et al.	N/A	N/A
5290286	12/1993	Parins	N/A	N/A
5293863	12/1993	Zhu et al.	N/A	N/A
5304115	12/1993	Pflueger et al.	N/A	N/A
D347474	12/1993	Olson	N/A	N/A
5309927	12/1993	Welch	N/A	N/A
5312023	12/1993	Green et al.	N/A	N/A
5313306	12/1993	Kuban et al.	N/A	N/A
5318563	12/1993	Malis et al.	N/A	N/A
5318564	12/1993	Eggers	N/A	N/A
5318565	12/1993	Kuriloff et al.	N/A	N/A
5318570	12/1993	Hood et al.	N/A	N/A
5318589	12/1993	Lichtman	N/A	N/A
5322055	12/1993	Davison et al.	N/A	N/A
5324260	12/1993	O'Neill et al.	N/A	N/A
5324299	12/1993	Davison et al.	N/A	N/A
5326013	12/1993	Green et al.	N/A	N/A
5330471	12/1993	Eggers	N/A	N/A
5330502	12/1993	Hassler et al.	N/A	N/A
5333624	12/1993	Tovey	N/A	N/A
5339723	12/1993	Huitema	N/A	N/A
5342359	12/1993	Rydell	N/A	N/A
5344420	12/1993	Hilal et al.	N/A	N/A
5346502	12/1993	Estabrook et al.	N/A	N/A
5352219	12/1993	Reddy	N/A	N/A
5359992	12/1993	Hori et al.	N/A	N/A
5361583	12/1993	Huitema	N/A	N/A
5366466	12/1993	Christian et al.	N/A	N/A
5370640	12/1993	Kolff	N/A	N/A
D354564	12/1994	Medema	N/A	N/A
5381067	12/1994	Greenstein et al.	N/A	N/A

5383874	12/1994	Jackson et al.	N/A	N/A
5387207	12/1994	Dyer et al.	N/A	N/A
5389098	12/1994	Tsuruta et al.	N/A	N/A
5395033	12/1994	Byrne et al.	N/A	N/A
5395312	12/1994	Desai	N/A	N/A
5395331	12/1994	O'Neill et al.	N/A	N/A
5395363	12/1994	Billings et al.	N/A	N/A
5395364	12/1994	Anderhub et al.	N/A	N/A
5396266	12/1994	Brimhall	N/A	N/A
5396900	12/1994	Slater et al.	N/A	N/A
5403312	12/1994	Yates et al.	N/A	N/A
5409483	12/1994	Campbell et al.	N/A	N/A
D358887	12/1994	Feinberg	N/A	N/A
5411481	12/1994	Allen et al.	N/A	N/A
5413575	12/1994	Haenggi	N/A	N/A
5417709	12/1994	Slater	N/A	N/A
5419761	12/1994	Narayanan et al.	N/A	N/A
5421829	12/1994	Olichney et al.	N/A	N/A
5428504	12/1994	Bhatla	N/A	N/A
5429131	12/1994	Scheinman et al.	N/A	N/A
5431640	12/1994	Gabriel	N/A	N/A
5443463	12/1994	Stern et al.	N/A	N/A
5445615	12/1994	Yoon	N/A	N/A
5445638	12/1994	Rydell et al.	N/A	N/A
5449370	12/1994	Vaitekunas	N/A	N/A
5451227	12/1994	Michaelson	N/A	N/A
5456684	12/1994	Schmidt et al.	N/A	N/A
5458598	12/1994	Feinberg et al.	N/A	N/A
5462604	12/1994	Shibano et al.	N/A	N/A
5465895	12/1994	Knodel et al.	N/A	N/A
5472443	12/1994	Cordis et al.	N/A	N/A
5476479	12/1994	Green et al.	N/A	N/A
5477788	12/1994	Morishita	N/A	N/A
5478003	12/1994	Green et al.	N/A	N/A
5480409	12/1995	Riza	N/A	N/A
5483501	12/1995	Park et al.	N/A	N/A
5484436	12/1995	Eggers et al.	N/A	N/A
5486162	12/1995	Brumbach	N/A	N/A
5486189	12/1995	Mudry et al.	N/A	N/A
5489256	12/1995	Adair	N/A	N/A
5496317	12/1995	Goble et al.	N/A	N/A
5500216	12/1995	Julian et al.	N/A	N/A
5501654	12/1995	Failla et al.	N/A	N/A
5504650	12/1995	Katsui et al.	N/A	N/A
5505693	12/1995	Mackool	N/A	N/A
5509922	12/1995	Aranyi et al.	N/A	N/A
5511556	12/1995	DeSantis	N/A	N/A
5520704	12/1995	Castro et al.	N/A	N/A
5522839	12/1995	Pilling	N/A	N/A
5531744	12/1995	Nardella et al.	N/A	N/A

5540648	12/1995	Yoon	N/A	N/A
5540681	12/1995	Strul et al.	N/A	N/A
5542916	12/1995	Hirsch et al.	N/A	N/A
5542938	12/1995	Avellanet et al.	N/A	N/A
5558671	12/1995	Yates	N/A	N/A
5562609	12/1995	Brumbach	N/A	N/A
5562610	12/1995	Brumbach	N/A	N/A
5562657	12/1995	Griffin	N/A	N/A
5563179	12/1995	Stone et al.	N/A	N/A
5569164	12/1995	Lurz	N/A	N/A
5571121	12/1995	Heifetz	N/A	N/A
5573534	12/1995	Stone	N/A	N/A
5584830	12/1995	Ladd et al.	N/A	N/A
5599350	12/1996	Schulze et al.	N/A	N/A
5601601	12/1996	Tal et al.	N/A	N/A
5604531	12/1996	Iddan et al.	N/A	N/A
5607436	12/1996	Pratt et al.	N/A	N/A
5607450	12/1996	Zvenyatsky et al.	N/A	N/A
5609573	12/1996	Sandock	N/A	N/A
5611813	12/1996	Lichtman	N/A	N/A
5618307	12/1996	Donlon et al.	N/A	N/A
5618492	12/1996	Auten et al.	N/A	N/A
5624452	12/1996	Yates	N/A	N/A
5626578	12/1996	Tihon	N/A	N/A
5628760	12/1996	Knoepfler	N/A	N/A
5630420	12/1996	Vaitekunas	N/A	N/A
5632432	12/1996	Schulze et al.	N/A	N/A
D381077	12/1996	Hunt	N/A	N/A
5643175	12/1996	Adair	N/A	N/A
5645065	12/1996	Shapiro et al.	N/A	N/A
5647871	12/1996	Levine et al.	N/A	N/A
5651780	12/1996	Jackson et al.	N/A	N/A
5653677	12/1996	Okada et al.	N/A	N/A
5653713	12/1996	Michelson	N/A	N/A
5657697	12/1996	Murai	N/A	N/A
5658281	12/1996	Heard	N/A	N/A
5662667	12/1996	Knodel	N/A	N/A
5665085	12/1996	Nardella	N/A	N/A
5665100	12/1996	Yoon	N/A	N/A
5669922	12/1996	Hood	N/A	N/A
5674219	12/1996	Monson et al.	N/A	N/A
5674220	12/1996	Fox et al.	N/A	N/A
5674235	12/1996	Parisi	N/A	N/A
5681260	12/1996	Ueda et al.	N/A	N/A
5688270	12/1996	Yates et al.	N/A	N/A
5690269	12/1996	Bolanos et al.	N/A	N/A
5693051	12/1996	Schulze et al.	N/A	N/A
5694936	12/1996	Fujimoto et al.	N/A	N/A
5700243	12/1996	Narciso, Jr.	N/A	N/A
5700261	12/1996	Brinkerhoff	N/A	N/A

5704900	12/1997	Dobrovolny et al.	N/A	N/A
5709680	12/1997	Yates et al.	N/A	N/A
5711472	12/1997	Bryan	N/A	N/A
5713896	12/1997	Nardella	N/A	N/A
5716366	12/1997	Yates	N/A	N/A
5720742	12/1997	Zacharias	N/A	N/A
5720744	12/1997	Eggleston et al.	N/A	N/A
5722326	12/1997	Post	N/A	N/A
5722426	12/1997	Kolff	N/A	N/A
5732636	12/1997	Wang et al.	N/A	N/A
5733074	12/1997	Stock et al.	N/A	N/A
5735848	12/1997	Yates et al.	N/A	N/A
5738652	12/1997	Boyd et al.	N/A	N/A
5741226	12/1997	Strukel et al.	N/A	N/A
5741305	12/1997	Vincent et al.	N/A	N/A
5743906	12/1997	Parins et al.	N/A	N/A
5752973	12/1997	Kieturakis	N/A	N/A
5755717	12/1997	Yates et al.	N/A	N/A
5762255	12/1997	Chrisman et al.	N/A	N/A
5776130	12/1997	Buysse et al.	N/A	N/A
5779701	12/1997	McBrayer et al.	N/A	N/A
5782834	12/1997	Lucey et al.	N/A	N/A
5792135	12/1997	Madhani et al.	N/A	N/A
5792138	12/1997	Shipp	N/A	N/A
5796188	12/1997	Bays	N/A	N/A
5797941	12/1997	Schulze et al.	N/A	N/A
5800432	12/1997	Swanson	N/A	N/A
5800449	12/1997	Wales	N/A	N/A
5805140	12/1997	Rosenberg et al.	N/A	N/A
5807393	12/1997	Williamson, IV et al.	N/A	N/A
5810718	12/1997	Akiba et al.	N/A	N/A
5810811	12/1997	Yates et al.	N/A	N/A
5810859	12/1997	DiMatteo et al.	N/A	N/A
5817033	12/1997	DeSantis et al.	N/A	N/A
5817084	12/1997	Jensen	N/A	N/A
5817093	12/1997	Williamson, IV et al.	N/A	N/A
5827323	12/1997	Klieman et al.	N/A	N/A
5828160	12/1997	Sugishita	N/A	N/A
5836867	12/1997	Speier et al.	N/A	N/A
5836909	12/1997	Cosmescu	N/A	N/A
5836943	12/1997	Miller, III	N/A	N/A
5836990	12/1997	Li	N/A	N/A
5843109	12/1997	Mehta et al.	N/A	N/A
5853412	12/1997	Mayenberger	N/A	N/A
5876401	12/1998	Schulze et al.	N/A	N/A
5878193	12/1998	Wang et al.	N/A	N/A
5879364	12/1998	Bromfield et al.	N/A	N/A
5880668	12/1998	Hall	N/A	N/A

5883454	12/1998	Hones et al.	N/A	N/A
5887018	12/1998	Bayazitoglu et al.	N/A	N/A
5891142	12/1998	Eggers et al.	N/A	N/A
5893835	12/1998	Witt et al.	N/A	N/A
5897569	12/1998	Kellogg et al.	N/A	N/A
5902239	12/1998	Buurman	N/A	N/A
5904147	12/1998	Conlan et al.	N/A	N/A
5906579	12/1998	Vander Salm et al.	N/A	N/A
5906625	12/1998	Bito et al.	N/A	N/A
5910129	12/1998	Koblish et al.	N/A	N/A
5921956	12/1998	Grinberg et al.	N/A	N/A
5929846	12/1998	Rosenberg et al.	N/A	N/A
5935143	12/1998	Hood	N/A	N/A
5935144	12/1998	Estabrook	N/A	N/A
5938633	12/1998	Beaupre	N/A	N/A
5944298	12/1998	Koike	N/A	N/A
5944718	12/1998	Austin et al.	N/A	N/A
5944737	12/1998	Tsonton et al.	N/A	N/A
5954736	12/1998	Bishop et al.	N/A	N/A
5954746	12/1998	Holthaus et al.	N/A	N/A
5957849	12/1998	Munro	N/A	N/A
5957882	12/1998	Nita et al.	N/A	N/A
5957943	12/1998	Vaitekunas	N/A	N/A
5968007	12/1998	Simon et al.	N/A	N/A
5968060	12/1998	Kellogg	N/A	N/A
D416089	12/1998	Barton et al.	N/A	N/A
5984938	12/1998	Yoon	N/A	N/A
5989182	12/1998	Hori et al.	N/A	N/A
5989274	12/1998	Davison et al.	N/A	N/A
5989275	12/1998	Estabrook et al.	N/A	N/A
5993972	12/1998	Reich et al.	N/A	N/A
6003517	12/1998	Sheffield et al.	N/A	N/A
6007484	12/1998	Thompson	N/A	N/A
6013052	12/1999	Durman et al.	N/A	N/A
6014580	12/1999	Blume et al.	N/A	N/A
6024741	12/1999	Williamson, IV et al.	N/A	N/A
6024744	12/1999	Kese et al.	N/A	N/A
6033375	12/1999	Brumbach	N/A	N/A
6033399	12/1999	Gines	N/A	N/A
6039734	12/1999	Goble	N/A	N/A
6050996	12/1999	Schmaltz et al.	N/A	N/A
6053172	12/1999	Hovda et al.	N/A	N/A
6063098	12/1999	Houser et al.	N/A	N/A
6066132	12/1999	Chen et al.	N/A	N/A
6068629	12/1999	Haissaguerre et al.	N/A	N/A
6068647	12/1999	Witt et al.	N/A	N/A
6074389	12/1999	Levine et al.	N/A	N/A
6077285	12/1999	Boukhny	N/A	N/A
6080152	12/1999	Nardella et al.	N/A	N/A

6083151	12/1999	Renner et al.	N/A	N/A
6083191	12/1999	Rose	N/A	N/A
6086584	12/1999	Miller	N/A	N/A
6090120	12/1999	Wright et al.	N/A	N/A
6091995	12/1999	Ingle et al.	N/A	N/A
6093186	12/1999	Goble	N/A	N/A
6099483	12/1999	Palmer et al.	N/A	N/A
6099550	12/1999	Yoon	N/A	N/A
6109500	12/1999	Alli et al.	N/A	N/A
6113594	12/1999	Savage	N/A	N/A
6113598	12/1999	Baker	N/A	N/A
6123466	12/1999	Persson et al.	N/A	N/A
H1904	12/1999	Yates et al.	N/A	N/A
6127757	12/1999	Swinbanks	N/A	N/A
6132368	12/1999	Cooper	N/A	N/A
6139320	12/1999	Hahn	N/A	N/A
6144402	12/1999	Norsworthy et al.	N/A	N/A
6152902	12/1999	Christian et al.	N/A	N/A
6152923	12/1999	Ryan	N/A	N/A
6154198	12/1999	Rosenberg	N/A	N/A
6159160	12/1999	Hsei et al.	N/A	N/A
6159175	12/1999	Strukel et al.	N/A	N/A
6162208	12/1999	Hipps	N/A	N/A
6173199	12/2000	Gabriel	N/A	N/A
6173715	12/2000	Sinanan et al.	N/A	N/A
6174309	12/2000	Wrublewski et al.	N/A	N/A
6176857	12/2000	Ashley	N/A	N/A
6190386	12/2000	Rydell	N/A	N/A
6193709	12/2000	Miyawaki et al.	N/A	N/A
6206844	12/2000	Reichel et al.	N/A	N/A
6206876	12/2000	Levine et al.	N/A	N/A
6206877	12/2000	Kese et al.	N/A	N/A
6210403	12/2000	Klicek	N/A	N/A
6214023	12/2000	Whipple et al.	N/A	N/A
6219572	12/2000	Young	N/A	N/A
6221007	12/2000	Green	N/A	N/A
6228080	12/2000	Gines	N/A	N/A
6228084	12/2000	Kirwan, Jr.	N/A	N/A
6231565	12/2000	Tovey et al.	N/A	N/A
6233476	12/2000	Strommer et al.	N/A	N/A
6238366	12/2000	Savage et al.	N/A	N/A
6241724	12/2000	Fleischman et al.	N/A	N/A
6248074	12/2000	Ohno et al.	N/A	N/A
D444365	12/2000	Bass et al.	N/A	N/A
6254623	12/2000	Haibel, Jr. et al.	N/A	N/A
6258034	12/2000	Hanafy	N/A	N/A
6258086	12/2000	Ashley et al.	N/A	N/A
6259230	12/2000	Chou	N/A	N/A
6267761	12/2000	Ryan	N/A	N/A
6270831	12/2000	Kumar et al.	N/A	N/A

6273852	12/2000	Lehe et al.	N/A	N/A
6273887	12/2000	Yamauchi et al.	N/A	N/A
6274963	12/2000	Estabrook et al.	N/A	N/A
6277115	12/2000	Saadat	N/A	N/A
6277117	12/2000	Tetzlaff et al.	N/A	N/A
6278218	12/2000	Madan et al.	N/A	N/A
6283981	12/2000	Beaupre	N/A	N/A
6292700	12/2000	Morrison et al.	N/A	N/A
6309400	12/2000	Beaupre	N/A	N/A
6315789	12/2000	Cragg	N/A	N/A
6319221	12/2000	Savage et al.	N/A	N/A
6325799	12/2000	Goble	N/A	N/A
6325811	12/2000	Messerly	N/A	N/A
6328751	12/2000	Beaupre	N/A	N/A
6340878	12/2001	Oglesbee	N/A	N/A
6352532	12/2001	Kramer et al.	N/A	N/A
6364888	12/2001	Niemeyer et al.	N/A	N/A
6371952	12/2001	Madhani et al.	N/A	N/A
6379320	12/2001	Lafon et al.	N/A	N/A
6379351	12/2001	Thapliyal et al.	N/A	N/A
D457958	12/2001	Dycus et al.	N/A	N/A
6383194	12/2001	Pothula	N/A	N/A
6387094	12/2001	Eitenmuller	N/A	N/A
6387109	12/2001	Davison et al.	N/A	N/A
6388657	12/2001	Natoli	N/A	N/A
6391026	12/2001	Hung et al.	N/A	N/A
6391042	12/2001	Cimino	N/A	N/A
6398779	12/2001	Buysse et al.	N/A	N/A
6409722	12/2001	Hoey et al.	N/A	N/A
H2037	12/2001	Yates et al.	N/A	N/A
6416469	12/2001	Phung et al.	N/A	N/A
6416486	12/2001	Wampler	N/A	N/A
6419675	12/2001	Gallo, Sr.	N/A	N/A
6423073	12/2001	Bowman	N/A	N/A
6423082	12/2001	Houser et al.	N/A	N/A
6430446	12/2001	Knowlton	N/A	N/A
6432118	12/2001	Messerly	N/A	N/A
6436114	12/2001	Novak et al.	N/A	N/A
6436115	12/2001	Beaupre	N/A	N/A
6443968	12/2001	Holthaus et al.	N/A	N/A
6443969	12/2001	Novak et al.	N/A	N/A
6454781	12/2001	Witt et al.	N/A	N/A
6454782	12/2001	Schwemberger	N/A	N/A
6458128	12/2001	Schulze	N/A	N/A
6458130	12/2001	Frazier et al.	N/A	N/A
6458142	12/2001	Faller et al.	N/A	N/A
6461363	12/2001	Gadberry et al.	N/A	N/A
6464689	12/2001	Qin et al.	N/A	N/A
6464702	12/2001	Schulze et al.	N/A	N/A
6464703	12/2001	Bartel	N/A	N/A

6471172	12/2001	Lemke et al.	N/A	N/A
6475211	12/2001	Chess et al.	N/A	N/A
6475216	12/2001	Mulier et al.	N/A	N/A
6480796	12/2001	Wiener	N/A	N/A
6485490	12/2001	Wampler et al.	N/A	N/A
6491690	12/2001	Goble et al.	N/A	N/A
6491691	12/2001	Morley et al.	N/A	N/A
6491701	12/2001	Tierney et al.	N/A	N/A
6491708	12/2001	Madan et al.	N/A	N/A
6497715	12/2001	Satou	N/A	N/A
6500112	12/2001	Khouri	N/A	N/A
6500176	12/2001	Truckai et al.	N/A	N/A
6500188	12/2001	Harper et al.	N/A	N/A
6503248	12/2002	Levine	N/A	N/A
6506208	12/2002	Hunt et al.	N/A	N/A
6511480	12/2002	Tetzlaff et al.	N/A	N/A
6514252	12/2002	Nezhat et al.	N/A	N/A
6517565	12/2002	Whitman et al.	N/A	N/A
6520960	12/2002	Blocher et al.	N/A	N/A
6522909	12/2002	Garibaldi et al.	N/A	N/A
6524316	12/2002	Nicholson et al.	N/A	N/A
6531846	12/2002	Smith	N/A	N/A
6533784	12/2002	Truckai et al.	N/A	N/A
6537196	12/2002	Creighton, IV et al.	N/A	N/A
6537272	12/2002	Christopherson et al.	N/A	N/A
6537291	12/2002	Friedman et al.	N/A	N/A
6540693	12/2002	Burbank et al.	N/A	N/A
6543456	12/2002	Freeman	N/A	N/A
6544260	12/2002	Markel et al.	N/A	N/A
6551309	12/2002	LePivert	N/A	N/A
6554829	12/2002	Schulze et al.	N/A	N/A
6558376	12/2002	Bishop	N/A	N/A
6561983	12/2002	Cronin et al.	N/A	N/A
6562037	12/2002	Paton et al.	N/A	N/A
6572632	12/2002	Zisterer et al.	N/A	N/A
6572639	12/2002	Ingle et al.	N/A	N/A
6575969	12/2002	Rittman, III et al.	N/A	N/A
6582451	12/2002	Marucci et al.	N/A	N/A
6584360	12/2002	Francischelli et al.	N/A	N/A
6585735	12/2002	Frazier et al.	N/A	N/A
6589200	12/2002	Schwemberger et al.	N/A	N/A
6589239	12/2002	Khandkar et al.	N/A	N/A
6594517	12/2002	Nevo	N/A	N/A
6599321	12/2002	Hyde, Jr.	N/A	N/A
6602252	12/2002	Mollenauer	N/A	N/A
6610060	12/2002	Mulier et al.	N/A	N/A
6616450	12/2002	Mossle et al.	N/A	N/A
6616600	12/2002	Pauker	N/A	N/A

