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<i>G21C 3/24</i> (2006.01)	<i>G21C 1/32</i> (2006.01)
<i>G21C 3/54</i> (2006.01)	<i>G21C 15/02</i> (2006.01)
<i>G21C 5/14</i> (2006.01)	<i>G21C 15/25</i> (2006.01)
<i>G21C 11/06</i> (2006.01)	<i>G21C 15/28</i> (2006.01)
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<i>G21C 15/26</i> (2006.01)	

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(54) Title: IMPROVED MOLTEN FUEL REACTOR THERMAL MANAGEMENT CONFIGURATIONS

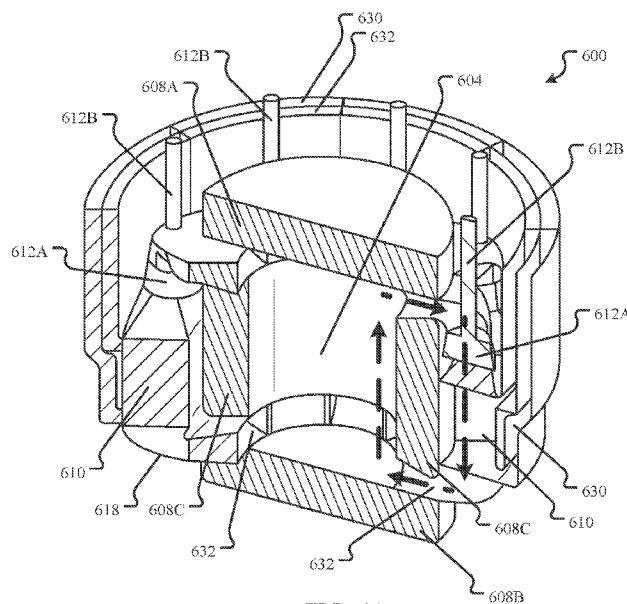


FIG. 6A

(57) Abstract: Configurations of molten fuel salt reactors are described that allow for active cooling of the containment vessel of the reactor by the primary coolant. Furthermore, naturally circulating reactor configurations are described in which the reactor cores are substantially frustum-shaped so that the thermal center of the reactor core is below the outlet of the primary heat exchangers. Heat exchanger configurations are described in which welded components are distanced from the reactor core to reduce the damage caused by neutron flux from the reactor. Radial loop reactor configurations are also described.



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# INTERNATIONAL SEARCH REPORT

International application No PCT/US2017/030455
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<b>A. CLASSIFICATION OF SUBJECT MATTER</b>				
INV. G21C1/22	G21C3/24	G21C3/54		
G21C15/243	G21C15/26	G21C15/12		
G21C15/25	G21C15/28	G21C1/14		
According to International Patent Classification (IPC) or to both national classification and IPC				
<b>B. FIELDS SEARCHED</b>				
Minimum documentation searched (classification system followed by classification symbols) G21C				
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) EPO-Internal				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
A	GB 835 266 A (GEN ELECTRIC) 18 May 1960 (1960-05-18) see fig. 3 and the description thereof -----	1		
X	FR 2 296 248 A1 (ELECTRICITE DE FRANCE [FR]) 23 July 1976 (1976-07-23) see fig. 1 and the description thereof -----	15-22		
A	JP S57 1991 A (SUMITOMO CORP) 7 January 1982 (1982-01-07) page 478, line 6 -----	19,20,39		
X	GB 2 073 938 A (FURUKAWA K) 21 October 1981 (1981-10-21) see fig 3 and the description thereof page 3, lines 22-23 -----	23-30		
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<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <span style="margin-left: 200px;"><input checked="" type="checkbox"/> See patent family annex.</span>				
* Special categories of cited documents : <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;"> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width: 50%; border: none; vertical-align: top;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p> </td> </tr> </table>			<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p>
<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p>			
Date of the actual completion of the international search	Date of mailing of the international search report			
23 January 2018	30/01/2018			
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Angloher, Godehard			

INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2017/030455

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 739 968 A (BABCOCK & WILCOX LTD) 2 November 1955 (1955-11-02) abstract	23-30
X	----- EP 0 617 430 A1 (FURUKAWA KAZUO [JP]) 28 September 1994 (1994-09-28) see fig. 1 and the description thereof -----	31-41

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2017/030455

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
  
2.  As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
  
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-14

subject-matter common to claims 1 - 14:

A molten salt nuclear reactor comprising:  
a substantially frustum-shaped reactor core containing a fissionable fuel salt, the reactor core having a heated fuel salt outlet, a cooled fuel salt inlet, and a thermal center above the cooled fuel salt inlet;  
at least one heat exchanger that receives heated fuel salt at a heat exchanger fuel salt inlet below the reactor core's heated fuel salt outlet, transfers heat from the fuel salt to a coolant, and discharges the cooled fuel salt at a heat exchanger fuel salt outlet fluidly connected to the reactor core's cooled fuel salt inlet; and  
wherein the thermal center of the reactor core is at a level below the heat exchanger fuel salt outlet; and  
wherein the location of the thermal center causes natural circulation in the case of a loss of forced flow while the reactor is in a state of criticality.

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2. claims: 15-22

subject-matter common to claims 15 - 22:

A method for actively cooling a containment vessel and fuel salt in a molten fuel salt nuclear reactor comprising:  
flowing primary coolant into the containment vessel adjacent to a first portion of the containment vessel, thereby cooling the first portion;  
flowing primary coolant into a heat exchanger within and spaced apart from the containment vessel, the heat exchanger discharging cooled fuel salt;  
routing discharged cooled fuel salt through a channel adjacent to a second portion of the containment vessel, thereby cooling the second portion;  
routing cooled fuel salt through the channel adjacent to a neutron reflector, thereby cooling the neutron reflector;  
and  
wherein the cooled neutron reflector is adjacent to a third portion of the containment vessel such that cooling the neutron reflector indirectly cools the third portion.

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3. claims: 23-30

subject-matter common to claims 23 - 30:

A molten fuel nuclear reactor comprising:  
an upper neutron reflector defining a top of a reactor core;  
a lower neutron reflector defining a bottom of the reactor core;  
at least one inner neutron reflector defining sides of the reactor core;

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

at least one heat exchanger that receives heated fuel salt at a heat exchanger fuel salt inlet below a reactor core heated fuel salt outlet, transfers heat from the fuel salt to a coolant, and discharges the cooled fuel salt at a heat exchanger fuel salt outlet fluidly connected to a reactor core cooled fuel salt inlet;

the at least one heat exchanger including a welded component separated from the fuel salt by one of the upper neutron reflector, the lower neutron reflector, the inner neutron reflector or a neutron moderator.

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4. claims: 31-41

subject-matter common to claims 31 - 41:

A radial loop molten salt reactor comprising:

a reactor core containment vessel;

one or more reflectors in the reactor core containment vessels, the one or more reflectors defining a reactor core volume within the reactor core containment vessel; and  
a plurality of heat exchanger legs spaced apart outside of the reactor core containment vessel, each heat exchanger leg having a reactor outlet pipe configured to receive heated fuel salt from the reactor core volume, a heat exchanger that transfers heat from the heated fuel salt to a primary coolant thereby creating a cooled fuel salt, and a reactor inlet pipe configured to return the cooled fuel salt into the reactor core volume.

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/030455

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