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(56) Documents Cited:
GB 2603168 A **US 20180050911 A1**
Journal of Nuclear Materials, Vols. 141-143, Part 1, 1986, Cheazone Hsu, Robert E. Buxbaum, Palladium-catalyzed oxidative diffusion for tritium extraction from breeder-blanket fluids at low concentrations, pages 238-243.

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INT CL **G21B**
Other: **WPI, EPODOC, Patent Fulltext, XPESP, XPI3E, XPIEE, XPIOP, XPAIP, XPIPCOM, XPMISC, XPSPRNG, XPOAC**

(54) Title of the Invention: **Tritium breeder blanket for fusion power systems**
Abstract Title: **Static tritium breeder blanket with channels comprising hydrogen permeable membrane**

(57) A static breeder blanket 100 comprising a tritium breeding composition 102, a plurality of channels 104, and a hydrogen permeable membrane 114 separating each of the plurality of channels and the tritium breeding composition. The hydrogen permeable membrane comprises a structural layer proximate to the channels and a hydrogen hyper-permeable material layer proximate to the breeding composition. The breeder blanket thus provides a dedicated vacuum extraction route for tritium to cycle back into a reactor. The structural layer of the membrane may comprise a vanadium-based alloy such as V-5Fe-5Al or V-4Cr-4Ti. The hydrogen permeable layer of the membrane may comprise palladium and/or niobium. The breeding composition may be a liquid, a lithium-based salt, a lithium-based liquid metal, or a lithium-based alloy, such as F-Li-Be or Pb-Li. The static breeder blanket may also comprise a front plate comprising neutron multiplying material.

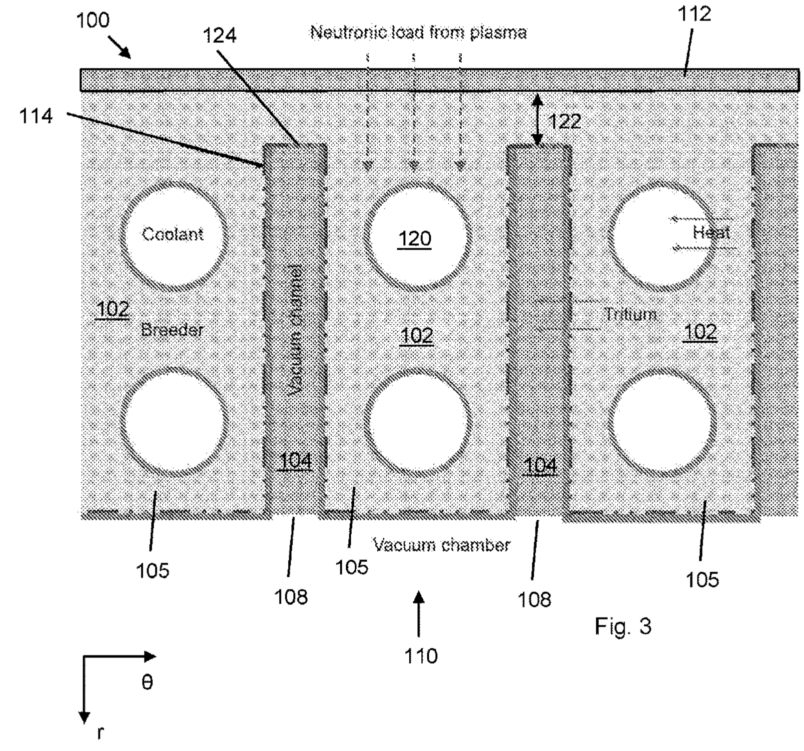

Fig. 3

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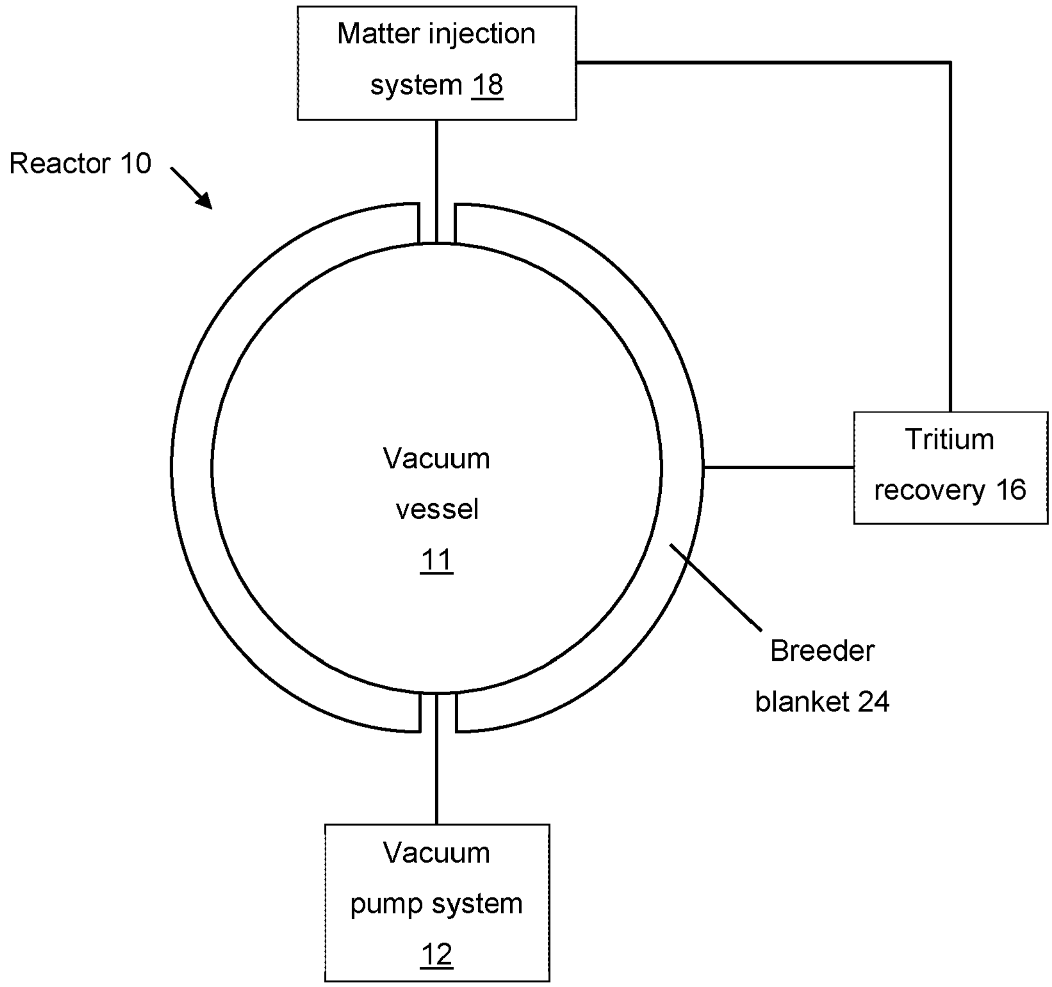

