

i-SMR 경쟁노형 피동안전계통 열수력 현안(특허분석 등)

한국원자력연구원
SMART계통기술개발부
2022-07-08

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1. SMR 선행특허 목록

SMR 선행특허 중 피동안전계통 관련 개념 주요 특허 목록

노형	등록번호	상태	만료일	국내 출원/등록번호	국내 만료일	비고
Westinghouse SMR (Westinghouse Electric)	US9748004B2	등록(Active)	2034-10-19	등록 10-2111812	2033-05-30	
	US9275761B2	등록(Active)	2033-01-17	등록 10-2111813	2033-05-31	
SMR-160 (Holtec, SMR Inventec)	US10665354B2	등록(Active)	2033-05-21	-	-	
	US20210012913A1	포기(Abandoned)	-	-	-	
	US9786393B2	등록(Active)	2033-10-22	-	-	
mPower (Bobcock & Wilcox)	US8638898B2	등록(Active)	2032-06-25	출원 10-2013-7025107 (취하)	-	
	US10720248B2	등록(Active)	2039-02-23	출원 10-2015-7029768 (취하)	-	
BWRX-300 (GE-Hitachi Nuclear Energy)	US20210202119A1	출원 중(Pending)	-	-	-	
	US11342085B2	등록(Active)	2040-06-18	-	-	
NUWARD (Technicatome)	US10255999B2	등록(Active)	2036-03-06	-	-	
	US20150016581A1	포기(Abandoned)	-	-	-	
	FR2847707A1	출원 중(Pending)	-	-	-	
NuScale (NuScale Power)	US8170173B2	등록(Active)	2029-05-04	등록 10-1215323	2028-11-06	
	US8824619B2	등록(Active)	2028-11-17	등록 10-1313789	2029-11-17	
	US8867689B2	등록(Active)	2033-08-27	등록 10-1940197	2032-02-14	
	US10186334B2	등록(Active)	2032-05-24	등록 10-1299979	2028-11-06	
	US8687759B2	등록(Active)	2030-01-27	-	-	

* NuScale 특허 중 RVV, RRV (IAB 포함) 관련 특허는 본 발표자료에서 다루지 않음.

2. Westinghouse SMR 특허

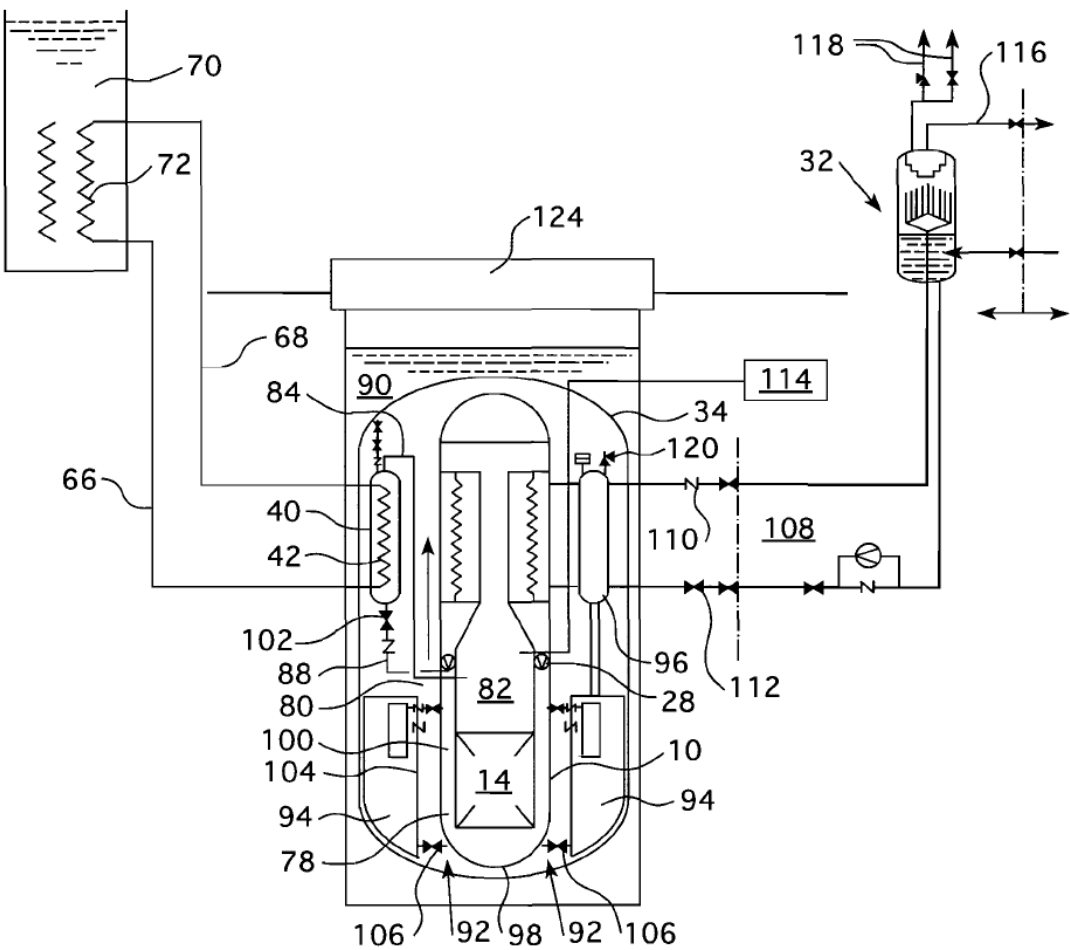
KR 10-2111813
US9275761B2

Westinghouse SMR 한국 특허(등록유지) 중 안전 계통 개념과 관련된 특허

소형 모듈식 원자로 안전 시스템

출원번호	10-2015-7000447
출원일자(국제)	2013-05-31
심사청구일자	2018-04-05
번역문제출일자	2015-01-08
국제출원번호	PCT/US2013/043551
국제공개일자	2013-12-19
우선권주장	13/495083 2012-06-13 미국(US)
등록번호	10-2111813
등록일자	2020-05-11
만료일자	2033-05-31
특허권자	웨스팅하우스 일렉트릭 컴퍼니 엘엘씨

전체 청구항 수: 총 15항
독립항: 1개항(1)
종속항: 14개항



10-2111813. 소형 모듈식 원자로 안전 시스템

소형 모듈식 원자로의 정지 수동 냉각 시스템에 관한 특허.

운전원 조치 또는 외부 전원 사용 없이 대략 7일 동안 지속적으로 원자로를 냉각시킬 수 있는 재순환 시스템 포함.

10-2111812의 발명에 재순환 시스템이 결합된 발명임.

격납 용기(34)는 물로 된 풀(90)에 잠겨 있음.

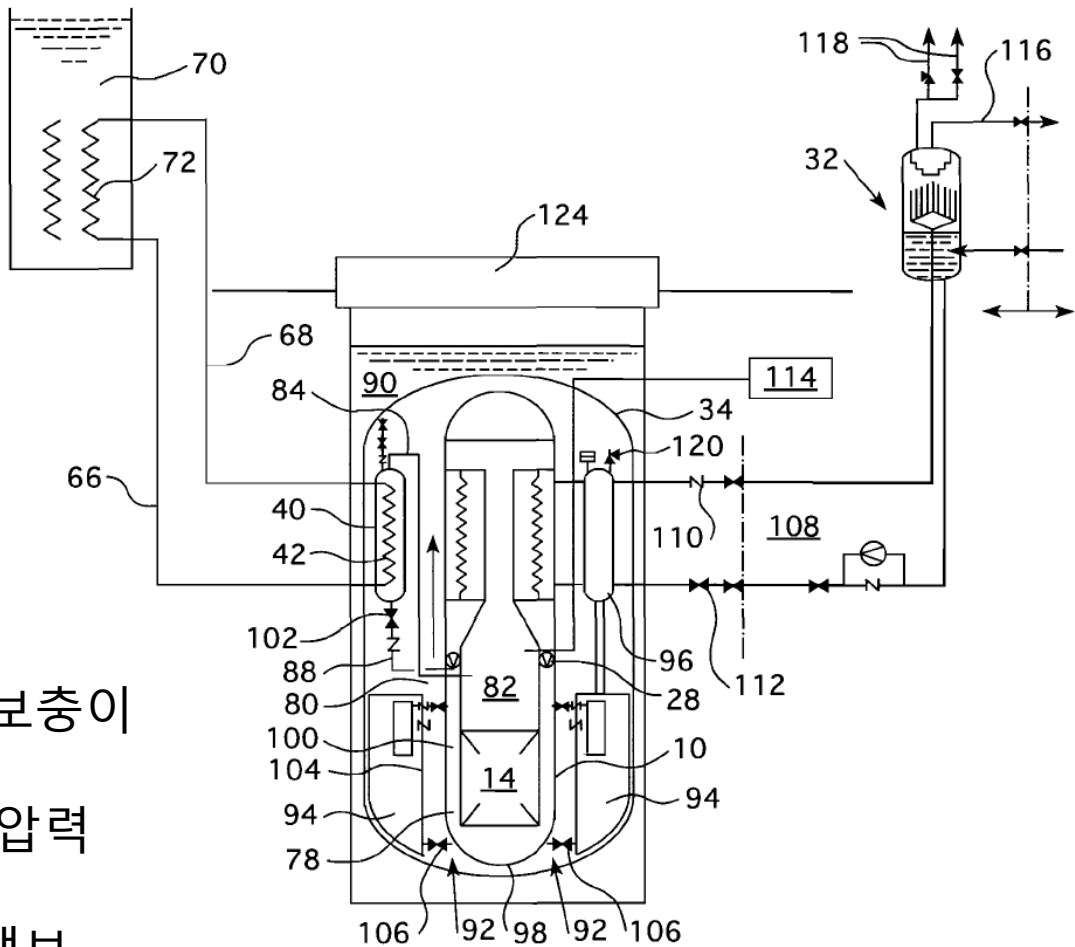
격납 용기 내부는 격납내 풀 탱크(96)에 연결된 격납내 풀 저장조(94)를 포함하는 격납내 풀 시스템(92)이며, 여기에는 CMT(40)도 위치함.

LOCA 발생 시 CMT-잔열제거 결합 시스템을 통한 열 제거 및 냉각재 보충이 이루어짐.

CMT 저수위 시 자동감압계통 격리밸브(102)가 개방되어 RV와 CV간 압력 평형이 이루어짐.

RV가 감압되면 격납내 풀 탱크(96)는 격납내 물 저장조(94) 및 체크 밸브(106)를 통해 중력으로 원자로 용기 공동에 물을 주입하여 RV 외부 냉각.

격납용기 내벽에서 응축된 물은 배수조(98)에 모이고, 격납내 풀 저장조(94) 및 배수조 분사 노즐(100)을 통해 RV로 재순환됨.



10-2111813. 소형 모듈식 원자로 안전 시스템

청구항 1

제거가능한 헤드(12)를 갖고, 핵노심(14)을 포함하는 원자로 압력 용기(10);

상기 원자로 압력 용기(10) 내에 포함된 핵원자로의 1차측 냉각재 루프;

상기 원자로 압력 용기(10)를 포함하는 격납 압력 용기(34)를 포함하고, 상기 **격납 압력 용기는 액체풀(90)에 실질적으로 잠기며**;

상기 핵노심(14) 위의 높이에 위치되는 격납내 풀 탱크(96)와 연결된 격납내 저장조(94)를 포함하는, 상기 격납 압력 용기내의 격납내 풀 시스템(92);

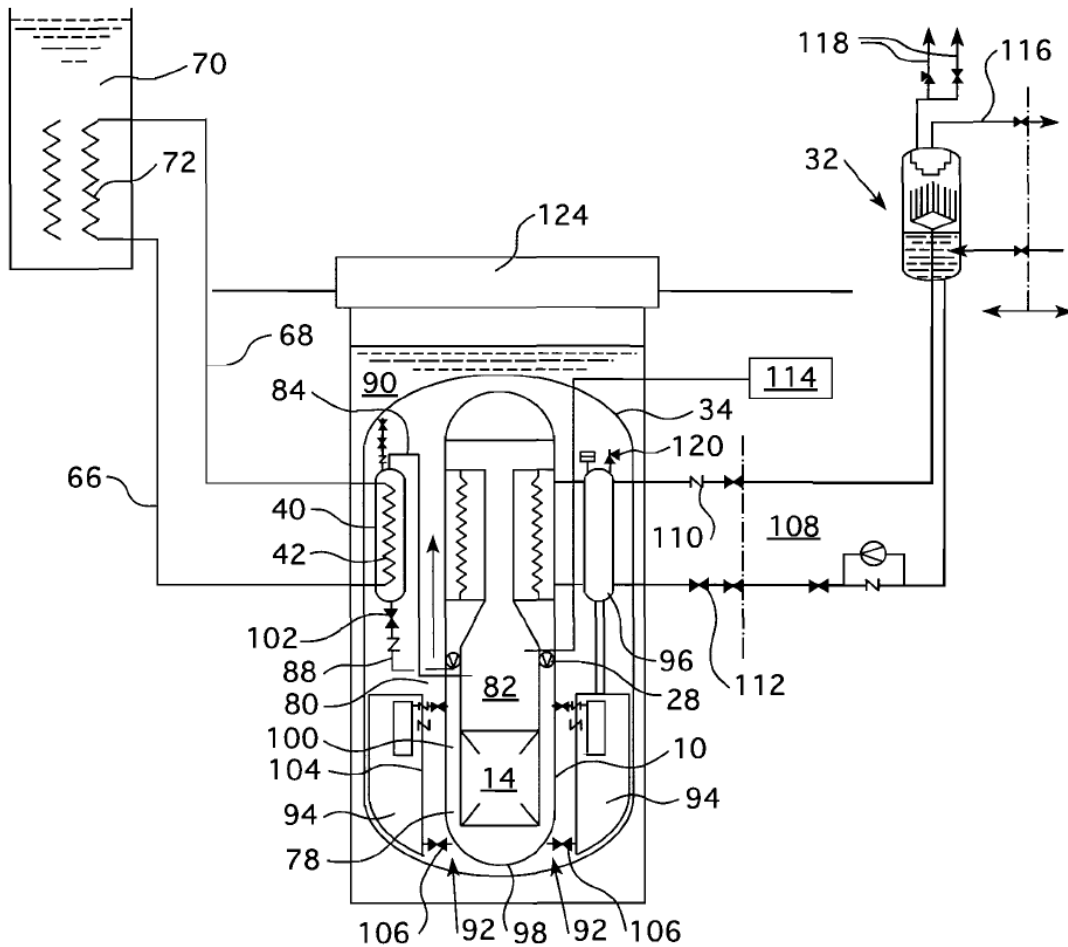
상기 격납내 풀 시스템(92)은 **체크 밸브(104)를 통한 배수조 분사 노즐로 상기 격납내 풀 저장조(94)를 통해 연결**되고;

상기 **체크 밸브(104)**는 상기 격납내 풀 시스템으로부터 상기 격납내 풀 저장조(94)를 통해 상기 원자로 1차측 냉각재 루프로 유동하는 것을 허용하도록 구성되고;

상기 **체크 밸브(104)**는 상기 격납내 풀 탱크(96)가 상기 격납내 저장조를 통해 중력 하에 상기 원자로 내로 배출하는 것을 허용하도록 구성되고;

상기 격납내 풀 시스템(92)도 **제 2 체크 밸브** 및 정상일 때 폐쇄되는 용기 내 유지 밸브(106)를 통해 상기 격납내 체적 또는 격납 배수조(98)의 하부에 연결되고, 상기 **제 2 체크 밸브**는 상기 격납 배수조(98)로부터 상기 격납내 풀 시스템(92)으로 유동하는 것을 허용하도록 구성되고; 그리고

상기 용기내 유지밸브(106)는 상기 **용기내 풀 시스템(92) 내의 물이 원자로 용기 공동 내로 직접 유동하고 그리고 상기 원자로 용기의 외부를 냉각시켜 상기 노심이 상기 원자로 용기를 통해 용융되는 것을 방지**하도록 구성되는 것을 특징으로 하는 모듈식 핵 원자로 시스템.