6619529	12/2002	Green et al.	N/A	N/A
6620129	12/2002	Stecker et al.	N/A	N/A
6620161	12/2002	Schulze et al.	N/A	N/A
6622731	12/2002	Daniel et al.	N/A	N/A
6623482	12/2002	Pendekanti et al.	N/A	N/A
6623501	12/2002	Heller et al.	N/A	N/A
6626926	12/2002	Friedman et al.	N/A	N/A
6633234	12/2002	Wiener et al.	N/A	N/A
6635057	12/2002	Harano et al.	N/A	N/A
6644532	12/2002	Green et al.	N/A	N/A
6648817	12/2002	Schara et al.	N/A	N/A
6651669	12/2002	Burnside	N/A	N/A
6656177	12/2002	Truckai et al.	N/A	N/A
6656198	12/2002	Tsonton et al.	N/A	N/A
6662127	12/2002	Wiener et al.	N/A	N/A
6663941	12/2002	Brown et al.	N/A	N/A
6669690	12/2002	Okada et al.	N/A	N/A
6673248	12/2003	Chowdhury	N/A	N/A
6676660	12/2003	Wampler et al.	N/A	N/A
6678621	12/2003	Wiener et al.	N/A	N/A
6679882	12/2003	Kornerup	N/A	N/A
6679899	12/2003	Wiener et al.	N/A	N/A
6682501	12/2003	Nelson et al.	N/A	N/A
6682544	12/2003	Mastri et al.	N/A	N/A
6695840	12/2003	Schulze	N/A	N/A
6696844	12/2003	Wong et al.	N/A	N/A
6716215	12/2003	David et al.	N/A	N/A
6719684	12/2003	Kim et al.	N/A	N/A
6719765	12/2003	Bonutti	N/A	N/A
6722552	12/2003	Fenton, Jr.	N/A	N/A
6723094	12/2003	Desinger	N/A	N/A
6726686	12/2003	Buysse et al.	N/A	N/A
6731047	12/2003	Kauf et al.	N/A	N/A
6733498	12/2003	Paton et al.	N/A	N/A
6733506	12/2003	McDevitt et al.	N/A	N/A
6736813	12/2003	Yamauchi et al.	N/A	N/A
6743229	12/2003	Buysse et al.	N/A	N/A
6746443	12/2003	Morley et al.	N/A	N/A
6752815	12/2003	Beaupre	N/A	N/A
6762535	12/2003	Take et al.	N/A	N/A
6766202	12/2003	Underwood et al.	N/A	N/A
6767349	12/2003	Ouchi	N/A	N/A
6770072	12/2003	Truckai et al.	N/A	N/A
6773409	12/2003	Truckai et al.	N/A	N/A
6773434	12/2003	Ciarrocca	N/A	N/A
6773435	12/2003	Schulze et al.	N/A	N/A
6773444	12/2003	Messerly	N/A	N/A
6775575	12/2003	Bommannan et al.	N/A	N/A
6776165	12/2003	Jin	N/A	N/A
6783524	12/2003	Anderson et al.	N/A	N/A

6786382	12/2003	Hoffman	N/A	N/A
6786383	12/2003	Stegelmann	N/A	N/A
6789939	12/2003	Schrodinger et al.	N/A	N/A
6790216	12/2003	Ishikawa	N/A	N/A
6796981	12/2003	Wham et al.	N/A	N/A
D496997	12/2003	Dycus et al.	N/A	N/A
6800085	12/2003	Selmon et al.	N/A	N/A
6802843	12/2003	Truckai et al.	N/A	N/A
6806317	12/2003	Morishita et al.	N/A	N/A
6808491	12/2003	Kortenbach et al.	N/A	N/A
6811842	12/2003	Ehrnsperger et al.	N/A	N/A
6814731	12/2003	Swanson	N/A	N/A
6817974	12/2003	Cooper et al.	N/A	N/A
6821273	12/2003	Mollenauer	N/A	N/A
6828712	12/2003	Battaglin et al.	N/A	N/A
6832998	12/2003	Goble	N/A	N/A
6835199	12/2003	McGuckin, Jr. et al.	N/A	N/A
6840938	12/2004	Morley et al.	N/A	N/A
6860880	12/2004	Treat et al.	N/A	N/A
6869439	12/2004	White et al.	N/A	N/A
6875220	12/2004	Du et al.	N/A	N/A
6877647	12/2004	Green et al.	N/A	N/A
6893435	12/2004	Goble	N/A	N/A
6905497	12/2004	Truckai et al.	N/A	N/A
6908463	12/2004	Treat et al.	N/A	N/A
6908472	12/2004	Wiener et al.	N/A	N/A
6913579	12/2004	Truckai et al.	N/A	N/A
6926716	12/2004	Baker et al.	N/A	N/A
6929622	12/2004	Chian	N/A	N/A
6929632	12/2004	Nita et al.	N/A	N/A
6929644	12/2004	Truckai et al.	N/A	N/A
6936003	12/2004	Iddan	N/A	N/A
D509589	12/2004	Wells	N/A	N/A
6939347	12/2004	Thompson	N/A	N/A
6945981	12/2004	Donofrio et al.	N/A	N/A
6953461	12/2004	McClurken et al.	N/A	N/A
D511145	12/2004	Donofrio et al.	N/A	N/A
6959852	12/2004	Shelton, IV et al.	N/A	N/A
6974462	12/2004	Sater	N/A	N/A
6976844	12/2004	Hickok et al.	N/A	N/A
6976969	12/2004	Messerly	N/A	N/A
6977495	12/2004	Donofrio	N/A	N/A
6984220	12/2005	Wuchinich	N/A	N/A
6986738	12/2005	Glukhovsky et al.	N/A	N/A
6986780	12/2005	Rudnick et al.	N/A	N/A
6994709	12/2005	Lida	N/A	N/A
7000818	12/2005	Shelton, IV et al.	N/A	N/A
7004951	12/2005	Gibbens, III	N/A	N/A
7011657	12/2005	Truckai et al.	N/A	N/A
7029435	12/2005	Nakao	N/A	N/A

7039453	12/2005	Mullick et al.	N/A	N/A
7041083	12/2005	Chu et al.	N/A	N/A
7041088	12/2005	Nawrocki et al.	N/A	N/A
7041102	12/2005	Truckai et al.	N/A	N/A
7044352	12/2005	Shelton, IV et al.	N/A	N/A
7044937	12/2005	Kirwan et al.	N/A	N/A
7052496	12/2005	Yamauchi	N/A	N/A
7055731	12/2005	Shelton, IV et al.	N/A	N/A
7056284	12/2005	Martone et al.	N/A	N/A
7063699	12/2005	Hess et al.	N/A	N/A
7066879	12/2005	Fowler et al.	N/A	N/A
7066936	12/2005	Ryan	N/A	N/A
7070597	12/2005	Truckai et al.	N/A	N/A
7074219	12/2005	Levine et al.	N/A	N/A
7077039	12/2005	Gass et al.	N/A	N/A
7077853	12/2005	Kramer et al.	N/A	N/A
7083579	12/2005	Yokoi et al.	N/A	N/A
7083617	12/2005	Kortenbach et al.	N/A	N/A
7083618	12/2005	Couture et al.	N/A	N/A
7083619	12/2005	Truckai et al.	N/A	N/A
7087054	12/2005	Truckai et al.	N/A	N/A
7090673	12/2005	Dycus et al.	N/A	N/A
7094235	12/2005	Francischelli	N/A	N/A
7096560	12/2005	Oddsen, Jr.	N/A	N/A
7101371	12/2005	Dycus et al.	N/A	N/A
7101372	12/2005	Dycus et al.	N/A	N/A
7101373	12/2005	Dycus et al.	N/A	N/A
7108695	12/2005	Witt et al.	N/A	N/A
7112201	12/2005	Truckai et al.	N/A	N/A
7118564	12/2005	Ritchie et al.	N/A	N/A
7118570	12/2005	Tetzlaff et al.	N/A	N/A
7120498	12/2005	Imran et al.	N/A	N/A
7124932	12/2005	Isaacson et al.	N/A	N/A
7125409	12/2005	Truckai et al.	N/A	N/A
7131970	12/2005	Moses et al.	N/A	N/A
7131971	12/2005	Dycus et al.	N/A	N/A
7135018	12/2005	Ryan et al.	N/A	N/A
7135030	12/2005	Schwemberger et al.	N/A	N/A
7137980	12/2005	Buysse et al.	N/A	N/A
7143925	12/2005	Shelton, IV et al.	N/A	N/A
7147138	12/2005	Shelton, IV	N/A	N/A
7147638	12/2005	Chapman et al.	N/A	N/A
7147650	12/2005	Lee	N/A	N/A
7153315	12/2005	Miller	N/A	N/A
7156189	12/2006	Bar-Cohen et al.	N/A	N/A
7156846	12/2006	Dycus et al.	N/A	N/A
7156853	12/2006	Muratsu	N/A	N/A
7157058	12/2006	Marhasin et al.	N/A	N/A
7159750	12/2006	Racenet et al.	N/A	N/A

7160296	12/2006	Pearson et al.	N/A	N/A
7160298	12/2006	Lawes et al.	N/A	N/A
7163548	12/2006	Stulen et al.	N/A	N/A
7169104	12/2006	Ueda et al.	N/A	N/A
7169146	12/2006	Truckai et al.	N/A	N/A
7169156	12/2006	Hart	N/A	N/A
7170823	12/2006	Fabricius et al.	N/A	N/A
7179271	12/2006	Friedman et al.	N/A	N/A
7186253	12/2006	Truckai et al.	N/A	N/A
7189233	12/2006	Truckai et al.	N/A	N/A
7195631	12/2006	Dumbauld	N/A	N/A
D541418	12/2006	Schechter et al.	N/A	N/A
7199545	12/2006	Oleynikov et al.	N/A	N/A
7204820	12/2006	Akahoshi	N/A	N/A
7207471	12/2006	Heinrich et al.	N/A	N/A
7208005	12/2006	Frecker et al.	N/A	N/A
7211094	12/2006	Gannoe et al.	N/A	N/A
7220951	12/2006	Truckai et al.	N/A	N/A
7223229	12/2006	Inman et al.	N/A	N/A
7225964	12/2006	Mastri et al.	N/A	N/A
7226448	12/2006	Bertolero et al.	N/A	N/A
7229455	12/2006	Sakurai et al.	N/A	N/A
7232440	12/2006	Dumbauld et al.	N/A	N/A
7235064	12/2006	Hopper et al.	N/A	N/A
7235073	12/2006	Levine et al.	N/A	N/A
7241290	12/2006	Doyle et al.	N/A	N/A
7241294	12/2006	Reschke	N/A	N/A
7241296	12/2006	Buysse et al.	N/A	N/A
7246734	12/2006	Shelton, IV	N/A	N/A
7251531	12/2006	Mosher et al.	N/A	N/A
7252667	12/2006	Moses et al.	N/A	N/A
7255697	12/2006	Dycus et al.	N/A	N/A
7267677	12/2006	Johnson et al.	N/A	N/A
7267685	12/2006	Butaric et al.	N/A	N/A
7270658	12/2006	Woloszko et al.	N/A	N/A
7270664	12/2006	Johnson et al.	N/A	N/A
7273483	12/2006	Wiener et al.	N/A	N/A
7276065	12/2006	Morley et al.	N/A	N/A
7282048	12/2006	Goble et al.	N/A	N/A
7282773	12/2006	Li et al.	N/A	N/A
7287682	12/2006	Ezzat et al.	N/A	N/A
7297145	12/2006	Woloszko et al.	N/A	N/A
7297149	12/2006	Vitali et al.	N/A	N/A
7300450	12/2006	Vleugels et al.	N/A	N/A
7303557	12/2006	Wham et al.	N/A	N/A
7307313	12/2006	Ohyanagi et al.	N/A	N/A
7309849	12/2006	Truckai et al.	N/A	N/A
7311709	12/2006	Truckai et al.	N/A	N/A
7317955	12/2007	McGreevy	N/A	N/A
7326236	12/2007	Andreas et al.	N/A	N/A

7329257	12/2007	Kanehira et al.	N/A	N/A
7331410	12/2007	Yong et al.	N/A	N/A
7344533	12/2007	Pearson et al.	N/A	N/A
7353068	12/2007	Tanaka et al.	N/A	N/A
7354440	12/2007	Truckal et al.	N/A	N/A
7357287	12/2007	Shelton, IV et al.	N/A	N/A
7360542	12/2007	Nelson et al.	N/A	N/A
7364577	12/2007	Wham et al.	N/A	N/A
7367973	12/2007	Manzo et al.	N/A	N/A
7367976	12/2007	Lawes et al.	N/A	N/A
7371227	12/2007	Zeiner	N/A	N/A
RE40388	12/2007	Gines	N/A	N/A
7380695	12/2007	Doll et al.	N/A	N/A
7381209	12/2007	Truckai et al.	N/A	N/A
7384420	12/2007	Dycus et al.	N/A	N/A
7390317	12/2007	Taylor et al.	N/A	N/A
7396356	12/2007	Mollenauer	N/A	N/A
7403224	12/2007	Fuller et al.	N/A	N/A
7404508	12/2007	Smith et al.	N/A	N/A
7407077	12/2007	Ortiz et al.	N/A	N/A
7408288	12/2007	Hara	N/A	N/A
7416101	12/2007	Shelton, IV et al.	N/A	N/A
D576725	12/2007	Shumer et al.	N/A	N/A
7422139	12/2007	Shelton, IV et al.	N/A	N/A
7422586	12/2007	Morris et al.	N/A	N/A
7422592	12/2007	Morley et al.	N/A	N/A
7429259	12/2007	Cadeddu et al.	N/A	N/A
D578643	12/2007	Shumer et al.	N/A	N/A
D578644	12/2007	Shumer et al.	N/A	N/A
D578645	12/2007	Shumer et al.	N/A	N/A
7431704	12/2007	Babaev	N/A	N/A
7435249	12/2007	Buysse et al.	N/A	N/A
7435582	12/2007	Zimmermann et al.	N/A	N/A
7439732	12/2007	LaPlaca	N/A	N/A
7441684	12/2007	Shelton, IV et al.	N/A	N/A
7442193	12/2007	Shields et al.	N/A	N/A
7442194	12/2007	Dumbauld et al.	N/A	N/A
7445621	12/2007	Dumbauld et al.	N/A	N/A
7448993	12/2007	Yokoi et al.	N/A	N/A
7449004	12/2007	Yamada et al.	N/A	N/A
7450998	12/2007	Zilberman et al.	N/A	N/A
7451904	12/2007	Shelton, IV	N/A	N/A
7464846	12/2007	Shelton, IV et al.	N/A	N/A
7472815	12/2008	Shelton, IV et al.	N/A	N/A
7473253	12/2008	Dycus et al.	N/A	N/A
7479148	12/2008	Beaupre	N/A	N/A
7479160	12/2008	Branch et al.	N/A	N/A
7487899	12/2008	Shelton, IV et al.	N/A	N/A
7488319	12/2008	Yates	N/A	N/A
7491201	12/2008	Shields et al.	N/A	N/A

7494468	12/2008	Rabiner et al.	N/A	N/A
7494501	12/2008	Ahlberg et al.	N/A	N/A
7498080	12/2008	Tung et al.	N/A	N/A
7503893	12/2008	Kucklick	N/A	N/A
7505812	12/2008	Eggers et al.	N/A	N/A
7506791	12/2008	Omaits et al.	N/A	N/A
7510107	12/2008	Timm et al.	N/A	N/A
7510556	12/2008	Nguyen et al.	N/A	N/A
7511733	12/2008	Takizawa et al.	N/A	N/A
7513025	12/2008	Fischer	N/A	N/A
7517349	12/2008	Truckai et al.	N/A	N/A
7520877	12/2008	Lee, Jr. et al.	N/A	N/A
7524320	12/2008	Tierney et al.	N/A	N/A
7534243	12/2008	Chin et al.	N/A	N/A
D594983	12/2008	Price et al.	N/A	N/A
7540872	12/2008	Schechter et al.	N/A	N/A
7543730	12/2008	Marczyk	N/A	N/A
7544200	12/2008	Houser	N/A	N/A
7550216	12/2008	Ofer et al.	N/A	N/A
7553309	12/2008	Buysse et al.	N/A	N/A
7559452	12/2008	Wales et al.	N/A	N/A
7566318	12/2008	Haefner	N/A	N/A
7567012	12/2008	Namikawa	N/A	N/A
7582086	12/2008	Privitera et al.	N/A	N/A
7582087	12/2008	Tetzlaff et al.	N/A	N/A
7586289	12/2008	Andruk et al.	N/A	N/A
7588176	12/2008	Timm et al.	N/A	N/A
7588177	12/2008	Racenet	N/A	N/A
7594925	12/2008	Danek et al.	N/A	N/A
7597693	12/2008	Garrison	N/A	N/A
7599743	12/2008	Hassler, Jr. et al.	N/A	N/A
7601119	12/2008	Shahinian	N/A	N/A
7604150	12/2008	Boudreaux	N/A	N/A
7608083	12/2008	Lee et al.	N/A	N/A
7611512	12/2008	Ein-Gal	N/A	N/A
7617961	12/2008	Viola	N/A	N/A
7621910	12/2008	Sugi	N/A	N/A
7621930	12/2008	Houser	N/A	N/A
7625370	12/2008	Hart et al.	N/A	N/A
7628791	12/2008	Garrison et al.	N/A	N/A
7628792	12/2008	Guerra	N/A	N/A
7632267	12/2008	Dahla	N/A	N/A
7632269	12/2008	Truckai et al.	N/A	N/A
7637410	12/2008	Marczyk	N/A	N/A
7640447	12/2008	Qiu	N/A	N/A
7641653	12/2009	Dalla Betta et al.	N/A	N/A
7641671	12/2009	Crainich	N/A	N/A
7644848	12/2009	Swayze et al.	N/A	N/A
7645277	12/2009	McClurken et al.	N/A	N/A
7648499	12/2009	Orszulak et al.	N/A	N/A

7658311	12/2009	Boudreaux	N/A	N/A
7662151	12/2009	Crompton, Jr. et al.	N/A	N/A
7665647	12/2009	Shelton, IV et al.	N/A	N/A
7666206	12/2009	Taniguchi et al.	N/A	N/A
7670334	12/2009	Hueil et al.	N/A	N/A
7678043	12/2009	Gilad	N/A	N/A
7678069	12/2009	Baker et al.	N/A	N/A
7678105	12/2009	McGreevy et al.	N/A	N/A
7686804	12/2009	Johnson et al.	N/A	N/A
7691095	12/2009	Bednarek et al.	N/A	N/A
7691098	12/2009	Wallace et al.	N/A	N/A
7691103	12/2009	Fernandez et al.	N/A	N/A
7703459	12/2009	Saadat et al.	N/A	N/A
7703653	12/2009	Shah et al.	N/A	N/A
7708735	12/2009	Chapman et al.	N/A	N/A
7708751	12/2009	Hughes et al.	N/A	N/A
7708758	12/2009	Lee et al.	N/A	N/A
7717312	12/2009	Beetel	N/A	N/A
7717914	12/2009	Kimura	N/A	N/A
7717915	12/2009	Miyazawa	N/A	N/A
7722527	12/2009	Bouchier et al.	N/A	N/A
7722607	12/2009	Dumbauld et al.	N/A	N/A
7725214	12/2009	Diolaiti	N/A	N/A
D618797	12/2009	Price et al.	N/A	N/A
7726537	12/2009	Olson et al.	N/A	N/A
7744615	12/2009	Couture	N/A	N/A
7751115	12/2009	Song	N/A	N/A
7753904	12/2009	Shelton, IV et al.	N/A	N/A
7753908	12/2009	Swanson	N/A	N/A
7753909	12/2009	Chapman et al.	N/A	N/A
7762445	12/2009	Heinrich et al.	N/A	N/A
D621503	12/2009	Otten et al.	N/A	N/A
7766210	12/2009	Shelton, IV et al.	N/A	N/A
7766910	12/2009	Hixson et al.	N/A	N/A
7770774	12/2009	Mastri et al.	N/A	N/A
7770775	12/2009	Shelton, IV et al.	N/A	N/A
7775972	12/2009	Brock et al.	N/A	N/A
7776036	12/2009	Schechter et al.	N/A	N/A
7776037	12/2009	Odom	N/A	N/A
7780651	12/2009	Madhani et al.	N/A	N/A
7780659	12/2009	Okada et al.	N/A	N/A
7780663	12/2009	Yates et al.	N/A	N/A
7784663	12/2009	Shelton, IV	N/A	N/A
7789283	12/2009	Shah	N/A	N/A
7789878	12/2009	Dumbauld et al.	N/A	N/A
7789883	12/2009	Takashino et al.	N/A	N/A
7793814	12/2009	Racenet et al.	N/A	N/A
7799027	12/2009	Hafner	N/A	N/A
7803156	12/2009	Eder et al.	N/A	N/A
7806891	12/2009	Nowlin et al.	N/A	N/A

7810692	12/2009	Hall et al.	N/A	N/A
7810693	12/2009	Broehl et al.	N/A	N/A
7815641	12/2009	Dodde et al.	N/A	N/A
7819298	12/2009	Hall et al.	N/A	N/A
7819299	12/2009	Shelton, IV et al.	N/A	N/A
7819872	12/2009	Johnson et al.	N/A	N/A
D627066	12/2009	Romero	N/A	N/A
7824401	12/2009	Manzo et al.	N/A	N/A
7832408	12/2009	Shelton, IV et al.	N/A	N/A
7832612	12/2009	Baxter, III et al.	N/A	N/A
7837699	12/2009	Yamada et al.	N/A	N/A
7845537	12/2009	Shelton, IV et al.	N/A	N/A
7846159	12/2009	Morrison et al.	N/A	N/A
7846160	12/2009	Payne et al.	N/A	N/A
7850688	12/2009	Hafner	N/A	N/A
D631155	12/2010	Peine et al.	N/A	N/A
7861906	12/2010	Doll et al.	N/A	N/A
7862560	12/2010	Marion	N/A	N/A
7867228	12/2010	Nobis et al.	N/A	N/A
7871392	12/2010	Sartor	N/A	N/A
7871423	12/2010	Livneh	N/A	N/A
D631965	12/2010	Price et al.	N/A	N/A
7877852	12/2010	Unger et al.	N/A	N/A
7877853	12/2010	Unger et al.	N/A	N/A
7879035	12/2010	Garrison et al.	N/A	N/A
7879070	12/2010	Ortiz et al.	N/A	N/A
7887535	12/2010	Lands et al.	N/A	N/A
7892606	12/2010	Thies et al.	N/A	N/A
7896875	12/2010	Heim et al.	N/A	N/A
7896878	12/2010	Johnson et al.	N/A	N/A
7901400	12/2010	Wham et al.	N/A	N/A
7901423	12/2010	Stulen et al.	N/A	N/A
7905881	12/2010	Masuda et al.	N/A	N/A
7909220	12/2010	Viola	N/A	N/A
7919184	12/2010	Mohapatra et al.	N/A	N/A
7922061	12/2010	Shelton, IV et al.	N/A	N/A
7922651	12/2010	Yamada et al.	N/A	N/A
7922953	12/2010	Guerra	N/A	N/A
7931649	12/2010	Couture et al.	N/A	N/A
D637288	12/2010	Houghton	N/A	N/A
D638540	12/2010	Ijiri et al.	N/A	N/A
7935114	12/2010	Takashino et al.	N/A	N/A
7942303	12/2010	Shah	N/A	N/A
7942868	12/2010	Cooper	N/A	N/A
7947039	12/2010	Sartor	N/A	N/A
7951165	12/2010	Golden et al.	N/A	N/A
7955331	12/2010	Truckai et al.	N/A	N/A
7959050	12/2010	Smith et al.	N/A	N/A
7959626	12/2010	Hong et al.	N/A	N/A
7963963	12/2010	Francischelli et al.	N/A	N/A