Fig. 1

-- PRIOR ART --

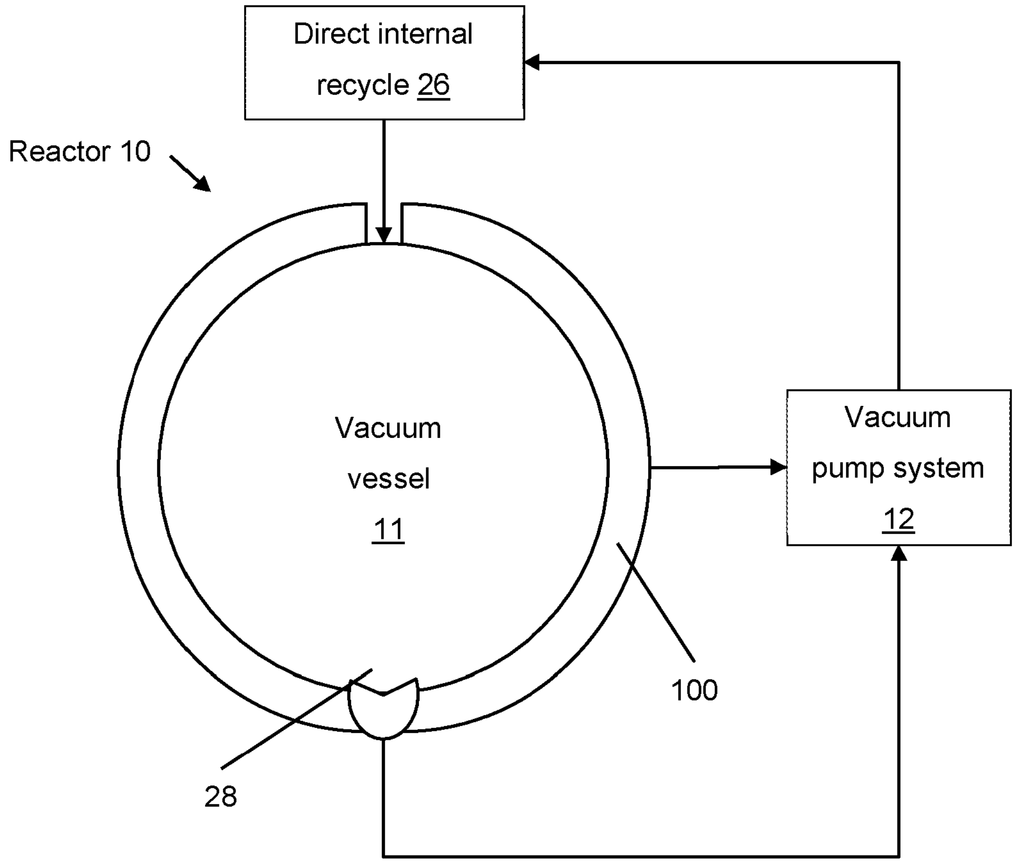
Direct internal
recycle 26
Reactor 10
Vacuum
vessel
11
Vacuum
pump system
12
100
28