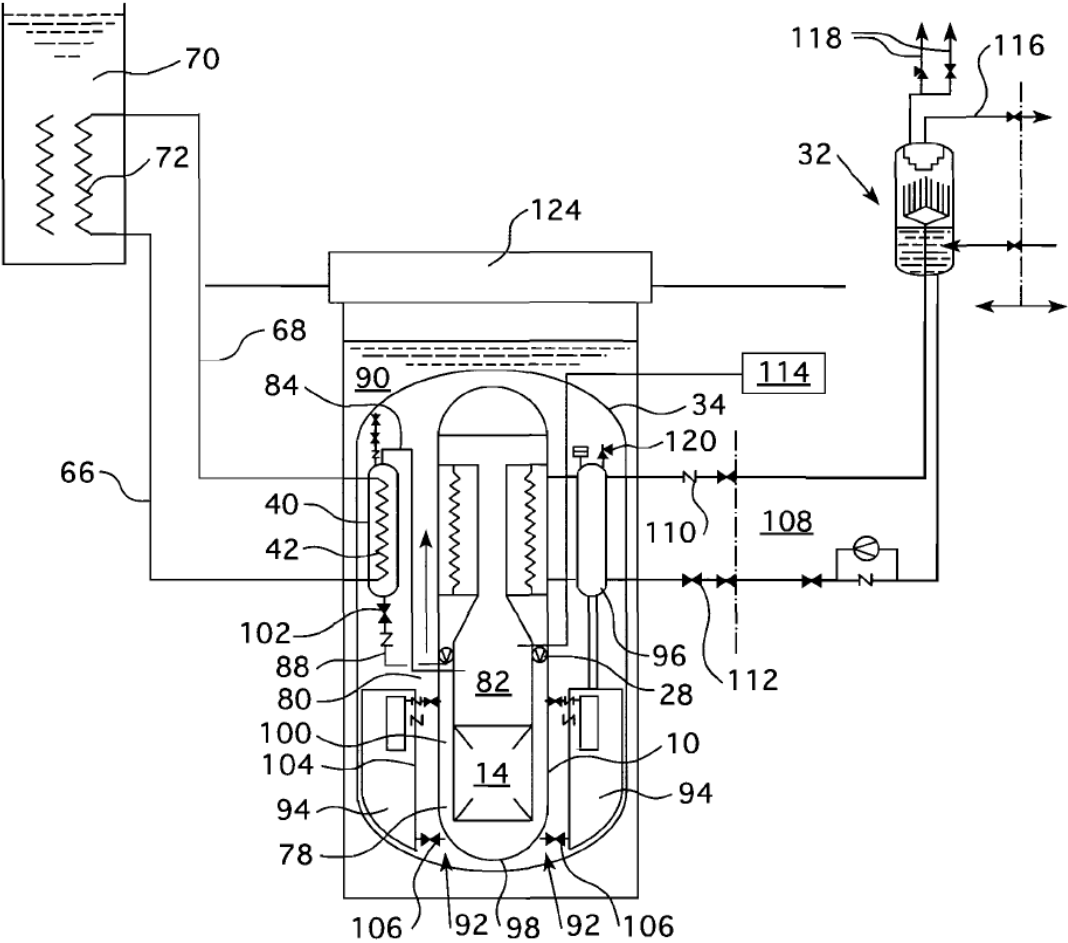


Westinghouse SMR 한국 특허(등록유지) 중 안전 계통 개념과 관련된 특허

PASSIVE REACTOR CONTAINMENT PROTECTION SYSTEM

Patent No.	US9275761B2
Date of Patent	Mar. 01, 2016
Assignee	Westinghouse Electric Company, LLC
Appl. No.	13/495083
Filed	Jun. 13, 2012
Adjusted Expiration	Jan. 17, 2033

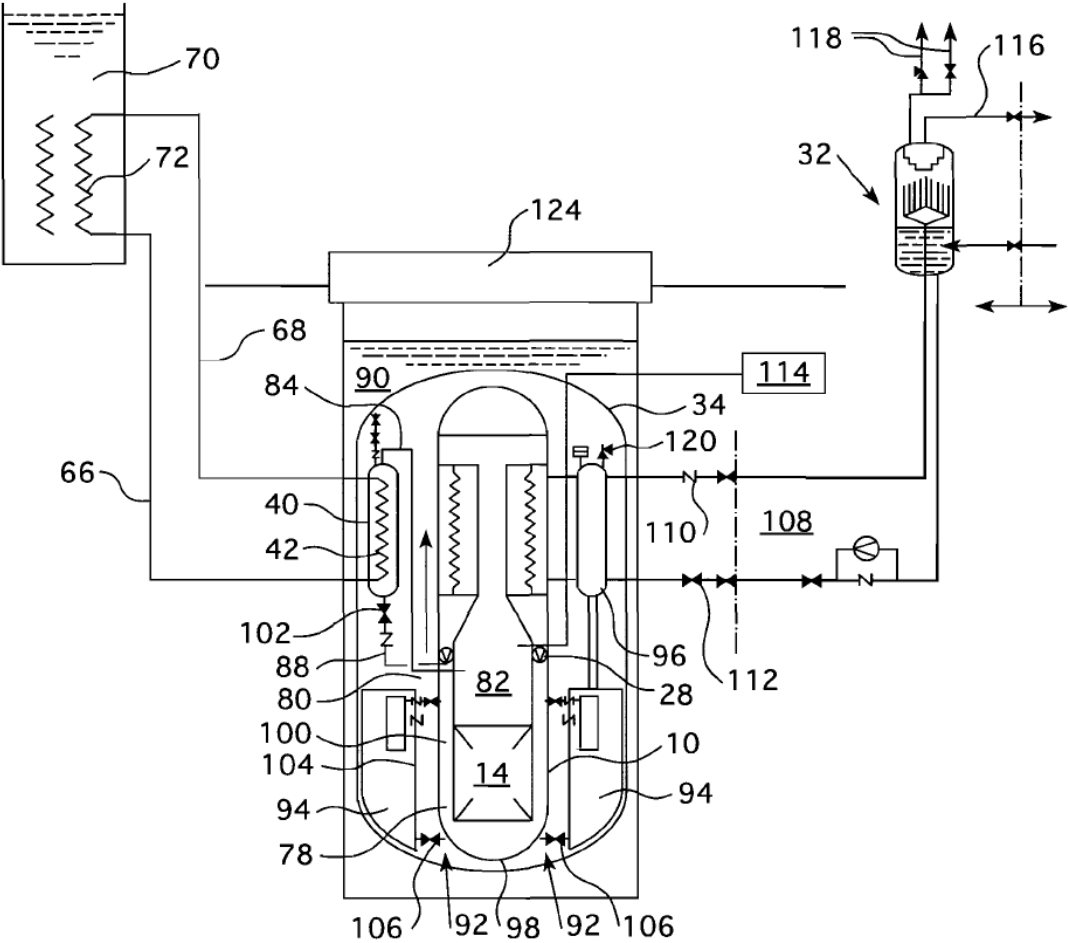
전체 청구항 수: 총 18항
독립항: 1개항(1)
종속항: 17개항



US9275761B2. SMALL MODULAR REACTOR SAFETY SYSTEMS

Claim 1

A modular nuclear reactor system comprising;
a reactor pressure vessel having a removable head;
a primary coolant loop of the nuclear reactor enclosed within the reactor pressure vessel for circulating a primary coolant within the reactor pressure vessel;
a containment pressure vessel enclosing the reactor pressure vessel, the **containment pressure vessel being substantially submerged in a liquid pool**;
an in-containment pool system located within the containment pressure vessel, outside of the reactor pressure vessel and **at least in part occupying a lower portion of the containment pressure vessel below an upper elevation of a reactor core** housed within the reactor pressure vessel, the **in-containment pool system having a reserve reservoir of the primary coolant** that is isolated from the primary coolant loop during normal reactor operation, with the reserve reservoir connected to an inlet to the reactor pressure vessel;
a sump, normally isolated from the in-containment pool system, at least in part extending into a lower portion of the containment pressure vessel, for collecting the primary coolant escaping out of the primary coolant loop and into the containment pressure vessel; and
a circulation system configured to passively circulate, by natural circulation by convection, the primary coolant from the sump through at least a portion of the in-containment pool system and into the reactor pressure vessel upon a preselected operating condition of the modular reactor system.



3. SMR-160 특허

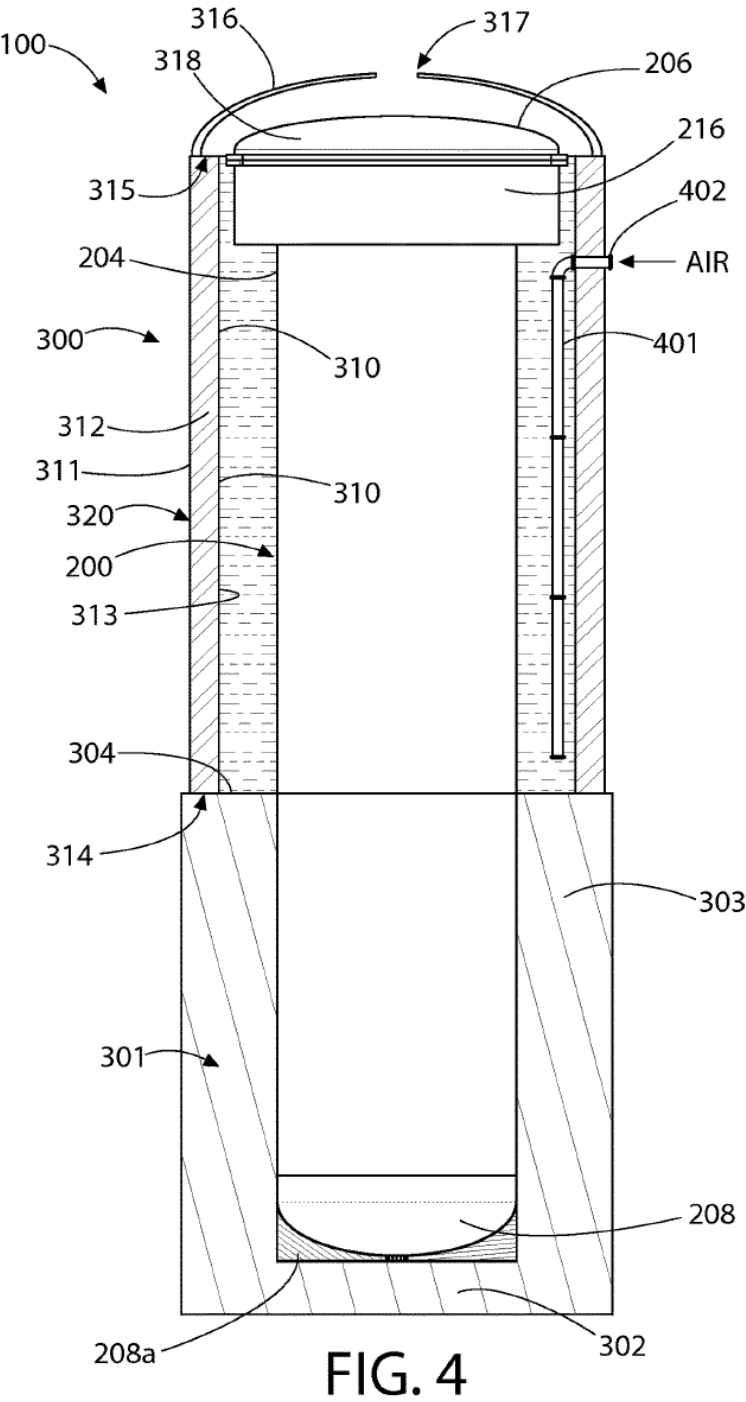
US9786393B2

SMR-160 미국 특허 중 안전 계통 개념과 관련된 특허

PASSIVE REACTOR CONTAINMENT PROTECTION SYSTEM

Patent No.	US9786393B2
Date of Patent	Oct. 10, 2017
Assignee	SMR INVENTEC, LLC
Appl. No.	14/403082
PCT Filed	May 21, 2013
Adjusted Expiration	Oct. 22, 2033

전체 청구항 수: 총 19항
독립항: 3개항(1, 17, 19)
종속항: 16개항



Claim 1

A nuclear reactor containment system and containment protection system comprising:
a CV comprising a cylindrical steel shell that surrounds a wet well, the CV defining containment space configured for housing a nuclear reactor containing a nuclear fuel core emitting heat, the reactor disposed in the wet well;
a **CES surrounding the CV and comprising a hollow cylindrical steel shell**; and
a concrete foundation comprised of a bottom slab supporting the cylindrical shell of the CV and vertically extending sidewalls rising from the slab forming **a top base mat supporting the CES, a lower portion of the CV being positioned inside the sidewalls of the concrete foundation below the base mat and an upper portion of the CV extending upwards from the base mat**;
a water-filled annular reservoir formed between the CV and CES for serving as the heat sink for the heat generated inside the containment space, the annular reservoir extending circumferentially around a perimeter of the upper portion of the CV above the base mat and the **lower portion of CV extending below the annular reservoir**;
wherein the annular reservoir is configured to cool the CV by receiving heat generated within the CV.