7967602	12/2010	Lindquist	N/A	N/A
7976544	12/2010	McClurken et al.	N/A	N/A
7980443	12/2010	Scheib et al.	N/A	N/A
7981113	12/2010	Truckai et al.	N/A	N/A
7988567	12/2010	Kim et al.	N/A	N/A
7997278	12/2010	Utley et al.	N/A	N/A
8020743	12/2010	Shelton, IV	N/A	N/A
8033173	12/2010	Ehlert et al.	N/A	N/A
8038612	12/2010	Paz	N/A	N/A
8038693	12/2010	Allen	N/A	N/A
8048070	12/2010	O'Brien et al.	N/A	N/A
8052672	12/2010	Laufer et al.	N/A	N/A
8056720	12/2010	Hawkes	N/A	N/A
8056787	12/2010	Boudreaux et al.	N/A	N/A
8057498	12/2010	Robertson	N/A	N/A
8058771	12/2010	Giordano et al.	N/A	N/A
8061014	12/2010	Smith et al.	N/A	N/A
8062211	12/2010	Duval et al.	N/A	N/A
8066167	12/2010	Measamer et al.	N/A	N/A
8070036	12/2010	Knodel	N/A	N/A
8070748	12/2010	Hixson et al.	N/A	N/A
8075555	12/2010	Truckai et al.	N/A	N/A
8075558	12/2010	Truckai et al.	N/A	N/A
8092475	12/2011	Cotter et al.	N/A	N/A
8100894	12/2011	Mucko et al.	N/A	N/A
8105323	12/2011	Buysse et al.	N/A	N/A
8105324	12/2011	Palanker et al.	N/A	N/A
8114104	12/2011	Young et al.	N/A	N/A
8114119	12/2011	Spivey et al.	N/A	N/A
8128624	12/2011	Couture et al.	N/A	N/A
8128657	12/2011	Shiono et al.	N/A	N/A
8133218	12/2011	Daw et al.	N/A	N/A
8136712	12/2011	Zingman	N/A	N/A
8141762	12/2011	Bedi et al.	N/A	N/A
8142461	12/2011	Houser et al.	N/A	N/A
8147488	12/2011	Masuda	N/A	N/A
8147508	12/2011	Madan et al.	N/A	N/A
8152825	12/2011	Madan et al.	N/A	N/A
8157145	12/2011	Shelton, IV et al.	N/A	N/A
8161977	12/2011	Shelton, IV et al.	N/A	N/A
8162940	12/2011	Johnson et al.	N/A	N/A
8177784	12/2011	Van Wyk et al.	N/A	N/A
8177794	12/2011	Cabrera et al.	N/A	N/A
8182502	12/2011	Stulen et al.	N/A	N/A
8186560	12/2011	Hess et al.	N/A	N/A
8187166	12/2011	Kuth et al.	N/A	N/A
8187267	12/2011	Pappone et al.	N/A	N/A
8192433	12/2011	Johnson et al.	N/A	N/A
8197472	12/2011	Lau et al.	N/A	N/A
8197479	12/2011	Olson et al.	N/A	N/A

8197494	12/2011	Jaggi et al.	N/A	N/A
8197502	12/2011	Smith et al.	N/A	N/A
8206212	12/2011	Iddings et al.	N/A	N/A
8221415	12/2011	Francischelli	N/A	N/A
8221416	12/2011	Townsend	N/A	N/A
8226675	12/2011	Houser et al.	N/A	N/A
8236019	12/2011	Houser	N/A	N/A
8236020	12/2011	Smith et al.	N/A	N/A
8241235	12/2011	Kahler et al.	N/A	N/A
8241283	12/2011	Guerra et al.	N/A	N/A
8241284	12/2011	Dycus et al.	N/A	N/A
8241312	12/2011	Messerly	N/A	N/A
8244368	12/2011	Sherman	N/A	N/A
8246615	12/2011	Behnke	N/A	N/A
8246618	12/2011	Bucciaglia et al.	N/A	N/A
8251994	12/2011	McKenna et al.	N/A	N/A
8252012	12/2011	Stulen	N/A	N/A
8257352	12/2011	Lawes et al.	N/A	N/A
8257377	12/2011	Wiener et al.	N/A	N/A
8262563	12/2011	Bakos et al.	N/A	N/A
8267300	12/2011	Boudreaux	N/A	N/A
8267854	12/2011	Asada et al.	N/A	N/A
8267935	12/2011	Couture et al.	N/A	N/A
8273085	12/2011	Park et al.	N/A	N/A
8277446	12/2011	Heard	N/A	N/A
8277447	12/2011	Garrison et al.	N/A	N/A
8277471	12/2011	Wiener et al.	N/A	N/A
8282581	12/2011	Zhao et al.	N/A	N/A
8282669	12/2011	Gerber et al.	N/A	N/A
8287528	12/2011	Wham et al.	N/A	N/A
8292886	12/2011	Kerr et al.	N/A	N/A
8292888	12/2011	Whitman	N/A	N/A
8298228	12/2011	Buysse et al.	N/A	N/A
8298232	12/2011	Unger	N/A	N/A
8303583	12/2011	Hosier et al.	N/A	N/A
8306629	12/2011	Mioduski et al.	N/A	N/A
8308040	12/2011	Huang et al.	N/A	N/A
8319400	12/2011	Houser et al.	N/A	N/A
8322455	12/2011	Shelton, IV et al.	N/A	N/A
8323302	12/2011	Robertson et al.	N/A	N/A
8323310	12/2011	Kingsley	N/A	N/A
8328061	12/2011	Kasvikis	N/A	N/A
8328761	12/2011	Widenhouse et al.	N/A	N/A
8328834	12/2011	Isaacs et al.	N/A	N/A
8333778	12/2011	Smith et al.	N/A	N/A
8333779	12/2011	Smith et al.	N/A	N/A
8334468	12/2011	Palmer et al.	N/A	N/A
8334635	12/2011	Voegele et al.	N/A	N/A
8338726	12/2011	Palmer et al.	N/A	N/A
8343146	12/2012	Godara et al.	N/A	N/A

8344596	12/2012	Nield et al.	N/A	N/A
8348880	12/2012	Messerly et al.	N/A	N/A
8348947	12/2012	Takashino et al.	N/A	N/A
8348967	12/2012	Stulen	N/A	N/A
8353297	12/2012	Dacquay et al.	N/A	N/A
8357158	12/2012	McKenna et al.	N/A	N/A
8361569	12/2012	Saito et al.	N/A	N/A
8372064	12/2012	Douglass et al.	N/A	N/A
8372099	12/2012	Deville et al.	N/A	N/A
8372101	12/2012	Smith et al.	N/A	N/A
8377053	12/2012	Orszulak	N/A	N/A
8377059	12/2012	Deville et al.	N/A	N/A
8377085	12/2012	Smith et al.	N/A	N/A
8382754	12/2012	Odom et al.	N/A	N/A
8382782	12/2012	Robertson et al.	N/A	N/A
8382792	12/2012	Chojin	N/A	N/A
8388646	12/2012	Chojin	N/A	N/A
8388647	12/2012	Nau, Jr. et al.	N/A	N/A
8394094	12/2012	Edwards et al.	N/A	N/A
8394115	12/2012	Houser et al.	N/A	N/A
8397971	12/2012	Yates et al.	N/A	N/A
8398633	12/2012	Mueller	N/A	N/A
8403926	12/2012	Nobis et al.	N/A	N/A
8403948	12/2012	Deville et al.	N/A	N/A
8403949	12/2012	Palmer et al.	N/A	N/A
8403950	12/2012	Palmer et al.	N/A	N/A
8409076	12/2012	Pang et al.	N/A	N/A
8414577	12/2012	Boudreaux et al.	N/A	N/A
8418349	12/2012	Smith et al.	N/A	N/A
8419757	12/2012	Smith et al.	N/A	N/A
8419758	12/2012	Smith et al.	N/A	N/A
8419759	12/2012	Dietz	N/A	N/A
8425410	12/2012	Murray et al.	N/A	N/A
8425545	12/2012	Smith et al.	N/A	N/A
8430811	12/2012	Hess et al.	N/A	N/A
8430876	12/2012	Kappus et al.	N/A	N/A
8430897	12/2012	Novak et al.	N/A	N/A
8430898	12/2012	Wiener et al.	N/A	N/A
8435257	12/2012	Smith et al.	N/A	N/A
8439911	12/2012	Mueller	N/A	N/A
8439939	12/2012	Deville et al.	N/A	N/A
8444662	12/2012	Palmer et al.	N/A	N/A
8444664	12/2012	Balanev et al.	N/A	N/A
8453906	12/2012	Huang et al.	N/A	N/A
8454599	12/2012	Inagaki et al.	N/A	N/A
8454639	12/2012	Du et al.	N/A	N/A
8460288	12/2012	Tamai et al.	N/A	N/A
8460292	12/2012	Truckai et al.	N/A	N/A
8461744	12/2012	Wiener et al.	N/A	N/A
8469956	12/2012	McKenna et al.	N/A	N/A

8469981	12/2012	Robertson et al.	N/A	N/A
8475361	12/2012	Barlow et al.	N/A	N/A
8475453	12/2012	Marczyk et al.	N/A	N/A
8480703	12/2012	Nicholas et al.	N/A	N/A
8484833	12/2012	Cunningham et al.	N/A	N/A
8485413	12/2012	Scheib et al.	N/A	N/A
8485970	12/2012	Widenhouse et al.	N/A	N/A
8486057	12/2012	Behnke, II	N/A	N/A
8486096	12/2012	Robertson et al.	N/A	N/A
8491625	12/2012	Horner	N/A	N/A
8496682	12/2012	Guerra et al.	N/A	N/A
8512336	12/2012	Couture	N/A	N/A
8512364	12/2012	Kowalski et al.	N/A	N/A
8512365	12/2012	Wiener et al.	N/A	N/A
8523889	12/2012	Stulen et al.	N/A	N/A
8529437	12/2012	Taylor et al.	N/A	N/A
8529565	12/2012	Masuda et al.	N/A	N/A
8531064	12/2012	Robertson et al.	N/A	N/A
8535311	12/2012	Schall	N/A	N/A
8535340	12/2012	Allen	N/A	N/A
8535341	12/2012	Allen	N/A	N/A
8540128	12/2012	Shelton, IV et al.	N/A	N/A
8542501	12/2012	Kyono	N/A	N/A
8553430	12/2012	Melanson et al.	N/A	N/A
8562516	12/2012	Saadat et al.	N/A	N/A
8562592	12/2012	Conlon et al.	N/A	N/A
8562598	12/2012	Falkenstein et al.	N/A	N/A
8562604	12/2012	Nishimura	N/A	N/A
8568390	12/2012	Mueller	N/A	N/A
8568412	12/2012	Brandt et al.	N/A	N/A
8569997	12/2012	Lee	N/A	N/A
8574187	12/2012	Marion	N/A	N/A
8574231	12/2012	Boudreaux et al.	N/A	N/A
8579176	12/2012	Smith et al.	N/A	N/A
8579928	12/2012	Robertson et al.	N/A	N/A
8579937	12/2012	Gresham	N/A	N/A
8591459	12/2012	Clymer et al.	N/A	N/A
8591506	12/2012	Wham et al.	N/A	N/A
D695407	12/2012	Price et al.	N/A	N/A
8596513	12/2012	Olson et al.	N/A	N/A
8597182	12/2012	Stein et al.	N/A	N/A
8597297	12/2012	Couture et al.	N/A	N/A
8608044	12/2012	Hueil et al.	N/A	N/A
8613383	12/2012	Beckman et al.	N/A	N/A
8622274	12/2013	Yates et al.	N/A	N/A
8623011	12/2013	Spivey	N/A	N/A
8623016	12/2013	Fischer	N/A	N/A
8623027	12/2013	Price et al.	N/A	N/A
8623044	12/2013	Timm et al.	N/A	N/A
8628529	12/2013	Aldridge et al.	N/A	N/A

8632461	12/2013	Glossop	N/A	N/A
8632539	12/2013	Twomey et al.	N/A	N/A
8636648	12/2013	Gazdzinski	N/A	N/A
8636736	12/2013	Yates et al.	N/A	N/A
8636761	12/2013	Cunningham et al.	N/A	N/A
8638428	12/2013	Brown	N/A	N/A
8640788	12/2013	Dachs, II et al.	N/A	N/A
8641712	12/2013	Couture	N/A	N/A
8647350	12/2013	Mohan et al.	N/A	N/A
8650728	12/2013	Wan et al.	N/A	N/A
8652120	12/2013	Giordano et al.	N/A	N/A
8652155	12/2013	Houser et al.	N/A	N/A
8663220	12/2013	Wiener et al.	N/A	N/A
8663222	12/2013	Anderson et al.	N/A	N/A
8663223	12/2013	Masuda et al.	N/A	N/A
8668691	12/2013	Heard	N/A	N/A
RE44834	12/2013	Dumbauld et al.	N/A	N/A
8684253	12/2013	Giordano et al.	N/A	N/A
8685020	12/2013	Weizman et al.	N/A	N/A
8685056	12/2013	Evans et al.	N/A	N/A
8696662	12/2013	Eder et al.	N/A	N/A
8696665	12/2013	Hunt et al.	N/A	N/A
8702609	12/2013	Hadjicostis	N/A	N/A
8702704	12/2013	Shelton, IV et al.	N/A	N/A
8708213	12/2013	Shelton, IV et al.	N/A	N/A
8709035	12/2013	Johnson et al.	N/A	N/A
8715270	12/2013	Weitzner et al.	N/A	N/A
8715277	12/2013	Weizman	N/A	N/A
8721640	12/2013	Taylor et al.	N/A	N/A
8734443	12/2013	Hixson et al.	N/A	N/A
8747238	12/2013	Shelton, IV et al.	N/A	N/A
8747351	12/2013	Schultz	N/A	N/A
8747404	12/2013	Boudreaux et al.	N/A	N/A
8752264	12/2013	Ackley et al.	N/A	N/A
8752749	12/2013	Moore et al.	N/A	N/A
8753338	12/2013	Widenhouse et al.	N/A	N/A
8758342	12/2013	Bales et al.	N/A	N/A
8764747	12/2013	Cummings et al.	N/A	N/A
8770459	12/2013	Racenet et al.	N/A	N/A
8784418	12/2013	Romero	N/A	N/A
8789740	12/2013	Baxter, III et al.	N/A	N/A
8790342	12/2013	Stulen et al.	N/A	N/A
8795274	12/2013	Hanna	N/A	N/A
8795276	12/2013	Dietz et al.	N/A	N/A
8795327	12/2013	Dietz et al.	N/A	N/A
8800838	12/2013	Shelton, IV	N/A	N/A
8801752	12/2013	Fortier et al.	N/A	N/A
8807414	12/2013	Ross et al.	N/A	N/A
8808319	12/2013	Houser et al.	N/A	N/A
8814856	12/2013	Elmouelhi et al.	N/A	N/A

8814865	12/2013	Reschke	N/A	N/A
8814870	12/2013	Paraschiv et al.	N/A	N/A
8827992	12/2013	Koss et al.	N/A	N/A
8827995	12/2013	Schaller et al.	N/A	N/A
8834466	12/2013	Cummings et al.	N/A	N/A
8834488	12/2013	Farritor et al.	N/A	N/A
8834518	12/2013	Faller et al.	N/A	N/A
8845630	12/2013	Mehta et al.	N/A	N/A
8851354	12/2013	Swensgard et al.	N/A	N/A
8852184	12/2013	Kucklick	N/A	N/A
8864757	12/2013	Klimovitch et al.	N/A	N/A
8864761	12/2013	Johnson et al.	N/A	N/A
8870867	12/2013	Walberg et al.	N/A	N/A
8876858	12/2013	Braun	N/A	N/A
8882766	12/2013	Couture et al.	N/A	N/A
8882791	12/2013	Stulen	N/A	N/A
8887373	12/2013	Brandt et al.	N/A	N/A
8888776	12/2013	Dietz et al.	N/A	N/A
8888783	12/2013	Young	N/A	N/A
8888809	12/2013	Davison et al.	N/A	N/A
8906012	12/2013	Conley et al.	N/A	N/A
8906016	12/2013	Boudreaux et al.	N/A	N/A
8906017	12/2013	Rioux et al.	N/A	N/A
8911438	12/2013	Swoyer et al.	N/A	N/A
8911460	12/2013	Neurohr et al.	N/A	N/A
8920414	12/2013	Stone et al.	N/A	N/A
8926607	12/2014	Norvell et al.	N/A	N/A
8926608	12/2014	Bacher et al.	N/A	N/A
8929888	12/2014	Rao et al.	N/A	N/A
8931682	12/2014	Timm et al.	N/A	N/A
8939287	12/2014	Markovitch	N/A	N/A
8939974	12/2014	Boudreaux et al.	N/A	N/A
8939975	12/2014	Twomey et al.	N/A	N/A
8944997	12/2014	Fernandez et al.	N/A	N/A
8945125	12/2014	Schechter et al.	N/A	N/A
8951248	12/2014	Messerly et al.	N/A	N/A
8951272	12/2014	Robertson et al.	N/A	N/A
8956349	12/2014	Aldridge et al.	N/A	N/A
8960520	12/2014	McCuen	N/A	N/A
8961515	12/2014	Twomey et al.	N/A	N/A
8961547	12/2014	Dietz et al.	N/A	N/A
8968276	12/2014	Zemlok et al.	N/A	N/A
8968308	12/2014	Horner et al.	N/A	N/A
8968312	12/2014	Marczyk et al.	N/A	N/A
8968332	12/2014	Farritor et al.	N/A	N/A
8974453	12/2014	Wang	N/A	N/A
8978845	12/2014	Kim	N/A	N/A
8979838	12/2014	Woloszko et al.	N/A	N/A
8979843	12/2014	Timm et al.	N/A	N/A
8979844	12/2014	White et al.	N/A	N/A

8979890	12/2014	Boudreaux	N/A	N/A
8986302	12/2014	Aldridge et al.	N/A	N/A
8989855	12/2014	Murphy et al.	N/A	N/A
8992422	12/2014	Spivey et al.	N/A	N/A
8992520	12/2014	Van Wyk	606/41	A61B 18/1402
8992526	12/2014	Brodbeck et al.	N/A	N/A
9005199	12/2014	Beckman et al.	N/A	N/A
9011437	12/2014	Woodruff et al.	N/A	N/A
9017326	12/2014	DiNardo et al.	N/A	N/A
9017372	12/2014	Artale et al.	N/A	N/A
9023035	12/2014	Allen, IV et al.	N/A	N/A
9028494	12/2014	Shelton, IV et al.	N/A	N/A
9028519	12/2014	Yates et al.	N/A	N/A
9031667	12/2014	Williams	N/A	N/A
9033983	12/2014	Takashino et al.	N/A	N/A
9039695	12/2014	Giordano et al.	N/A	N/A
9039705	12/2014	Takashino	N/A	N/A
9039731	12/2014	Joseph	N/A	N/A
9044227	12/2014	Shelton, IV et al.	N/A	N/A
9044243	12/2014	Johnson et al.	N/A	N/A
9044245	12/2014	Condie et al.	N/A	N/A
9044256	12/2014	Cadeddu et al.	N/A	N/A
9044261	12/2014	Houser	N/A	N/A
9050093	12/2014	Aldridge et al.	N/A	N/A
9050098	12/2014	Deville et al.	N/A	N/A
9050113	12/2014	Bloom	N/A	A61B 17/1671
9055961	12/2014	Manzo et al.	N/A	N/A
9060770	12/2014	Shelton, IV et al.	N/A	N/A
9060775	12/2014	Wiener et al.	N/A	N/A
9060776	12/2014	Yates et al.	N/A	N/A
9066723	12/2014	Beller et al.	N/A	N/A
9072535	12/2014	Shelton, IV et al.	N/A	N/A
9072536	12/2014	Shelton, IV et al.	N/A	N/A
9078664	12/2014	Palmer et al.	N/A	N/A
9089327	12/2014	Worrell et al.	N/A	N/A
9089360	12/2014	Messerly et al.	N/A	N/A
9094006	12/2014	Gravati et al.	N/A	N/A
9095362	12/2014	Dachs, II et al.	N/A	N/A
9095367	12/2014	Olson et al.	N/A	N/A
9101385	12/2014	Shelton, IV et al.	N/A	N/A
9107672	12/2014	Tetzlaff et al.	N/A	N/A
9113889	12/2014	Reschke	N/A	N/A
9113900	12/2014	Buysse et al.	N/A	N/A
9119630	12/2014	Townsend et al.	N/A	N/A
9119657	12/2014	Shelton, IV et al.	N/A	N/A
9119957	12/2014	Gantz et al.	N/A	N/A
9125662	12/2014	Shelton, IV	N/A	N/A
9125667	12/2014	Stone et al.	N/A	N/A

