

(12) **United States Patent**
Whyatt et al.

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(54) **RAPID START FUEL REFORMING SYSTEMS AND TECHNIQUES**

USPC 48/61; 165/166, 167
See application file for complete search history.

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(56) **References Cited**

U.S. PATENT DOCUMENTS

3,176,763 A 4/1965 Frohlich
4,434,845 A 3/1984 Steeb

(Continued)

FOREIGN PATENT DOCUMENTS

JP 03-266369 3/1990
JP 11-250925 2/1998

(Continued)

OTHER PUBLICATIONS

Whyatt et al., "Progress on the Development of a Microchannel Steam Reformer for Automotive Applications," Presentation at the AIChE 2002 Spring National Meeting, IMRET 6—6th International conference on Microreaction Technology, Mar. 10-14, 2002, New Orleans, Louisiana.

(Continued)

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(57) **ABSTRACT**

An on-board fuel processor includes a microchannel steam reforming reactor (30) and a water vaporizer (40) heated in series with a combustion gas. The reformer (30) and the vaporizer (40) are both of a cross-flow panel configuration that allows for low combustion side pressure drop. Fuel is directly injected into the steam, and during a rapid cold start, both the combustion gas flow rate and the steam to carbon ratio are substantially increased relative to their steady state operating values. A rapid cold start can be achieved in under 30 seconds with a manageable amount of electric power consumption, removing impediments to use in automotive fuel cell applications.

6 Claims, 18 Drawing Sheets

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(58) **Field of Classification Search**
CPC F28F 9/02; F28F 9/0246; F28F 9/026; F28F 9/0263