Fig. 2

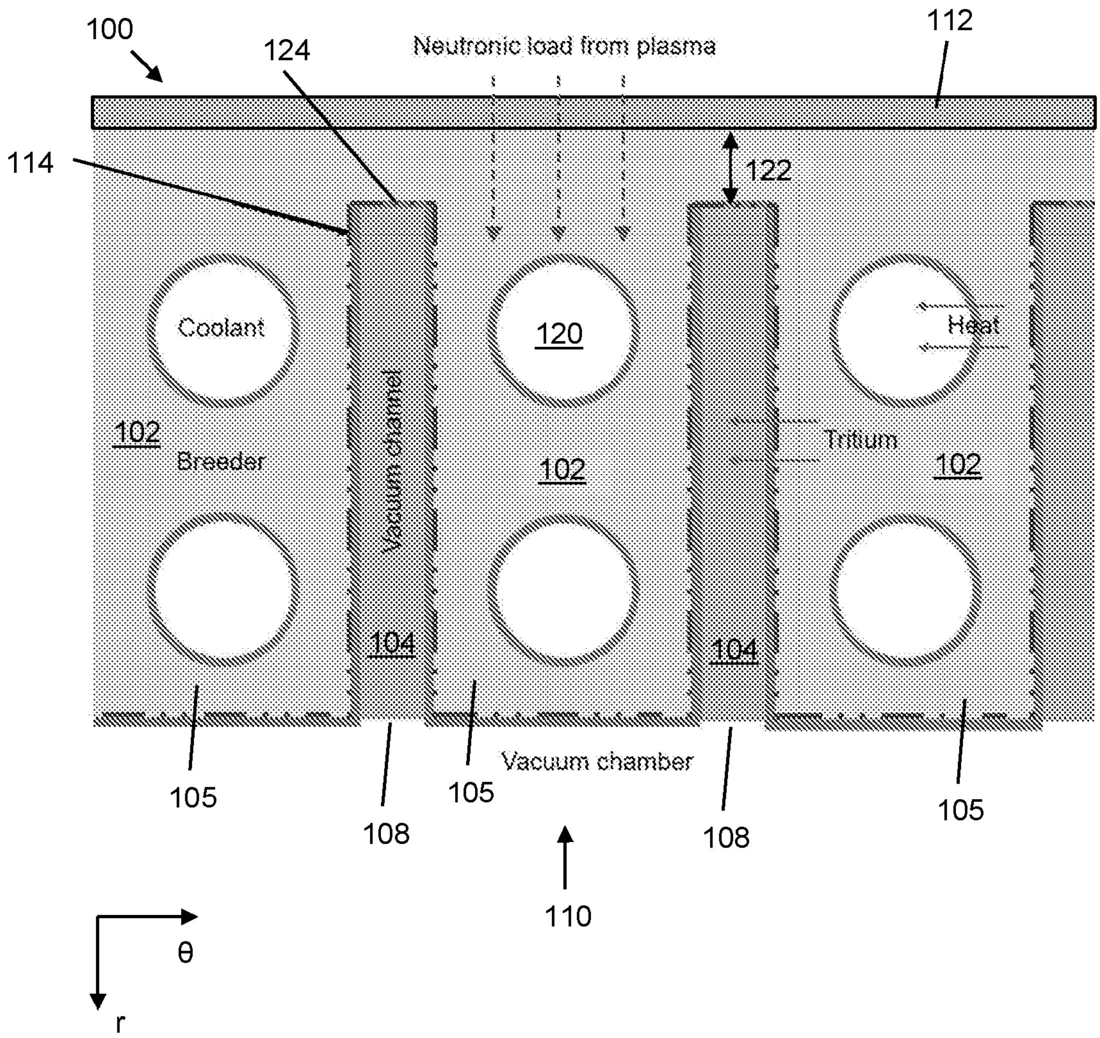
100
124
Neutronic load from plasma
112
114
122
Coolant
120
Heat
102
Breeder
Vacuum channel
102
Tritium
102
104
104
105
108
105
Vacuum chamber
108
105
110
θ
r