9138289	12/2014	Conley et al.	N/A	N/A
9149324	12/2014	Huang et al.	N/A	N/A
9149325	12/2014	Worrell et al.	N/A	N/A
9155585	12/2014	Bales, Jr. et al.	N/A	N/A
9161803	12/2014	Yates et al.	N/A	N/A
9168054	12/2014	Turner et al.	N/A	N/A
9168082	12/2014	Evans et al.	N/A	N/A
9168085	12/2014	Juzkiw et al.	N/A	N/A
9168089	12/2014	Buysse et al.	N/A	N/A
9179912	12/2014	Yates et al.	N/A	N/A
9186204	12/2014	Nishimura et al.	N/A	N/A
9187758	12/2014	Cai et al.	N/A	N/A
9192380	12/2014	Racenet et al.	N/A	N/A
9192421	12/2014	Garrison	N/A	N/A
9192431	12/2014	Woodruff et al.	N/A	N/A
9198714	12/2014	Worrell et al.	N/A	N/A
9198715	12/2014	Livneh	N/A	N/A
9198716	12/2014	Masuda et al.	N/A	N/A
9204879	12/2014	Shelton, IV	N/A	N/A
9204919	12/2014	Brandt et al.	N/A	N/A
9216050	12/2014	Condie et al.	N/A	N/A
9220559	12/2014	Worrell et al.	N/A	N/A
9226751	12/2015	Shelton, IV et al.	N/A	N/A
9226767	12/2015	Stulen et al.	N/A	N/A
9237891	12/2015	Shelton, IV	N/A	N/A
9254165	12/2015	Aronow et al.	N/A	N/A
9259234	12/2015	Robertson et al.	N/A	N/A
9259265	12/2015	Harris et al.	N/A	N/A
9265567	12/2015	Orban, III et al.	N/A	N/A
9265571	12/2015	Twomey et al.	N/A	N/A
9265926	12/2015	Strobl et al.	N/A	N/A
9271784	12/2015	Evans et al.	N/A	N/A
9274988	12/2015	Hsu et al.	N/A	N/A
9277962	12/2015	Koss et al.	N/A	N/A
9282974	12/2015	Shelton, IV	N/A	N/A
9283027	12/2015	Monson et al.	N/A	N/A
9283045	12/2015	Rhee et al.	N/A	N/A
9289256	12/2015	Shelton, IV et al.	N/A	N/A
9295514	12/2015	Shelton, IV et al.	N/A	N/A
9308014	12/2015	Fischer	N/A	N/A
9314292	12/2015	Trees et al.	N/A	N/A
9326788	12/2015	Batross et al.	N/A	N/A
9326812	12/2015	Waaler et al.	N/A	N/A
9333025	12/2015	Monson et al.	N/A	N/A
9339323	12/2015	Eder et al.	N/A	N/A
9339326	12/2015	McCullagh et al.	N/A	N/A
9344042	12/2015	Mao	N/A	N/A
9345481	12/2015	Hall et al.	N/A	N/A
9345900	12/2015	Wu et al.	N/A	N/A
9351754	12/2015	Vakharia et al.	N/A	N/A

9358061	12/2015	Plascencia, Jr. et al.	N/A	N/A
9358065	12/2015	Ladtkow et al.	N/A	N/A
9364225	12/2015	Sniffin et al.	N/A	N/A
9364230	12/2015	Shelton, IV et al.	N/A	N/A
9375232	12/2015	Hunt et al.	N/A	N/A
9375256	12/2015	Cunningham et al.	N/A	N/A
9375267	12/2015	Kerr et al.	N/A	N/A
9381060	12/2015	Artale et al.	N/A	N/A
9386983	12/2015	Swensgard et al.	N/A	N/A
9393037	12/2015	Olson et al.	N/A	N/A
9402682	12/2015	Worrell et al.	N/A	N/A
9408606	12/2015	Shelton, IV	N/A	N/A
9408622	12/2015	Stulen et al.	N/A	N/A
9408660	12/2015	Strobl et al.	N/A	N/A
9414880	12/2015	Monson et al.	N/A	N/A
9421060	12/2015	Monson et al.	N/A	N/A
9456863	12/2015	Moua	N/A	N/A
9456864	12/2015	Witt et al.	N/A	N/A
9456876	12/2015	Hagn	N/A	N/A
9468490	12/2015	Twomey et al.	N/A	N/A
9492224	12/2015	Boudreaux et al.	N/A	N/A
9504524	12/2015	Behnke, II	N/A	N/A
9510906	12/2015	Boudreaux et al.	N/A	N/A
9522029	12/2015	Yates et al.	N/A	N/A
9526564	12/2015	Rusin	N/A	N/A
9526565	12/2015	Strobl	N/A	N/A
9549663	12/2016	Larkin	N/A	N/A
9554845	12/2016	Arts	N/A	N/A
9554846	12/2016	Boudreaux	N/A	N/A
9554854	12/2016	Yates et al.	N/A	N/A
9561038	12/2016	Shelton, IV et al.	N/A	N/A
9585709	12/2016	Krapohl	N/A	N/A
9597143	12/2016	Madan et al.	N/A	N/A
9610091	12/2016	Johnson et al.	N/A	N/A
9610114	12/2016	Baxter, III et al.	N/A	N/A
9615877	12/2016	Tyrrell et al.	N/A	N/A
9622810	12/2016	Hart et al.	N/A	N/A
9627120	12/2016	Scott et al.	N/A	N/A
9629629	12/2016	Leimbach et al.	N/A	N/A
9642669	12/2016	Takashino et al.	N/A	N/A
9649111	12/2016	Shelton, IV et al.	N/A	N/A
9649144	12/2016	Aluru et al.	N/A	N/A
9649151	12/2016	Goodman et al.	N/A	N/A
9662131	12/2016	Omori et al.	N/A	N/A
9668806	12/2016	Unger et al.	N/A	N/A
9687295	12/2016	Joseph	N/A	N/A
9700339	12/2016	Nield	N/A	N/A
9707005	12/2016	Strobl et al.	N/A	N/A
9707027	12/2016	Ruddenklau et al.	N/A	N/A
9707030	12/2016	Davison et al.	N/A	N/A

9713489	12/2016	Woloszko et al.	N/A	N/A
9713491	12/2016	Roy et al.	N/A	N/A
9724118	12/2016	Schulte et al.	N/A	N/A
9724152	12/2016	Horlle et al.	N/A	N/A
9737355	12/2016	Yates et al.	N/A	N/A
9737358	12/2016	Beckman et al.	N/A	N/A
9743929	12/2016	Leimbach et al.	N/A	N/A
9757128	12/2016	Baber et al.	N/A	N/A
9757142	12/2016	Shimizu	N/A	N/A
9757186	12/2016	Boudreaux et al.	N/A	N/A
9775665	12/2016	Ellman	N/A	A61B 18/1402
9775669	12/2016	Marczyk et al.	N/A	N/A
9782214	12/2016	Houser et al.	N/A	N/A
9782220	12/2016	Mark et al.	N/A	N/A
9788891	12/2016	Christian et al.	N/A	N/A
9795436	12/2016	Yates et al.	N/A	N/A
9802033	12/2016	Hibner et al.	N/A	N/A
9808244	12/2016	Leimbach et al.	N/A	N/A
9808308	12/2016	Faller et al.	N/A	N/A
9814460	12/2016	Kimsey et al.	N/A	N/A
9814514	12/2016	Shelton, IV et al.	N/A	N/A
9820768	12/2016	Gee et al.	N/A	N/A
9820771	12/2016	Norton et al.	N/A	N/A
9833239	12/2016	Yates et al.	N/A	N/A
9848937	12/2016	Trees et al.	N/A	N/A
9848939	12/2016	Mayer et al.	N/A	N/A
9861265	12/2017	Yamaoka	N/A	A61M 13/003
9861428	12/2017	Trees et al.	N/A	N/A
9872725	12/2017	Worrell et al.	N/A	N/A
9877720	12/2017	Worrell et al.	N/A	N/A
9877776	12/2017	Boudreaux	N/A	N/A
9877782	12/2017	Voegele et al.	N/A	N/A
9888954	12/2017	Van Wyk	N/A	A61B 18/149
9888958	12/2017	Evans et al.	N/A	N/A
9901390	12/2017	Allen, IV et al.	N/A	N/A
9901754	12/2017	Yamada	N/A	N/A
9907563	12/2017	Germain et al.	N/A	N/A
9913680	12/2017	Voegele et al.	N/A	N/A
9918730	12/2017	Trees et al.	N/A	N/A
9918773	12/2017	Ishikawa et al.	N/A	N/A
9931157	12/2017	Strobl et al.	N/A	N/A
9937001	12/2017	Nakamura	N/A	N/A
9943357	12/2017	Cunningham et al.	N/A	N/A
9949620	12/2017	Duval et al.	N/A	N/A
9949785	12/2017	Price et al.	N/A	N/A
9949788	12/2017	Boudreaux	N/A	N/A
9974539	12/2017	Yates et al.	N/A	N/A

9993289	12/2017	Sobajima et al.	N/A	N/A
10010339	12/2017	Witt et al.	N/A	N/A
10016207	12/2017	Suzuki et al.	N/A	N/A
10022142	12/2017	Aranyi et al.	N/A	N/A
10034707	12/2017	Papaioannou et al.	N/A	N/A
10041822	12/2017	Zemlok	N/A	N/A
10052044	12/2017	Shelton, IV et al.	N/A	N/A
10058376	12/2017	Horner et al.	N/A	N/A
10070916	12/2017	Artale	N/A	N/A
10080606	12/2017	Kappus et al.	N/A	N/A
10092310	12/2017	Boudreaux et al.	N/A	N/A
10092348	12/2017	Boudreaux	N/A	N/A
10092350	12/2017	Rothweiler et al.	N/A	N/A
10105174	12/2017	Krapohl	N/A	N/A
10111699	12/2017	Boudreaux	N/A	N/A
10117702	12/2017	Danziger et al.	N/A	N/A
10130410	12/2017	Strobl et al.	N/A	N/A
10130414	12/2017	Weiler et al.	N/A	N/A
10135242	12/2017	Baber et al.	N/A	N/A
10159524	12/2017	Yates et al.	N/A	N/A
10166060	12/2018	Johnson et al.	N/A	N/A
10172669	12/2018	Felder et al.	N/A	N/A
10194911	12/2018	Miller et al.	N/A	N/A
10194972	12/2018	Yates et al.	N/A	N/A
10194976	12/2018	Boudreaux	N/A	N/A
10194977	12/2018	Yang	N/A	N/A
10211586	12/2018	Adams et al.	N/A	N/A
10231776	12/2018	Artale et al.	N/A	N/A
10238387	12/2018	Yates et al.	N/A	N/A
10245095	12/2018	Boudreaux	N/A	N/A
10258404	12/2018	Wang	N/A	N/A
10265118	12/2018	Gerhardt	N/A	N/A
10278721	12/2018	Dietz et al.	N/A	N/A
10307203	12/2018	Wyatt	N/A	N/A
10314638	12/2018	Gee et al.	N/A	N/A
10321950	12/2018	Yates et al.	N/A	N/A
10342602	12/2018	Strobl et al.	N/A	N/A
10413352	12/2018	Thomas et al.	N/A	N/A
10420601	12/2018	Marion et al.	N/A	N/A
10420607	12/2018	Woloszko et al.	N/A	N/A
10426873	12/2018	Schultz	N/A	N/A
10433900	12/2018	Harris et al.	N/A	N/A
10441345	12/2018	Aldridge et al.	N/A	N/A
10463421	12/2018	Boudreaux et al.	N/A	N/A
10478243	12/2018	Couture et al.	N/A	N/A
10485607	12/2018	Strobl et al.	N/A	N/A
10524852	12/2019	Cagle et al.	N/A	N/A
10524854	12/2019	Woodruff et al.	N/A	N/A
10568682	12/2019	Dycus et al.	N/A	N/A
10575868	12/2019	Hall et al.	N/A	N/A

10595929	12/2019	Boudreaux et al.	N/A	N/A
10603103	12/2019	Thomas et al.	N/A	N/A
10603117	12/2019	Schings et al.	N/A	N/A
10639092	12/2019	Corbett et al.	N/A	N/A
10646269	12/2019	Worrell et al.	N/A	N/A
10675082	12/2019	Shelton, IV et al.	N/A	N/A
10702329	12/2019	Strobl et al.	N/A	N/A
10716614	12/2019	Yates et al.	N/A	N/A
10751109	12/2019	Yates et al.	N/A	N/A
10751110	12/2019	Ding	N/A	N/A
10751117	12/2019	Witt et al.	N/A	N/A
10758294	12/2019	Jones	N/A	N/A
10779876	12/2019	Monson et al.	N/A	N/A
10799284	12/2019	Renner et al.	N/A	N/A
10813640	12/2019	Adams et al.	N/A	N/A
10820938	12/2019	Fischer et al.	N/A	N/A
10856934	12/2019	Trees et al.	N/A	N/A
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10903685	12/2020	Yates et al.	N/A	N/A
10912600	12/2020	Kitagawa et al.	N/A	N/A
10959771	12/2020	Boudreaux et al.	N/A	N/A
10959806	12/2020	Hibner et al.	N/A	N/A
10966779	12/2020	Hart et al.	N/A	N/A
10987156	12/2020	Trees et al.	N/A	N/A
11033323	12/2020	Witt et al.	N/A	N/A
11033325	12/2020	Yates et al.	N/A	N/A
11090103	12/2020	Ruddenklau et al.	N/A	N/A
2001/0025184	12/2000	Messerly	N/A	N/A
2001/0031950	12/2000	Ryan	N/A	N/A
2001/0039419	12/2000	Francischelli et al.	N/A	N/A
2002/0002377	12/2001	Cimino	N/A	N/A
2002/0019649	12/2001	Sikora et al.	N/A	N/A
2002/0022836	12/2001	Goble et al.	N/A	N/A
2002/0049551	12/2001	Friedman et al.	N/A	N/A
2002/0077550	12/2001	Rabiner et al.	N/A	N/A
2002/0095175	12/2001	Brock et al.	N/A	N/A
2002/0107517	12/2001	Witt et al.	N/A	N/A
2002/0133149	12/2001	Bessette	N/A	N/A
2002/0156493	12/2001	Houser et al.	N/A	N/A
2003/0014053	12/2002	Nguyen et al.	N/A	N/A
2003/0055443	12/2002	Spotnitz	N/A	N/A
2003/0066938	12/2002	Zimmerman	N/A	N/A
2003/0109875	12/2002	Tetzlaff et al.	N/A	N/A
2003/0114731	12/2002	Cadeddu et al.	N/A	N/A
2003/0114851	12/2002	Truckai et al.	N/A	N/A
2003/0130693	12/2002	Levin et al.	N/A	N/A
2003/0139741	12/2002	Goble et al.	N/A	N/A
2003/0144660	12/2002	Mollenauer	N/A	N/A
2003/0158548	12/2002	Phan et al.	N/A	N/A
2003/0171747	12/2002	Kanehira et al.	N/A	N/A

2003/0181910	12/2002	Dycus et al.	N/A	N/A
2003/0204199	12/2002	Novak et al.	N/A	N/A
2003/0212332	12/2002	Fenton et al.	N/A	N/A
2003/0229344	12/2002	Dycus et al.	N/A	N/A
2004/0030254	12/2003	Babaev	N/A	N/A
2004/0047485	12/2003	Sherrit et al.	N/A	N/A
2004/0054364	12/2003	Aranyi et al.	N/A	N/A
2004/0092921	12/2003	Kadziauskas et al.	N/A	N/A
2004/0092992	12/2003	Adams et al.	N/A	N/A
2004/0093039	12/2003	Schumert	N/A	N/A
2004/0097919	12/2003	Wellman et al.	N/A	N/A
2004/0097996	12/2003	Rabiner et al.	N/A	N/A
2004/0102804	12/2003	Chin	N/A	N/A
2004/0133089	12/2003	Kilcoyne et al.	N/A	N/A
2004/0138621	12/2003	Jahns et al.	N/A	N/A
2004/0167508	12/2003	Wham et al.	N/A	N/A
2004/0193150	12/2003	Sharkey et al.	N/A	N/A
2004/0199193	12/2003	Hayashi et al.	N/A	N/A
2004/0249367	12/2003	Saadat et al.	N/A	N/A
2004/0249374	12/2003	Tetzlaff et al.	N/A	N/A
2004/0260273	12/2003	Wan	N/A	N/A
2004/0260300	12/2003	Gorensek et al.	N/A	N/A
2005/0015125	12/2004	Mioduski et al.	N/A	N/A
2005/0033278	12/2004	McClurken	606/49	A61B 18/14
2005/0033337	12/2004	Muir et al.	N/A	N/A
2005/0090817	12/2004	Phan	N/A	N/A
2005/0096502	12/2004	Khalili	N/A	N/A
2005/0119640	12/2004	Sverduk et al.	N/A	N/A
2005/0131390	12/2004	Heinrich et al.	N/A	N/A
2005/0143769	12/2004	White et al.	N/A	N/A
2005/0149108	12/2004	Cox	N/A	N/A
2005/0165429	12/2004	Douglas et al.	N/A	N/A
2005/0171522	12/2004	Christopherson	N/A	N/A
2005/0177184	12/2004	Easley	N/A	N/A
2005/0192610	12/2004	Houser et al.	N/A	N/A
2005/0215858	12/2004	Vail	N/A	N/A
2005/0256405	12/2004	Makin et al.	N/A	N/A
2005/0261588	12/2004	Makin et al.	N/A	N/A
2005/0267464	12/2004	Truckai et al.	N/A	N/A
2005/0272972	12/2004	Iddan	N/A	N/A
2005/0273139	12/2004	Krauss et al.	N/A	N/A
2005/0288555	12/2004	Binmoeller	N/A	N/A
2005/0288659	12/2004	Kimura et al.	N/A	N/A
2006/0030797	12/2005	Zhou et al.	N/A	N/A
2006/0058825	12/2005	Ogura et al.	N/A	N/A
2006/0063130	12/2005	Hayman et al.	N/A	N/A
2006/0064086	12/2005	Odom	N/A	N/A
2006/0106379	12/2005	O'Brien et al.	N/A	N/A
2006/0159731	12/2005	Shoshan	N/A	N/A
2006/0190034	12/2005	Nishizawa et al.	N/A	N/A

2006/0211943	12/2005	Beaupre	N/A	N/A
2006/0253050	12/2005	Yoshimine et al.	N/A	N/A
2006/0270916	12/2005	Skwarek et al.	N/A	N/A
2006/0293656	12/2005	Shadduck et al.	N/A	N/A
2007/0008744	12/2006	Heo et al.	N/A	N/A
2007/0010709	12/2006	Reinschke	N/A	N/A
2007/0016235	12/2006	Tanaka et al.	N/A	N/A
2007/0016236	12/2006	Beaupre	N/A	N/A
2007/0020065	12/2006	Kirby	N/A	N/A
2007/0032701	12/2006	Fowler et al.	N/A	N/A
2007/0032704	12/2006	Gandini et al.	N/A	N/A
2007/0032785	12/2006	Diederich et al.	N/A	N/A
2007/0051766	12/2006	Spencer	N/A	N/A
2007/0055228	12/2006	Berg et al.	N/A	N/A
2007/0063618	12/2006	Bromfield	N/A	N/A
2007/0073185	12/2006	Nakao	N/A	N/A
2007/0073341	12/2006	Smith et al.	N/A	N/A
2007/0106317	12/2006	Shelton et al.	N/A	N/A
2007/0118115	12/2006	Artale et al.	N/A	N/A
2007/0123748	12/2006	Meglan	N/A	N/A
2007/0130771	12/2006	Ehlert et al.	N/A	N/A
2007/0135686	12/2006	Pruitt et al.	N/A	N/A
2007/0149881	12/2006	Rabin	N/A	N/A
2007/0173803	12/2006	Wham et al.	N/A	N/A
2007/0173813	12/2006	Odom	N/A	N/A
2007/0173872	12/2006	Neuenfeldt	N/A	N/A
2007/0182842	12/2006	Sonnenschein et al.	N/A	N/A
2007/0185474	12/2006	Nahen	N/A	N/A
2007/0191713	12/2006	Eichmann et al.	N/A	N/A
2007/0203483	12/2006	Kim et al.	N/A	N/A
2007/0208340	12/2006	Ganz et al.	N/A	N/A
2007/0219481	12/2006	Babaev	N/A	N/A
2007/0232926	12/2006	Stulen et al.	N/A	N/A
2007/0232928	12/2006	Wiener et al.	N/A	N/A
2007/0236213	12/2006	Paden et al.	N/A	N/A
2007/0249941	12/2006	Salehi et al.	N/A	N/A
2007/0260242	12/2006	Dycus et al.	N/A	N/A
2007/0265560	12/2006	Soltani et al.	N/A	N/A
2007/0265613	12/2006	Edelstein et al.	N/A	N/A
2007/0265616	12/2006	Couture et al.	N/A	N/A
2007/0270651	12/2006	Gilad et al.	N/A	N/A
2007/0275348	12/2006	Lemon	N/A	N/A
2007/0276424	12/2006	Mikkaichi et al.	N/A	N/A
2007/0287933	12/2006	Phan et al.	N/A	N/A
2008/0015413	12/2007	Barlow et al.	N/A	N/A
2008/0015575	12/2007	Odom et al.	N/A	N/A
2008/0058775	12/2007	Darian et al.	N/A	N/A
2008/0058845	12/2007	Shimizu et al.	N/A	N/A
2008/0071269	12/2007	Hilario et al.	N/A	N/A

