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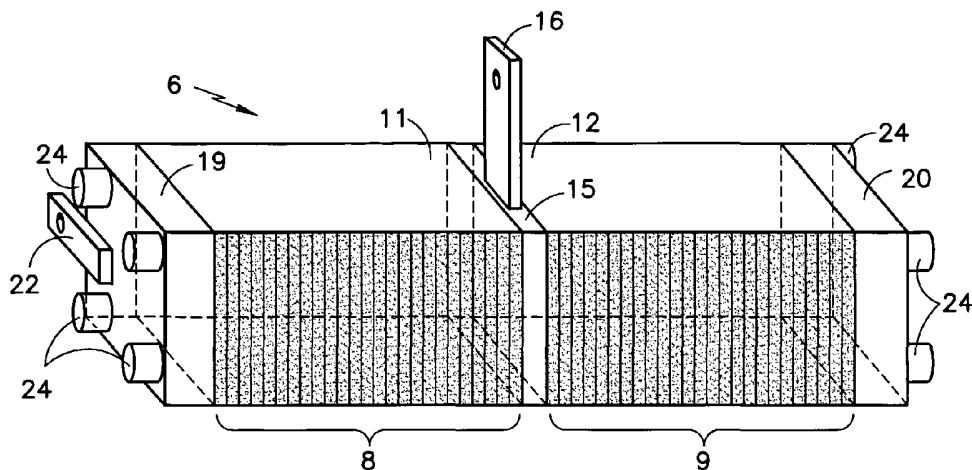
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(54) Title: CATHODE-TO-CATHODE FUEL CELL STACKS



(57) Abstract: A plurality of fuel cells stacks (8, 8a, 9, 9a) have their cathode ends (11, 12) contiguous with either a common current collector (15a-15d) or respective current collectors (15a, 15b) which may be separated by electrical isolation (27a, 27b). The cathode-to-cathode relationship protects the cathode of each of the stacks from cold ambient environments, thereby permitting improved cold starts and mitigation of performance loss as a result of cold starts as well as freeze/thaw cycles. Heaters (30, 30a-30d) may be provided in current collectors, or in or between electrical isolation. Four stacks may share one current collector, or each may have its own current collector.



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CATHODE-TO-CATHODE FUEL CELL STACKS

Technical Field

This invention relates to a plurality of fuel cell stacks which are contiguous at their cathode ends so as to reduce cathode end exposure to cold temperatures, thereby reducing startup time as well as performance loss resulting from cold cathodes at startup and freeze/thaw cycling; optional heaters may be used.

Background Art

It is known that the startup of a polymer electrolyte, proton exchange membrane (PEM) fuel cell at temperatures below the freezing point of water may result in delays in startup as well as loss of performance of the fuel cell (the voltage at any current density). Causes of the performance loss include water frozen on the surface of the membrane electrode assembly and in the gas diffusion layer which impedes access of the reactant gases to the catalytic surface of the membrane electrode assembly. Another cause is freezing of water generated by the electrochemical reaction (product water) at the cathode, restricting or totally blocking the oxidant gas pathways, which significantly slows down the reaction. Ice in the fuel cell interfaces may result in high cell electrical resistance which reduces current flow and power output, slowing the process of warming the fuel cell stack.

All of these performance factors relate to the amount and location of water in the fuel cells. It is known to have shut down procedures which include draining processes to reduce the amount of water in the fuel cells, which however leaves some water within the membrane electrode assembly, as well as in coolant channels (if such are used) within the reactant gas channel plates.

Copending PCT patent application Serial No. 04/17997, filed June 2, 2004, teaches that a temperature gradient moves water through the fuel cells from one place with a higher temperature to another place with a lower temperature. Successful startup at subfreezing temperatures requires that the amount of water on the cathode side of the fuel cells be reduced to facilitate access of the oxidant, such as air, to the catalytic surface, and to increase pore volume available for newly generated product water.

Similar problems result simply from allowing an inoperative fuel cell to undergo freeze/thaw cycles.

