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(54) **MICROCOMBUSTORS, MICROREFORMERS, AND METHODS INVOLVING COMBUSTING OR REFORMING LIQUIDS**

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(58) **Field of Classification Search** 422/211, 422/600, 602, 603, 625, 629, 633
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,615,164	A	10/1971	Baker et al.	
4,876,162	A	10/1989	McElroy	
5,015,444	A	5/1991	Koga et al.	
5,164,163	A *	11/1992	Aoki et al.	422/211
5,432,023	A	7/1995	Yamada et al.	
5,858,314	A	1/1999	Hsu et al.	
6,117,578	A	9/2000	Lesieur	
6,180,846	B1 *	1/2001	Dandekar et al.	422/198
6,192,596	B1	2/2001	Bennett et al.	
6,193,501	B1	2/2001	Masel et al.	
6,200,536	B1	3/2001	Wang et al.	
6,241,875	B1	6/2001	Gough	
6,277,339	B1	8/2001	Boneberg et al.	
6,447,736	B1	9/2002	Autenrieth et al.	
6,497,856	B1 *	12/2002	Lomax et al.	422/198
6,506,513	B1	1/2003	Yonetsu et al.	
6,932,958	B2	8/2005	Wangerow et al.	
7,077,643	B2	7/2006	Holladay et al.	
7,585,472	B2	9/2009	Holladay et al.	
2002/0031471	A1	3/2002	Tonkovich et al.	
2002/0144600	A1	10/2002	TeGrotenhuis et al.	
2003/0072699	A1	4/2003	Tonkovich et al.	
2003/0091502	A1	5/2003	Holladay et al.	
2004/0033455	A1	2/2004	Tonkovich et al.	

* cited by examiner

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(57) **ABSTRACT**

The invention describes combustors and steam reformers and methods of combustion and steam reforming. For example, integrated combustion reactors are described in which heat from combustion is transferred to an endothermic reaction. Thermally efficient reactors and methods of alcohol steam reforming are also described. Also described is an integrated combustor/reformer containing a methanation catalyst.

13 Claims, 9 Drawing Sheets