주: 몇몇 단어는 가독성 향상을 위해 약어(abbreviation)로 기재하였음.
CV: Containment Vessel
CES: Containment Enclosure Structure

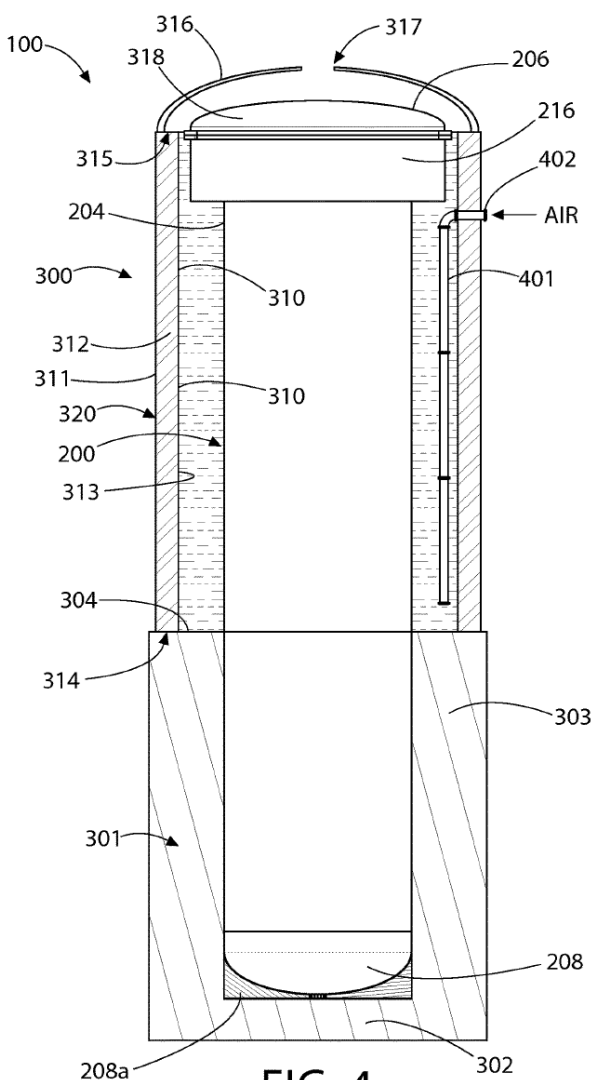


FIG. 4

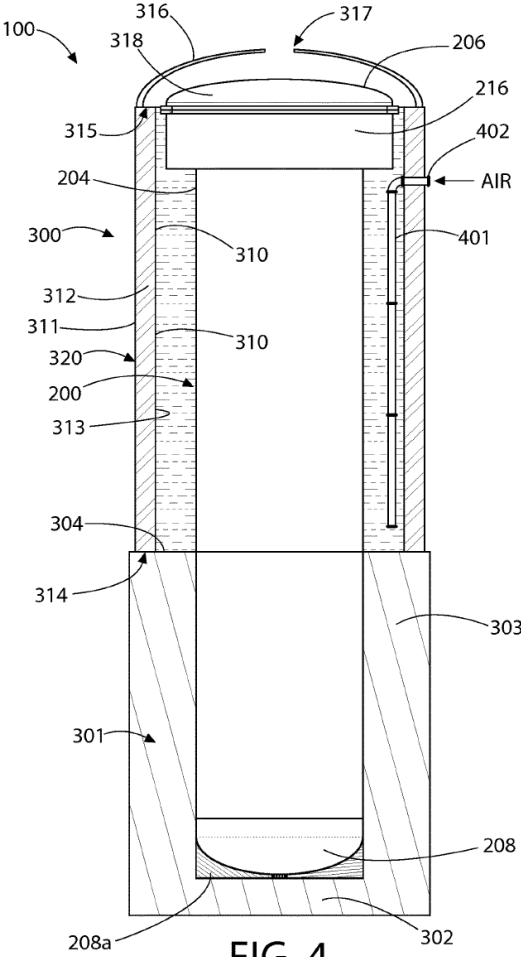
US9786393B2. PASSIVE REACTOR CONTAINMENT PROTECTION SYSTEM

CV: Containment Vessel
CES: Containment Enclosure Structure

Claim 17

A nuclear reactor containment system comprising:

- a CV comprising a cylindrical steel shell configured for housing a nuclear reactor containing a nuclear fuel core emitting heat;
- a **CES surrounding the CV and comprising a hollow cylindrical steel shell**;
- a water filled annulus formed between the CV and CES for cooling the CV;
- a plurality of **substantially radial fins protruding outwards from the CV** and located in the water filled annulus;
- a concrete foundation comprised of a bottom slab supporting the cylindrical shell of the CV and vertically extending sidewalls rising from the slab forming a **top base mat supporting the CES, a lower portion of the CV being positioned inside the sidewalls of the concrete foundation below the base mat and an upper portion of the CV extending upwards from the base mat**;
- the water filled annulus extending circumferentially around a perimeter of the upper portion of the CV above the base mat and the **lower portion of CV extending below the water filled annulus**;
- wherein the water filled annulus is configured to cool the CV by receiving heat generated within the CV by the fuel core which is transferred to the water filled annulus via the **substantially radial fins**;
- wherein the water in the annulus is heated and a portion is evaporated and **vented to atmosphere through the CES in the form of water vapor**.



Claim 19

A nuclear reactor containment system comprising:

- a CV including a cylindrical steel shell having an outer cylindrical wall, the cylindrical shell configured for housing a nuclear reactor containing a nuclear fuel core emitting heat;
- a cylindrical **CES surrounding the CV and comprising a hollow cylindrical steel shell**, the cylindrical containment having an inner cylindrical wall that faces the outer cylindrical wall;
- an annular reservoir containing water and formed between the outer cylindrical wall and the inner cylindrical wall, the annular reservoir for cooling the CV;
- a concrete foundation comprised of a bottom slab supporting the cylindrical shell of the CV and vertically extending sidewalls rising from the slab forming a **top base mat supporting the CES, a lower portion of the CV being positioned inside the sidewalls of the concrete foundation below the base mat and an upper portion of the CV extending upwards from the base mat**;
- the annular reservoir extending circumferentially around a perimeter of the upper portion of the CV above the top base mat and the **lower portion of CV extending below the annular reservoir**;
- a plurality of external substantially radial fins protruding outwards from the CV into the annular reservoir and extending between outer cylindrical wall and the inner cylindrical wall; and
- an **air cooling system including a plurality of vertical inlet air conduits** spaced circumferentially around the CV in the annular reservoir, the **air conduits being in fluid communication with the annular reservoir and outside ambient air** external to the CES;

wherein the radial fins have bottom ends attached to and supported by a circumferential annular rib attached to the outer cylindrical wall of the CV and protruding radially outwards beyond the outer cylindrical wall, the circumferential annular rib seated on the top base mat of the foundation;

wherein the annular reservoir is configured to cool the CV by receiving heat generated within the CV via the fins and transferring the heat to the annular reservoir.

4. mPower 특허

US8638898B2

mPower 미국 특허 중 안전 계통 개념과 관련된 특허

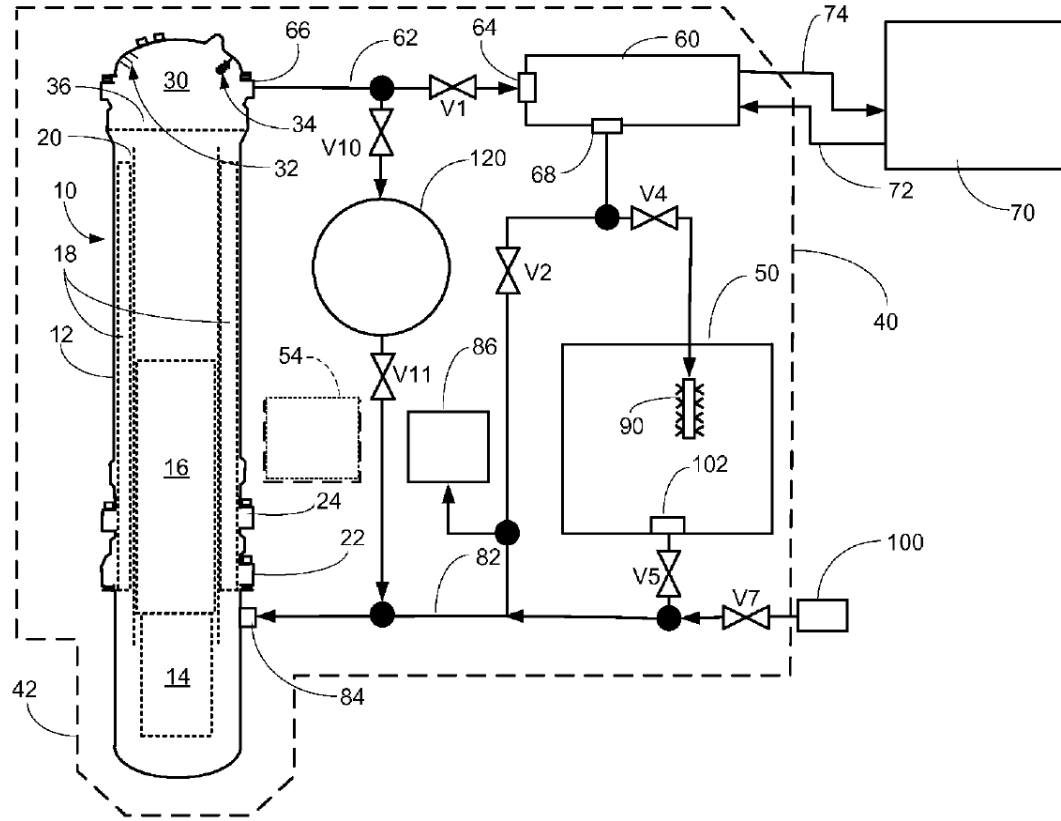
EMERGENCY CORE COOLING SYSTEM FOR PRESSURIZED WATER REACTOR

Patent No.	US8638898B2
Date of Patent	Jan. 28, 2014
Assignee	Babcock & Wilcox mPower, Inc.
Appl. No.	13/069657
Filed	Mar. 23, 2011
Adjusted Expiration	Jun. 25, 2032

전체 청구항 수: 총 19항

독립항: 3개 항(1, 12, 16)

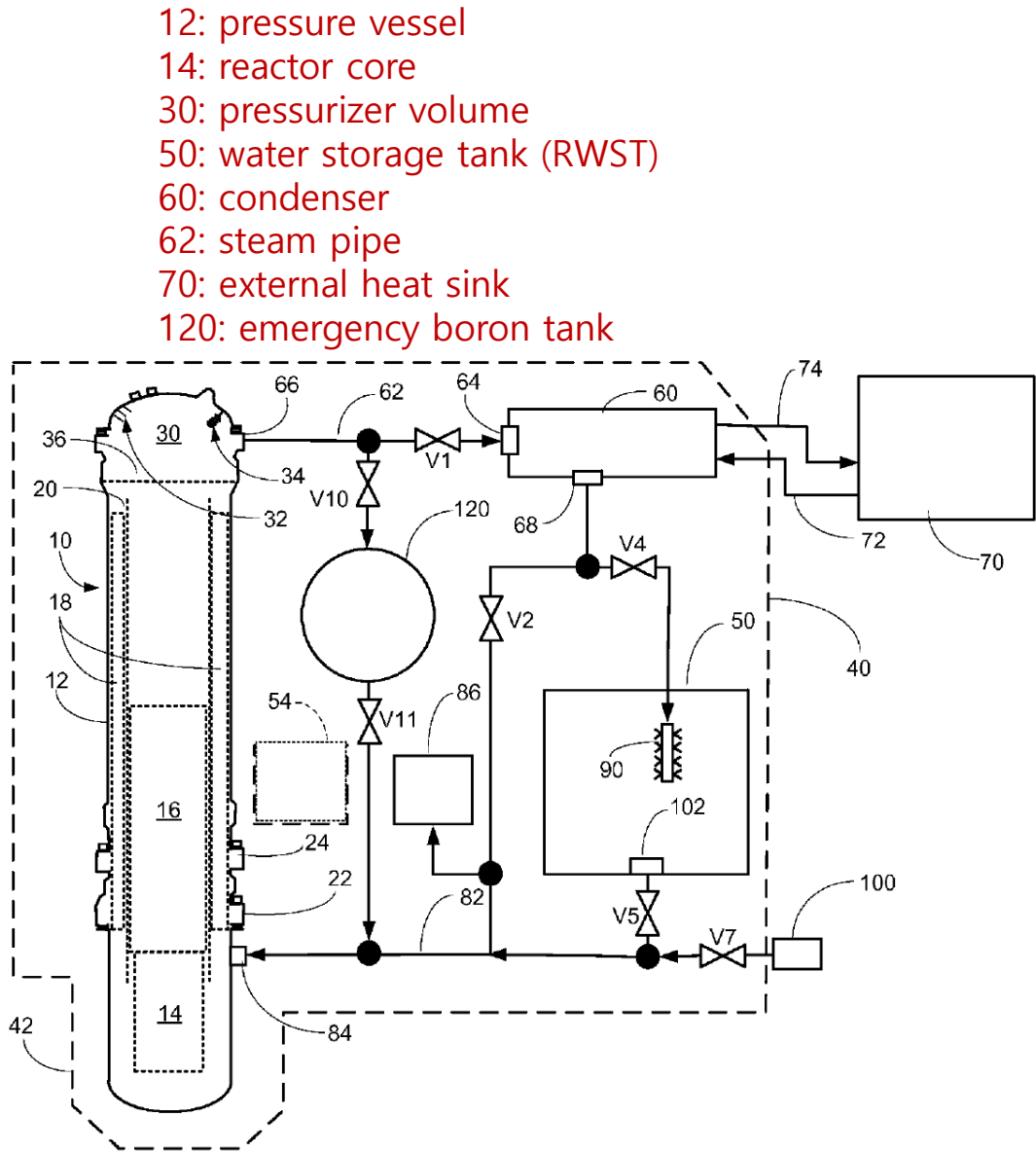
종속항: 16개항



US8638898B2. EMERGENCY CORE COOLING SYSTEM FOR PRESSURIZED WATER REACTOR

Claim 1

An apparatus comprising:
a pressurizer water reactor (PWR) including a pressure vessel containing a nuclear reactor core and primary coolant water, the pressure vessel defining an internal pressurizer volume containing a steam bubble and having at least one steam pressure control device;
a containment structure surrounding the PWR;
an **external heat sink disposed outside of the containment structure;**
a **condenser disposed inside the containment structure and operatively connected with the external heat sink;** and
a **valve assembly comprising one or more valves, the valve assembly operatively connecting the PWR with the condenser** responsive to an abnormal operation signal such that the **condenser condenses steam from the steam bubble while rejecting heat to the external heat sink and returns the condensed water to the PWR.**