Disclosure of Invention

Aspects of the invention include: reducing problems of subfreezing startup
5 fuel cell power plants; mitigating performance loss as a result of starting fuel cell power plants at subfreezing temperatures or freeze/thaw cycling; reducing the effects of cold temperatures on the starting performance of fuel cell power plants; reduced startup time; and improved fuel cell power plant operation.

According to the present invention, a pair of fuel cell stacks are
10 interconnected contiguously at their cathode ends, whereby to reduce the exposure of the cathode ends of the fuel cell stacks to cold temperatures, thereby to mitigate performance loss and reduce startup time.

More than two fuel cell stacks may have their cathode ends disposed in mutual proximity in order to reduce heat loss at the cathode end of each stack.

15 There may be a heater disposed between the cathode ends of two or more stacks, or the current collectors at the cathode ends may themselves have heaters disposed therein.

The invention may be practiced with the cathode-to-cathode fuel cell stacks sharing a single current collector between the two cathodes, or with each fuel cell
20 stack having its own current collector, the current collectors being electrically isolated. The invention may be practiced with internal reactant gas and coolant manifolds or with external manifolds, or a combination thereof.

Brief Description of the Drawings

Fig. 1 is a simplified, stylized perspective view of a fuel cell power plant
25 having two cathode-to-cathode fuel cell stacks sharing a common current collector.

Fig. 2 is a simplified, stylized perspective view of a fuel cell power plant having two cathode-to-cathode fuel cell stacks each having its own current collector.

Fig. 3 is a simplified, stylized perspective view of a fuel cell power plant with a heater between end plates of contiguous fuel cell stacks.

30 Fig. 4 is a simplified, stylized perspective view of a fuel cell power plant with heaters in each current collector of the respective stacks.

Fig. 5 is a simplified stylized perspective view of a fuel cell power plant having a heater disposed in electrical isolation between the respective stacks.

Fig. 6 is a simplified, stylized perspective view of four fuel cell stacks sharing a common current collector at the their cathode ends.

5 Fig. 7 is a simplified, stylized perspective view of a fuel cell power plant having four fuel cell stacks with their cathode ends together, each having a current collector and a heater.

Mode(s) for Carrying Out the Invention

Referring to Fig. 1, a fuel cell power plant 6 according to the invention
10 includes a pair of fuel cell stacks 8, 9 having their cathode ends 11, 12 contiguous with a common current collector 15 and a current output bus bar 16. At the end of each stack 8, 9 there is a corresponding pressure plate 19, 20 (sometimes referred to as "end plates"). In the configurations herein, the pressure plates 19, 20 also serve as current collectors, and each has an anode current output bus bar 22. In this
15 configuration, tie rods (not shown for clarity) will draw both of the stack assemblies together by tightening against the pressure plates 19, 20.

In the configurations herein, fittings 24 for internal manifolds are shown. Not shown, for clarity, are external manifolds which may, for instance, either be on the top and bottom of the stack or at the front and back of the stacks or both. Various
20 combinations of internal and external manifolds are consistent with the invention.

Because the two cathode ends 11, 12 of the stacks 8, 9 are contiguous, the cathode ends are not exposed to the ambient environment to the same extent as they would be in fuel cell stacks not connected cathode-to-cathode. A typical twin-stack configuration has two stacks contiguous at reactant gas inlet manifolds (equivalent to
25 the front and/or the back of the fuel cell stacks 8, 9 as shown in Fig. 1. This leaves the cathodes exposed on one end and the anodes exposed on another end, in a configuration illustrated in copending U.S. patent application Serial No. 10/713,799, filed November 13, 2003.

With less exposure to cold ambient environment, the cathode ends 11, 12 of
30 the stacks 8, 9 are less subject to the aforementioned water migration and cathode freezing and flooding problems.

In Fig. 2, another embodiment of the invention employs a current collector 15a, 15b for each stack 8, 9. Each current collector has a cathode current output bus bar 16a, 16b. In Fig. 2, the two current collectors 15a, 15b are electrically isolated from each other by electrical isolation 27, such as rigid insulation which can
5 withstand the pressure of the tie rods as described hereinbefore.