Fig. 3

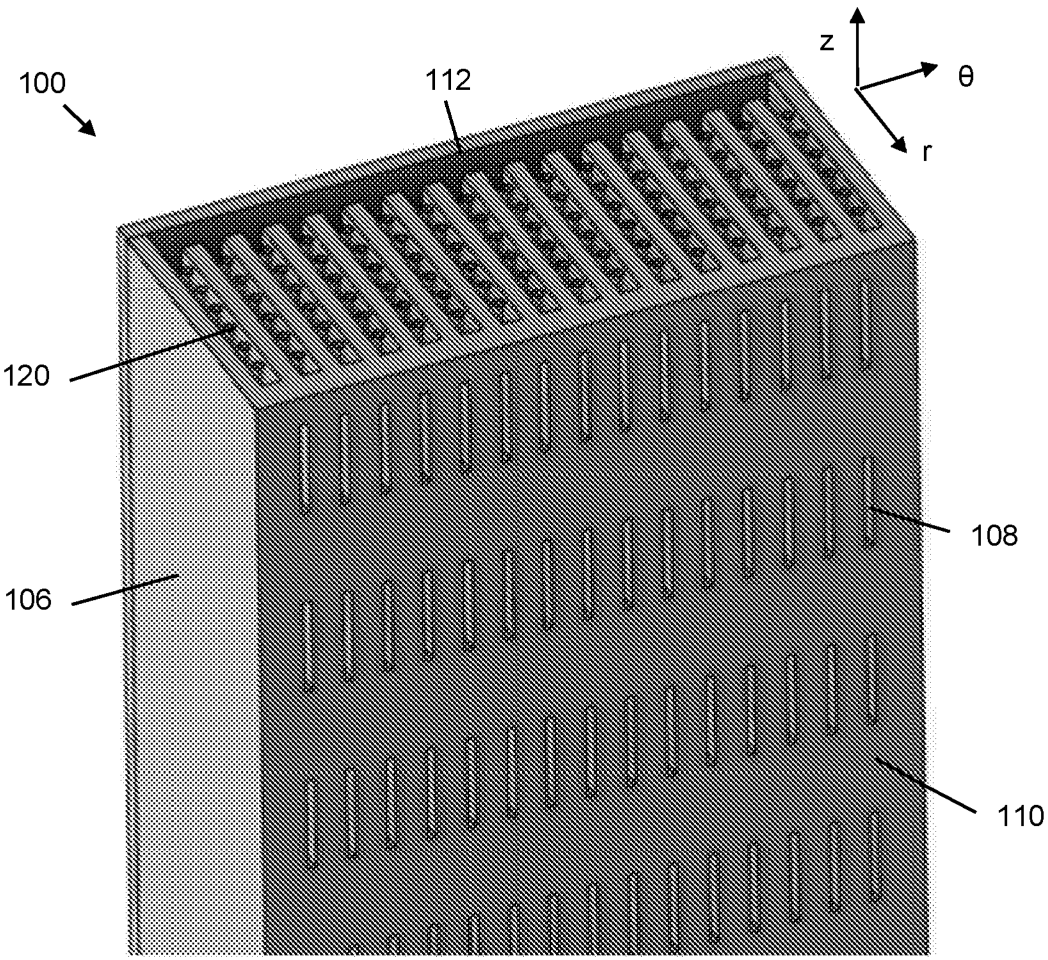

Fig. 4

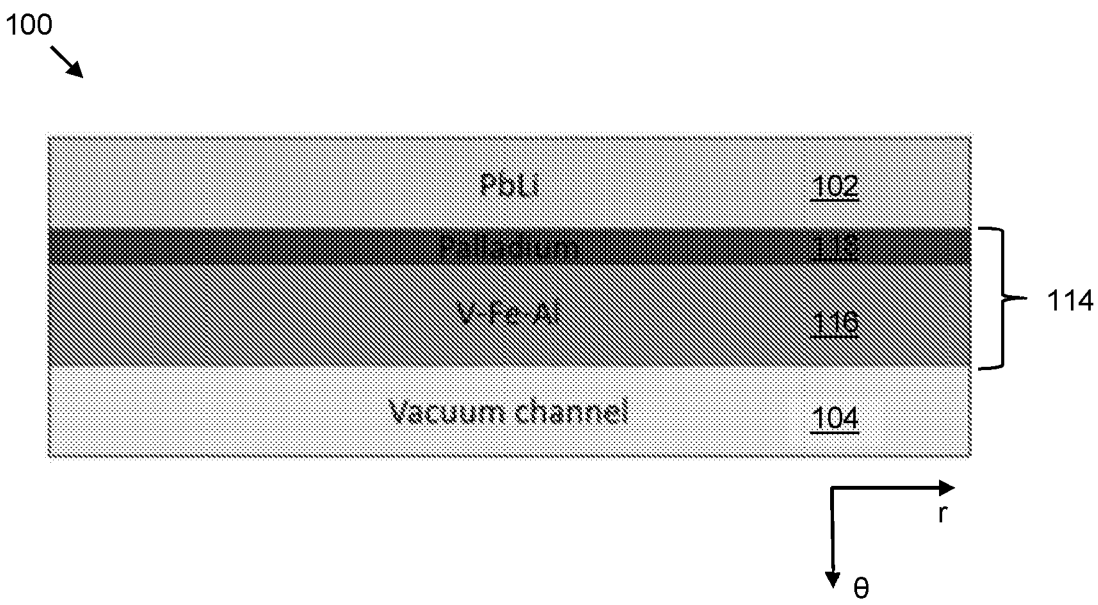
100
PbLi
102
Palladium
118
V-Fe-Al
116
114
Vacuum channel
104
r
θ

Fig. 5

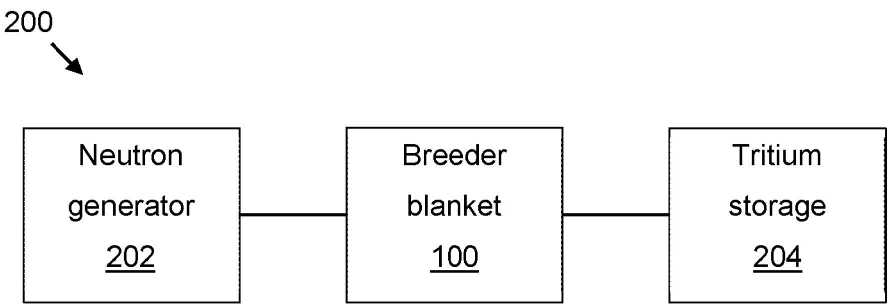
200
Neutron generator 202
Breeder blanket 100
Tritium storage 204

Fig. 6

TRITIUM BREEDER BLANKET FOR FUSION POWER SYSTEMS

Field of the Invention

[01] The present disclosure relates generally to producing tritium for use in fusion power systems. More specifically, the disclosure is concerned with a static breeder blanket which feeds tritium directly into the reactor pumping chain.

Background

[02] Currently, fusion reactors which rely on magnetic confinement, principally those designed on the principles of the tokamak, utilise a fusion fuel comprising a mix of deuterium and tritium (i.e., hydrogen isotopes). While deuterium is readily available by, e.g., extraction from seawater, natural Tritium is incredibly rare; current estimates put the quantity of tritium on earth at only 20 kilograms (kg), and the current cost is approximately thirty thousand dollars per gram. DEMO, the demonstration power plant planned as the follow on to ITER, is estimated to require 300g of tritium a day for continuous power generation. STEP is similarly estimated to require hundreds of grams a day for continuous operation. It is therefore desirable to find techniques for manufacturing tritium for use in fusion reactors.

[03] Interestingly, tritium can be produced from the reaction of neutrons with lithium. Neutrons are, of course, produced by the fusion reactor, and so one proposed technique for tritium production is to coat the reactor in a lithium blanket. Of course, this raises the problem of how to recover the tritium being produced in the blanket for use in the reactor. Current approaches extract tritium from the blanket via coolant fluid (particularly for solid breeder blankets) or, in the case of liquid blankets, by pumping the breeder fluid out of the blanket, and then later on extracting the tritium from the coolant/breeder fluid. Such techniques are however costly, complex, and slow, involving numerous components any number of which could fail.

