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(71) Applicant: **BABCOCK & WILCOX MPOWER, INC.**
[US/US]; 11525 N. Community House Road, Suite 600,
Charlotte, NC 28277 (US).

(72) Inventors: **MALLOY, John, D., III**; 131 Piccadilly
Court, Goode, VA 24556 (US). **BINGHAM, Billy, E.**;
110 Old Wiggington Road, Lynchburg, VA 24502-4669

(US). **WATSON, Ronald, C.**; 602 Jefferson Woods Drive,
Forest, VA 24551 (US). **WILLIAM, Jason, G.**; 66 Waling
Trail Drive, Concord, VA 24538 (US). **ALES, Matthew,
W.**; 1481 Lake Shore Drive, Forest, VA 24551 (US). **IN-
MAN, James, B.**; 112 Stirling Court, Forest, VA 24551
(US). **BOYLE, Sean, M.**; 1532 Cleveland Ave, Charlotte,
NC 28203 (US).

(74) Agent: **BRULEY, Kenneth C.**; Nelson Mullins Riley &
Scarborough, LLP, 100 North Tryon Street, 42nd Floor,
Charlotte, North Carolina 28202 (US).

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MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
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SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,

[Continued on next page]

(54) Title: PASSIVE TECHNIQUES FOR LONG-TERM REACTOR COOLING

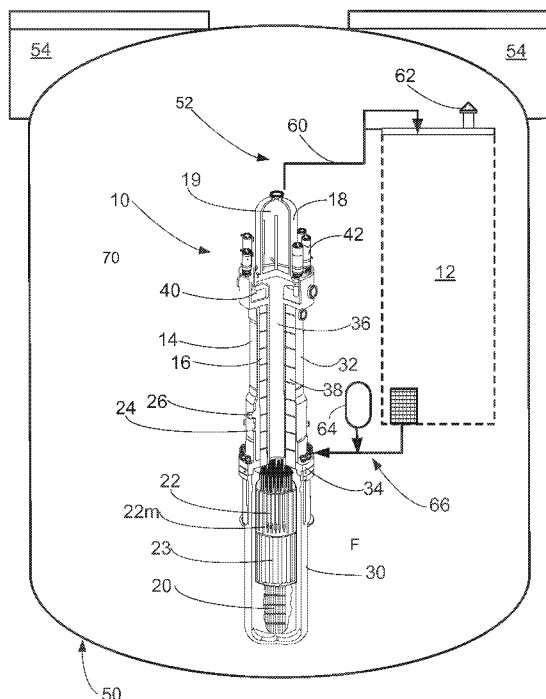


FIG. 1

(57) Abstract: In a pressurized water reactor (PWR), emergency core cooling (ECC) responds to depressurization due to a vessel penetration break at the top of the pressure vessel by draining water from a body of water through an injection line into the pressure vessel. A barrier operates concurrently with the ECC to suppress flow of liquid water from the pressure vessel out the vessel penetration break. The barrier may comprise one or more of: (1) an injection line extension passing through the central riser to drain water into the central riser; (2) openings in a lower portion of a central riser to shunt some upward flow from the central riser into a lower portion of the downcomer annulus; and (3) a surge line providing fluid communication between a pressurizer volume at the top of the pressure vessel and the remainder of the pressure vessel which directs water outboard toward the downcomer annulus.



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/30393

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G21C 9/00, G21C 11/00, G21C 13/10 (2014.01)

CPC - G21C 9/00, G21C 11/00, G21C 13/10

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)

IPC(8)- G21C 9/00, G21C 11/00, G21C 13/10 (2014.01);

CPC- G21C 9/00, G21C 11/00, G21C 13/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC- 376/281, 376/282, 376/283;

Patents and NPL (classification, keyword; search terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Pub West (US EP JP WO), Pat Base (AU BE BR CA CH CN DE DK EP ES FI FR GB IN JP KR SE TH TW US WO), Google Patent, Google Scholar, Free Patents Online; search terms: pressure, water, react, cool, shut, close, drain, leak, emergency, core, melt, breach, break, penetrate, downcomer, barrier, block, suppress, flow, depressurize

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/0196948 A1 (CONWAY et al.) 07 October 2004 (07.10.2004), Fig. 1; para [0005], [0010], [0022], [0024], [0033], [0034]	1-11
Y	US 4,692,297 A (SCHLONSKI et al.) 08 September 1987 (08.09.1987), Figs. 1, 2; col 1, ln 19-30; col 4, ln 53-64; col 5, ln 24 to col 6, ln 18	1-11
Y	US 4,587,079 A (FAJEAU et al.) 06 May 1986 (06.05.1986), Fig. 1; col 2, ln 61-64; col 4, ln 16-22; col 4, ln 23-56	1-11
Y	US 2012/0243651 A1 (MALLOY) 27 September 2012 (27.09.2012), para [0008]-[0048]	1-11
Y	US 4,972,596 A (MINNICK) 22 May 1990 (22.05.1990), col 2, ln 27 to col 9, ln 30	1-11
Y	US 4,421,716 A (HENCH et al.) 20 December 1983 (20.12.1983), col 1, ln 47 to col 27, ln 24	1-11

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"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

"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

"&" document member of the same patent family

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Authorized officer:

Lee W. Young

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/30393

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:

-- Please See Extra 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 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.:

1-11

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.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/30393

Continued from Box No. III, Observations where unity of invention is lacking:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-11, drawn to an apparatus.

Group II: Claims 12-21, drawn to a method.

The inventions listed as Groups I through II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features

Group II does not require:

a radiological containment structure inside of which a pressurized water reactor (PWR) is disposed;
an emergency core cooling system configured to respond to a vessel penetration break at the top of the pressure vessel that results in depressurization of the pressure vessel by draining water from a body of water through an injection line into the pressure vessel; and
a barrier configured to operate concurrently with the emergency core cooling system to suppress flow of liquid water from the pressure vessel out the vessel penetration break at the top of the pressure vessel, as required by Group I.

Group I does not require:

operating a pressurized water reactor (PWR); responding to a vessel penetration break at the top of the pressure vessel that results in depressurization of the pressure vessel by operations including: draining water from a body of water through an injection line into the pressure vessel, and during the draining, suppressing flow of liquid water from the pressure vessel out the vessel penetration break, as required by Group II.

Shared Common Features

The only feature shared by Groups I and II that would otherwise unify the groups is a pressurized water reactor (PWR) comprising a pressure vessel containing a nuclear reactor core comprising fissile material. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is anticipated by US 2012/0321030 A1 to Malloy, et al. (hereinafter 'Malloy'). Malloy discloses a pressurized water reactor (PWR) comprising a pressure vessel containing a nuclear reactor core comprising fissile material (para [0008]).

As the technical feature was known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups.

Groups I and II therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.