In Fig. 3, the electrical isolation is in two parts 27a, 27b and a heater 30 is disposed therebetween. In Fig. 4, each of the end plates 15c, 15d has a respective heater 30a, 30b. In Fig. 5, the electrical isolation 27a has a heater 30c disposed therein.

10 Fig. 6 illustrates four fuel cell stacks 8, 8a, 9, 9a disposed with their cathodes contiguous to a common current collector 15. In this arrangement, external manifolds may be used only on the top of the stacks 8, 9 and only on the bottom of the stacks 8a, 9a, for one of the reactant gases, the other reactant gas being provided through the internal manifolds 24.

15 In Fig. 7, four fuel cell stacks 8, 8a, 9, 9a, are disposed so that the cathode end of each stack is contiguous with an end of two adjacent stacks. In the embodiment of Fig. 7, each of the current collectors 15a-15d has a respective heater 30d-30g disposed adjacent thereto. This embodiment allows the use of external reactant gas manifolds on both sides of each stack.

20 The heater 30, 30a-30g may take any suitable form described in copending patent application Serial No. 10/839,667, filed May 5, 2004.

Claims

1. A fuel cell power plant (6) comprising:
a plurality of fuel cell stacks (8, 8a, 9, 9a) each having a cathode end (11, 12); and
characterized by:
5 one or more current collectors (15, 15a-15d) disposed between the cathode ends of said plurality of stacks;
each of said cathode ends disposed toward at least one other of said cathode ends, and each of said cathode ends either (A) contiguous with another one of said cathode ends or (B) separated from another one of said cathode ends by apparatus
10 selected from (i) one of said current collectors or (ii) a plurality of said current collectors separated by (a) an electrical isolator or (b) a plurality of electrical isolators and one or more heaters.
2. A fuel cell power plant according to claim 1 wherein:
there are two stacks (8, 9); and
there is one current collector (15), the cathode ends (11, 12) of both stacks being contiguous with said one current collector.
3. A fuel cell power plant according to claim 1 wherein:
there are two stacks; and
each of said stacks has a corresponding current collector (15a, 15b); and
further comprising:
5 an electrical isolator (27, 27a, 27b), disposed between and contiguous with said current collectors.
4. A fuel cell power plant according to claim 3, further comprising:
a heater disposed within said electrical isolator.
5. A fuel cell power plant according to claim 3 wherein there are two electrical isolators (27a, 27b) disposed between said current collectors, each

contiguous with a corresponding one of said current collectors; and a heater disposed between said electrical isolators.

6. A fuel cell power plant according to claim 1 wherein:
there are four stacks (8, 8a, 9, 9a).
7. A fuel cell power plant according to claim 6 wherein:
the cathode ends of all of said four stacks are contiguous with one current collector.
8. A fuel cell power plant according to claim 6 wherein:
there are four current collectors (15a-15c), one contiguous with the cathode end of each of said stacks.
9. A fuel cell power plant according to claim 1, further comprising:
at least one heater disposed between said cathode ends.
10. A fuel cell power plant according to claim 9 wherein:
said heater is disposed within said at least one current collector.
11. A fuel cell power plant according to claim 9 wherein:
there are a plurality of current collectors; and
said at least one heater is disposed between said current collectors.
12. A fuel cell power plant according to claim 9 wherein:
there are a plurality of current collectors; and
each said at least one heater is disposed contiguously with a
corresponding one of said current collectors.

13. A method of reducing exposure of cathode ends (11, 12) of a plurality of fuel cell stacks (8, 8a, 9, 9a) in a fuel cell power plant (6) which includes one or more current collectors (15, 15a-15d) disposed between said cathode ends of
5 said plurality of stacks, characterized by:

disposing each of said cathode ends toward at least one other of said cathode ends with each of said cathode ends either (A) contiguous with another one of said cathode ends or (B) separated from another one of said cathode ends by apparatus selected from (i) one of said current collectors or (ii) a plurality of said current
10 collectors separated by (a) an electrical isolator or (b) a plurality of electrical isolators and one or more heaters.