[04] Hence it is desirable to develop improved and/or alternative techniques for tritium breeding and cycling to provide fuel for fusion systems.

Summary

[05] The present invention is defined according to the independent claims. Additional features will be appreciated from the dependent claims and the description herein. Any embodiments which are described but which do not fall within the scope of the claims are to be interpreted merely as examples useful for a better understanding of the invention.

[06] The example embodiments have been provided with a view to addressing at least some of the difficulties that are encountered with current approaches to tritium breeding, whether those difficulties have been specifically mentioned above or will otherwise be appreciated from the discussion herein.

[07] Broadly, the present techniques aim to eliminate a requirement for the continuous treatment of the breeder material outside the breeder blanket; i.e., a requirement to actively pump out tritium comprised coolant/breeder fluid. Instead, the present techniques facilitate a system in which tritium is allowed to permeate directly into the reactors vacuum pumping chain which leads into the reactors vacuum vessel. In particular, the present techniques are concerned with a quasi-static breeder in which liquid breeder is left stagnant within the blanket (i.e., not pumped). Beneficially the present techniques reduce tritium residence time in the fuel cycle loop, require fewer intrusions of pipework into and about the vacuum vessel (which can cause points of failure) compared to contemporary techniques, and reduce the required tritium inventory. Tritium is a radioactive material, and so there are safety and regulatory aspects to storing too much tritium that the present disclosure helps address. Another benefit is a saving on energy required in producing and (re)cycling tritium. Thus, the present techniques represent a crucial step toward achieving continuous operation of a reactor that will enable commercial energy production.

[08] Accordingly, in one aspect of the invention there is provided a static breeder blanket for generating tritium for use in a nuclear power system. The breeder blanket comprises a tritium breeding composition (preferably liquid, such as a molten lithium based salt), a plurality of tritium extraction channels (preferably under vacuum), and a hydrogen permeable membrane separating each of the plurality of tritium extraction channels and the tritium breeding composition. Here the hydrogen permeable membrane comprises a structural layer (such as a vanadium based alloy) proximate to the channels and a hydrogen hyper-permeable material layer (such as palladium or niobium) proximate to the breeding composition. Coolant conduits are provided separately to the tritium extraction channels, which instead are held under negative pressure (when the blanket is in use) to route tritium which permeates into the channels from the composition to a suitable destination. Beneficially the breeder blanket provides a dedicated route for tritium extraction which can be capitalised on in the design of corresponding power systems to route tritium directly into the reactor without a need for external processing (i.e., by connecting the tritium extraction channels to a suitable vacuum system).

[09] Suitably, in another aspect of the invention there is provided a nuclear fusion power system comprising a vacuum vessel and a static breeder. The static breeder may be configured as part of a wall of the vacuum vessel (i.e., forms an integral part thereof), or may be mounted as a separate component to the vacuum vessel. Either way, the static breeder may be suitably arranged so that it is external to a first wall of the vacuum vessel (the plasma being internal), and indeed may be suitably formed to comprise the first wall of the vacuum vessel – first wall here being used in its typical tokamak nomenclature as the layer of the vacuum vessel/reactor which is exposed to, and therefore takes the initial hit from, the reactor plasma heat and neutron load. The static breeding blanket comprises a tritium breeding composition, a plurality of tritium extraction channels, and a hydrogen permeable membrane separating each of the plurality of tritium extraction channels and the tritium breeding composition. The power system also

comprises a vacuum system arranged to extract exhaust gas from the vacuum vessel, and which is also coupled to the plurality of tritium extraction channels. In this way tritium bred by and extracted from the breeder blanket may be advantageously processed along with other exhaust gasses, in particular unspent tritium being recovered from the reactor, thereby greatly saving on space and components required for the reactor (and it will be appreciated that fewer parts means fewer potential points of failure).

[10] In yet another aspect of the invention there is provided a tritium breeding system comprising a neutron generator, an aforementioned static breeder blanket (and as otherwise described herein) arranged to receive neutrons generated by the neutron generator, and a tritium storage coupled to the plurality of tritium extraction channels of the static breeder blanket.

Brief Description of the Drawings

[11] For a better understanding of the present disclosure reference will now be made by way of example only to the accompanying drawings, in which:

[12] Fig. 1 shows a process schematic for a prior art breeding system;

[13] Fig. 2 shows a process schematic for an improved breeding system according to the present techniques;

[14] Fig. 3 illustrates a cross section in the r, θ plane of an example static breeder blanket;

[15] Fig. 4 illustrates a perspective view of an example static breeder blanket;

[16] Fig. 5 illustrates an example hydrogen permeable membrane used in the static breeder blanket; and

[17] Fig. 6 shows a generalised tritium breeding system.

Detailed Description

[18] At least some of the following example embodiments provide an improved technique for tritium breeding. Other advantages and improvements may also be apparent from the discussed embodiments herein.

[19] Figure 1 shows a simplified process schematic of a prior art breeding system. Here, a reactor 10 utilises deuterium and tritium as fusion fuel, the reaction of which produces neutrons. The fusion reaction takes place in the reactor vacuum vessel 11, with the neutrons penetrating the vacuum vessel 11 wall to enter a breeding blanket 24. Fluid comprising tritium/tritiated species (either in the form of coolant or breeder liquid) is pumped from the blanket 24 so that tritium can be extracted by a suitable tritium recovery system 16. The recovered tritium is then typically stored and then sometime later cycled into the reactor by a suitable matter injection system 18.