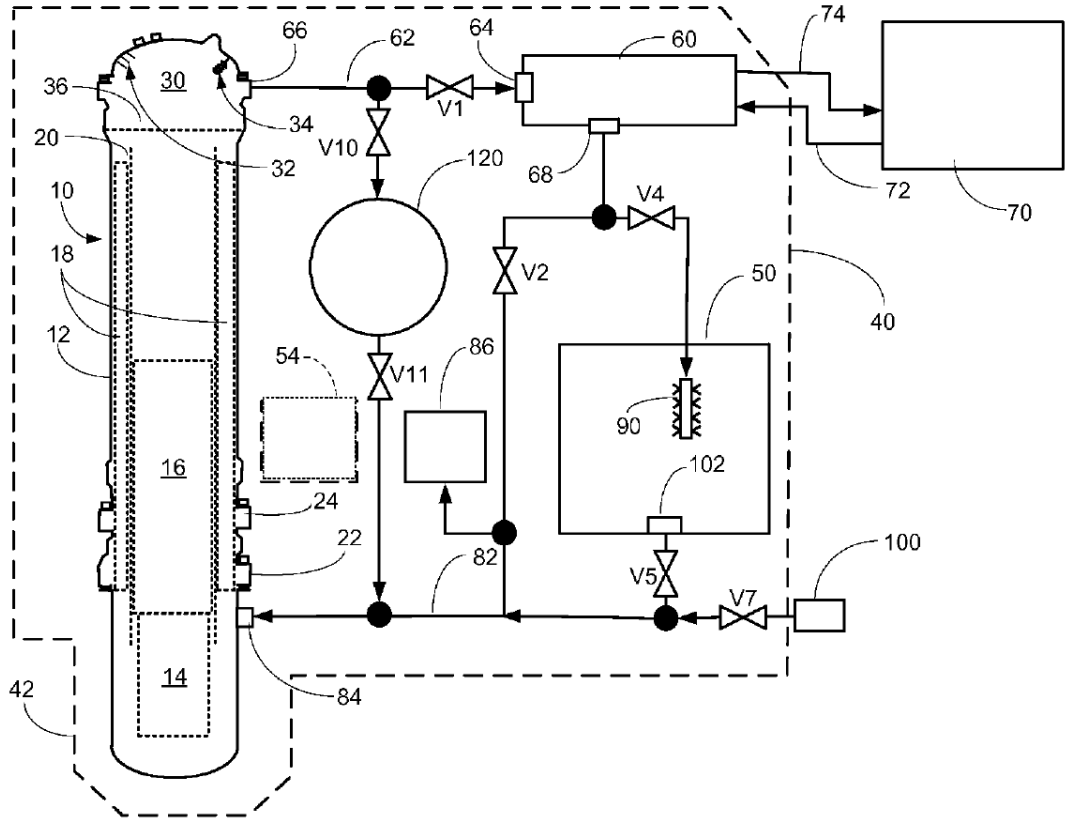


US8638898B2. EMERGENCY CORE COOLING SYSTEM FOR PRESSURIZED WATER REACTOR

Claim 12

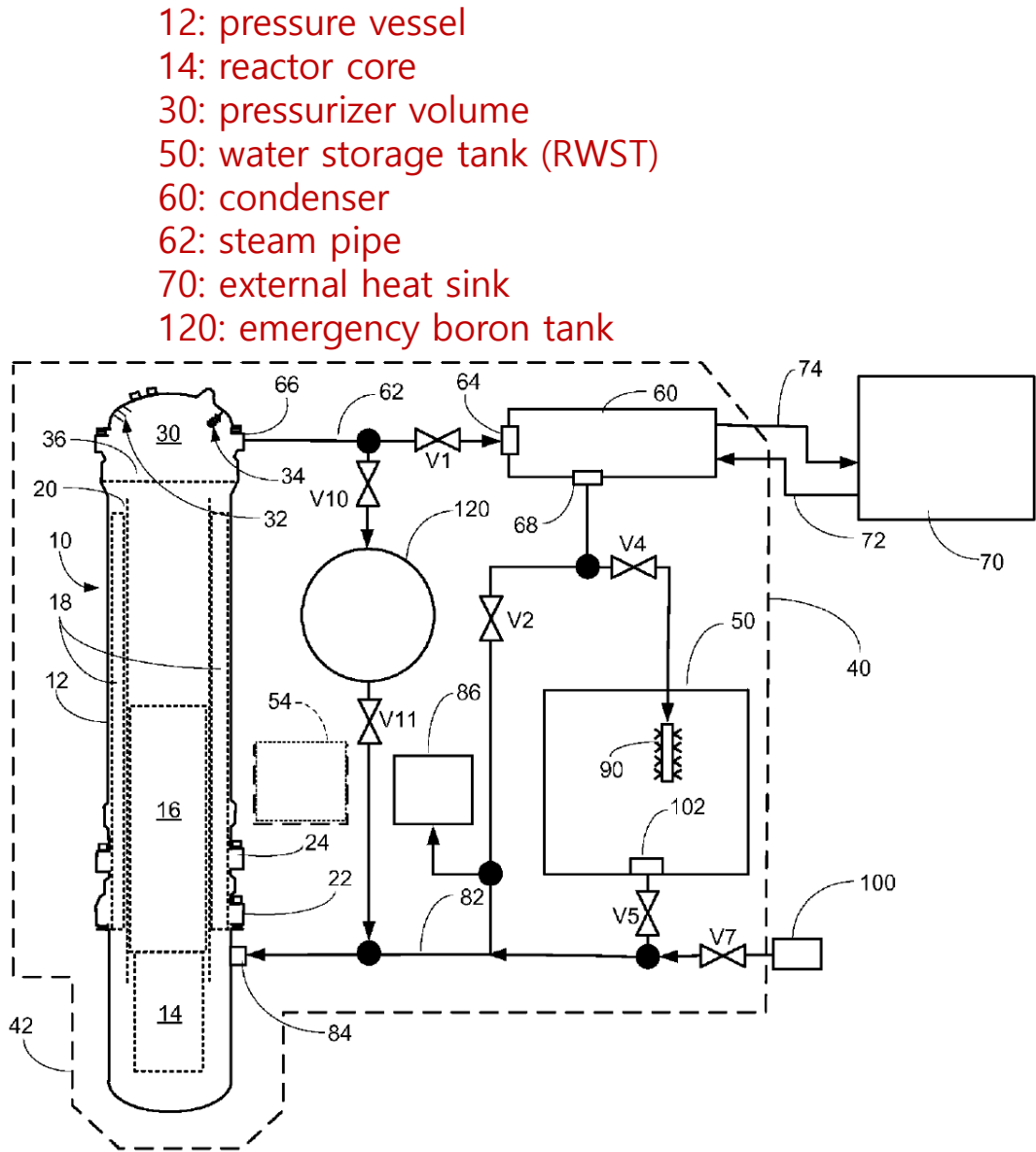
A method comprising:
operating a pressurized water reactor (PWR) disposed in a containment structure, the PWR including a pressure vessel containing a nuclear reactor core and primary coolant water and an internal pressure-regulating steam bubble; and
responsive to an abnormal operation signal, performing an emergency core cooling process including operatively connecting **a condenser disposed in the containment structure** with the PWR to condense steam from the steam bubble while **rejecting heat to an external heat sink disposed outside of the containment structure** and to **return the condensed water to the PWR**.

- 12: pressure vessel
- 14: reactor core
- 30: pressurizer volume
- 50: water storage tank (RWST)
- 60: condenser
- 62: steam pipe
- 70: external heat sink
- 120: emergency boron tank



Claim 16

An apparatus comprising:
a pressurized water reactor (PWR) including a pressure vessel containing a nuclear reactor core and primary coolant water, the pressure vessel defining an internal pressurizer volume containing a steam bubble and having at least one steam pressure control device;
a containment structure surrounding the PWR;
an **external heat sink disposed outside of the containment structure**;
at least one **condenser disposed inside the containment structure and operatively connected with the external heat sink**; and
a **valve assembly comprising one or more valves**, the valve assembly configured to (1) **respond to a loss of heat sink event** by operatively connecting the at least one condenser with the PWR to condense steam from the steam bubble and **return the condensed water to the PWR** and to (2) **response to a loss of coolant accident (LOCA)** by operatively connecting the at least one condenser with the PWR to condense steam from the steam bubble and **return the condensed water to the PWR**.



5. NuScale 특허

KR 10-1940197

US8867689B2

KR 10-1299979

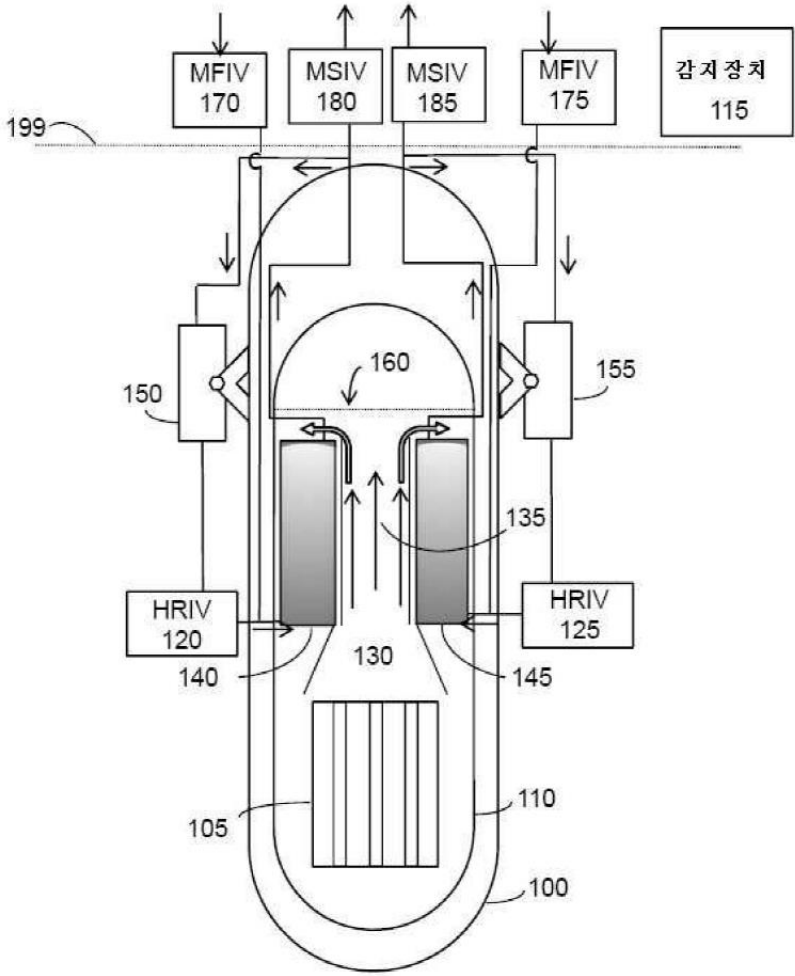
US10186334B2

NuScale 한국 특허(등록유지) 중 안전 계통 개념과 관련된 특허

원자로와 함께 사용되기 위한 열 제거 시스템 및 방법

출원번호	10-2013-7024407		
출원일자(국제)	2012-02-14		
심사청구일자	2017-02-08		
번역문제출일자	2013-09-13		
국제출원번호	PCT/US2012/025001		
국제공개일자	2012-08-23		
우선권주장	13/303408	2011-11-23	미국(US)
	61/463282	2011-02-15	미국(US)
등록번호	10-1940197		
등록일자	2019-01-14		
만료일자	2032-02-14		
특허권자	웨스팅하우스 일렉트릭 컴퍼니 엘엘씨		

전체 청구항 수: 총 20항
독립항: 4개항(1, 9, 14, 17)
종속항: 16개항



안전계통 3. 원자로와 함께 사용되기 위한 열 제거 시스템 및 방법
(10-2013-7024407 , 10-1940197)

청구항 1

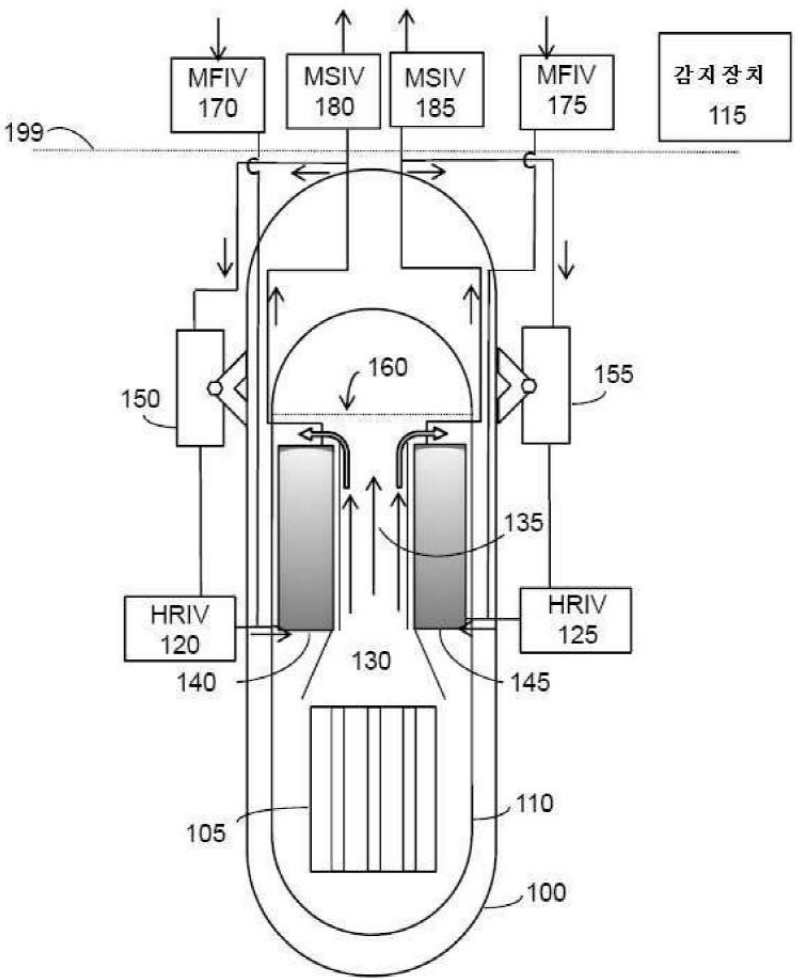
원자로 용기;

원자로 용기를 둘러싸는 격납 용기;

원자로 용기 안으로부터의 냉각제를 수용하는 제 1 콘덴서; 및,

격납 용기를 둘러싸고 상기 격납 용기로부터 분리된 원자로 베이(reactor bay)로서, **상기 원자로 베이는 공통의 풀(pool)을 적어도 부분적으로 형성하는 복수개의 벽들을 포함**하고, 상기 벽들은 격납 용기와 상기 벽들 사이에 있는 상기 공통의 풀 안의 냉각제를 에워싸는, 원자로 베이;를 포함하고,