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FIG. 1

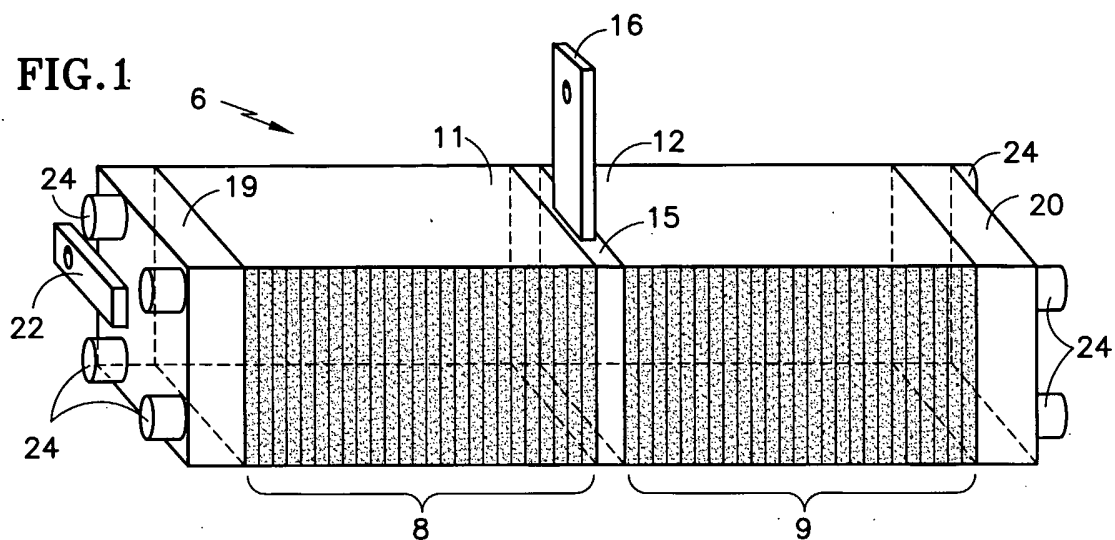