[20] Figure 2 shows a process schematic for an improved technique for tritium breeding in a fusion power system. Here an example breeder blanket 100 is provided to surround (at least in part) an area of the reactor 10 in which fusion is taking place; that is, to surround the plasma which is undergoing fusion within the vacuum vessel 11. For example, in the case of a spherical tokamak, the breeder blanket 100 is also substantially spherical in order to cover the reactor in substantially all parts of its shell. The blanket 100 is preferably formed from a plurality of interconnecting panels which better allow the blanket to conform to the required shape of the vacuum vessel 11. In one example implementation, the blanket 100 and vacuum vessel 11 may be considered (and indeed manufactured) as separate entities, the breeder blanket 100 being suitably mounted to the first wall of the vacuum vessel (i.e., the wall which first receives heat and neutron load from the reactor plasma). It will also be appreciated that the breeder blanket 100 could be formed as a contingent part of the reactor 10 by, e.g., forming an integral part of the shell of the vacuum vessel 11. In particular, the breeder blanket 100 may be constructed to comprise the first wall of the vacuum vessel, the first wall being the layer of the vacuum vessel which is exposed to the plasma and therefore the component of the vacuum vessel that first receives heat radiated from the plasma and the neutron load. Suitably, where the breeder blanket is formed from a plurality of interconnected panels, each panel may comprise a part of the first wall of the vacuum vessel so as to form the first wall in conjunction with the other panels (and optionally other first wall panels not part of the breeder blanket).

[21] The example breeder 100 is coupled to a vacuum pump system 12. More specifically, the example breeder 100 is coupled to a vacuum pump system 12 which is arranged to extract exhaust gasses from the vacuum vessel 11 of the reactor 10. In particular, where the breeder blanket is arranged internally within the vacuum vessel 11, the vacuum pump system 12 may preferably couple to the breeder blanket via a reactor's divertor 28. In one example, the vacuum pump system 12 routes the tritium from the blanket 100 with the other exhaust gasses for suitable processing (i.e., where unspent tritium fuel is recycled from the exhaust gas). In a preferred example, as shown, the vacuum pump system 12 is further coupled to a direct internal recycle system 26, which is analogous to the matter injection system 18 of existing fusion test systems, but suitably modified to receive and route tritium recovered from the breeder 100 directly to the reactor 10. Thus in the preferred example, the present techniques facilitate a substantially closed fuel cycle loop for the fusion power system whereby, provided the breeder generates sufficient tritium (and provision is made for diversion of other contaminants from the vessel exhaust), the fusion power system could become self-sustaining and self-fuelling. It will be appreciated that this technique for tritium generation and use provides a far faster fuel cycle compared to techniques which externally extract tritium from a breeder blanket.

[22] Figures 3, 4 and 5 show the example breeder blanket 100 in more detail.

[23] The breeder blanket 100 comprises a tritium breeder composition 102. The composition 102 comprises lithium which generates tritium when subjected to a neutron flux

generated from plasma in the reactor 10. In principle the present techniques could be utilised by a solid or liquid (i.e. molten) breeding composition, but in a preferred example composition 102 is a fluid, which in contrast to prior art systems is not pumped through the blanket 100, such that the example breeder 100 may be termed a quasi-static, or stagnant, breeder. Preferably the composition is a lithium-based salt or liquid metal, for example fluorine lithium beryllium, F Li Be, or a liquid metal such as Li, or eutectic alloy of lithium such as Pb Li. Moreover, conventional wisdom asserts that magneto hydrodynamic (MHD) effects in liquid breeders are detrimental due to negatively impacting the flow rate of the breeder out of the blanket for treatment (i.e., tritium extraction). In the present example, however, MHD effects are in fact beneficial due to MHD causing mixing of the stagnant fluid, which leads to better tritium extraction (by permeation) and better heat exchange in the breeder blanket.

[24] The static breeder blanket 100 also comprises a plurality of tritium extraction channels 104; the channels 104 may also be termed vacuum channels, because when the breeder blanket 100 is in use the channels will be (typically) under negative (vacuum) pressure. The channels 104 are spaced, preferably regularly, throughout a body 106 of the breeder 100 so that they penetrate into the body 106 which is comprised with the breeder composition 102. Put another way, the channels 104 are spaced apart such that the body 106 comprises thin fins 105 (comprising composition 102) between each of the channels 104; in the present examples a width of the fins 105 (i.e., the spacing between the walls of adjacent channels 104) may be between 1.4 cm (centimetres) and 5 cm, inclusive, and preferably between 2.4 cm and 3.7 cm, inclusive. The low velocity of the breeder composition 102 (arising from its quasi-static nature based on MHD effects), in combination with the thin layers/fins 105, increases the rate of permeation of tritium into the vacuum channels 104. However, there is a trade-off that the fins 105 are not made too thin (i.e., by adding too many channels 104) as this reduces space in the blanket 100 for breeder composition 102, which reduces the tritium breeding rate.