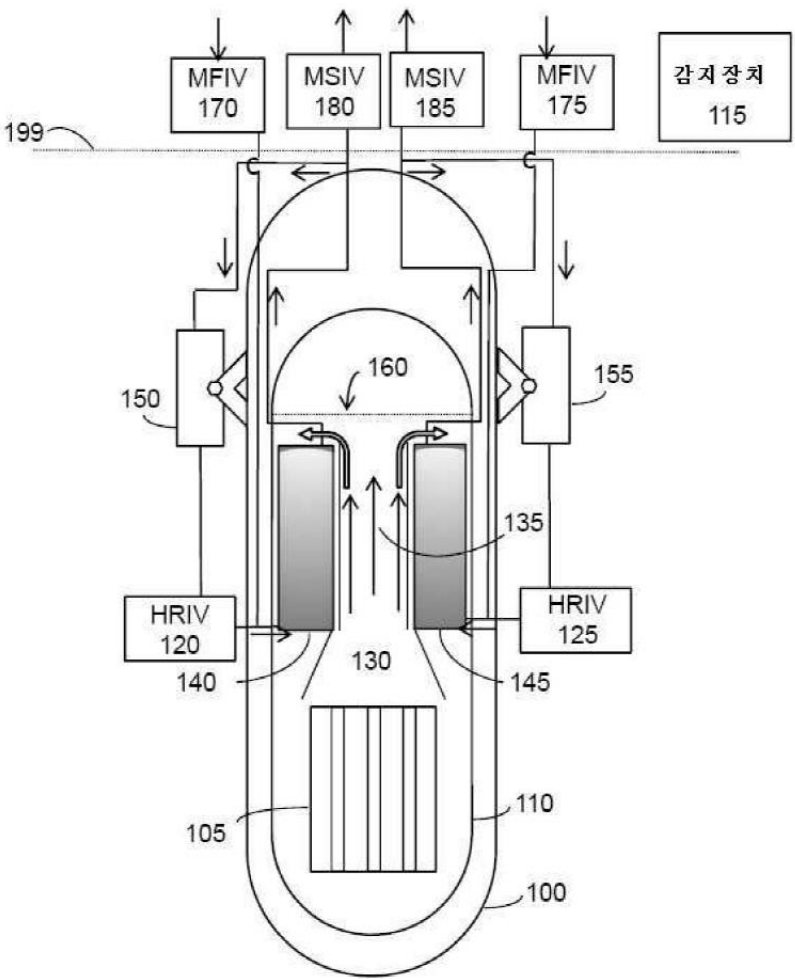
격납 용기 및 제 1 콘덴서가 공통의 풀(pool) 안에 적어도 부분적으로 잠겨있는, 원자로.



안전계통 3. 원자로와 함께 사용되기 위한 열 제거 시스템 및 방법
(10-2013-7024407 , 10-1940197)

청구항 9

원자로로부터 열을 제거하는 방법으로서는,
제어 장치를 작동시키는 단계 이전에, 원자로의 냉각 성능의 열화를 감지하는 단계;
제어 장치를 작동시키는 단계; 및,
제어 장치의 작동에 응답하여, 증발된 냉각제를 콘덴서를 통해 이송시키는 단계;를
포함하고,
원자로의 격납 용기 및 콘덴서는 적어도 부분적으로 공통의 풀 안에 잠기고,
콘덴서 및 격납 용기는 공통의 풀의 액체와 직접 접촉하는, 원자로의 열 제거 방법.



안전계통 3. 원자로와 함께 사용되기 위한 열 제거 시스템 및 방법
(10-2013-7024407 , 10-1940197)

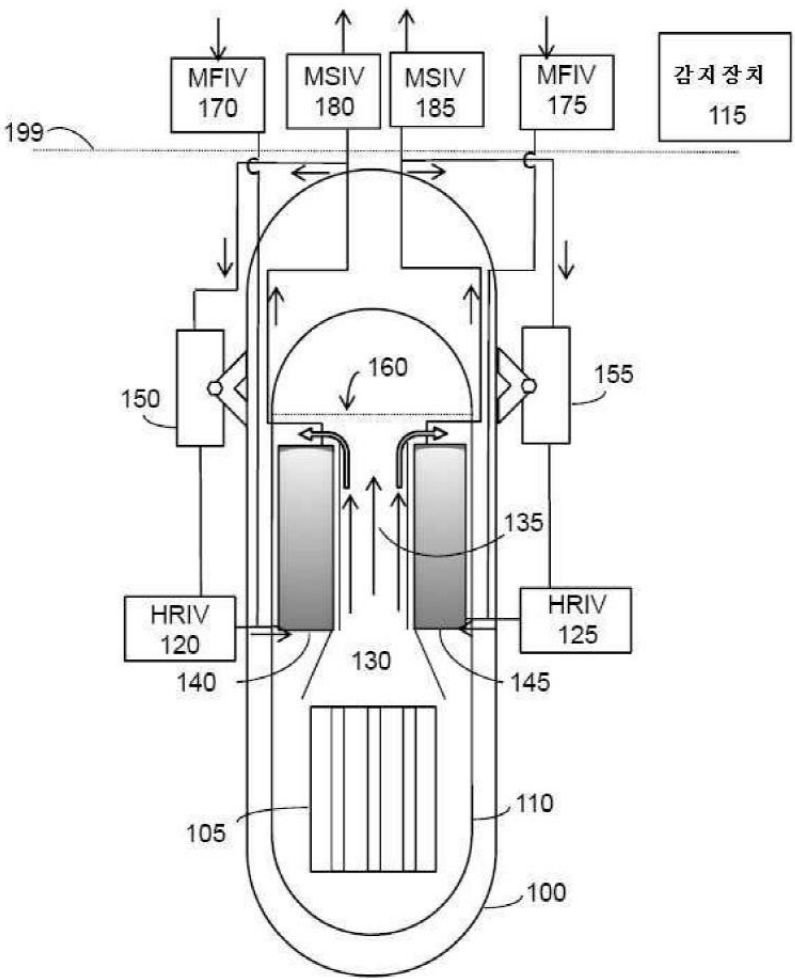
청구항 14

원자로 및 관련 콘덴서의 사용을 위한 구성 방법으로서,

콘덴서를 원자로에 장착시키거나 또는 콘덴서를 원자로에 유체 소통되게 연결시키는 단계; 및,

콘덴서 및 원자로를 원자로 베이 안에 있는 액체의 공통의 풀(common pool) 안에 적어도 부분적으로 잠기게 하는 단계로서, 상기 공통의 풀은 상기 원자로 베이의 벽들과 격납 용기 사이에 적어도 부분적으로 감싸이는, 단계;를 포함하고,

적어도 부분적으로 잠긴 콘덴서는 공통 풀의 액체와 직접 접촉되는, 원자로 및 관련 콘덴서의 구성 방법.



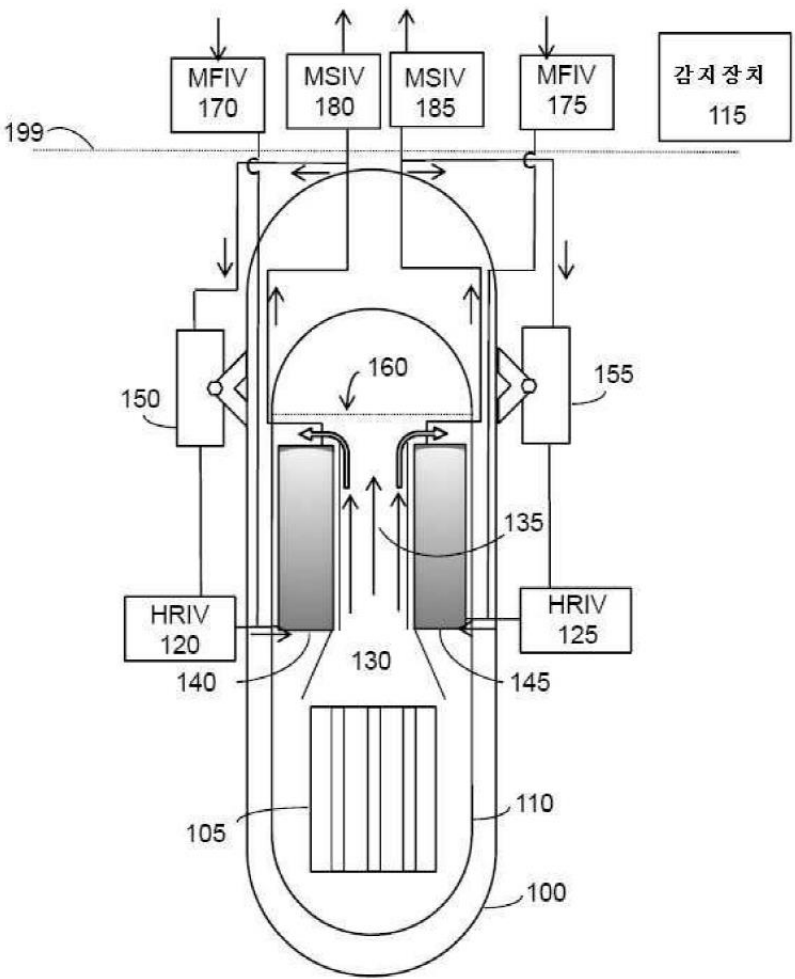
안전계통 3. 원자로와 함께 사용되기 위한 열 제거 시스템 및 방법
(10-2013-7024407 , 10-1940197)

청구항 17

원자로로부터 열을 제거하도록 작동될 수 있고 원자로를 둘러싸는 풀 안에 적어도 부분적으로 잠기는 콘덴서로서, 상기 풀은 원자로 베이의 벽들과 격납 용기 사이에 적어도 부분적으로 감싸이는, 콘덴서;

원자로의 냉각 성능의 열화를 검출하는 수단; 및,

냉각 성능의 열화를 검출하는 수단으로부터의 출력 신호에 응답하여, 증발된 냉각제가 콘덴서로 유동하는 것을 제어하는 수단;을 포함하는, 열 제거 시스템.

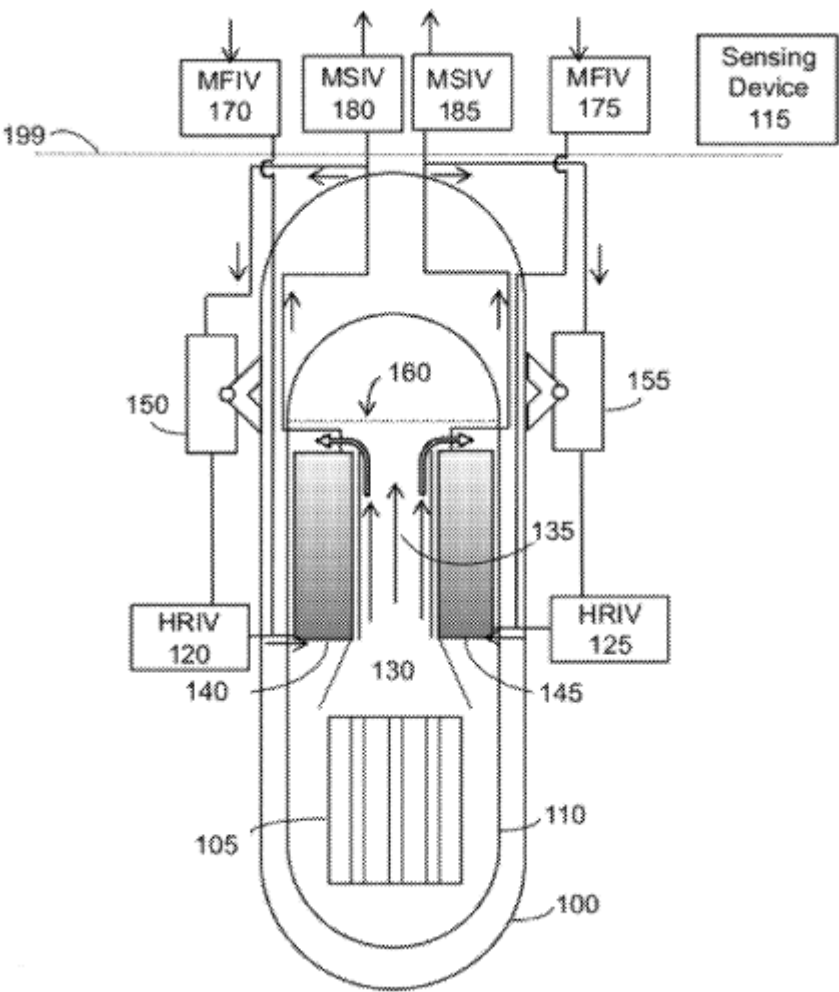


NuScale 미국 특허 중 안전 계통 개념과 관련된 특허

HEAT REMOVAL SYSTEM AND METHOD FOR USE WITH A NUCLEAR REACTOR

Patent No.	US8867689B2
Date of Patent	Oct. 21, 2014
Assignee	NuScale Power, LLC.
Appl. No.	13/303408
Filed	Nov. 23, 2011
Adjusted Expiration	Aug. 27, 2033

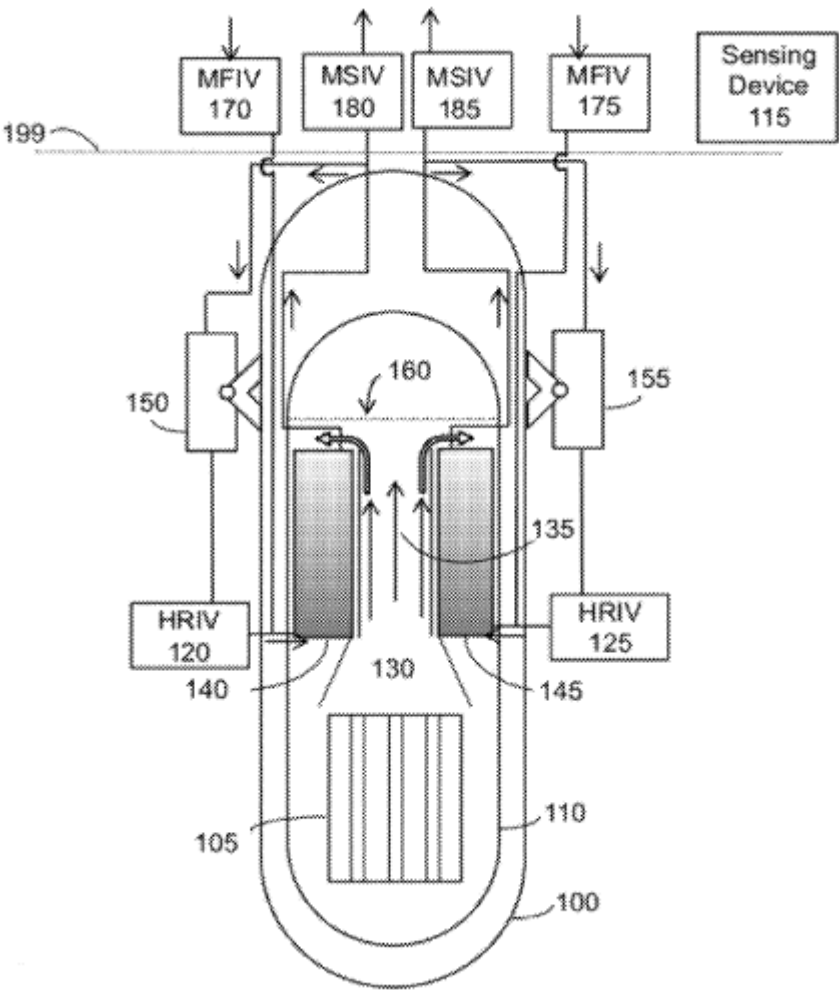
전체 청구항 수: 총 31항
독립항: 5개항(1, 14, 18, 21, 25)
종속항: 26개항