FIG. 2

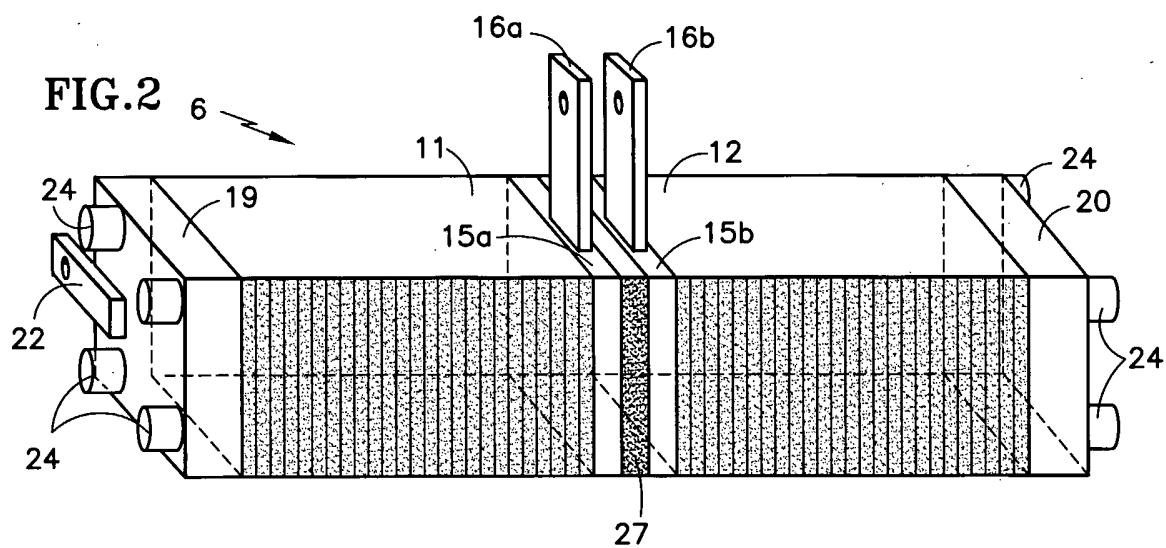
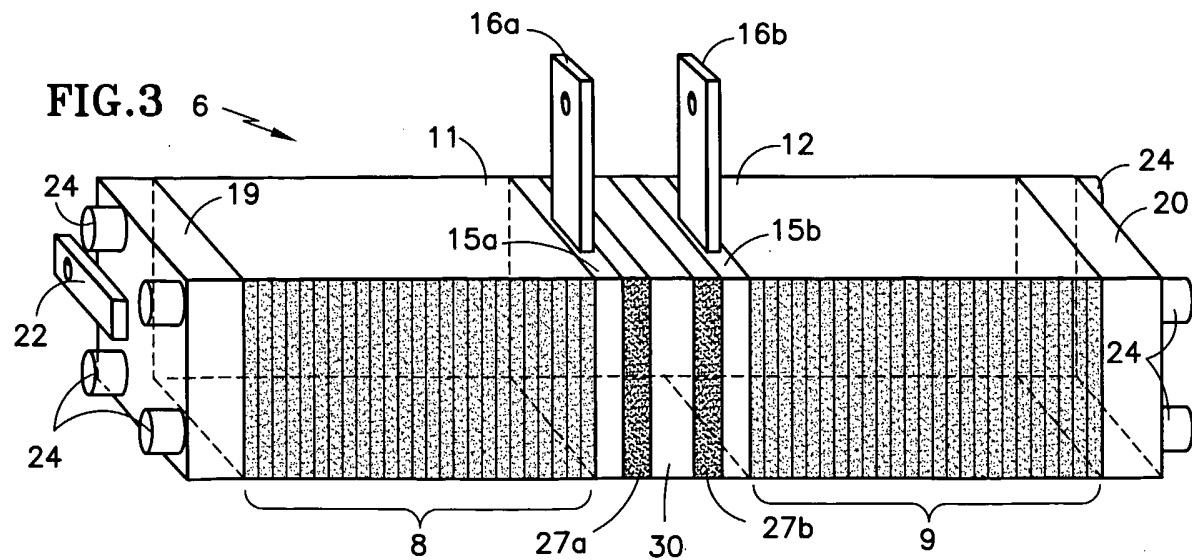