[25] The channels 104 comprise an aperture 108 to a rear of the blanket 110; a width (theta dimension) of an aperture 108 is preferably in a range of 3.6 mm (millimetres) to 6 mm, inclusive, and a height (*z* dimension) of an aperture 108 preferably between 3 cm and 9.6 cm, inclusive (all channels in a given blanket 100 preferably having the same dimensions). In one example, the vacuum channels 104 extend fully through the body 106 from a front plate 112 of the breeder blanket to the rear 110 of the body 106; i.e., the channels 104 abut the front plate 112 and open to the rear 110 via the aperture 108. Preferably, however, the channels 104 only extend partially into the body 106 (starting from the aperture 108) so that a space 122 remains between a (closed) end of the channels 124 and the front plate 122. This space 122 is suitably filled with breeder composition 102, so that the breeder composition is closer to the reactor plasma and therefore MHD effects which promotes mixing and breeding. In either case, a length of a channel 104 in the *r* dimension (i.e., the degree to which a channel 104 penetrates into the body 106 from the aperture 108) may be in a range of 0.1 m (metres) to 1 m, inclusive, and further preferably in a

range of 0.12 m to 0.26 m, inclusive. It has been found that the above channel dimensions encourage a suitable rate of tritium permeation into the vacuum channels 104 while keeping the channels small enough, and spaced apart enough, to allow sufficient space in the breeder blanket 100 for composition 102 in order achieve a desirable tritium breeding rate. However, it will be appreciated that absolute dimensions may need to change or scale dependent on the size of the vacuum vessel 11 which is related to the plasma radius of the particular tokamak reactor.

[26] In the present examples, the rear 110 and front (plate 112) refer to the orientation of the breeder blanket 100 when mounted to the reactor 10; the front (plate 112) being arranged to face a plasma generating (and so neutron generating) region of the reactor, and the rear 110 facing the opposite direction to facilitate coupling to the vacuum pump system 12. Thus, the apertures 108, and more generally the whole rear of the blanket 110, are suitably coupled to the vacuum pump system 12 (when the breeder blanket 100 is installed on the reactor ready for use); e.g., via the vessels divertor 28 in a preferred arrangement where the breeder blanket is installed internally. Suitably, the front plate 112 may comprise high temperature resistant materials, so as to act as a heat shield. This is particularly desirable where the front plate 112 is intended to act as the first wall of the vacuum vessel. Moreover, the front plate 112 may comprise a neutron multiplying material in order to increase cross-section of the lithium-neutron interaction and so increase tritium yield. The front plate 112 may be manufactured separately to the body 106 and attached to the body 106 to form the front of the blanket 100.

[27] The vacuum channels 104 are formed with a hydrogen permeable shell 114 that allows hydrogen, and specifically tritium, to permeate into the channels 104 from the composition 102 but that suitably prevents egress of the breeder composition 102 into the vacuum channels 104 (i.e., the channels shells 114 are impermeable to the breeder composition 102). Put another way, the breeder blanket 100 may be considered to comprise a hydrogen permeable membrane 114 which separates the vacuum channels 104 from the breeder composition 102, the arrangement of the membrane 114 defining the shape, size, spacing, etc, of the vacuum channels 104.

[28] As shown, the hydrogen permeable membrane 114 comprises a structural layer 116 (which is hydrogen permeable) and a hydrogen hyper-permeable material layer 118.

[29] The structural layer 116 provides the bulk material by which the channels 104 are given the structural strength to hold the breeder composition within the body 106 while also not collapsing under negative pressure. An example material which satisfies the structural considerations while being hydrogen permeable is vanadium, although it has been discovered that while pure vanadium is hydrogen permeable, it also has a tendency to retain tritium. Suitably the structural layer 116 may be formed from a vanadium-based alloy, which have been determined to still allow tritium permeation but with a much lower retention rate. Example alloys include vanadium iron aluminium, e.g., V-5Fe-5Al, or vanadium chromium titanium,

e.g., V-4Cr-4Ti. Vanadium based alloys are particularly preferred where the composition 102 is formed from PbLi.

[30] The hydrogen hyper-permeable material layer 118 is suitably provided to enhance the tritium permeation rate through the membrane 114. That is, it has been found that applying certain coatings to the structural layer 116 encourages diffusion of tritium through the membrane 114 into the channels 104 for collection. As such the hyper-permeable layer 118 is suitably coated onto the structural layer 116 so that it is between the structural layer 116 and composition 102, preferably in contact with the breeder composition 102. Put another way, the hydrogen permeable membrane 114 is arranged such that the structural layer 116 is proximate (/exposed) to the vacuum channels 104, while the hydrogen hyper-permeable material layer 118 is proximate to (/in contact with) the breeder composition 104. In addition, such an arrangement also has the added benefit of protecting the breeder composition from the structural layer 116, as it has been found that vanadium can react and foul certain types of breeder compositions 104.

[31] Example hydrogen hyper-permeable materials suitable for use in the example breeder blanket 100 are palladium and niobium.

[32] Suitably, in some arrangements (depending on the coupling to the vacuum system 12) the rear section 110 (i.e., the rear 110 of the body 106) of the blanket may also be formed from the same (or a different) hydrogen permeable membrane.

[33] It is desirable to maintain the breeding composition at a temperature which the materials used in the blanket construction can withstand. Therefore, the breeder blanket 100 may suitably comprise a plurality of cooling tubes, or conduits, 120. The conduits 120 pass through the body 106 so as to penetrate the breeder composition 102. Put another way, space in the body 106 in between the cooling conduits 120 is comprised of breeder composition 102. The conduits 120 are preferably regularly spaced apart through the body 106. In this example, the cooling conduits 120 run orthogonal to the vacuum channels 104; this is primarily for ease of construction, although it should be appreciated that other arrangements would also be possible. By way of example, the cooling conduits 120 may be sized with a radius between 5.3 mm and 8.6 mm. The conduits are suitably formed from a hydrogen impermeable material. Example coolants used in the tubes 120 include helium and carbon dioxide.