US8867689B2. HEAT REMOVAL SYSTEM AND METHOD FOR USE WITH A NUCLEAR REACTOR

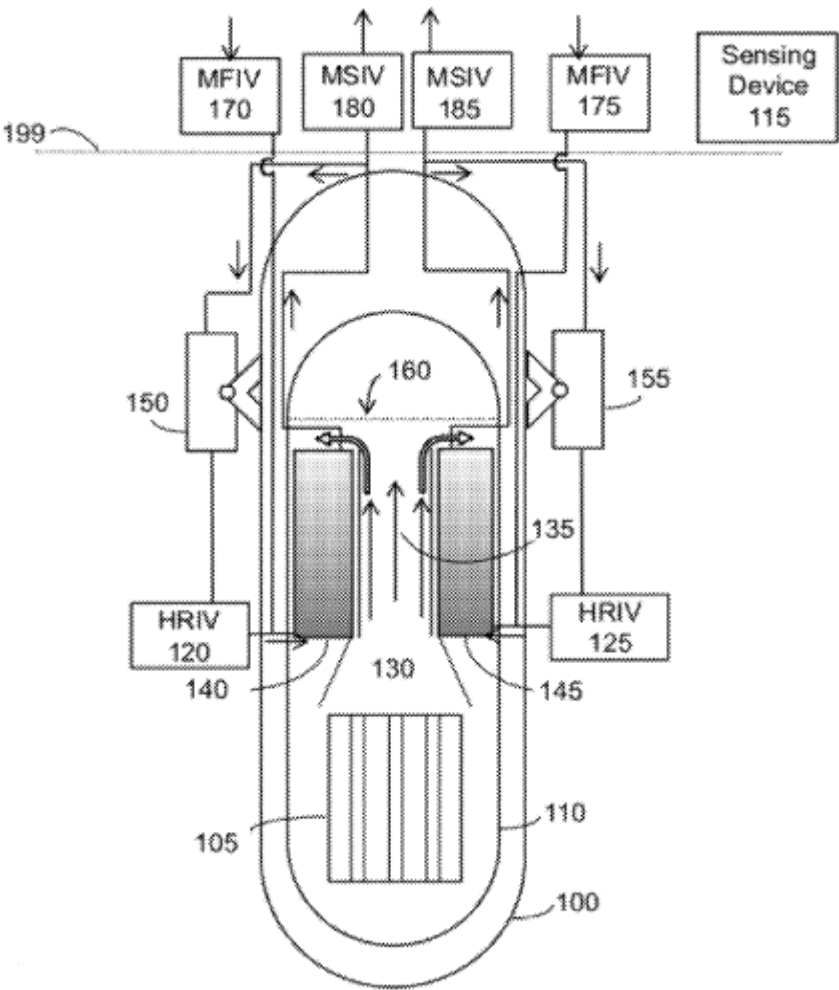
Claim 1

A nuclear reactor, comprising:
a reactor vessel;
a **containment vessel that surrounds the reactor vessel**;
a **first condenser that receives coolant from within the reactor vessel**, the **containment vessel and the first condenser at least partially submerged within a common pool**; and
a **reactor bay separate from the containment vessel that surrounds the containment vessel**, the reactor bay comprising a plurality of walls that at least partially define the common pool and **enclose a coolant in the common pool between the containment vessel and the walls**.



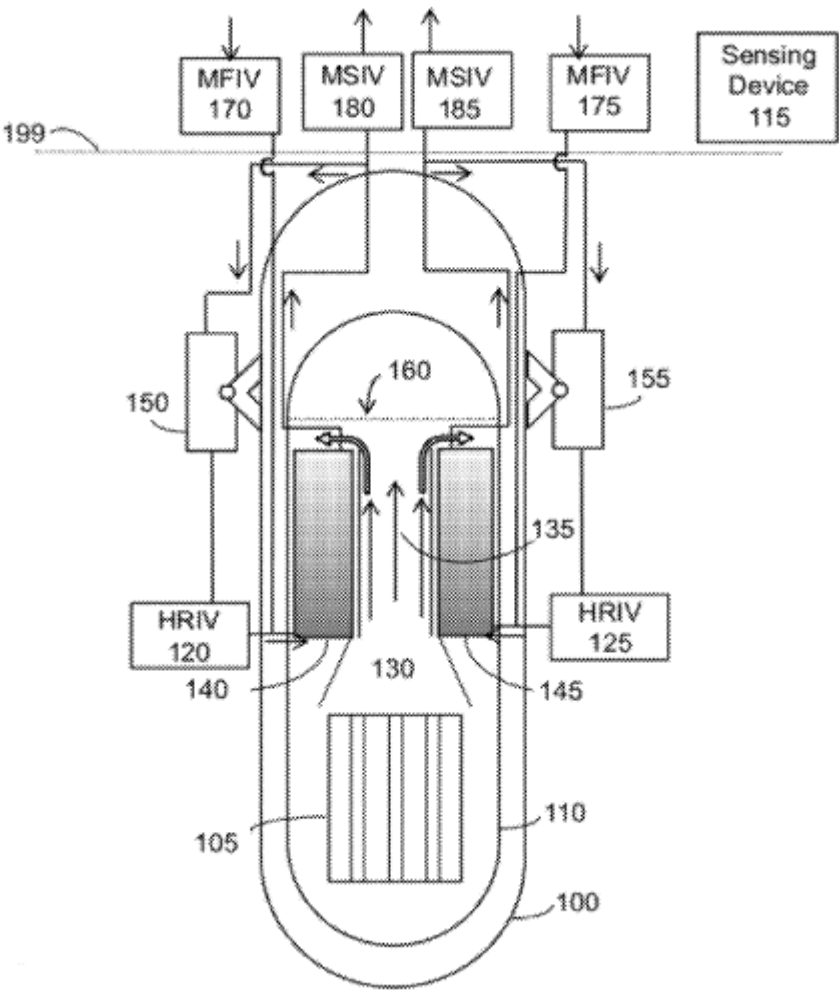
Claim 14

A method of removing heat from a nuclear reactor, comprising:
sensing, prior to actuating a control device, a degradation in cooling capability of a nuclear reactor;
actuating the control device; and
conveying, responsive to actuation of the control device, **vaporized coolant through a condenser**, wherein the **condenser and a containment vessel of the nuclear reactor are at least partially submerged in a common pool**, and wherein the condenser and the containment vessel are in direct contact with liquid of the common pool.



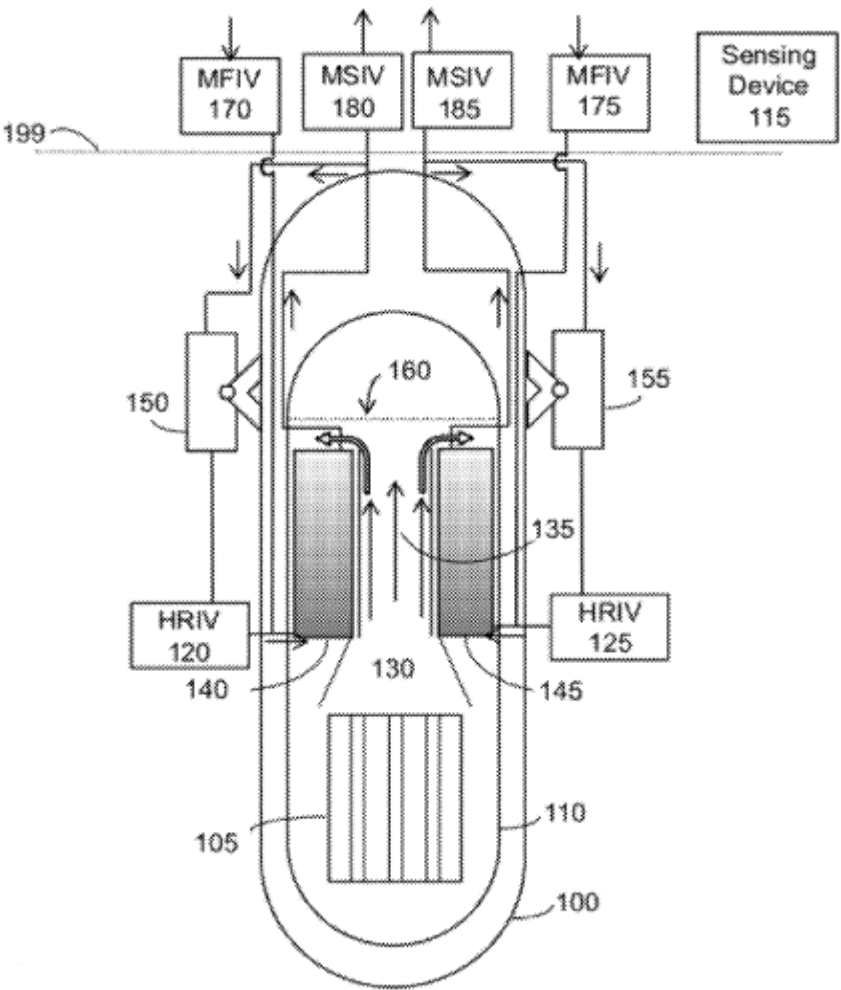
Claim 18

A method of configuring a nuclear reactor and **associated condenser** for use, the method comprising:
coupling, structurally or fluidly, the condenser to the **nuclear reactor that is housed in a containment vessel**; and
at least **partially submerging the condenser and the nuclear reactor into a common pool of liquid within a reactor bay**, the common pool at least partially enclosed between a plurality of walls of the reactor bay and the containment vessel, wherein
the at least partially submerged condenser makes direct contact with liquid of the common pool.



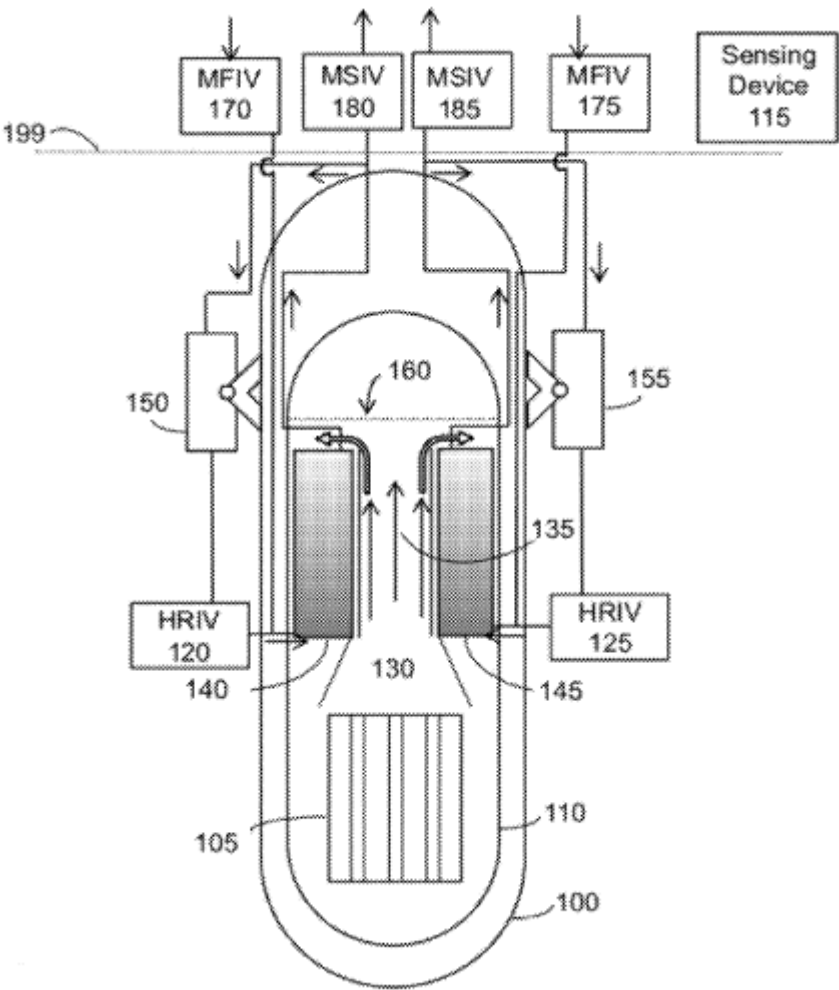
Claim 21

A heat removal system, comprising:
a **condenser operable to remove heat from a nuclear reactor**, the **condenser being at least partially submerged in a pool surrounding the nuclear reactor**;
means for detecting a degradation in cooling capability of the nuclear reactor; and
means for controlling vaporized coolant flow to the condenser in response to an output signal from the means for detecting a degradation in cooling capability.



Claim 25

A nuclear reactor, comprising:
a reactor vessel;
a **containment vessel that surrounds the reactor vessel**;
a **first condenser that receives coolant from within the reactor vessel**, the **containment vessel and the first condenser at least partially submerged within a common pool**;
a control device adjustable to permit coolant to flow from the first condenser to a first portion of a heat exchanger within the reactor vessel; and
a degradation sensor responsive to degradation in a cooling system of the nuclear reactor, the degradation sensor operable to generate an output signal to an input port of the control device, and the control device adjustable to permit coolant to flow from the first condenser to the heat exchanger within the reactor vessel.