2008/0077129	12/2007	Van Wyk	606/46	A61B 18/149
2008/0082039	12/2007	Babaev	N/A	N/A
2008/0082098	12/2007	Tanaka et al.	N/A	N/A
2008/0103495	12/2007	Mihori et al.	N/A	N/A
2008/0114355	12/2007	Whayne et al.	N/A	N/A
2008/0147058	12/2007	Horrell et al.	N/A	N/A
2008/0147062	12/2007	Truckai et al.	N/A	N/A
2008/0167645	12/2007	Woloszko	604/28	A61B 18/12
2008/0171938	12/2007	Masuda et al.	N/A	N/A
2008/0177268	12/2007	Daum et al.	N/A	N/A
2008/0188755	12/2007	Hart	N/A	N/A
2008/0200940	12/2007	Eichmann et al.	N/A	N/A
2008/0208231	12/2007	Ota et al.	N/A	N/A
2008/0214967	12/2007	Aranyi et al.	N/A	N/A
2008/0228179	12/2007	Eder et al.	N/A	N/A
2008/0234709	12/2007	Houser	N/A	N/A
2008/0281200	12/2007	Voic et al.	N/A	N/A
2008/0281315	12/2007	Gines	N/A	N/A
2008/0287948	12/2007	Newton et al.	N/A	N/A
2008/0300588	12/2007	Groth et al.	N/A	N/A
2008/0312502	12/2007	Swain et al.	N/A	N/A
2009/0012516	12/2008	Curtis et al.	N/A	N/A
2009/0048589	12/2008	Takashino et al.	N/A	N/A
2009/0076506	12/2008	Baker	N/A	N/A
2009/0082716	12/2008	Akahoshi	N/A	N/A
2009/0082766	12/2008	Unger et al.	N/A	N/A
2009/0114701	12/2008	Zemlok et al.	N/A	N/A
2009/0143678	12/2008	Keast et al.	N/A	N/A
2009/0182322	12/2008	D'Amelio et al.	N/A	N/A
2009/0182331	12/2008	D'Amelio et al.	N/A	N/A
2009/0182332	12/2008	Long et al.	N/A	N/A
2009/0248021	12/2008	McKenna	N/A	N/A
2009/0254080	12/2008	Honda	N/A	N/A
2009/0264879	12/2008	McClurken	606/41	A61B 18/1206
2009/0270771	12/2008	Takahashi	N/A	N/A
2009/0270853	12/2008	Yachi et al.	N/A	N/A
2009/0287205	12/2008	Ingle	N/A	N/A
2010/0022824	12/2009	Cybulski	600/104	A61B 1/012
2010/0036370	12/2009	Mirel et al.	N/A	N/A
2010/0081863	12/2009	Hess et al.	N/A	N/A
2010/0081864	12/2009	Hess et al.	N/A	N/A
2010/0081883	12/2009	Murray et al.	N/A	N/A
2010/0094323	12/2009	Isaacs et al.	N/A	N/A
2010/0158307	12/2009	Kubota et al.	N/A	N/A
2010/0187283	12/2009	Crainich et al.	N/A	N/A
2010/0204802	12/2009	Wilson et al.	N/A	N/A
2010/0222752	12/2009	Collins, Jr. et al.	N/A	N/A
2010/0274278	12/2009	Fleenor et al.	N/A	N/A

2010/0280368	12/2009	Can et al.	N/A	N/A
2010/0298743	12/2009	Nield et al.	N/A	N/A
2011/0009857	12/2010	Subramaniam et al.	N/A	N/A
2011/0028964	12/2010	Edwards	N/A	N/A
2011/0087224	12/2010	Cadeddu et al.	N/A	N/A
2011/0118601	12/2010	Barnes	600/439	A61B 18/14
2011/0125151	12/2010	Strauss et al.	N/A	N/A
2011/0257680	12/2010	Reschke et al.	N/A	N/A
2011/0270242	12/2010	Marion	606/34	A61B 18/148
2011/0270245	12/2010	Horner et al.	N/A	N/A
2011/0278343	12/2010	Knodel et al.	N/A	N/A
2011/0284014	12/2010	Cadeddu et al.	N/A	N/A
2011/0290856	12/2010	Shelton, IV et al.	N/A	N/A
2011/0295295	12/2010	Shelton, IV et al.	N/A	N/A
2011/0306967	12/2010	Payne et al.	N/A	N/A
2011/0313415	12/2010	Fernandez et al.	N/A	N/A
2012/0016413	12/2011	Timm et al.	N/A	N/A
2012/0022519	12/2011	Huang et al.	N/A	N/A
2012/0022526	12/2011	Aldridge et al.	N/A	N/A
2012/0041358	12/2011	Mann et al.	N/A	N/A
2012/0078244	12/2011	Worrell et al.	N/A	N/A
2012/0080334	12/2011	Shelton, IV et al.	N/A	N/A
2012/0085358	12/2011	Cadeddu et al.	N/A	N/A
2012/0109186	12/2011	Parrott et al.	N/A	N/A
2012/0116222	12/2011	Sawada et al.	N/A	N/A
2012/0116265	12/2011	Houser et al.	N/A	N/A
2012/0265241	12/2011	Hart et al.	N/A	N/A
2012/0296371	12/2011	Kappus et al.	N/A	N/A
2013/0023925	12/2012	Mueller	N/A	N/A
2013/0123776	12/2012	Monson et al.	N/A	N/A
2013/0158659	12/2012	Bergs et al.	N/A	N/A
2013/0158660	12/2012	Bergs et al.	N/A	N/A
2013/0190753	12/2012	Garrison et al.	N/A	N/A
2013/0253256	12/2012	Griffith et al.	N/A	N/A
2013/0296843	12/2012	Boudreaux et al.	N/A	N/A
2014/0001231	12/2013	Shelton, IV et al.	N/A	N/A
2014/0001234	12/2013	Shelton, IV et al.	N/A	N/A
2014/0005640	12/2013	Shelton, IV et al.	N/A	N/A
2014/0005678	12/2013	Shelton, IV et al.	N/A	N/A
2014/0005702	12/2013	Timm et al.	N/A	N/A
2014/0005705	12/2013	Weir et al.	N/A	N/A
2014/0005718	12/2013	Shelton, IV et al.	N/A	N/A
2014/0014544	12/2013	Bugnard et al.	N/A	N/A
2014/0039493	12/2013	Conley et al.	N/A	N/A
2014/0131419	12/2013	Bettuchi	N/A	N/A
2014/0194864	12/2013	Martin et al.	N/A	N/A
2014/0194874	12/2013	Dietz et al.	N/A	N/A
2014/0194875	12/2013	Reschke et al.	N/A	N/A
2014/0207135	12/2013	Winter	N/A	N/A

2014/0263541	12/2013	Leimbach et al.	N/A	N/A
2014/0263552	12/2013	Hall et al.	N/A	N/A
2015/0032150	12/2014	Ishida et al.	N/A	N/A
2015/0080876	12/2014	Worrell et al.	N/A	N/A
2015/0257819	12/2014	Dycus et al.	N/A	N/A
2015/0272571	12/2014	Leimbach et al.	N/A	N/A
2015/0272659	12/2014	Boudreaux et al.	N/A	N/A
2015/0327918	12/2014	Sobajima et al.	N/A	N/A
2016/0045248	12/2015	Unger et al.	N/A	N/A
2016/0051316	12/2015	Boudreaux	N/A	N/A
2016/0066980	12/2015	Schall et al.	N/A	N/A
2016/0100747	12/2015	Nitsan et al.	N/A	N/A
2016/0175029	12/2015	Witt et al.	N/A	N/A
2016/0270842	12/2015	Strobl et al.	N/A	N/A
2016/0296270	12/2015	Strobl et al.	N/A	N/A
2016/0367307	12/2015	Ishikawa	N/A	A61B 18/14
2017/0105786	12/2016	Scheib et al.	N/A	N/A
2017/0105787	12/2016	Witt et al.	N/A	N/A
2017/0135751	12/2016	Rothweiler et al.	N/A	N/A
2017/0164972	12/2016	Johnson et al.	N/A	N/A
2017/0312018	12/2016	Trees et al.	N/A	N/A
2017/0325878	12/2016	Messerly et al.	N/A	N/A
2017/0325886	12/2016	Graham et al.	N/A	N/A
2018/0125571	12/2017	Witt et al.	N/A	N/A
2018/0161034	12/2017	Scheib et al.	N/A	N/A
2018/0235626	12/2017	Shelton, IV et al.	N/A	N/A
2018/0280075	12/2017	Nott et al.	N/A	N/A
2019/0000470	12/2018	Yates et al.	N/A	N/A
2019/0000536	12/2018	Yates et al.	N/A	N/A
2019/0059980	12/2018	Shelton, IV et al.	N/A	N/A
2019/0099209	12/2018	Witt et al.	N/A	N/A
2019/0099212	12/2018	Davison et al.	N/A	N/A
2019/0099217	12/2018	Witt et al.	N/A	N/A
2019/0200998	12/2018	Shelton, IV et al.	N/A	N/A
2019/0314015	12/2018	Shelton, IV et al.	N/A	N/A
2020/0375651	12/2019	Witt et al.	N/A	N/A
2021/0100605	12/2020	Renner et al.	N/A	N/A
2022/0167975	12/2021	Shelton, IV et al.	N/A	N/A
2022/0167984	12/2021	Shelton, IV et al.	N/A	N/A
2022/0168038	12/2021	Shelton, IV et al.	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
1634601	12/2004	CN	N/A
1922563	12/2006	CN	N/A
2868227	12/2006	CN	N/A
4300307	12/1993	DE	N/A
29623113	12/1996	DE	N/A
20004812	12/1999	DE	N/A

10201569	12/2002	DE	N/A
102005032371	12/2006	DE	N/A
0171967	12/1985	EP	N/A
0705571	12/1995	EP	N/A
1862133	12/2006	EP	N/A
2060238	12/2008	EP	N/A
1747761	12/2008	EP	N/A
1767164	12/2012	EP	N/A
2578172	12/2012	EP	N/A
2419159	12/2012	ES	N/A
2032221	12/1979	GB	N/A
S537994	12/1977	JP	N/A
H08229050	12/1995	JP	N/A
2002186627	12/2001	JP	N/A
2009213878	12/2008	JP	N/A
2010057926	12/2009	JP	N/A
2012019846	12/2011	JP	N/A
WO-8103272	12/1980	WO	N/A
WO-9314708	12/1992	WO	N/A
WO-9800069	12/1997	WO	N/A
WO-9923960	12/1998	WO	N/A
WO-0024330	12/1999	WO	N/A
WO-0128444	12/2000	WO	N/A
WO-02080794	12/2001	WO	N/A
WO-2004078051	12/2003	WO	N/A
WO-2008130793	12/2007	WO	N/A
WO-2009067649	12/2008	WO	N/A
WO-2010104755	12/2009	WO	N/A
WO-2011008672	12/2010	WO	N/A
WO-2011044343	12/2010	WO	N/A
WO-2011144911	12/2010	WO	N/A
WO-2012044606	12/2011	WO	N/A
WO-2012061638	12/2011	WO	N/A
WO-2013131823	12/2012	WO	N/A
WO-2016088017	12/2015	WO	N/A

OTHER PUBLICATIONS

Technology Overview, printed from www.harmonicscalpel.com, Internet site, website accessed on Jun. 13, 2007, (3 pages). cited by applicant
Sherrit et al., “Novel Horn Designs for Ultrasonic/Sonic Cleaning Welding, Soldering, Cutting and Drilling,” Proc. SPIE Smart Structures Conference, vol. 4701, Paper No. 34, San Diego, CA, pp. 353-360, Mar. 2002. cited by applicant
Lim et al., “A Review of Mechanism Used in Laparoscopic Surgical Instruments,” Mechanism and Machine Theory, vol. 38, pp. 1133-1147, (2003). cited by applicant
Gooch et al., “Recommended Infection-Control Practices for Dentistry, 1993,” Published: May 28, 1993; [retrieved on Aug. 23, 2008]. Retrieved from the internet: URL: http//wonder.cdc.gov/wonder/prevguid/p0000191/p0000191.asp (15 pages). cited by applicant
Dean, D.A., “Electrical Impedance Spectroscopy Study of Biological Tissues,” J. Electrostat, 66(3-4), Mar. 2008, pp. 165-177. Accessed Apr. 10, 2018: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2597841/. cited by applicant

Hörmann et al., "Reversible and irreversible denaturation of collagen fibers." Biochemistry, 10, pp. 932-937 (1971). cited by applicant
Covidien Brochure, The LigaSure Precise™ Instrument, dated Mar. 2011 (2 pages). cited by applicant
AST Products, Inc., "Principles of Video Contact Angle Analysis," 20 pages, (2006). cited by applicant
Leonard I. Malis, M.D., "The Value of Irrigation During Bipolar Coagulation," 1989. cited by applicant
Abbott, et al. Proceedings of the 2007 IEEEIRDJ International Conference on Intelligent Robots and Systems. 410-416, 2007. cited by applicant
Cadeddu et al., "Magnetic positioning system for trocarless laparoscopic instruments," American College of Surgeons Poster, 2004. cited by applicant
Cadeddu et al., "Novel magnetically guided intra-abdominal camera to facilitate laparoendoscopic single site surgery: initial human experience," Surgical Endoscopy, SAGES Oral Manuscript, 2009. cited by applicant
Cadeddu et al., "Transabdominal magnetic anchoring system for trocar-less laparoscopic surgery," American Urological Association Poster, 2002. cited by applicant
Cadeddu et al., "Transabdominal magnetic anchoring system for trocar-less laparoscopic surgery," Journal of Urology Abstract, 2002. cited by applicant
Castellvi et al., "Completely transvaginal NOTES cholecystectomy in a porcine model using novel endoscopic instrumentation," Accepted for Poster Presentation, SAGES Annual Meeting, 2009. cited by applicant
Castellvi et al., "Hybrid transgastric NOTES cholecystectomy in a porcine model using a magnetically anchored cautery and novel instrumentation," Submitted for Presentation, ASGE, 2009. cited by applicant
Castellvi et al., "Hybrid transvaginal NOTES sleeve gastrectomy in a porcine model using a magnetically anchored camera and novel instrumentation," Accepted for Poster Presentation, SAGES Annual Meeting, 2009. cited by applicant
Duchene et al., "Magnetic positioning system for trocarless laparoscopic instruments," Engineering and Urology Society Poster, 2004. cited by applicant
Fernandez et al., "Development of a transabdominal anchoring system for trocar-less laparoscopic surgery," ASME Proceedings of/MECE, 2003. cited by applicant
Gedeon et al., "Maximizing coupling strength of magnetically anchored notes instruments: How thick can we go?" Submittedfor Presentation, Poster, SAGES Annual Meeting, 2008. cited by applicant
Gedeon et al., "Maximizing coupling strength of magnetically anchored notes instruments: How thick can we go?" SAGES Annual Meeting Poster, 2008. cited by applicant
Park et al., "Trocar-less Instrumentation for Laparoscopy: Magnetic Positioning of Intra-Abdominal Camera and Retractor", Annals of Surgery, vol. 245, No. 3, pp. 379-384, Mar. 2007. cited by applicant
Peirs et al., "A miniature manipulator for integration in self-propelling endoscope," Sensors and Actuators, 92:343-9, 2001. cited by applicant
Raman et al., "Complete transvaginal NOTES nephrectomy using magnetically anchored instrumentation," Journal of Endourology, 23(3):, 2009.367-371,2009. cited by applicant
Rapaccini et al., "Gastric Wall Thickness in Normal and Neoplastic Subjects: A Prospective Study Performed by Abdominal Ultrasound", Gastrointestinal Radiology, vol. 13, pp. 197-199. 1988. cited by applicant
Scott et al., "A randomized comparison of laparoscopic, flexible endoscopic, and wired and wireless magnetic NOTES cameras on ex-vivo and in-vivo surgical performance," Digestive Disease Week (DDW), American Society for Gastrointestinal Endoscopy (ASGE) Annual Meeting

Abstract, 2008. cited by applicant
Scott et al., “Completely transvaginal NOTES cholecystectomy using magnetically anchored instruments,” Surg. Endosc., 21:2308-2316, 2007. cited by applicant
Scott et al., “Evaluation of a novel air seal access port for transvaginal notes cholecystectomy,” Submitted for Presentation, SAGES Annual Meeting, 2008. cited by applicant
Scott et al., “Magnetically anchored instruments for transgastric endoscopic surgery,” Oral Presentation for SAGES Annual Meeting, Emerging Technology Oral Abstract ET005, 2006. cited by applicant
Scott et al., “Optimizing magnetically anchored camera, light source, graspers, and cautery dissector for transvaginal notes cholecystectomy,” Submitted for Presentation, SAGES Annual Meeting, 2008. cited by applicant
Scott et al., “Short-term survival outcomes following transvaginal NOTES cholecystectomy using magnetically anchored instruments,” Oral Presentation, ASGE Annual Meeting/DDW, 2007. cited by applicant
Scott et al., “Trans gastric, transcolonic, and transvaginal cholecystectomy using magnetically anchored instruments,” SAGES Annual Meeting Poster, 2007. cited by applicant
Scott et al., “Transvaginal NOTES cholecystectomy using magnetically anchored instruments,” Abstract for Video Submission, ASGE II1h Annual Video Forum, 2007. cited by applicant
Scott et al., “Transvaginal single access ‘pure’ NOTES sleeve gastrectomy using a deployable magnetically anchored video camera,” Digestive Disease Week (DDW), American Society for Gastrointestinal Endoscopy (ASGE) Annual Meeting Poster, 2008. cited by applicant
Swain et al., “Linear stapler formation of ileo-rectal, entero-enteral and gastrojejunal anastomoses during dual and single access ‘pure’ NOTES procedures: Methods, magnets and stapler modifications,” Digestive Disease Week (DDW), American Society for Gastrointestinal Endoscopy (ASGE) Annual Meeting Abstract, 2008. cited by applicant
Swain et al., “Wireless endosurgery for NOTES,” Digestive Disease Week (DDW), American Society for Gastrointestinal Endoscopy (ASGE) Annual Meeting Abstract, 2008. cited by applicant
Tang et al., “Live video manipulator for endoscopy and natural orifice transluminal endoscopic surgery (with videos), ” Gastrointestinal Endoscopy, 68:559-564, 2008. cited by applicant
Zeltser et al., “Single trocar laparoscopic nephrectomy using magnetic anchoring and guidance system in the porcine model,” The Journal of Urology, 178:288-291, 2007. cited by applicant
Huston et al., “Magnetic and Magnetostrictive Properties of Cube Textured Nickel for Magnetostrictive Transducer Applications,” IEEE Transactions on Magnetics, vol. 9(4), pp. 636-640 (Dec. 1973). cited by applicant
Orr et al., “Overview of Bioheat Transfer,” pp. 367-384 in Optical-Thermal Response of Laser-Irradiated Tissue, A. J. Welch and M. J. C. van Gemert, eds., Plenum, New York (1995). cited by applicant
F. A. Duck, “Optical Properties of Tissue Including Ultraviolet and Infrared Radiation,” pp. 43-71 in Physical Properties of Tissue (1990). cited by applicant
Campbell et al., “Thermal Imaging in Surgery,” p. 19-3, in Medical Infrared Imaging, N. A. Diakides and J. D. Bronzino, Eds. (2008). cited by applicant
Sullivan, “Cost-Constrained Selection of Strand Diameter and Number in a Litz-Wire Transformer Winding,” IEEE Transactions on Power Electronics, vol. 16, No. 2, Mar. 2001, pp. 281-288. cited by applicant
Covidien Brochure, [Value Analysis Brief], LigaSure Advance™ Pistol Grip, dated Rev. Apr. 2010 (7 pages). cited by applicant
Wright, et al., “Time-Temperature Equivalence of Heat-Induced Changes in Cells and Proteins,” Feb. 1998. ASME Journal of Biomechanical Engineering, vol. 120, pp. 22-26. cited by applicant
Covidien Brochure, LigaSure Impact™ Instrument LF4318, dated Feb. 2013 (3 pages). cited by applicant

Covidien Brochure, LigaSure Atlas™ Hand Switching Instruments, dated Dec. 2008 (2 pages). cited by applicant
Covidien Brochure, The LigaSure™ 5 mm Blunt Tip Sealer/Divider Family, dated Apr. 2013 (2 pages). cited by applicant
Erbe Electrosurgery VIO® 200 S, (2012), p. 7, 12 pages, accessed Mar. 31, 2014 at http://www.erbe-med. com/erbe/media/Marketing materialien/85140170 ERBE EN VIO 200 S D027541. cited by applicant
Jang, J. et al. “Neuro-fuzzy and Soft Computing.” Prentice Hall, 1997, pp. 13-89, 199-293, 335-393, 453-496, 535-549. cited by applicant
Sullivan, “Optimal Choice for Number of Strands in a Litz-Wire Transformer Winding,” IEEE Transactions on Power Electronics, vol. 14, No. 2, Mar. 1999, pp. 283-291. cited by applicant
Weir, C.E., “Rate of shrinkage of tendon collagen - heat, entropy and free energy of activation of the shrinkage of untreated tendon. Effect of acid salt, pickle, and tannage on the activation of tendon collagen.” Journal of the American Leather Chemists Association, 44, pp. 108-140 (1949). cited by applicant
Henriques. F.C., “Studies in thermal injury V. The predictability and the significance of thermally induced rate processes leading to irreversible epidermal injury.” Archives of Pathology, 434, pp. 489-502 (1947). cited by applicant
Wall et al., “Thermal modification of collagen,” J Shoulder Elbow Surg, No. 8, pp. 339-344 (Jul./Aug. 1999). cited by applicant
Arnoczky et al., “Thermal Modification of Conective Tissues: Basic Science Considerations and Clinical Implications,” J. Am Acad Orthop Surg, vol. 8, No. 5, pp. 305-313 (Sep./Oct. 2000). cited by applicant
Chen et al., “Heat-Induced Changes in the Mechanics of a Collagenous Tissue: Isothermal Free Shrinkage,” Transactions of the ASME, vol. 119, pp. 372-378 (Nov. 1997). cited by applicant
Chen et al., “Heat-Induced Changes in the Mechanics of a Collagenous Tissue: Isothermal, Isotonic Shrinkage,” Transactions of the ASME, vol. 120, pp. 382-388 (Jun. 1998). cited by applicant
Chen et al., “Phenomenological Evolution Equations for Heat-Induced Shrinkage of a Collagenous Tissue,” IEEE Transactions on Biomedical Engineering, vol. 45, No. 10, pp. 1234-1240 (Oct. 1998). cited by applicant
Harris et al., “Kinetics of Thermal Damage to a Collagenous Membrane Under Biaxial Isotonic Loading,” IEEE Transactions on Biomedical Engineering, vol. 51, No. 2, pp. 371-379 (Feb. 2004). cited by applicant
Harris et al., “Altered Mechanical Behavior of Epicardium Due to Isothermal Heating Under Biaxial Isotonic Loads,” Journal of Biomechanical Engineering, vol. 125, pp. 381-388 (Jun. 2003). cited by applicant
Lee et al., “A multi-sample denaturation temperature tester for collagenous biomaterials,” Med. Eng. Phy., vol. 17, No. 2, pp. 115-121 (Mar. 1995). cited by applicant
Moran et al., “Thermally Induced Shrinkage of Joint Capsule,” Clinical Orthopaedics and Related Research, No. 281, pp. 248-255 (Dec. 2000). cited by applicant
Wells et al., “Altered Mechanical Behavior of Epicardium Under Isothermal Biaxial Loading,” Transactions of the ASME, Journal of Biomedical Engineering, vol. 126, pp. 492-497 (Aug. 2004). cited by applicant
Gibson, “Magnetic Refrigerator Successfully Tested,” U.S. Department of Energy Research News, accessed online on Aug. 6, 2010 at http://www.eurekalert.org/features/doe/2001-11/dl-mrs062802.php (Nov. 1, 2001). cited by applicant
Humphrey, J.D., “Continuum Thermomechanics and the Clinical Treatment of Disease and Injury,” Appl. Mech. Rev., vol. 56, No. 2 pp. 231-260 (Mar. 2003). cited by applicant
National Semiconductors Temperature Sensor Handbook—http://www.national.com/appinfo/tempsensors/files/temphb.pdf; accessed online: Apr. 1, 2011.

cited by applicant
Hayashi et al., “The Effect of Thermal Heating on the Length and Histologic Properties of the Glenohumeral Joint Capsule,” American Journal of Sports Medicine, vol. 25, Issue 1, 11 pages (Jan. 1997), URL: http://www.mdconsult.com/das/article/body/156183648-2/jorg=journal&source=MI&sp=1 . . . , accessed Aug. 25, 2009. cited by applicant
Douglas, S.C. “Introduction to Adaptive Filter”. Digital Signal Processing Handbook. Ed. Vijay K. Madisetti and Douglas B. Williams. Boca Raton: CRC Press LLC, 1999. cited by applicant
Chen et al., “Heat-induced changes in the mechanics of a collagenous tissue: pseudoelastic behavior at 37° C.,” Journal of Biomechanics, 31, pp. 211-216 (1998). cited by applicant
Kurt Gieck & Reiner Gieck, *Engineering Formulas* § Z.7 (7th ed. 1997). cited by applicant
https://www.kjmagnetics.com/fieldcalculator.asp, retrieved Jul. 11, 2016, backdated to Nov. 11, 2011 via
https://web.archive.org/web/20111116164447/http://www.kjmagnetics.com/fieldcalculator.asp. cited by applicant

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Primary Examiner: Giuliani; Thomas A

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION (1) This application is a divisional patent application claiming priority under 35 U.S.C. § 121 to U.S. patent application Ser. No. 15/720,831, entitled SYSTEMS AND METHODS FOR MANAGING FLUID AND SUCTION IN ELECTROSURGICAL SYSTEMS, which issued on Jun. 15, 2021 as U.S. Pat. No. 11,033,323, the entire disclosure of which is hereby incorporated by reference herein.