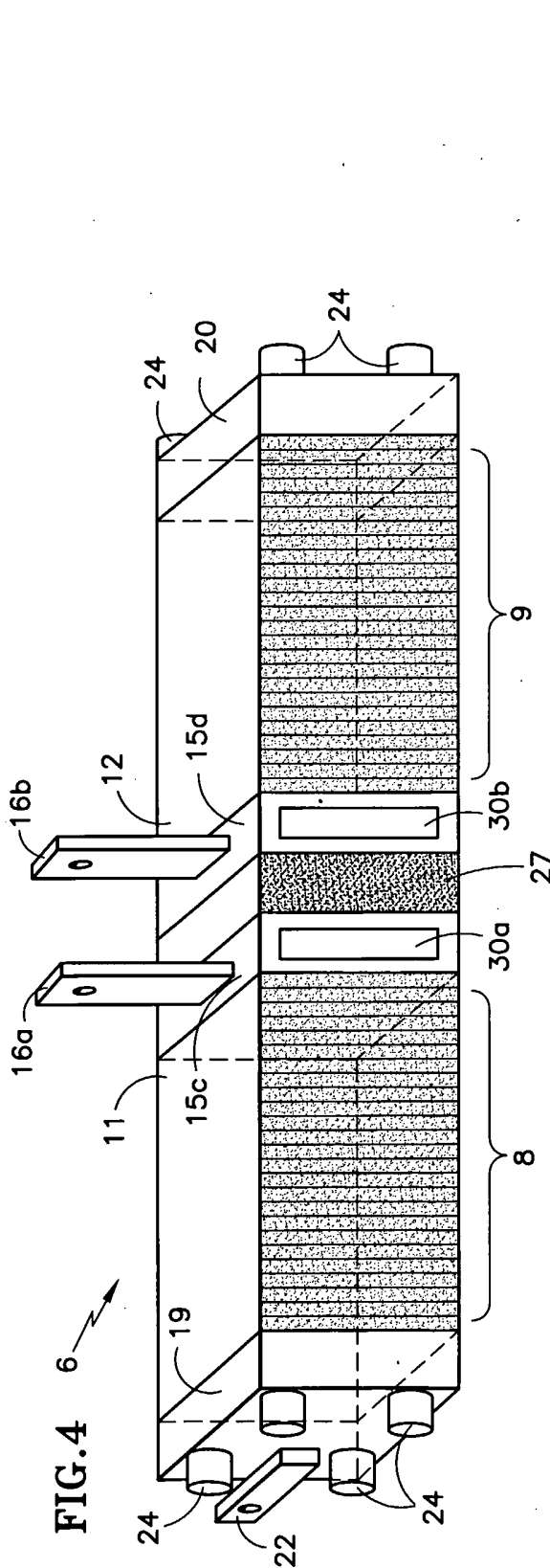
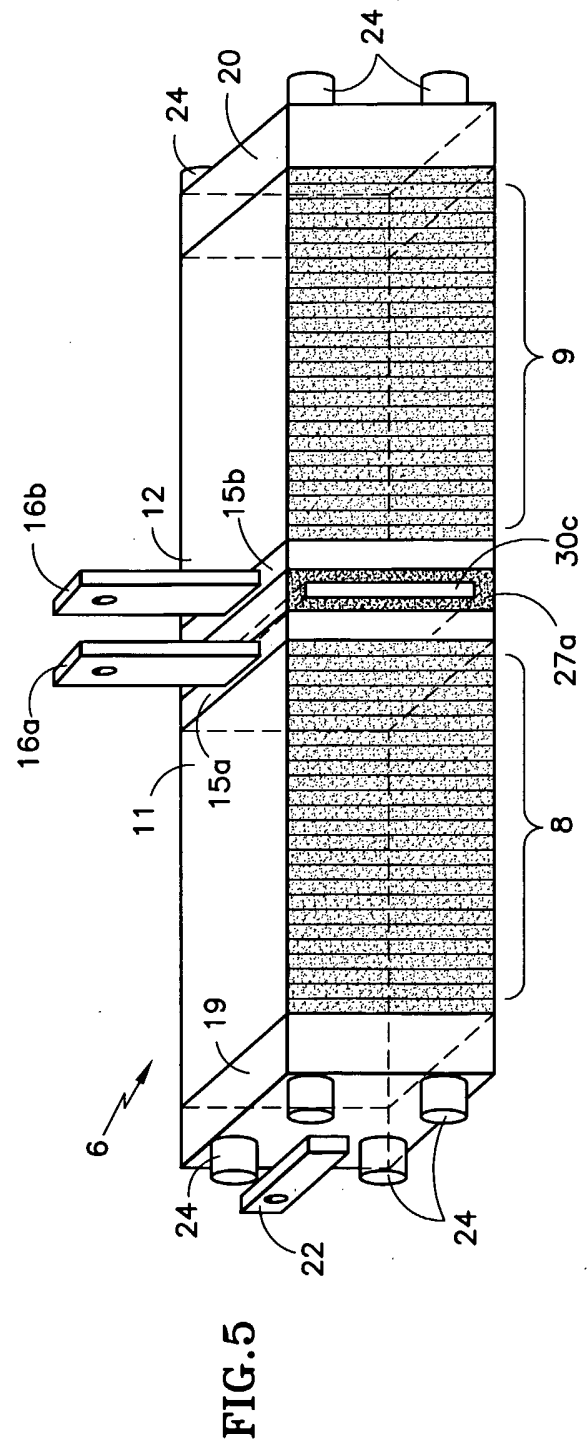