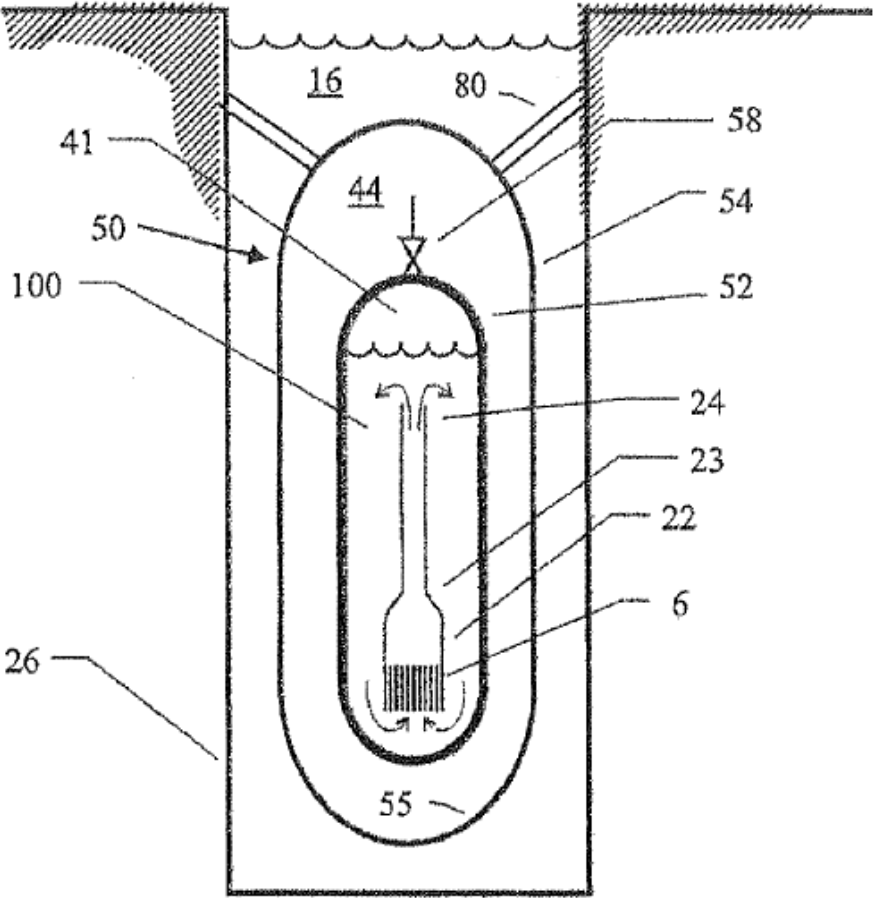


NuScale 한국 특허(등록유지) 중 안전 계통 개념과 관련된 특허

원자로를 포함하는 원자로 조립체 및 원자로의 냉각 방법

출원번호	10-2010-7013054		
출원일자(국제)	2008-11-06		
심사청구일자	2010-06-14		
번역문제출일자	2010-06-14		
국제출원번호	PCT/US2008/082617		
국제공개일자	2009-05-22		
우선권주장	11/941024	2007-11-15	미국(US)
등록번호	10-1299979		
등록일자	2013-08-20		
만료일자	2028-11-06		
최종권리자	웨스팅하우스 일렉트릭 컴퍼니 엘엘씨		

전체 청구항 수: 총 22항
독립항: 3개항(1, 13, 22)
종속항: 19개항



안전계통 2. 원자로를 포함하는 원자로 조립체 및 원자로의 냉각 방법 (10-2010-7013054 , 10-1299979)

청구항 1

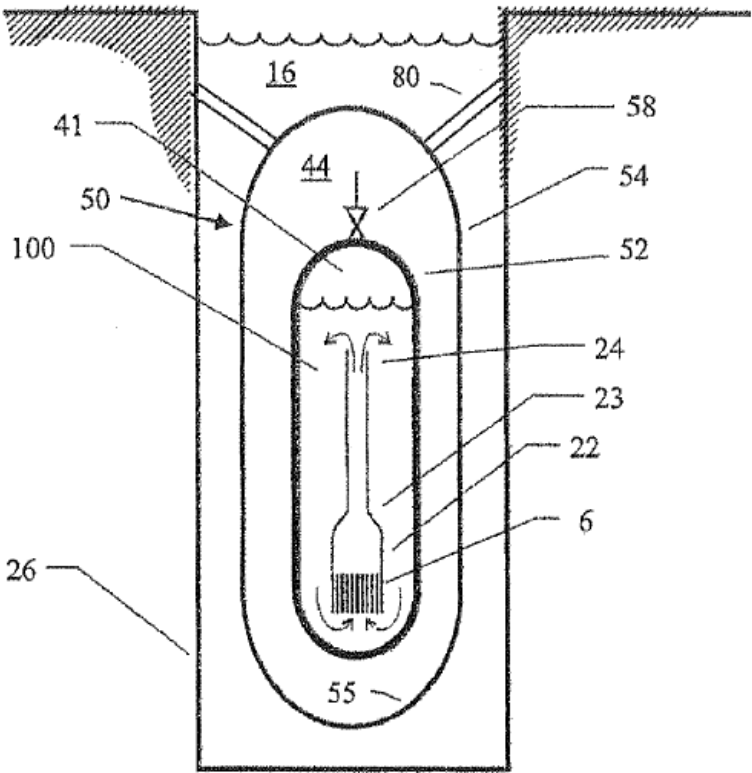
원자로 조립체(power module assembly)로서,

원자로 용기(nuclear reactor vessel);

상기 원자로 용기 내에 수용된 원자로 노심으로서, 상기 원자로 용기 내에 수용된 1차 냉각제(primary coolant) 내에 잠겨진(immersed), 원자로 노심(nuclear reactor core);

상기 원자로 용기를 부분 진공(partial vacuum) 상태로 둘러싸고 액체 내에 잠수되는 격납 용기로서, 상기 격납용기와 상기 원자로 용기 사이에 배치된 격납 영역은 상기 원자로 조립체의 정상 작동(normal operation) 중에 건조하게 유지되고, 상기 격납 용기는 상기 1차 냉각제가 격납 용기 밖으로 방출되는 것을 방지하도록 구성된, 격납 용기(containment vessel); 및

상기 원자로 용기 내의 과도-압력(over-pressurization) 발생 중에 상기 1차 냉각제를 상기 원자로 용기로부터 상기 격납 영역 안으로 제어가능하게 배출시키도록 구성된 증기 배출부(steam vent; 58)로서, 상기 격납 용기의 내측 표면에서의 상기 1차 냉각제의 응축을 통하여 상기 원자로 노심의 붕괴열이 제거되도록 하는, 증기 배출부;를 포함하는, 원자로 조립체(power module assembly).



안전계통 2. 원자로를 포함하는 원자로 조립체 및 원자로의 냉각 방법
(10-2010-7013054 , 10-1299979)

청구항 13

원자로 용기 내에서 고압 발생이 나타나는 경우에 원자로가 긴급정지(scramming)되는, 원자로 긴급정지 단계;

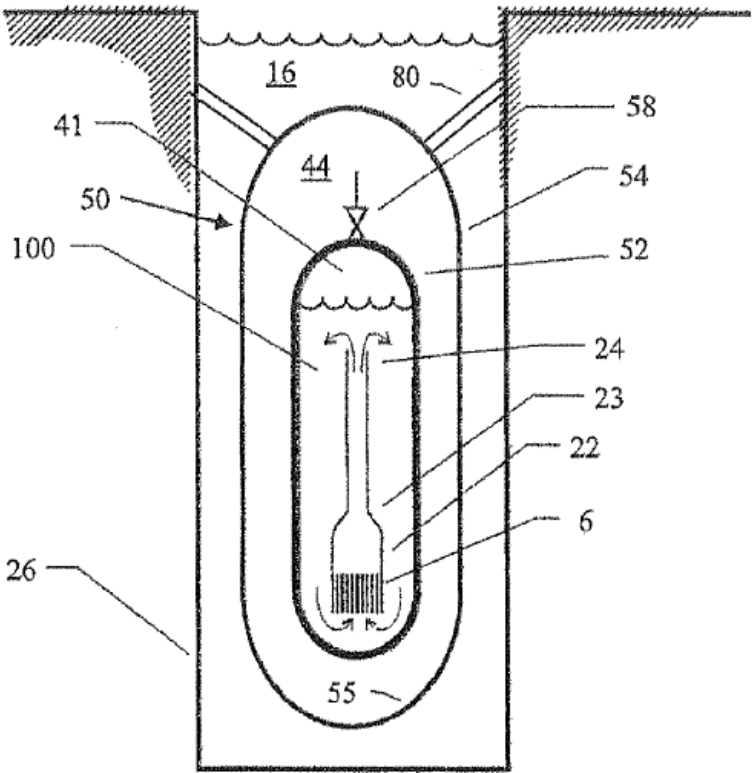
1차 냉각제가, 증기 배출부에 의하여, 상기 원자로 용기로부터, 상기 원자로 용기와 격납 용기 사이에 배치되고 **상기 고압 발생 전에는 건조한 격납 영역(containment region) 안으로, 증기로서 제어가능하게 방출**되는, 증기 방출 단계;

방출된 상기 증기가 상기 격납 용기의 내측 표면(55)에서 응축되는, 증기 응축 단계;

상기 격납 용기를 둘러싸고 있는 액체 매체로 붕괴열이 전달되는, 붕괴열 전달 단계; 및

상기 내측 표면에서의 증기의 응축에 의하여, 격납 압력(containment pressure)이 설계 한계 내로 유지되는, 격납 압력 유지 단계;를 포함하고,

상기 원자로 긴급정지 단계, 증기 방출 단계, 증기 응축 단계, 붕괴열 전달 단계, 및 격납 압력 유지 단계는 위에서 기재된 순서대로 수행되는, 원자로의 냉각 방법.



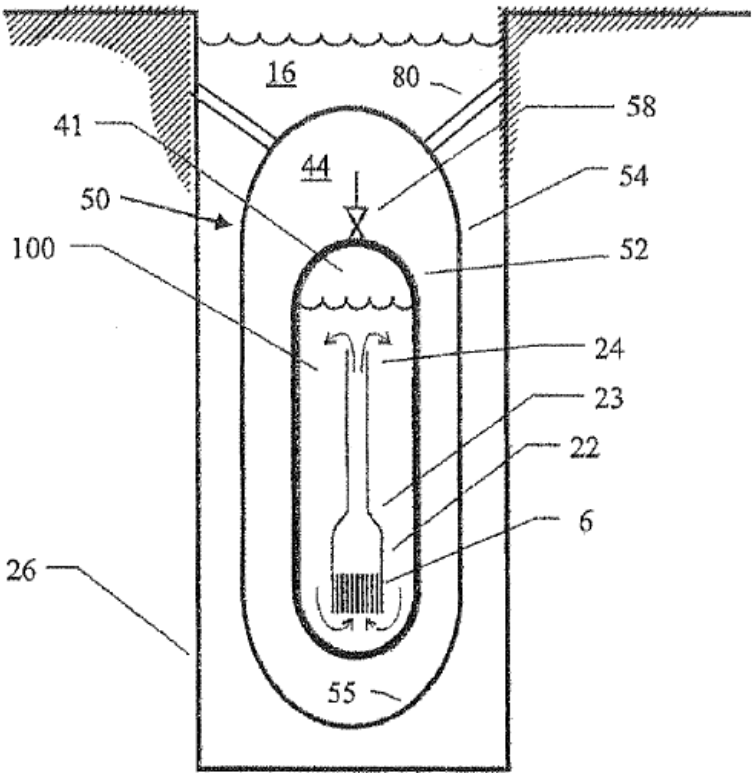
안전계통 2. 원자로를 포함하는 원자로 조립체 및 원자로의 냉각 방법
(10-2010-7013054 , 10-1299979)

청구항 22

원자로 노심을 통하여 1차 냉각제를 순환시키도록 구성된 원자로 용기(52)로서, 상기 원자로 노심 및 상기 1차 냉각제는 상기 원자로 용기 내에 수용되는, 원자로 용기;

상기 원자로 용기 내의 고압 상태에 응답하여 상기 원자로 용기를 둘러싸는 격납 용기 안으로 상기 1차 냉각제를 증기로서 제어가능하게 방출시키도록 구성된 증기 배출부(58)로서, 상기 1차 냉각제가 증기로서 상기 격납 용기 안으로 방출되기 전에는 상기 격납 용기의 내측 표면 전체가 건조하고, 상기 증기는 상기 격납 용기의 상기 내측 표면에서 응축되며, 상기 응축된 증기는 상기 격납 용기의 상기 내측 표면과 상기 원자로 용기의 외측 벽 사이에서 연장된 1차 냉각제의 풀(pool)을 형성하는, 증기 배출부(58); 및

상기 1차 냉각제의 풀을 상기 원자로 용기 안으로 되돌려 상기 원자로 노심을 통과하도록 순환시키게끔 구성된 유동 밸브(57)로서, 상기 1차 냉각제의 풀은 응축된 증기로서만 만들어진, 유동 밸브;를 포함하는, 원자로 조립체.

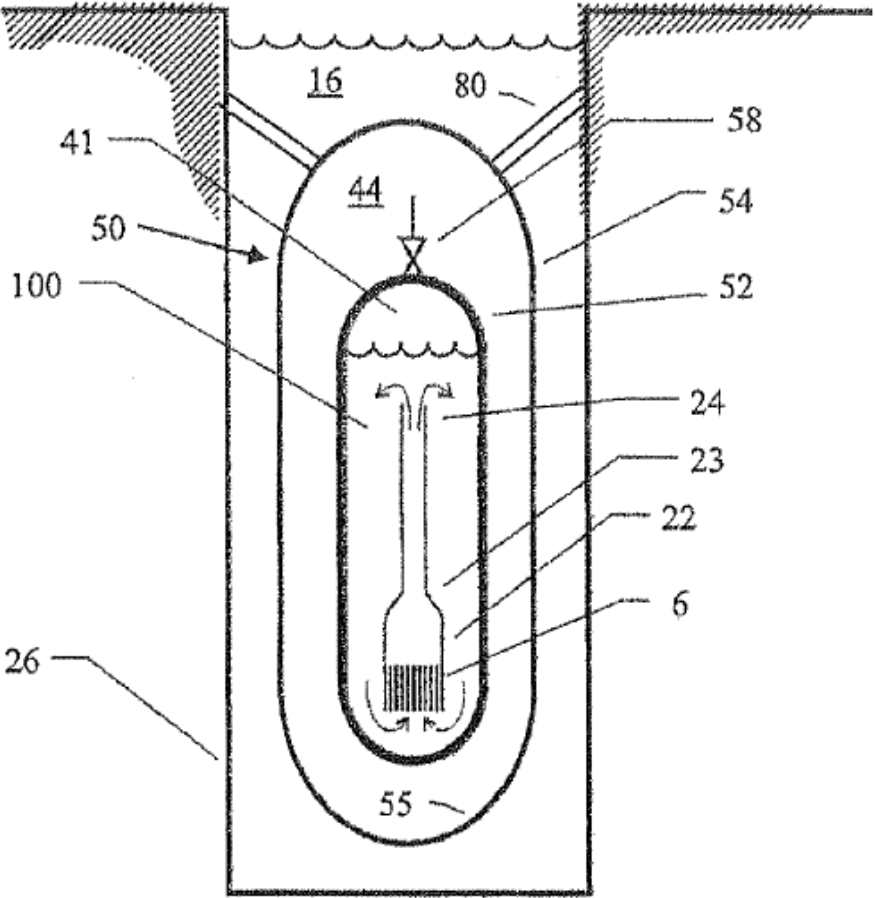


NuScale 미국 특허 중 안전 계통 개념과 관련된 특허

INTERNAL DRY CONTAINMENT VESSEL FOR A NUCLEAR REACTOR

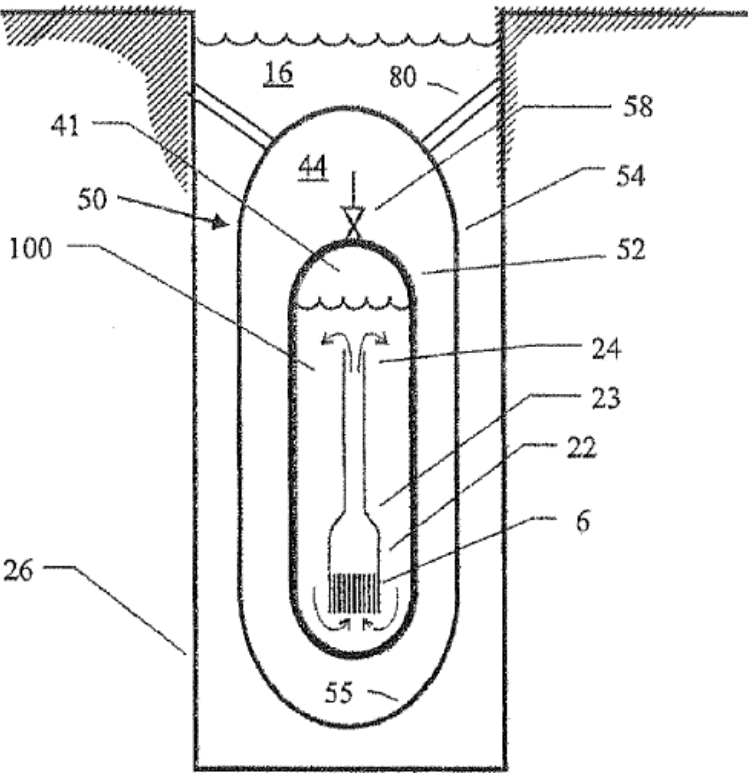
Patent No.	US10186334B2
Date of Patent	Jan. 22, 2019
Assignee	NuScale Power, LLC.
Appl. No.	13/563527
Filed	Jul. 31, 2012
Adjusted Expiration	May 24, 2032