BACKGROUND
(1) Many internal surgical procedures require the removal of tissue as part of the surgical procedure. The removal of such tissue invariably results in severing multiple blood vessels leading to localized blood loss. Significant blood loss may comprise the patient's health by potentially leading to hypovolemic shock. Even minor blood loss may complicate the surgery by resulting in blood pooling into the surgical site, thereby obscuring the visibility of the tissue from the surgeons and surgical assistants. The problem of blood loss into the surgical site may be especially important in broad area surgeries, such as liver resection, in which multiple blood vessels may be severed during the procedure.
(2) Typically, an electrosurgical device is used to seal the blood vessels, thereby preventing blood loss. Such electrosurgical devices may include bipolar devices that incorporate a pair of electrodes that are powered by RF (radiofrequency) energy to heat and coagulate the tissue and blood vessels. Direct application of the electrodes to the tissue may lead to unwanted effects such as localized tissue charring and fouling of the electrodes by charred tissue matter sticking to them.
(3) A method to reduce charring and fouling may include introducing a saline fluid into the surgical site to irrigate the site. Alternatively, the saline fluid may be heated by the electrodes to form a steam to coagulate the tissue. In this manner, the tissue is not placed in direct contact with the electrodes and electrode fouling is prevented. Although a saline fluid may be used, any electrically conducting fluid (for example, an aqueous mixture containing ionic salts) may be used to promote steam-based coagulation. After the steam coagulates the tissue by transferring its heat thereto, the steam may condense to water. The resulting water may be used to clear the surgical site of unwanted material such as the remnants of the coagulated tissue. An aspirator or other vacuum device may be used to remove the mixture of water and tissue remnants. It may be difficult and

inefficient for the surgeon to coagulate and aspirate the tissue especially if separate devices are required. Thus, a device incorporating the coagulation and aspiration functions is desirable.
(4) The incorporation of both a saline source and an evacuation source for aspiration into a bipolar electrosurgical coagulation instrument may be problematic. If the aspirator operates continuously, then the saline may not reside in contact with the electrodes long enough to be heated and form steam. If the saline source operates continuously, then excess saline may be delivered to the surgical site and obscure the area from the surgeon. It is possible to have a device with multiple actuators to allow the surgeon to selectively emit a fluid to be vaporized by the electrodes and evacuate the surgical site. However, such multiple actuators may be clumsy to use and lead to hand and finger fatigue during a long surgical procedure.
(5) Nevertheless, it is still possible that the electrodes may experience fouling from charred tissue matter sticking to them. Such charred material may interfere with the operation of the electrodes by acting as localized insulators at the electrode surfaces. Such localized insulation may distort or even reduce the electric fields produced by the electrodes, thereby reducing the effectiveness of the coagulation process. As a result, tissue coagulation may be reduced or impeded, thereby permitting blood to continue to flow into the surgical site despite the application of the electrical field to the electrodes. One method to address electrode fouling may be to remove the electrosurgical device from the surgical site and to manually remove the material from the electrodes. However, this method is not optimal as it may permit un-coagulated tissue to continue bleeding and will present an unwanted interruption to the surgical procedure.
(6) Therefore, it is desirable to have an electrosurgical device that permits a surgeon to efficiently remove charred material from the surface of the electrodes while permitting the device to remain in situ.

SUMMARY

(7) In one aspect, an electrosurgical device is presented that includes: a housing; a shaft extending distally from the housing; an end effector coupled to a distal end of the shaft, the end effector comprising: an electrode; a suction port; and a fluid port; and a control system communicatively coupled to the suction port and the fluid port and configured to control a rate of fluid flowing out of the fluid port and a rate of suction flowing into the suction port.
(8) In another aspect, the electrosurgical device further includes: a first fluid path in fluid communication with the fluid port; and a second fluid path in fluid communication with the suction port; wherein the housing is configured to enclose a first portion of the first fluid path and a first portion of the second fluid path; and wherein the shaft is configured to enclose a second portion of the first fluid path and a second portion of the second fluid path.
(9) In another aspect, the electrosurgical device further includes an impedance sensor configured to measure impedance experienced at the electrode.
(10) In another aspect of the electrosurgical device, the control system is configured to control the rate of fluid flowing out of the fluid port based on the measured impedance experienced at the electrode.
(11) In another aspect of the electrosurgical device, the control system is further configured to control the rate of suction flowing into of the suction port based on the measured impedance experienced at the electrode.
(12) In another aspect, the electrosurgical device further includes a radio frequency (RF) current sensor configured to measure RF current applied to the electrode.
(13) In another aspect of the electrosurgical device, the control system is configured to control the rate of fluid flowing out of the fluid port based on the measured RF current applied to the electrode.
(14) In another aspect of the electrosurgical device, the control system is further configured to control the rate of suction flowing into of the suction port based on the measured RF current applied to the electrode.
(15) In another aspect, the electrosurgical device further includes a temperature sensor configured

to measure temperature of the fluid suctioned into the suction port.
(16) In another aspect of the electrosurgical device, the control system is configured to control the rate of fluid flowing out of the fluid port based on the measured temperature of the fluid into the suction port.
(17) In another aspect of the electrosurgical device, the control system is further configured to control the rate of suction flowing into of the suction port based on the measured temperature of the fluid into the suction port.
(18) In another aspect of the electrosurgical device, the end effector further comprises a partially deflectable member that is configured to increase the rate of fluid out of the fluid port as the partially deflectable member increases in deflection.
(19) In another aspect of the electrosurgical device, the control system is further configured to increase the rate of fluid flowing out of the fluid port the longer the electrode applies energy.
(20) In another aspect of the electrosurgical device, the control system is further configured to decrease the rate of fluid flowing out of the fluid port the longer the electrode applies energy.
(21) In another aspect, the electrosurgical device further includes a user interface console communicatively coupled to the control system and configured to receive an input from a user to manually control an initial fluid rate of the fluid port.
(22) In another aspect of the electrosurgical device, the control system is further configured to automatically increase the fluid rate of the fluid port after the initial fluid rate is manually specified from the user interface console; wherein the automatic increase of the fluid rate occurs based on an earlier rise in measured temperature of the fluid at the suction port if the initial fluid rate is manually specified at a slower fluid rate, and the automatic increase of the fluid rate occurs based on a later rise in measured temperature of the fluid at the suction port if the initial fluid rate is manually specified at a faster fluid rate.
(23) In another aspect of the electrosurgical device, the control system is configured to: detect an impedance spike based on a drastic change in impedance from the impedance sensor; and in response, increase the rate of fluid flowing out of the fluid port.
(24) In another aspect, a method of a control system of an electrosurgical device is presented, the method comprising: accessing data from one or more sensors related to a physical characteristic of a function occurring at an end effector of the electrosurgical device; controlling a rate of fluid flowing to a fluid port of the electrosurgical device, based on the data related to the physical characteristic; and controlling a rate of suction flowing from a suction port of the electrosurgical device, based on the data related to the physical characteristic.
(25) In another aspect of the method, the physical characteristic comprises a measure of impedance experienced at an electrode of the end effector of the electrosurgical device.
(26) In another aspect of the method, the physical characteristic comprises a measure of RF current applied to an electrode of the end effector of the electrosurgical device.
(27) In another aspect of the method, the physical characteristic comprises a temperature of fluid measured at the suction port at the end effector of the electrosurgical device.

Description

BRIEF DESCRIPTION OF THE FIGURES
(1) The features of the various aspects are set forth with particularity in the appended claims. The various aspects, however, both as to organization and methods of operation, together with advantages thereof, may best be understood by reference to the following description, taken in conjunction with the accompanying drawings as follows:
(2) FIG. **1** illustrates a perspective view of one aspect of an electrosurgical device.
(3) FIG. **2** illustrates an expanded view of one aspect of an end effector of the electrosurgical

device depicted in FIG. **1**.
(4) FIG. **3** illustrates a side perspective view of one aspect of the electrosurgical device depicted in FIG. **1**.
(5) FIG. **4** illustrates a partial sectional perspective view of one aspect of the electrosurgical device depicted in FIG. **1**.
(6) FIG. **5** illustrates a partial sectional plan front (distal) view of one aspect of the electrosurgical device depicted in FIG. **1**.
(7) FIG. **6** illustrates a perspective view of one aspect of the interior components of the electrosurgical device depicted in FIG. **1**.
(8) FIG. **7** illustrates an additional perspective view of one aspect of the interior components of the electrosurgical device depicted in FIG. **1**.
(9) FIG. **8** illustrates an expanded perspective view of one aspect of an end effector of the electrosurgical device depicted in FIG. **7**.
(10) FIG. **9** illustrates an expanded perspective view of one aspect of activation controls of the electrosurgical device depicted in FIG. **7**.
(11) FIG. **10** illustrates a cross-sectional view of one aspect of the electrosurgical device depicted in FIG. **4**.
(12) FIG. **11** illustrates partial sectional perspective view of one aspect of the electrosurgical device depicted in FIG. **4** illustrating a first position of one aspect of a slide switch.
(13) FIG. **12** illustrates partial sectional perspective view of one aspect of the electrosurgical device depicted in FIG. **4** illustrating a second position of one aspect of a slide switch.
(14) FIG. **13** illustrates an additional perspective view of one aspect of the interior components of the electrosurgical device depicted in FIG. **4** illustrating a second position of one aspect of a slide switch.
(15) FIG. **14** illustrates an expanded perspective view of one aspect of an end effector of the electrosurgical device depicted in FIG. **13** illustrating an extended position of one aspect of an aspiration tube.
(16) FIG. **15** illustrates an expanded perspective view of one aspect of activation controls of the electrosurgical device depicted in FIG. **13** illustrating a second position of one aspect of a slide switch.
(17) FIGS. **16**, **17**, and **18** illustrate plan views of the top, side, and bottom, respectively, of one aspect of the electrosurgical device depicted in FIG. **13** illustrating a second position of one aspect of a slide switch.
(18) FIGS. **19**, **20**, and **21** illustrate plan views of the top, side, and bottom, respectively, of one aspect of the electrosurgical device depicted in FIG. **4** illustrating a first position of one aspect of a slide switch.
(19) FIG. **22** illustrates a perspective view of one aspect of an end effector of the electrosurgical device depicted in FIG. **1**.
(20) FIG. **23** illustrates a perspective view of a model of one aspect of an end effector of the electrosurgical device depicted in FIG. **1**.
(21) FIG. **24** shows an example plot of an amount of impedance experienced by an end effector providing electrosurgical energy to coagulate tissue at the surgical site, over a period of time.
(22) FIG. **25** shows an example of an undesirable impedance plot, including many impedance spikes, amidst an ordinary level of impedance over time as indicated by the plot line.
(23) FIG. **26** provides an additional example of an end effector with a physically deflectable member to help regulate fluid flow, according to some aspects.
(24) FIG. **27** provides an example of how this physically deflectable member of FIG. **26** may appear and operate when deflected by pressing against a surface.
(25) FIG. **28** shows a block diagram of various functional components of an electrosurgical system configured to vary the saline flow at the end effector based on measured RF current, according to

some aspects.
(26) FIG. **29** shows a block diagram of various functional components of an electrosurgical system configured to vary the saline flow at the end effector, based on measured RF impedance, according to some aspects.
(27) FIG. **30** shows how, in some aspects, the amount of saline flow may be measured against electrode temperature.
(28) FIG. **31** shows how, in some aspects, the saline flow may depend on activation time of the electrodes.
(29) FIG. **32** shows how, in some aspects, at least a portion of the flow rate may be adjustable by the user, while other portions thereafter may be adjusted automatically.
(30) FIG. **33** provides a data plot of both a level of impedance and of current at a surgical site over time, where the data plot shows a smooth impedance line over time, indicating no sticking at the surgical site.
(31) FIG. **34** shows a data plot including a large number of impedance spikes, along with a plot of the current, over time.
(32) FIG. **35** shows a data plot of an example of automatic adjustment of fluid flow rate (Q) as a function of the measured temperature of exiting fluid (T).
(33) FIG. **36** shows a data plot of an example of automatic adjustment of suction (S) as a function of the measured temperature of exiting fluid (T).
(34) FIG. **37** shows a superposition of the data plots of FIG. **35** and FIG. **36**.
(35) FIG. **38** shows a block diagram of an example of functional elements that are used in implementing a control system for managing fluid flow and suction.

DETAILED DESCRIPTION

(36) Applicant of the present application owns the following patent applications filed concurrently herewith and which are each herein incorporated by reference in their respective entireties:
(37) U.S. patent application Ser. No. 15/720,810, titled BIPOLAR ELECTRODE SALINE LINKED CLOSED LOOP MODULATED VACUUM SYSTEM, by inventors David A. Witt et al., filed on Sep. 29, 2017, now U.S. Patent Application Publication No. 2019/0099209.
(38) U.S. patent application Ser. No. 15/720,822, titled IMPROVING SALINE CONTACT WITH ELECTRODES, by inventors Mark A. Davison et al., filed on Sep. 29, 2017, now U.S. Patent Application Publication No. 2019/0099212.
(39) U.S. patent application Ser. No. 15/720,840, titled FLEXIBLE ELECTROSURGICAL INSTRUMENT, by inventors David A. Witt et al., filed on Sep. 29, 2017, now U.S. Patent Application Publication No. 2019/0099217.
(40) Aspects of the present disclosure include control systems of an electrosurgical system for managing the flow of fluid, such as saline, and rates of aspiration or suction, in response to various states of conditions at a surgical site. The control systems may monitor and adjust to impedance at the surgical site, temperature of the surgical tissue, RF current of electrodes, and may account for certain undesirable conditions, such as the electrodes sticking. The control systems may include various automatic sensing scenarios, while also allowing for several manual conditions. Rather than rely on a user to manually control settings to adjust for fluid rate and suction rate, the control system(s) may relieve a user of these tasks and control more reliably the fluid and suction rates to produce more reliable results. The control systems described herein may increase safety and produce more accurate surgical procedures, due to the surgeon being able to devote more attention to perform the acts of surgery and not have to divert attention to manually controlling rates of suction and fluid flow.
(41) FIGS. **1-3** depict views of one example of such an electrosurgical device **100**, according to aspects of the present disclosure. For FIGS. **1-22**, common reference numbers refer to common components within the figures.
(42) The electrosurgical device **100** may include a housing **105** with a shaft **135** extending distally

from the housing **105**. The housing **105** may include, on a proximal end, a proximal fluid source port **115** and a proximal fluid evacuation port **110**. In some electrosurgical device systems, the proximal fluid source port **115** may be placed in fluid communication with a source of a fluid, for example saline, buffered saline, Ringer's solution, or other electrically conducting fluids such as aqueous fluids containing ionic salts. The fluid source may operate as a gravity feed source or it may include components to actively pump the fluid into the proximal fluid source port **115**. An actively pumping fluid source may include, without limitation, a power supply, a pump, a fluid source, and control electronics to allow a user to actively control the pumping operation of the actively pumping fluid source. In some electrosurgical device systems, the fluid evacuation port **110** may be placed in fluid communication with a vacuum source. The vacuum source may include a power supply, a pump, a storage component to store material removed by the vacuum source, and control electronics to allow a user to actively control the pumping operation of the vacuum source.

(43) In addition, the housing **105** may include a connector to which a cable **117** of an energy source **120** may be attached. The energy source **120** may be configured to supply energy (for example RF or radiofrequency energy) to the electrodes **145***a,b*. The energy source **120** may include a generator configured to supply power to the electrosurgical device **100** through external means, such as through the cable **117**. In certain instances, the energy source **120** may include a microcontroller coupled to an external wired generator. The external generator may be powered by AC mains. The electrical and electronic circuit elements associated with the energy source **120** may be supported by a control circuit board assembly, for example. The microcontroller may generally comprise a memory and a microprocessor ("processor") operationally coupled to the memory. The electronic portion of the energy source **120** may be configured to control transmission of energy to electrodes **145***a,b* at the end effector **140** of the electrosurgical device **100**. It should be understood that the term processor as used herein includes any suitable microprocessor, microcontroller, or other basic computing device that incorporates the functions of a computer's central processing unit (CPU) on an integrated circuit or at most a few integrated circuits. The processor may be a multipurpose, programmable device that accepts digital data as input, processes it according to instructions stored in its memory, and provides results as output. It is an example of sequential digital logic, as it has internal memory. Processors operate on numbers and symbols represented in the binary numeral system. The energy source **120** may also include input devices to allow a user to program the operation of the energy source **120**.

(44) The housing **105** may also include one or more activation devices to permit a user to control the functions of the electrosurgical device **100**. In some non-limiting examples, the electrosurgical device **100** may include a metering valve **125** that may be activated by a user to control an amount of fluid flowing through the electrosurgical device and provide, at the distal end, an amount of the fluid to the end effector **140**. In some non-limiting examples, the metering valve **125** may also permit the user to control an amount of energy supplied by the energy source **120** to the electrodes **145***a,b* at the end effector **140**. As an example, the metering valve **125** may comprise a screw activation pinch valve to regulate the flow of fluid through the electrosurgical device **100**. Additionally, the metering valve **125** may have a push-button activation function to permit current to flow from the energy source **120** to the electrodes **145***a,b* upon depression of the push-button by a user. It may be recognized that in some non-limiting examples, the housing **105** may include the metering valve **125** to allow regulation of fluid flow through the electrosurgical device **100** and a separate energy control device to control the amount of current sourced to the electrodes **145***a,b*.

(45) The housing **105** may also be attached to a shaft **135** at a distal end of the housing **105**. An end effector **140** may be associated with a distal end of the shaft **135**. The end effector **140** may include electrodes **145***a,b* that may be in electrical communication with the energy source **120** and may receive electrical power therefrom. In some non-limiting examples, a first electrode **145***a* may receive electrical energy of a first polarity (such as a positive polarity) from the energy supply **120** and the second electrode **145***b* may receive electrical energy of a second and opposing polarity

(such as a negative polarity) from the energy supply **120**. Alternatively, the first electrode **145***a* may be connected to a ground terminal of the energy supply **120**, and the second electrode **145***b* may be connected to a varying AC voltage terminal of the energy supply **120**. The electrodes **145***a,b* may extend beyond the distal end of the shaft **135**. The extended ends of the electrodes **145***a,b* be separated by a diverter **155**. The diverter **155** may contact the first electrode **145***a* at a first edge of the diverter **155**, and the diverter **155** may contact the second electrode **145***b* at a second edge of the diverter **155**. The diverter **155** may comprise an electrically insulating material and/or a heat resistant material, which may include, without limitation, a plastic such as a polycarbonate or a ceramic. The diverter **155** may be deformable or non-deformable. In some non-limiting examples, the housing **105** may include a mechanism to control a shape of a deformable diverter **155**.

(46) The end effector **140** may also include a fluid discharge port **150** that may be in fluid communication with the fluid source port **115** through a first fluid path. The first fluid path, such as a source fluid path (see **315** in FIG. **6**), may permit the fluid to flow from the fluid source port **115** to the fluid discharge port **150**. In some non-limiting examples, the fluid discharge port **150** may be positioned above the diverter **155** so that a fluid emitted by the fluid discharge port **150** may be collected on a top surface of the diverter **155**. The end effector may also include a fluid aspiration port **165** that may be in fluid communication with the fluid evacuation port **110** through a second fluid path. The second fluid path, such as an aspirated fluid path (see **210** in FIGS. **7** and **9**), may permit a liquid mixture generated at the surgical site to flow from the fluid aspiration port **165** to the fluid evacuation port **110**. The liquid mixture may then be removed from the electrosurgical device **100** by the vacuum source and stored in the storage component for later removal.