[34] It should be noted that, in contrast to existing blanket techniques, there is preferably no coolant layer in between the front plate 112. That is, the breeder blanket 100 is preferably arranged so that the breeder composition 102 abuts the front plate 112. In this way the breeder composition 102 is provided as close as possible to the reactor 10 which better exposes the composition 102 to MHD effects arising from the reactor 10, leading to better mixing of the stagnant composition 102 which aids in (convective) heat transfer through the composition and eventually heat transfer to coolant in the conduits 120. MHD effects also promote tritium passage through the membrane 114.

[35] Although the above has focussed on the application of the breeder blanket 100 to a fusion power system, it will be appreciated that the breeder blanket may be suitably coupled to any source of neutrons to generate tritium which can then be stored and used elsewhere. For example, nuclear fission reactors are also a good source of neutrons from which tritium could be produced.

[36] Suitably, the present embodiments also extend to a generalised tritium breeding system 200 comprising a neutron generator 202, a static breeder blanket 100 according to the above discussion arranged to receive the generated neutrons, and a suitable tritium storage 204 coupled to the breeder blanket 100 (specifically, coupled to the tritium extraction channels 104).

[37] In summary, exemplary embodiments of a static breeder blanket to produce tritium have been described. The described exemplary embodiments enable improved fusion power techniques that facilitates continuous operation of the reactor: an important consideration for commercial energy production. Moreover, the exemplary embodiments reduce the energy requirements for tritium production associated with existing breeder blankets, and also allow for a reduction in onsite tritium inventory.

[38] The example breeder blanket and ancillary systems may be manufactured industrially. An industrial application of the example embodiments will be clear from the discussion herein. Additionally, the described exemplary embodiments are convenient to manufacture and straightforward to use.

[39] Although preferred embodiment(s) of the present invention have been shown and described, it will be appreciated by those skilled in the art that changes may be made without departing from the scope of the invention as defined in the claims.

[40] Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[41] All of the features disclosed in this specification, and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[42] Each feature disclosed in this specification may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[43] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification, or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. A static breeder blanket for a nuclear reactor, comprising:

a tritium breeding composition;

a plurality of tritium extraction channels; and

a hydrogen permeable membrane separating each of the plurality of tritium extraction channels and the tritium breeding composition,

wherein the hydrogen permeable membrane comprises a structural layer proximate to the channels and a hydrogen hyper-permeable material layer proximate to the breeding composition.

2. The static breeder blanket of claim 1, wherein the structural layer is a vanadium-based alloy.

3. The static breeder blanket of claim 2, wherein the vanadium-based alloy comprises at least one of V-5Fe-5Al r V-4Cr-4Ti.

4. The static breeder blanket of claims 1 or 2, wherein the hydrogen permeable material layer comprises at least one of palladium and niobium.

5. The static breeder blanket of any preceding claim, wherein the breeding composition is a liquid.

6. The static breeder blanket of claim 5, wherein the breeder composition comprises at least one of a lithium-based salt, a lithium-based liquid metal, or a lithium-based alloy.

7. The static breeder blanket of claim 6, wherein the breeder composition comprises at least one of F-Li-Be and Pb-Li.

8. The static breeder blanket of any preceding claim, further comprising a front plate comprising a neutron multiplying material.

9. The static breeder blanket of claim 8, wherein the breeder composition is in contact with the front plate.

10. The static breeder blanket of any preceding claim, wherein a rear of the breeder blanket is also formed from the hydrogen permeable membrane.

11. The static breeder blanket of any preceding claim, wherein a closed end of each of the plurality of tritium extraction channels is spaced apart from a/the front plate of the breeder blanket.

12. The static breeder blanket of any preceding claim, further comprising a plurality of coolant conduits penetrating the tritium breeding composition.

13. A nuclear fusion power system, comprising:

a vacuum vessel;

a static breeder blanket configured as a part of, or mounted to, a wall of the vacuum vessel, the static breeding blanket comprising:

a tritium breeding composition;

a plurality of tritium extraction channels; and

a hydrogen permeable membrane separating each of the plurality of tritium extraction channels and the tritium breeding composition;

a vacuum system, coupled to the plurality of tritium extraction channels, arranged to extract exhaust gas from the vacuum vessel.

14. The nuclear fusion power system of claim 13, wherein the vacuum vessel comprises a divertor by which exhaust gasses are extracted from the vessel by the vacuum system, and the plurality of tritium extraction channels are coupled to the divertor.

15. A tritium breeding system, comprising:

a neutron generator;

a static breeder blanket according to any of claims 1 to 12 arranged to receive neutrons generated by the neutron generator; and a tritium storage coupled to the plurality of tritium extraction channels of the static breeder blanket.

Intellectual Property Office

Application No:	GB2211465.6	**Examiner:**	Daniel Martyres
Claims searched:	1-15	**Date of search:**	30 November 2022

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-7	Journal of Nuclear Materials, Vols. 141-143, Part 1, 1986, Cheazone Hsu, Robert E. Buxbaum, Palladium-catalyzed oxidative diffusion for tritium extraction from breeder-blanket fluids at low concentrations, pages 238-243. Abstract, sections 1 & 6, figure 1, and table 4 most relevant.
A	-	GB2603168 A DAVIS, MUSGROVE; whole document, especially figure 1.
A	-	US 2018/050911 A1 TSANG; figure 8 and associated description.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

G21B

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, Patent Fulltext, XPESP, XPI3E, XPIEE, XPIOP, XPAIP, XPIPCOM, XPMISC, XPSPRNG, XPOAC

International Classification:

Subclass	Subgroup	Valid From
G21B	0001/11	01/01/2006