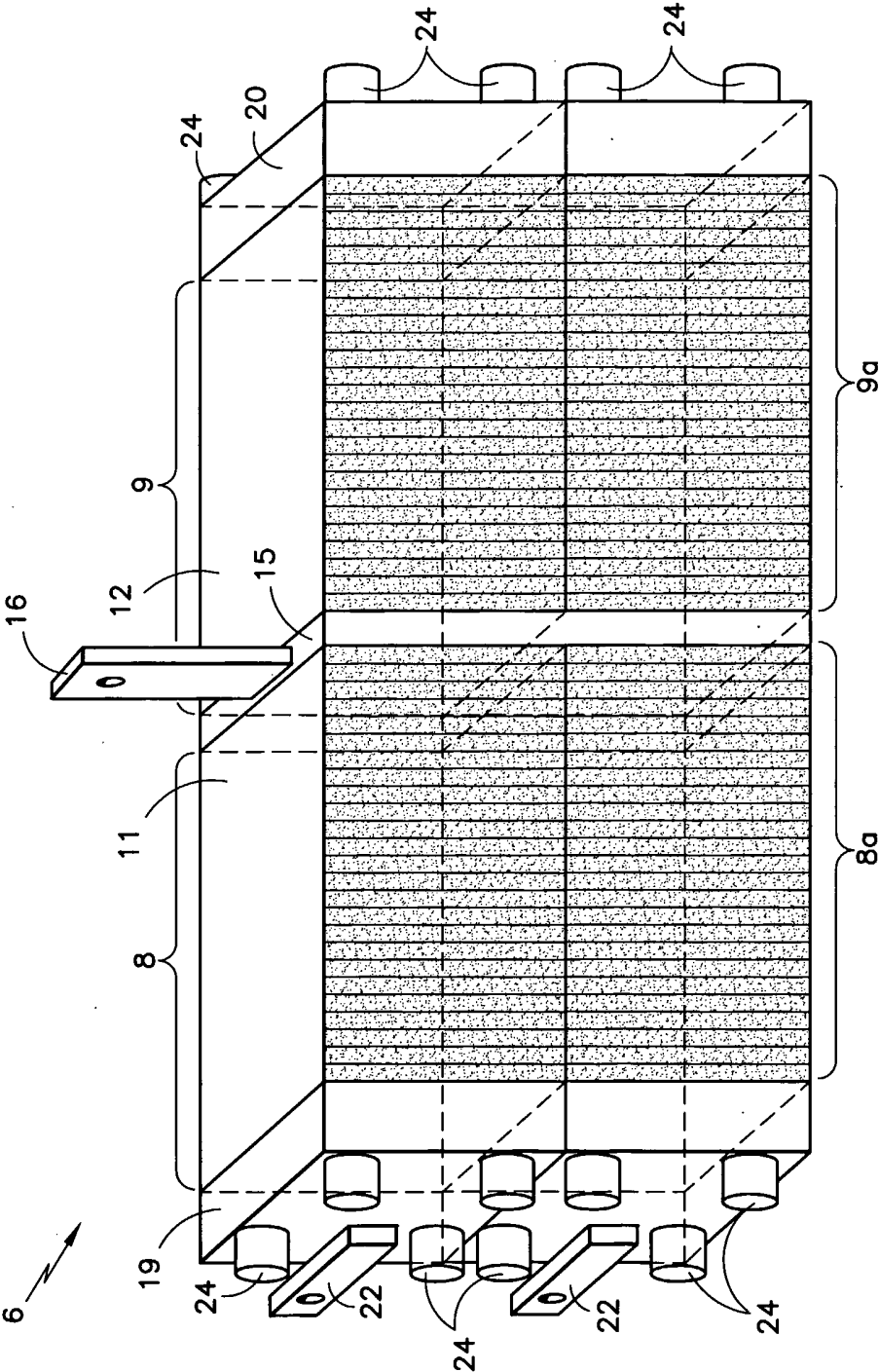
FIG. 3





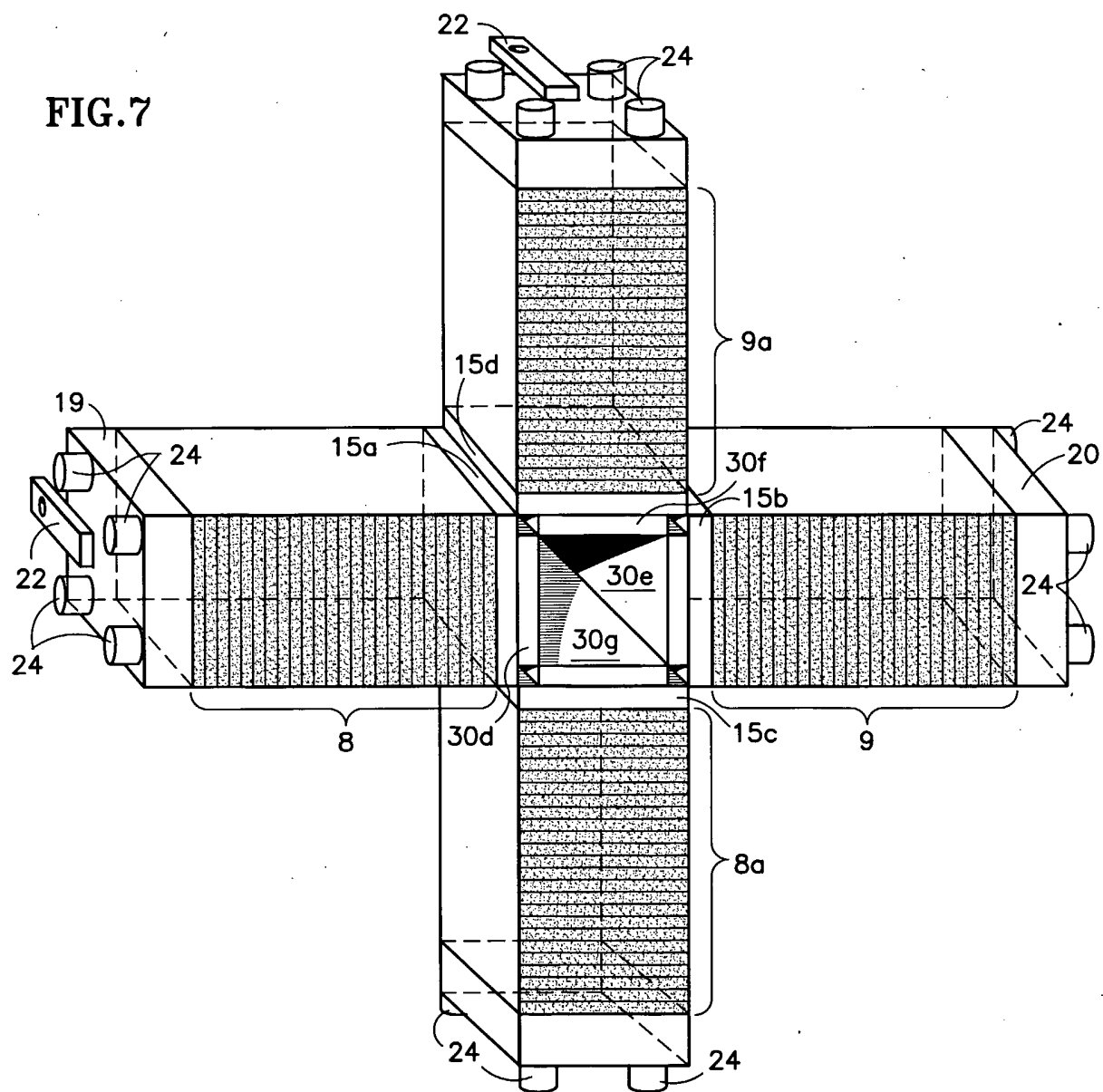
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FIG.6



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FIG. 7



INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER		
IPC(7) : H01M8/04		
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According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
U.S. : 429/26,32,13		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
US Pat., US PG PUB, EPO, JPO, Derwent		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	US 2005/0170235 A1 (Hu et al) 04 August 2005 See Figures 4 and 6	1,2,13
Y	US 2001/0036568 A1 (Farkash et al) 01 November 2001 Page 4, Paragraphs 66 and 67 Page 6, Paragraph 91	3,5-12
A	US 2002/0168560 A1 (Mukerjee et al) 14 November 2002 See Figure 1	6-8
A	US 2003/0044657 A1 (Hayashi et al) 6 March 2003 See Figure 8	1-13
A	JP 08-167424 (FUJI ELECTRIC CO LTD) 25 June 1996 See Drawing 1	1, 4-5, 9-12
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