(47) In some non-limiting examples, the fluid aspiration port **165** may be formed at the distal end of an aspiration tube **160**. The aspiration tube **160** may also form part of the aspirated fluid path **210**. The aspiration tube **160** may be located within the shaft **135** or it may be located outside of and beneath the shaft **135**. An aspiration tube **160** located outside of the shaft **135** may be in physical communication with an external surface of the shaft **135**. In some examples, the aspiration tube **160** may have a fixed location with respect to the shaft **135**. In some alternative examples, the aspiration tube **160** may be extendable in a distal direction with respect to the shaft **135**. Extension of the extendable aspiration tube **160** may be controlled by means of an aspiration tube control device. As one non-limiting example, the aspiration tube control device may comprise a slide switch **130**. The slide switch **130**, in a first position (for example, in a proximal position), may cause the aspiration tube **160** to remain in a first or retracted position in which the aspiration port **165** is located essentially below the fluid discharge port **150**. However, the slide switch **130** in a second position (for example in a distal position), may cause the aspiration tube **160** to extend in a distal direction to a fully extended position so that the aspiration port **165** is located distal from and beneath the fluid discharge port **150**. In one example, the slide switch **130** may preferentially position the aspiration tube **160** in one of two positions, such as the retracted position and the fully extended position. It may be recognized, however, that the slide switch **130** may also permit the aspiration tube **160** to assume any position between the retracted position and the fully extended position. Regardless of the position of the aspiration tube **160** as disclosed above, the aspiration port **165** may be maintained at a location beneath a plane defined by the top surface of the diverter **155**. In this manner, the diverter **155** is configured to prevent fluid emitted by the fluid discharge port **150** from directly being removed at the aspiration port **165**.

(48) FIGS. **4** and **5** present partial interior views of an electrosurgical device **200**. In addition to the components disclosed above with respect to FIGS. **1-3**, the electrosurgical device **200** includes an aspirated fluid path **210** that forms a fluid connection between the proximal fluid evacuation port **110** and the distal fluid aspiration port **165**. Also illustrated are valve components **225** of the metering valve **125** and control components **230** of the aspiration tube such as, for example, a slide switch **130**. Fluid discharge port **150**, electrodes **145***a,b*, fluid aspiration port **165**, and a portion of housing **105** are also illustrated in FIGS. **4** and **5**.

(49) FIGS. **6-9** present a variety of views of the interior components of electrosurgical device **300**. FIG. **8** is a close-up view of the distal end of the electrosurgical device **300** shown in FIG. **7**, and FIG. **9** is a close-up view of actuator components of the electrosurgical device **300** shown in FIG. **7** depicting the metering valve **125** and slide switch **130**. Additional components depicted in FIGS. **6-9** include the source fluid path **315** that forms a fluid connection between the proximal fluid source port **115** and the distal fluid discharge port **150**. In some examples, the valve components **225** of the metering valve **125** are disposed along the length of the source fluid path **315** permitting a user of electrosurgical device **300** to regulate a flow of fluid through the source fluid path **315** from the fluid source port **115** to the fluid discharge port **150**. In some examples of the valve components **225**, a screw actuator, such as a pinch valve, may be used to compress a portion of the source fluid path **315**, thereby restricting a flow of fluid therethrough. It may be recognized that any number of fluid control valves may be used as valve components **225** including, without limitation, a ball valve, a butterfly valve, a choke valve, a needle valve, and a gate valve. It may be understood from FIGS. **6-9** that source fluid path **315** extends from fluid source port **115** through the housing **105** and through shaft **135** to the distal fluid discharge port **150**. Similarly, it may be understood from FIGS. **6-9** that aspirated fluid path **210** extends form the proximal fluid evacuation port **110** through the housing **105** and through shaft **135** to the distal fluid aspiration port **165**. Additionally, electrodes **145***a,b* may extend from housing **105** through shaft **135** and extend distally and protrude from the end of shaft **135**. Alternatively, electrodes **145***a,b* may extend only through the shaft **135** and extend distally and protrude from the end of shaft **135**. Proximal ends **345***a,b* of the electrodes **145***a,b,* may receive connectors to place the electrodes **145***a,b* in electrical communication with energy source **120**. Electrodes **145***a,b* may receive the electrical energy from the energy source **120** to permit coagulation to the tissue in the surgical site either through direct contact of the tissue with the protruding portion of the electrodes **145***a,b*, or through heating a fluid contacting electrodes **145***a,b.*

(50) FIG. **10** is a cross-sectional view of electrosurgical device **400**. In particular, the cross-sectional view **400** illustrates the two fluid paths through the device. Thus, FIG. **10** illustrates source fluid path **315** in fluid communication with the proximal fluid source port **115** and the distal fluid discharge port **150**. Additionally, FIG. **10** illustrates an example of a physical relationship between source fluid path **315** and the valve components **225** of the metering valve **125**. FIG. **10** also illustrates an example in which the source fluid path **315** may extend through both the housing **105** and the shaft **135** (see e.g., FIG. **4**). Further, FIG. **10** illustrates aspirated fluid path **210** in fluid communication with the proximal fluid evacuation port **110** and the distal fluid aspiration port **165**. The aspirated fluid path **210** may also include an aspiration tube **160** that may be disposed at a distal end of the aspirated fluid path **210**. The distal fluid aspiration port **165** may be formed at a distal end of the aspiration tube **160**.

(51) FIGS. **11-21** illustrate partial interior views of an electrosurgical device **200** having an aspiration tube **160** in a proximal or retracted position and an electrosurgical device **500** (FIG. **12**) having an aspiration tube **160** in an distal or extended position Z. FIG. **11** is similar to FIG. **4** and particularly illustrates a first and proximal position X of the slide switch **130** (as a non-limiting example of an aspiration tube control device) along with a proximal or retracted position of aspiration tube **160**. FIG. **12** particularly illustrates a second and distal position Y of the slide switch **130** (as a non-limiting example of an aspiration tube control device) in addition to a distal or extended position Z of aspiration tube **160**. FIG. **13** illustrates an alternative perspective view of electrosurgical device **500**. FIG. **14** is an expanded perspective view of the distal end of the electrosurgical device **500** shown in FIG. **13**, particularly illustrating the distal end of aspiration tube **160** in the extended position Z. FIG. **15** is an expanded perspective view of actuator components of the electrosurgical device **500** shown in FIG. **13**, particularly illustrating the second or distal position X of the slide switch **130**. FIGS. **16**, **17**, and **18** present plan views of the top, side, and bottom, respectively, of electrosurgical device **500**. FIGS. **16-18** may be compared with

FIGS. **19**, **20**, and **21** which present plan views of the top, side, and bottom, respectively, of electrosurgical device **200**. FIGS. **16-18** illustrate the distal positions Y and Z of slide switch **130** and aspiration tube **160**, respectively. FIGS. **19-21** illustrate the proximal position X of slide switch **130** and the proximal or retracted position of aspiration tube **160**.

(52) FIG. **22** presents a perspective view of a general example of an end effector **600**. As disclosed above, the end effector may be composed of a pair of electrodes **145***a,b*, extending from a shaft **135**, a distal fluid discharge port **150**, a diverter **155**, and an aspiration port **165** that may be part of an aspiration tube **160**. The diverter **155** may be placed between the pair of electrodes **145***a,b* in such a manner as to form a contact of a first edge of the diverter **155** with a surface of one electrode **145***a*, and a contact of a second edge of the diverter **155** with a surface on a second electrode **145***b*. In some examples, a proximal edge of the diverter **155** may form a mechanical communication with an end surface of the shaft **135**. In this manner, fluid emitted by the distal fluid discharge port **150** may be retained on a first or top surface of the diverter **155**. The fluid on the top surface of the diverter **155** may be retained on that surface for a sufficient time to maintain contact of the fluid with a surface of both electrodes **145***a,b*. If the fluid is an ionic fluid, current passing through the fluid between the electrodes **145***a,b* may heat the fluid sufficiently to form a steam capable of cauterizing tissue.

(53) It may be recognized that the electrodes **145***a,b* may be fabricated to have any type of geometry that may improve the effectiveness of the electrodes **145***a,b*. For example, the electrodes **145***a,b* may be chamfered to result in oval distal ends in which the respective long axes are directed towards an inner portion of the end effector and pointing towards the diverter. Alternatively the distal portion of the electrodes **145***a,b* may have a circular or oval cross section, but the electrodes **145***a,b* may have a fabiform or kidney-shaped cross section closer (proximal) to the shaft **135**.

(54) FIG. **23** depicts a perspective view of a fabricated model of the end effector **600** as depicted in FIG. **22**.

(55) Aspects of the present disclosure include control systems of an electrosurgical system for managing the flow of fluid, such as saline, and rates of aspiration or suction, in response to various states of conditions at the surgical site. The control systems may monitor and adjust to impedance at the surgical site, temperature of the surgical tissue, RF current of electrodes, and may account for certain undesirable conditions, such as the electrodes sticking. The control systems may include various automatic sensing scenarios, while also allowing for several manual conditions.

(56) Referring to FIG. **24**, graph **2400** shows an example plot **2410** of an amount of impedance experienced by an end effector (e.g., end effector **140**) providing electrosurgical energy to coagulate tissue at the surgical site, over a period of time. In this example, the amount of impedance, expressed in ohms, gradually changes at the surgical site. This is a sign that amount of fluid flowing to the surgical site and appropriate amount of suction is well-managed, in that too much or too little fluid would create wild imbalances in measured impedance. The various example techniques described herein for managing flow of fluid and suction are designed to establish such a smooth curve in impedance over time.

(57) Referring to FIG. **25**, graph **2500** shows an example of an undesirable impedance plot, including many impedance spikes, e.g., spikes **2520** and **2530**, amidst an ordinary level of impedance over time as indicated by the plot line **2510**. It has been observed that sudden impedance spikes are a precursor and an indicator of sticking by the electrodes. Unwanted sticking by the electrodes can create a danger that the electrodes may apply to much energy to a particular location at the surgical site, possibly causing errors during surgery. It is therefore desirable to adjust the fluid rate automatically as much as possible based on sensed conditions at the surgical site to prevent impedance spikes, and ultimately reduce the possibility of sticking by the electrodes. FIGS. **26-39** describe various aspects to address these problems.

(58) Referring to FIG. **26**, illustration **2600** provides an additional example of an end effector with a physically deflectable member to help regulate fluid flow, according to some aspects. As shown,

the end effector of illustration **2600** is shaped in a bendable and flat configuration, similar to a spatula. The middle is hollow, to allow space for the suction port **2620**. Electrodes **2610***a* and **2610***b* are located at the end of the end effector, while fluid ports, such as ports **2630***a* and **2630***b*, are spaced along the bendable portion of the end effector. In this example, there are a total of 12 fluid ports, six on the top and six on the bottom. In other examples not shown, fluid ports may also be positioned at the distal end of the end effector, while the electrodes may be positioned at other strategic locations.

(59) Referring to FIG. **27**, illustration **2700** provides an example of how this physically deflectable member may appear and operate when deflected by pressing against a surface. The deflected portion is shown at position **2710**. In some aspects, a minimum flow or "weep" of saline automatically flows even when the end effector is not deflected. In some aspects, increasing the deflection of the end effector operates the fluid valve such that more fluid flows with increasing deflection. In some aspects, this physical deflection may be combined with other mechanisms that control the flow of saline.

(60) Referring to FIG. **28**, illustration **2800** shows a block diagram of various functional components of an electrosurgical system configured to vary the saline flow at the end effector **2830** based on measured RF current, according to some aspects. The electrosurgical system includes an electrosurgical unit (ESU) **2805** that is configured to provide power to the system. At least one current sensor **2810** is coupled to the ESU **2805** and is configured to measure an amount of RF current that is being supplied by the ESU **2005**. The RF current may be dictated by one or more mechanisms on the electrosurgical device (e.g. device **100**), and may be controlled at least in part by a human user operating the device. In some aspects, an amplifier **2815** is configured to magnify the signal of the current sensor to feed into a proportional or multistage valve **2825**. The amount of RF current, as expressed through the amplifier **2815**, can be used to control the proportional or multistage valve **2825**. The fluid, such as saline **2820**, passes through the valve **2825** at a rate according to an amount of current provided by the ESU **2805**. In some aspects, the amount of saline flow is a function of the RF current according to the graph shown in plot **2835**, as just one example. In general, the amount of saline flow may be designed to appropriately match the amount of energy supplied at the electrodes of the end effector **2830**, based on how much RF current is being supplied. The current may be proportional to the work being done in the tissue at the surgical site. Higher current tends to mean that the surgeon is in contact with a lot of tissue, and turning up the flow rate automatically would appropriately match the situation the surgeon is facing.

(61) Referring to FIG. **29**, illustration **2900** shows a block diagram of various functional components of an electrosurgical system configured to vary the saline flow at the end effector **2930**, based on measured RF impedance, according to some aspects. Similar to illustration **2800**, the electrosurgical system includes an ESU **2905** that is configured to provide power to the system. At least one impedance measure or monitor **2910** is coupled to the ESU **2905** and the electrosurgical device (e.g. device **100**), and is configured to measure an amount of impedance experienced at the surgical site. In some aspects, the impedance monitor **2910** may include current and voltage sensor measures configured to calculate RF tissue impedance. In some aspects, an amplifier **2915** is configured to magnify the signal from the impedance measure **2910** and is fed into a proportional or multistage valve **2925**. The fluid, such as saline **2920**, passes through the valve **2925** at a rate according to an amount inversely proportional to the measured impedance. In some aspects, the amount of saline flow is a function of the measured RF impedance according to the graph shown in plot **2935**, just as one example. In general, the amount of saline flow may be designed to appropriately counterbalance the amount of measured impedance at the surgical site. The RF impedance may be inversely proportional to the saline flow. Low tissue impedance generally implies that there is a lot of work to be done in the tissue, and saline flow should therefore be increased. Higher impedance means that the surgeon is probably in contact with less tissue or the tissue is mostly coagulated, and therefore the flow can be reduced.

(62) Referring to FIG. **30**, in some aspects, the amount of saline flow may be measured against electrode temperature. Illustration **3000** shows a plot representing how a control algorithm may be configured to vary the saline flow rate based on measured temperature of the electrodes during surgery. In this example, there are predetermined minimums and maximums of the flow rate, and the flow rate may vary in a linear proportion as the temperature increases from 60° C. to 90° C. One or more temperature sensors may be communicatively coupled to one or more of the electrodes at an end effector, which may be coupled to a proportional or multistage valve (e.g., valves **2825** or **2925**), which may be used to control the flow of saline through it. In some aspects, the control system may be configured to monitor temperature in addition to one or more of tissue impedance and RF current. That is, multiple types of sensors may be included in the control system, such that the flow rate of saline may be varied according to any of these different measurements. In some aspects, a user of the system may be able to specify which sensors would control the flow rate.
(63) Referring to FIG. **31**, in some aspects, the saline flow may depend on activation time of the electrodes. Illustration **3100** shows a plot of two different modes that reflect different amounts of saline flow for a given amount of activation time. In certain modes of operation, saline flow is increased over a given activation time in order to provide more irrigation as the surgeon is working at the surgical site. This concept is reflected by the curve **3105** of ode 1. In this case, the amount of saline is provided substantially after a couple seconds of activation time have elapsed, reflecting providing more fluid after a brief amount of time of the electrodes working at the surgical site. Mode 1 reflects providing more fluid to cool the surgical site in order to satisfy a need that is developing at that very moment. In other modes of operation, saline flow starts at a maximum rate at the beginning of activation, and then decreases to a minimum. This provides maximum irrigation during the very first part of tissue contact and decreases as less saline is required to aid in the coagulation function. This is reflected graphically in the curve **3110** of mode 2. In some aspects, in activation button or other mechanism for activating the RF is tied to a proportional or multistage variable valve that controls the flow of saline (e.g., valves **2825** or **2925**). As the activation time increases, the control signal to the valve changes to either increase or decrease the flow according to the setting of either mode 1 or mode 2, respectively.
(64) Referring to FIG. **32**, in some aspects, at least a portion of the flow rate may be adjustable by the user, while other portions thereafter may be adjusted automatically. Illustration **3200** provides a graph of 3 different plots **3210**, **3220**, and **3230**, showing how an initial flow rate can be set manually and then adjusted automatically thereafter. In this case, the temperature of the return port, e.g., the suction port, is monitored. A user first sets a nominal flow rate, shown as the lower horizontal line in each of the three plots **3210**, **3220**, and **3230**. As return temperature increases, the flow may be increased automatically to compensate for the higher temperature return fluid and to keep the coagulation and tissue effect at or near a desired temperature. This is reflected in the rise of lines in each of the plots after the 1st horizontal lines. In this example, the settings initially at lower temperatures start rising at an earlier increase in temperature (e.g., T3, T2, and T1, respectively, where $T3<T2<T1$). If ever the measure temperature at the return port reaches a near maximum temperature, the flow rate may then be increased to a maximum in response, for all cases, as shown in illustration **3200**. In some aspects, this concept to partially manually select and partially auto adjust may be applied to different measurements, such as temperature of the electrodes, tissue impedance, or RF current. In other words, the concept of enabling a portion of the control system to be manually selectable may be applied to any of the previous control systems described herein.
(65) Referring to FIGS. **33** and **34**, in some aspects, a control system to manage the fluid flow of an electrosurgical system may also be configured to monitor impedance spikes in order to prevent or reduce the occurrence of the electrodes sticking to the tissue at the surgical site. In general, keeping the electrodes cool and lubricated with fluid, such as saline, helps reduce the occurrence of

sticking. Increasing the flow of saline as appropriate, according to various indicia, will offset heat generated at the surgical site and prevent or at least reduce the occurrence of sticking. One notable sign is an impedance spike. It has been observed that sudden spikes in the impedance are a precursor and an indicator of sticking. Thus, in some aspects, the control system may be configured to adjust the flow to increase automatically upon observation of an impedance spike. FIG. **33** provides a data plot **3300** of both a level of impedance **3320** and of current **3310** at a surgical site over time. Data plot **3300** shows a smooth impedance line over time, indicating no sticking at the surgical site.

(66) In contrast, referring to FIG. **34**, data plot **3400** shows a large number of impedance spikes (e.g., spike **3410**, etc.), along with a plot of the current, over time. A control system may be configured to determine whenever an amount of impedance drastically increases over a short amount of time, say over one or two sampling points. This is highly likely to represent an impedance spike, and as a result, the control system may be configured to automatically increase the flow of saline or other fluid automatically. It is noted that this conditional check occurring in the control system can be implemented with any of the other control algorithms described herein. That is, the control system may be configured to perform normally according to any of the other conditions described in the control algorithms previously, and then may perform an override procedure to automatically increase the flow of saline or other fluid when an impedance spike is detected.

(67) Still referring to FIG. **34**, is worth noting that the current plot **3420** shows corresponding drops in current whenever there are impedance spikes. This makes sense because of the general inverse nature of impedance to current, and also when contemplating the fact that an impedance spike tends to suggest that a circuit through the electrodes and the surgical site cannot be completed anymore, there by causing a drop in the current reading. As such, in some aspects, the control system may be configured to monitor sudden drops in current while power is still being applied, as an alternative or additional way to determine when to automatically increase the flow of saline or other fluid.

(68) Aspects of the present disclosure also include methods for controlling the suction functionality of the electrosurgical device in order to vary the amount of suction applied at the surgical site. In general, it is desirable to generate an amount of suction that is portion it to the amount of fluid at the surgical site. A rate of suction that is constant may fail to account for a sufficient number of scenarios that have varying amounts of fluid flow. Too much vacuum may not allow the intended tissue to coagulate, which then allows the tissue to dry out quickly, causing the electrodes to stick to the tissue. Too little vacuum tends to leave extra saline unattended at the tissue surface, which then leads to unintended extra surface burning. In general, it is desirable to change the rate of suction at an amount or frequency that is appropriate to the other factors at the surgical site, such as the amount of saline flowing and the temperature in the target tissue or at the surgical site generally.

(69) Thus, in some aspects, the suction can be modulated on and off with a variable duty cycle and rate, such as two seconds on one second off, which can repeat. This is an example of a 66% duty cycle at a three second rate. This can be accomplished, for example, by turning on and off the vacuum order, opening and closing bypass valves, opening and closing direct valves on the vacuum line, and so forth. A control system may be configured to control these different mechanisms according to a control algorithm that specifies an appropriate variable duty cycle rate. The duty cycle rate may be changeable by the control system, in order to increase or decrease the amount of suction.

(70) In some aspects, the suction can be modulated as a function of the power settings on the generator or a measure of the power delivered to the tissue. For example, an increase of power would result in a corresponding increase in the suction. This increase, or any change in the suction, can be accomplished by changing the rate and duty cycle as previously described, or by increasing or decreasing apertures, remote from the tissue site, on the vacuum line that effectively bypasses

the suction at the tissue site. In general, the control system may be configured to manipulate the duty cycle rate and/or the control of these apertures.

(71) Referring to FIGS. **35-37**, shown are plots that illustrate how a rate of suction can correspond to a rate of fluid flow, according to some aspects. In FIG. **35**, plot **3500** shows an example of automatic adjustment of the fluid flow rate (Q), as a function of measured temperature of exiting fluid (T). The solid line **3510** shows that the rate of fluid starts at a minimum at certain measured low temperatures. The flow rate may increase steadily once the temperature is measured between 70 to 100° C. The flow rate may then be set to a maximum upon reaching a maximum temperature of 100° C. This is just one example of how the flow rate may be automatically adjusted, and other control algorithms as described above may also apply here.

(72) Referring to FIG. **36**, plot **3600** shows an example of automatic adjustment of the suction (S), as a function of the measured temperature of exiting fluid (T). The dashed and dotted line **3610** shows that the rate of suction starts at a minimum at certain measured low temperatures. The suction rate may increase to be at a maximum prior to reaching a maximum fluid temperature, as shown.

(73) Referring to FIG. **37**, plot **3700** shows a superposition of the two lines **3510** and **3610** to illustrate more clearly the interactions between the rate of suction and the rate of fluid flow, according to some aspects. In this example, it can be seen that the minimum rate of suction is higher than the minimum flow rate, and the maximum suction rate is higher than the maximum flow rate. Also, all temperatures, the rate of suction is generally higher than the rate of fluid flow. However, the rate of suction is not drastically higher than the rate of fluid flow at any given temperature, which reflects the desire to sufficiently vacuum the fluid but not drastically so that the surgical site gets to hot and burns.

