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(54) **ALCOHOL STEAM REFORMING CATALYSTS AND METHODS OF ALCOHOL STEAM REFORMING**

(75) Inventors: **Jamelyn D. Holladay**, Kennewick, WA (US); **Yong Wang**, Richland, WA (US); **Jianli Hu**, Kennewick, WA (US); **Ya-Huei Chin**, Richland, WA (US); **Robert A. Dagle**, Richland, WA (US); **Guanguang Xia**, Pasco, WA (US); **Eddie G. Baker**, Pasco, WA (US); **Daniel R. Palo**, Kennewick, WA (US); **Max R. Phelps**, Richland, WA (US); **Heon Jung**, Suhku (KR)

(73) Assignee: **Battelle Memorial Institute**, Richland, WA (US)

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(58) **Field of Classification Search** 423/652; 502/329, 333, 339, 342, 343, 355, 415, 439; 252/373

See application file for complete search history.

(56) **References Cited**

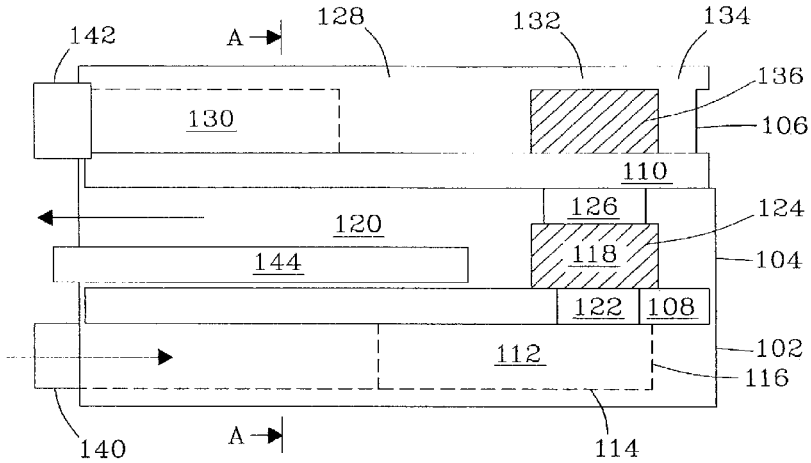
U.S. PATENT DOCUMENTS

3,823,088	A	*	7/1974	Box, Jr. et al.	210/762
3,867,309	A		2/1975	Oleck et al.	
4,177,219	A	*	12/1979	Feinstein et al.	585/489
4,188,490	A	*	2/1980	Hinnenkamp et al.	560/245
4,511,673	A		4/1985	Eto	
4,522,894	A	*	6/1985	Hwang et al.	429/17
4,596,782	A	*	6/1986	Courty et al.	502/302
4,613,584	A	*	9/1986	Schneider et al.	502/304
4,743,576	A		5/1988	Schneider et al.	
4,795,618	A		1/1989	Laumen	
4,985,230	A	*	1/1991	Baden et al.	423/650
5,075,277	A		12/1991	Sakai et al.	
5,356,851	A	*	10/1994	Sarrazin et al.	502/185
5,510,056	A	*	4/1996	Jacobs et al.	252/373
5,756,207	A		5/1998	Clough et al.	
6,232,005	B1		5/2001	Pettit	

(Continued)

Primary Examiner—Cam N. Nguyen
(74) *Attorney, Agent, or Firm*—Derek H. Maughan; Frank Rosenberg

(57) **ABSTRACT**

The present invention provides steam reforming catalyst compositions containing Pd and Zn, and methods of steam reforming alcohols over a catalyst. Surprisingly superior results and properties of the present invention, including low temperature activity and/or low carbon monoxide output, are also described. Methods of making a steam reforming catalyst are also provided.

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