전체 청구항 수: 총 20항
독립항: 2개항(1, 11)
종속항: 18개항



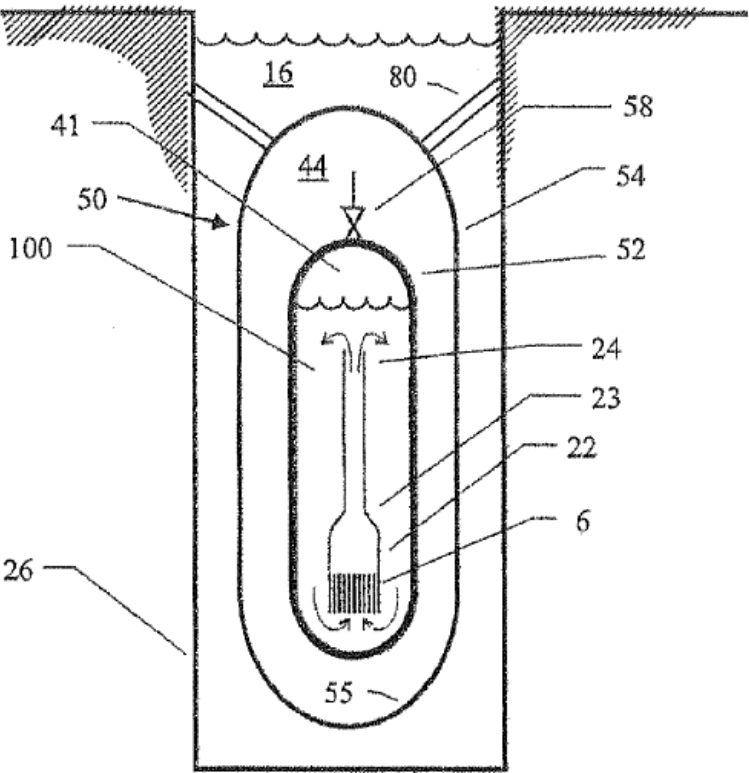
Claim 1

A power module assembly comprising:
a reactor core;
a reactor vessel housing the reactor core, wherein the reactor core is submerged in primary coolant contained within the reactor vessel;
a **containment vessel which substantially surrounds the reactor vessel**, wherein the **containment vessel is internally dry** and forms a **containment region which is maintained at a below atmospheric pressure during normal operation** of the power module assembly; and
a **vent configured to controllably release the primary coolant from the reactor vessel into the containment vessel as primarily steam during an over-pressurization event**, wherein the **containment vessel is configured to retain all of the released primary coolant within the containment vessel**, wherein the **containment vessel is at least partially surrounded by a heat sink**, and wherein a **decay heat of the reactor core is transferred to the heat sink primarily through condensation of the released primary coolant** on an inner surface of the containment vessel.



Claim 11

A power module assembly comprising:
a reactor core;
a reactor vessel housing the reactor core, wherein the reactor core is submerged in primary coolant contained within the reactor vessel;
a **containment vessel which substantially surrounds the reactor vessel**;
means for controllably **releasing the primary coolant as steam into the containment vessel in response to a high pressure condition within the reactor vessel**, wherein an **inner surface of the containment vessel is dry prior to releasing the primary coolant** as steam in to the containment vessel, and wherein **steam that condenses on the inner surface of the containment vessel forms a pool of primary coolant in the containment vessel**; and
means for drawing the pool of primary coolant back into the reactor vessel.

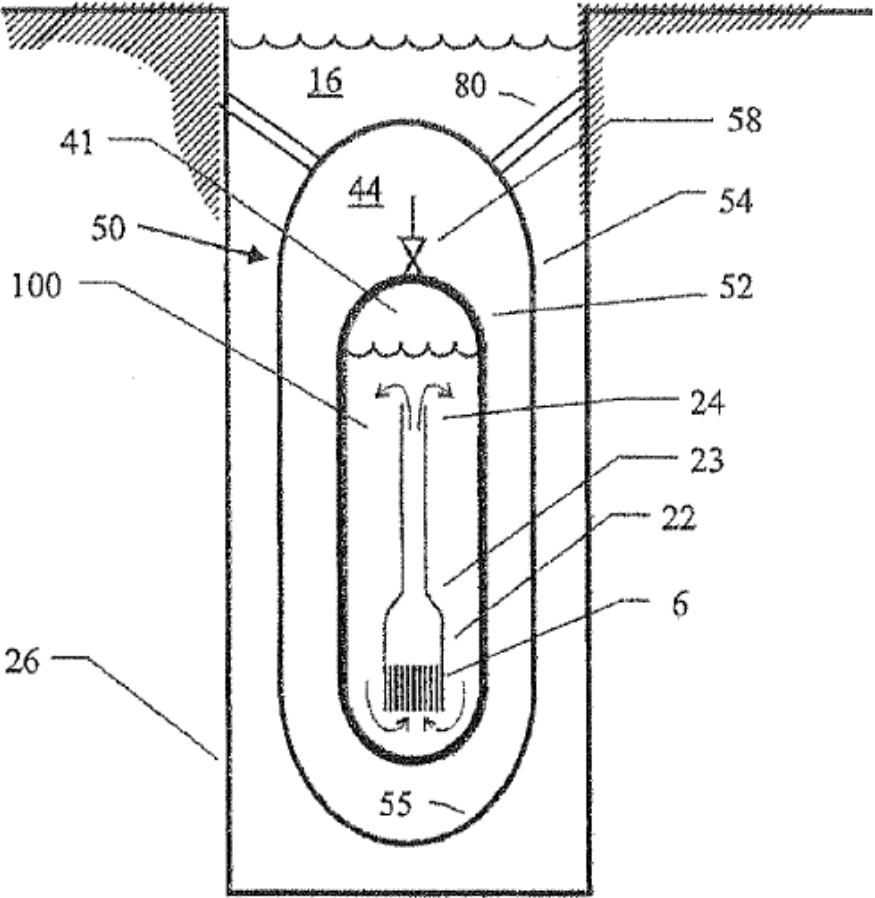


NuScale 미국 특허 중 안전 계통 개념과 관련된 특허

INTERNAL DRY CONTAINMENT VESSEL FOR A NUCLEAR REACTOR

Patent No.	US8687759B2
Date of Patent	Apr. 1, 2014
Current Assignee	NuScale Power, LLC.
Appl. No.	11/941024
Filed	Nov. 15, 2007
Adjusted Expiration	Jan. 27, 2030

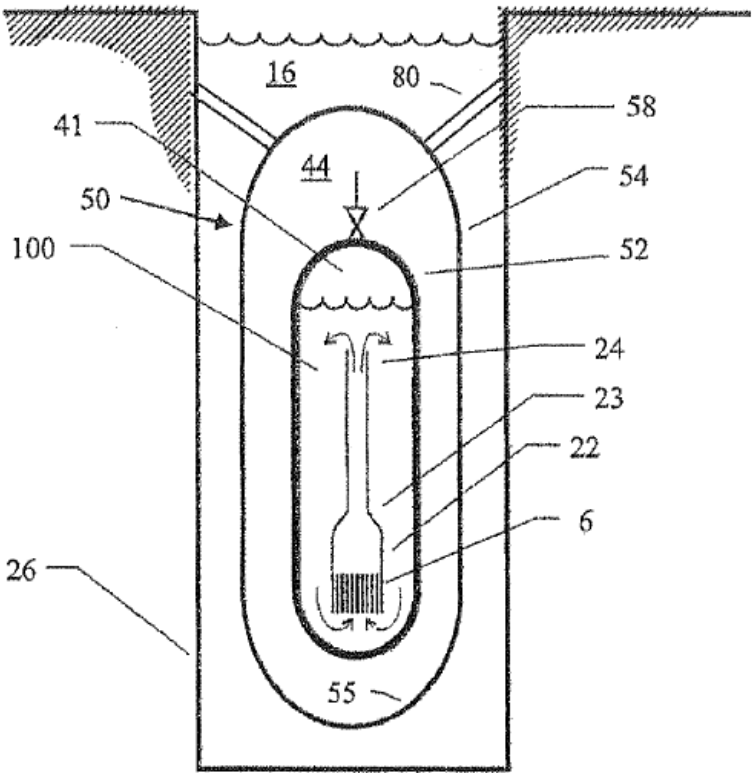
전체 청구항 수: 총 30항
독립항: 3개항(1, 14,26)
종속항: 27개항



US8687759B2. INTERNAL DRY CONTAINMENT VESSEL FOR A NUCLEAR REACTOR

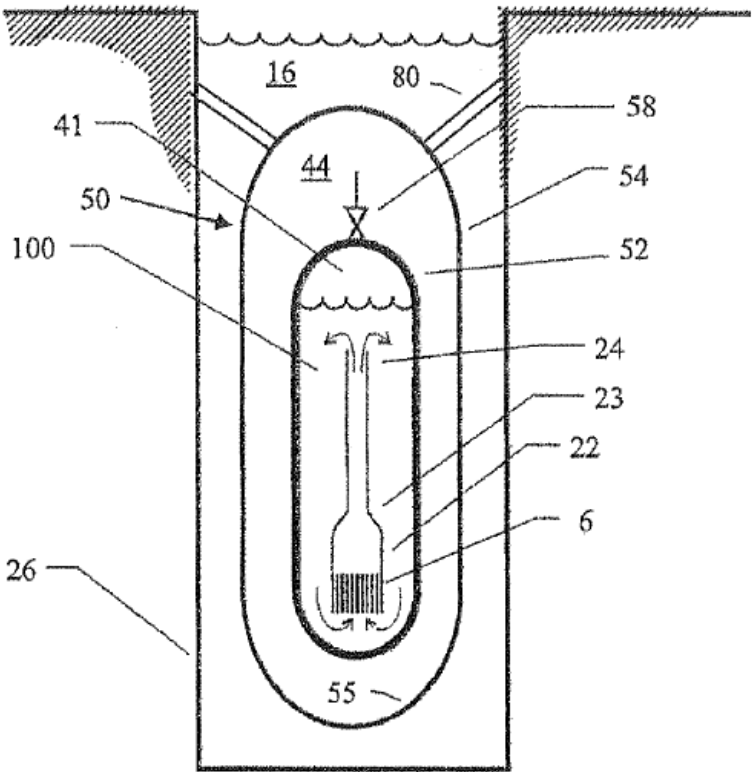
Claim 1

A power module assembly comprising:
a reactor core immersed in a primary coolant;
a reactor vessel housing the primary coolant and the reactor core, wherein an inner surface of the reactor vessel is exposed directly to the primary coolant during normal operation of the power module assembly;
an **internal dry containment vessel in direct contact with and completely submerged in liquid**, wherein the containment vessel substantially surrounds the reactor vessel in a below atmospheric pressure condition, wherein an outer surface of the reactor vessel is exposed directly to the below atmospheric pressure condition during the normal operation of the power module assembly, and wherein the containment vessel is configured to prohibit a release of the primary coolant out of the containment vessel;
and
a vent configured to controllably release the primary coolant into the containment vessel as primarily steam during an over-pressurization event.



Claim 14

A power module comprising:
a **containment vessel in contact with and substantially submerged in a liquid**, wherein during normal operation of the power module, the containment vessel is configured to prohibit a release of a primary coolant out of the containment vessel, and wherein **during normal operation of the power module, the containment vessel is maintained at a below atmospheric pressure condition**;
a reactor vessel mounted inside the containment vessel, wherein during normal operation of the power module, substantially **all thermal insulation of the reactor vessel is provided by the below atmospheric pressure condition**;
a reactor core submerged in the primary coolant; and
a steam vent connected to the reactor vessel, wherein **when the reactor core becomes over-heated the steam vent controllably releases the primary coolant as primarily steam in to the containment vessel**, wherein the steam condenses on an inner surface of the containment vessel and forms a pool of primary coolant extending between the inner surface of the containment vessel and an outer surface of the reactor vessel, and wherein the **entire inner surface of the containment vessel is dry during the normal operation of the power module and prior to the steam being vented into the containment vessel**.



Claim 26

Claim 26

A power module assembly, comprising:
means for circulating primary coolant through a reactor core, wherein the reactor core and the primary coolant are housed in a reactor vessel;
means for controllably releasing the primary coolant as steam into a containment vessel substantially surrounding the reactor vessel in response to a high pressure condition within the reactor vessel, wherein an **entire inner surface of the containment vessel is dry prior to releasing the primary coolant as steam into the containment vessel**, wherein the **steam condenses on the inner surface of the containment vessel**, and wherein the condensed steam forms a pool of primary coolant extending between an outer wall of the reactor vessel and the inner surface of the containment vessel; and
means for circulating the pool of primary coolant back into the reactor vessel and through the reactor core, wherein the **pool of primary coolant is made up entirely of the condensed steam**.