(74) Referring to FIG. **38**, block diagram **3800** provides one example of functional elements that are used in implementing a control system for managing fluid flow and suction, according to some aspects of the present disclosure. In this example, a fluid source, such as saline bag **3805** is fluidically coupled to the electrosurgical device **3830**. In this example, there are two tubes connected to the saline bag **3805**: a full irrigation tube and a dripping tube. The full irrigation tube may allow for steady flow of the fluid directly into the electrosurgical device **3830**. This may be accessed when maximum fluid flow is desired. In other cases, the dripping tube may be used, which is connected to a pump **3810** that is controlled by a generator **3815**. The generator **3815** may be activated by a button or switch on the electrosurgical device, e.g., button **1** as shown. In some cases, the switch may be a dial or keypad that allows the user to select multiple options for more specific settings to control the flow rate. In this example, another button, e.g., button **3**, may be used to enable the full irrigation functionality. In other cases, a single button or switch may be used to activate irrigation generally, which may be tied to the generator **3815** as well as the full irrigation tube. In other cases, a single button or switch may be used to activate irrigation through a single flow tube from the saline bag **3005**, in which a pump **3810** and a generator **3815** may be used to control all flow rates, including enabling full irrigation. Examples of these systems are described in previous figures, above.

(75) Still referring to FIG. **38**, the vacuum or aspiration system may include a vacuum source, such as a vacuum from the wall, and a valve **3820** and controller **3825**. The vacuum source may come from a generator and is plugged into a wall, as an alternative example. In this example, the electrosurgical device **3830** allows for two paths of enabling the vacuum functionality: a full vacuum path and the pulsing vacuum path. In this example, a tube running directly from the vacuum is connected to the electrosurgical device **3830** to allow for maximum vacuum functionality. A separate tube may connect from the valve **3822** another port and the electrosurgical device **3830** to allow for pulsing vacuum functionality. The controller **3825** may be configured to control the valve **3820**, to allow for a ratio of opening and closing of the valve **3820** to mimic or simulate pulsing vacuuming, which may effectively produce varying or fractional amounts of the

suction. In this example, button **1** may control the pulsing vacuum functionality, as it is connected to the controller **3025**. Button **2** may control the full vacuum functionality. In other examples, a single button or switch may be used to activate the vacuum or suction generally, which may be tied to the controller **3025** as well as a full vacuum tube. In this way, the valve **3820** may be configured to allow for full suction when it is completely open, as well as fractional rates of suction due to the controller **3825** creating a duty cycle rate of opening and closing, or by having the valve **3820** include or be a part of multiple valves that can be opened to relieve vacuum pressure. Examples of these systems are described in previous figures, above.

(76) It will be appreciated that the terms "proximal" and "distal" are used throughout the specification with reference to a clinician manipulating one end of an instrument used to treat a patient. The term "proximal" refers to the portion of the instrument closest to the clinician and the term "distal" refers to the portion located furthest from the clinician. It will further be appreciated that for conciseness and clarity, spatial terms such as "vertical," "horizontal," "up," or "down" may be used herein with respect to the illustrated aspects. However, surgical instruments may be used in many orientations and positions, and these terms are not intended to be limiting or absolute.

(77) Various aspects of surgical instruments are described herein. It will be understood by those skilled in the art that the various aspects described herein may be used with the described surgical instruments. The descriptions are provided for example only, and those skilled in the art will understand that the disclosed examples are not limited to only the devices disclosed herein, but may be used with any compatible surgical instrument or robotic surgical system.

(78) Reference throughout the specification to "various aspects," "some aspects," "one example," "one aspect," "an aspect," "one form," or "a form" means that a particular feature, structure, or characteristic described in connection with the aspect is included in at least one example. Thus, appearances of the phrases "in various aspects," "in some aspects," "in one example," or "in one aspect" in places throughout the specification are not necessarily all referring to the same aspect. Furthermore, the particular features, structures, or characteristics illustrated or described in connection with one example may be combined, in whole or in part, with features, structures, or characteristics of one or more other aspects without limitation.

(79) While various aspects herein have been illustrated by description of several aspects and while the illustrative aspects have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications may readily appear to those skilled in the art. For example, it is generally accepted that endoscopic procedures are more common than laparoscopic procedures. Accordingly, the present invention has been discussed in terms of endoscopic procedures and apparatus. However, use herein of terms such as "endoscopic", should not be construed to limit the present invention to an instrument for use only in conjunction with an endoscopic tube (e.g., trocar). On the contrary, it is believed that the present invention may find use in any procedure where access is limited to a small incision, including but not limited to laparoscopic procedures, as well as open procedures.

(80) It is to be understood that at least some of the figures and descriptions herein have been simplified to illustrate elements that are relevant for a clear understanding of the disclosure, while eliminating, for purposes of clarity, other elements. Those of ordinary skill in the art will recognize, however, that these and other elements may be desirable. However, because such elements are well known in the art, and because they do not facilitate a better understanding of the disclosure, a discussion of such elements is not provided herein.

(81) While several aspects have been described, it should be apparent, however, that various modifications, alterations and adaptations to those aspects may occur to persons skilled in the art with the attainment of some or all of the advantages of the disclosure. For example, according to various aspects, a single component may be replaced by multiple components, and multiple components may be replaced by a single component, to perform a given function or functions. This

application is therefore intended to cover all such modifications, alterations and adaptations without departing from the scope and spirit of the disclosure as defined by the appended claims.
(82) Any patent, publication, or other disclosure material, including, but not limited to U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications, non-patent publications referred to in this specification and/or listed in any Application Data Sheet, or any other disclosure material are incorporated herein by reference in whole or in part, is incorporated herein only to the extent that the incorporated materials does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.
(83) While various details have been set forth in the foregoing description, it will be appreciated that the various aspects of the techniques for operating a generator for digitally generating electrical signal waveforms and surgical instruments may be practiced without these specific details. One skilled in the art will recognize that the herein described components (e.g., operations), devices, objects, and the discussion accompanying them are used as examples for the sake of conceptual clarity and that various configuration modifications are contemplated. Consequently, as used herein, the specific exemplars set forth and the accompanying discussion are intended to be representative of their more general classes. In general, use of any specific exemplar is intended to be representative of its class, and the non-inclusion of specific components (e.g., operations), devices, and objects should not be taken limiting.
(84) Further, while several forms have been illustrated and described, it is not the intention of the applicant to restrict or limit the scope of the appended claims to such detail. Numerous modifications, variations, changes, substitutions, combinations, and equivalents to those forms may be implemented and will occur to those skilled in the art without departing from the scope of the present disclosure. Moreover, the structure of each element associated with the described forms can be alternatively described as a means for providing the function performed by the element. Also, where materials are disclosed for certain components, other materials may be used. It is therefore to be understood that the foregoing description and the appended claims are intended to cover all such modifications, combinations, and variations as falling within the scope of the disclosed forms. The appended claims are intended to cover all such modifications, variations, changes, substitutions, modifications, and equivalents.
(85) For conciseness and clarity of disclosure, selected aspects of the foregoing disclosure have been shown in block diagram form rather than in detail. Some portions of the detailed descriptions provided herein may be presented in terms of instructions that operate on data that is stored in one or more computer memories or one or more data storage devices (e.g. floppy disk, hard disk drive, Compact Disc (CD), Digital Video Disk (DVD), or digital tape). Such descriptions and representations are used by those skilled in the art to describe and convey the substance of their work to others skilled in the art. In general, an algorithm refers to a self-consistent sequence of steps leading to a desired result, where a “step” refers to a manipulation of physical quantities and/or logic states which may, though need not necessarily, take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It is common usage to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like. These and similar terms may be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities and/or states.
(86) Unless specifically stated otherwise as apparent from the foregoing disclosure, it is appreciated that, throughout the foregoing disclosure, discussions using terms such as “processing” or

“computing” or “calculating” or “determining” or “displaying” or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

(87) In a general sense, those skilled in the art will recognize that the various aspects described herein which can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or any combination thereof can be viewed as being composed of various types of “electrical circuitry.” Consequently, as used herein “electrical circuitry” includes, but is not limited to, electrical circuitry having at least one discrete electrical circuit, electrical circuitry having at least one integrated circuit, electrical circuitry having at least one application specific integrated circuit, electrical circuitry forming a general purpose computing device configured by a computer program (e.g., a general purpose computer configured by a computer program which at least partially carries out processes and/or devices described herein, or a microprocessor configured by a computer program which at least partially carries out processes and/or devices described herein), electrical circuitry forming a memory device (e.g., forms of random access memory), and/or electrical circuitry forming a communications device (e.g., a modem, communications switch, or optical-electrical equipment). Those having skill in the art will recognize that the subject matter described herein may be implemented in an analog or digital fashion or some combination thereof.

(88) The foregoing detailed description has set forth various forms of the devices and/or processes via the use of block diagrams, flowcharts, and/or examples. Insofar as such block diagrams, flowcharts, and/or examples contain one or more functions and/or operations, it will be understood by those within the art that each function and/or operation within such block diagrams, flowcharts, and/or examples can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. In one form, several portions of the subject matter described herein may be implemented via an application specific integrated circuits (ASIC), a field programmable gate array (FPGA), a digital signal processor (DSP), or other integrated formats. However, those skilled in the art will recognize that some aspects of the forms disclosed herein, in whole or in part, can be equivalently implemented in integrated circuits, as one or more computer programs running on one or more computers (e.g., as one or more programs running on one or more computer systems), as one or more programs running on one or more processors (e.g., as one or more programs running on one or more microprocessors), as firmware, or as virtually any combination thereof, and that designing the circuitry and/or writing the code for the software and or firmware would be well within the skill of one of skill in the art in light of this disclosure. In addition, those skilled in the art will appreciate that the mechanisms of the subject matter described herein are capable of being distributed as one or more program products in a variety of forms, and that an illustrative form of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution. Examples of a signal bearing medium include, but are not limited to, the following: a recordable type medium such as a floppy disk, a hard disk drive, a Compact Disc (CD), a Digital Video Disk (DVD), a digital tape, a computer memory, etc.; and a transmission type medium such as a digital and/or an analog communication medium (e.g., a fiber optic cable, a waveguide, a wired communications link, a wireless communication link (e.g., transmitter, receiver, transmission logic, reception logic, etc.), etc.).

(89) In some instances, one or more elements may be described using the expression “coupled” and “connected” along with their derivatives. It should be understood that these terms are not intended as synonyms for each other. For example, some aspects may be described using the term “connected” to indicate that two or more elements are in direct physical or electrical contact with

each other. In another example, some aspects may be described using the term “coupled” to indicate that two or more elements are in direct physical or electrical contact. The term “coupled,” however, also may mean that two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other. It is to be understood that depicted architectures of different components contained within, or connected with, different other components are merely examples, and that in fact many other architectures may be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively “associated” such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen as “associated with” each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated also can be viewed as being “operably connected,” or “operably coupled,” to each other to achieve the desired functionality, and any two components capable of being so associated also can be viewed as being “operably couplable,” to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically interacting components, and/or wirelessly interactable, and/or wirelessly interacting components, and/or logically interacting, and/or logically interactable components, and/or electrically interacting components, and/or electrically interactable components, and/or optically interacting components, and/or optically interactable components.

(90) In other instances, one or more components may be referred to herein as “configured to,” “configurable to,” “operable/operative to,” “adapted/adaptable,” “able to,” “conformable/conformed to,” etc. Those skilled in the art will recognize that “configured to” can generally encompass active-state components and/or inactive-state components and/or standby-state components, unless context requires otherwise.

(91) While particular aspects of the present disclosure have been shown and described, it will be apparent to those skilled in the art that, based upon the teachings herein, changes and modifications may be made without departing from the subject matter described herein and its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as are within the true scope of the subject matter described herein. It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as “open” terms (e.g., the term “including” should be interpreted as “including but not limited to,” the term “having” should be interpreted as “having at least,” the term “includes” should be interpreted as “includes but is not limited to,” etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases “at least one” and “one or more” to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles “a” or “an” limits any particular claim containing such introduced claim recitation to claims containing only one such recitation, even when the same claim includes the introductory phrases “one or more” or “at least one” and indefinite articles such as “a” or “an” (e.g., “a” and/or “an” should typically be interpreted to mean “at least one” or “one or more”); the same holds true for the use of definite articles used to introduce claim recitations.

(92) In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean at least the recited number (e.g., the bare recitation of “two recitations,” without other modifiers, typically means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to “at least one of A, B, and C, etc.” is used, in general such a construction is intended in the sense one having skill in the art would understand the convention

(e.g., “a system having at least one of A, B, and C” would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to “at least one of A, B, or C, etc.” is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., “a system having at least one of A, B, or C” would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that typically a disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms unless context dictates otherwise. For example, the phrase “A or B” will be typically understood to include the possibilities of “A” or “B” or “A and B.”

(93) With respect to the appended claims, those skilled in the art will appreciate that recited operations therein may generally be performed in any order. Also, although various operational flows are presented in a sequence(s), it should be understood that the various operations may be performed in other orders than those which are illustrated, or may be performed concurrently. Examples of such alternate orderings may include overlapping, interleaved, interrupted, reordered, incremental, preparatory, supplemental, simultaneous, reverse, or other variant orderings, unless context dictates otherwise. Furthermore, terms like “responsive to,” “related to,” or other past-tense adjectives are generally not intended to exclude such variants, unless context dictates otherwise.

(94) With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations are not expressly set forth herein for sake of clarity.

(95) In certain cases, use of a system or method may occur in a territory even if components are located outside the territory. For example, in a distributed computing context, use of a distributed computing system may occur in a territory even though parts of the system may be located outside of the territory (e.g., relay, server, processor, signal-bearing medium, transmitting computer, receiving computer, etc. located outside the territory).

(96) A sale of a system or method may likewise occur in a territory even if components of the system or method are located and/or used outside the territory. Further, implementation of at least part of a system for performing a method in one territory does not preclude use of the system in another territory.

(97) In summary, numerous benefits have been described which result from employing the concepts described herein. The foregoing description of the one or more forms has been presented for purposes of illustration and description. It is not intended to be exhaustive or limiting to the precise form disclosed. Modifications or variations are possible in light of the above teachings. The one or more forms were chosen and described in order to illustrate principles and practical application to thereby enable one of ordinary skill in the art to utilize the various forms and with various modifications as are suited to the particular use contemplated. It is intended that the claims submitted herewith define the overall scope.

(98) Various aspects of the subject matter described herein are set out in the following numbered clauses:

(99) Example 1: An electrosurgical device comprising: a housing; a shaft extending distally from the housing; an end effector coupled to a distal end of the shaft, the end effector comprising: an electrode; a suction port; and a fluid port; and a control system communicatively coupled to the suction port and the fluid port and configured to control a rate of fluid flowing out of the fluid port and a rate of suction flowing into the suction port.

(100) Example 2: The electrosurgical device of Example 1, further comprising: a first fluid path in fluid communication with the fluid port; and a second fluid path in fluid communication with the

suction port; wherein the housing is configured to enclose a first portion of the first fluid path and a first portion of the second fluid path; and wherein the shaft is configured to enclose a second portion of the first fluid path and a second portion of the second fluid path.

(101) Example 3: The electrosurgical device of one or more of Examples 1-2, further comprising an impedance sensor configured to measure impedance experienced at the electrode.

(102) Example 4: The electrosurgical device of Example 3, wherein the control system is configured to control the rate of fluid flowing out of the fluid port based on the measured impedance experienced at the electrode.

(103) Example 5: The electrosurgical device of Example 4, wherein the control system is further configured to control the rate of suction flowing into of the suction port based on the measured impedance experienced at the electrode.

(104) Example 6: The electrosurgical device of one or more of Examples 1-5, further comprising a radio frequency (RF) current sensor configured to measure RF current applied to the electrode.

(105) Example 7: The electrosurgical device of Example 6, wherein the control system is configured to control the rate of fluid flowing out of the fluid port based on the measured RF current applied to the electrode.

(106) Example 8: The electrosurgical device of Example 7, wherein the control system is further configured to control the rate of suction flowing into of the suction port based on the measured RF current applied to the electrode.

(107) Example 9: The electrosurgical device of one or more of Examples 1-8, further comprising a temperature sensor configured to measure temperature of the fluid suctioned into the suction port.

(108) Example 10: The electrosurgical device of Example 9, wherein the control system is configured to control the rate of fluid flowing out of the fluid port based on the measured temperature of the fluid into the suction port.

(109) Example 11: The electrosurgical device of Example 10, wherein the control system is further configured to control the rate of suction flowing into of the suction port based on the measured temperature of the fluid into the suction port.

(110) Example 12: The electrosurgical device of one or more of Examples 1-11, wherein the end effector further comprises a partially deflectable member that is configured to increase the rate of fluid out of the fluid port as the partially deflectable member increases in deflection.

(111) Example 13: The electrosurgical device of one or more of Examples 1-12, wherein the control system is further configured to increase the rate of fluid flowing out of the fluid port the longer the electrode applies energy.

(112) Example 14: The electrosurgical device of one or more of Examples 1-13, wherein the control system is further configured to decrease the rate of fluid flowing out of the fluid port the longer the electrode applies energy.

(113) Example 15: The electrosurgical device of one or more of Examples 1-14, further comprising a user interface console communicatively coupled to the control system and configured to receive an input from a user to manually control an initial fluid rate of the fluid port.

(114) Example 16: The electrosurgical device of Example 15, wherein the control system is further configured to automatically increase the fluid rate of the fluid port after the initial fluid rate is manually specified from the user interface console; wherein the automatic increase of the fluid rate occurs based on an earlier rise in measured temperature of the fluid at the suction port if the initial fluid rate is manually specified at a slower fluid rate, and the automatic increase of the fluid rate occurs based on a later rise in measured temperature of the fluid at the suction port if the initial fluid rate is manually specified at a faster fluid rate.

(115) Example 17: The electrosurgical device of one or more of Examples 3-16, wherein the control system is configured to: detect an impedance spike based on a drastic change in impedance from the impedance sensor; and in response, increase the rate of fluid flowing out of the fluid port.

(116) Example 18: A method of a control system of an electrosurgical device, the method

comprising: accessing data from one or more sensors related to a physical characteristic of a function occurring at an end effector of the electrosurgical device; controlling a rate of fluid flowing to a fluid port of the electrosurgical device, based on the data related to the physical characteristic; and controlling a rate of suction flowing from a suction port of the electrosurgical device, based on the data related to the physical characteristic.
(117) Example 19: The method of Example 18, wherein the physical characteristic comprises a measure of impedance experienced at an electrode of the end effector of the electrosurgical device.
(118) Example 20: The method of one or more of Examples 18-19, wherein the physical characteristic comprises a measure of RF current applied to an electrode of the end effector of the electrosurgical device.
(119) Example 21: The method of one or more of Examples 18-20, wherein the physical characteristic comprises a temperature of fluid measured at the suction port at the end effector of the electrosurgical device.

Claims

1. A method of a control system of an electrosurgical device, the method comprising: accessing data from one or more sensors related to a physical characteristic of a function occurring at an end effector of the electrosurgical device, wherein the end effector comprises: a first electrode and a second electrode; and a diverter comprising a planar top surface, a planar bottom surface in opposition to the planar top surface, a first terminal lateral side in mechanical communication with an inner side of an exposed longitudinal extent of the first electrode and a second terminal lateral side in mechanical communication with an inner side of an exposed longitudinal extent of the second electrode; controlling a rate of fluid flowing to a fluid port of the electrosurgical device, the fluid port disposed above the planar top surface of the diverter, based on the data related to the physical characteristic; and controlling a rate of suction flowing from a suction port of the electrosurgical device, the suction port disposed below the planar bottom surface of the diverter, based on the data related to the physical characteristic.
2. The method of claim 1, wherein accessing data from one or more sensors related to a physical characteristic of a function comprises accessing the data from the one or more sensors measuring an impedance experienced at the first electrode or the second electrode of the end effector of the electrosurgical device.
3. The method of claim 2, wherein accessing the data from the one or more sensors measuring an impedance experienced at the first electrode or the second electrode of the end effector of the electrosurgical device comprises accessing the data from the one or more sensors detecting an impedance spike at the first electrode or the second electrode of the end effector of the electrosurgical device.
4. The method of claim 1, wherein accessing data from one or more sensors related to a physical characteristic of a function comprises accessing the data from the one or more sensors measuring an RF current applied to the first electrode or the second electrode of the end effector of the electrosurgical device.
5. The method of claim 1, wherein accessing data from one or more sensors related to a physical characteristic of a function comprises accessing the data from the one or more sensors measuring a temperature of fluid at the suction port at the end effector of the electrosurgical device.
6. The method of claim 1, wherein accessing data from one or more sensors related to a physical characteristic of a function comprises accessing the data from the one or more sensors measuring an activation time of the first electrode or the second electrode disposed at the end effector.
7. The method of claim 1, wherein controlling a rate of fluid flowing to a fluid port of the electrosurgical device, based on the data related to the physical characteristic comprises controlling an operation of a proportional valve fluidically coupled to a source of a saline fluid based on the

data related to the physical characteristic.

8. The method of claim 1, wherein controlling a rate of fluid flowing to a fluid port of the electrosurgical device, based on the data related to the physical characteristic comprises controlling an operation of a multi-stage valve fluidically coupled to a source of a saline fluid based on the data related to the physical characteristic.

9. The method of claim 1, wherein controlling a rate of fluid flowing to a fluid port of the electrosurgical device, based on the data related to the physical characteristic comprises controlling a first portion of the rate of fluid flowing to the fluid port of the electrosurgical device, based on the data related to the physical characteristic.

10. The method of claim 9, further comprising manually adjusting a second portion of the rate of fluid flowing to the fluid port of the electrosurgical device by a user.

11. The method of claim 1, wherein controlling a rate of suction flowing from a suction port of the electrosurgical device, based on the data related to the physical characteristic comprises controlling the rate of suction flowing from the suction port of the electrosurgical device based on a measurement of power delivered to a tissue.

12. The method of claim 1, wherein controlling a rate of suction flowing from a suction port of the electrosurgical device, based on the data related to the physical characteristic comprises controlling the rate of suction flowing from the suction port of the electrosurgical device, based on a temperature of fluid measured at the suction port at the end effector of the electrosurgical device.

13. The method of claim 1, wherein controlling a rate of suction flowing from a suction port of the electrosurgical device, based on the data related to the physical characteristic comprises generating an amount of suction at the suction port of the electrosurgical device proportional to an amount of fluid at a surgical site.

14. The method of claim 13, wherein generating an amount of suction at the suction port of the electrosurgical device comprises modulating a variable duty cycle of a vacuum controlling valve.