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VIALS FOR STORAGE OF BIOLOGICAL SAMPLES

FIELD OF INVENTION

The present invention relates generally to vials for storing biological samples, in particular,
5 to vials for containing and storing biological samples at very low temperatures.

BACKGROUND OF INVENTION

The following discussion of the background of the invention is intended to facilitate an understanding of the present invention. However, it should be appreciated that the
10 discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge in any jurisdiction as at the priority date of the application.

Biorepositories or biobanks use vials/containers to store biological specimens or samples
15 at very low temperatures for cryopreservation. Such specimens or samples are commonly used by hospitals, research labs, academic centers and pharmaceutical/commercial labs. In the United States, the number of tissue samples in biobanks was estimated at more than 300 million at the turn of the 21st century, and is increasing by 20 million annually. Solid samples are estimated to make up 10% of all samples and based on the rate of growth of
20 the number of samples annually, there would be 50 million solid samples in the United States by the year 2020.

Vials/containers for storage of biological samples at low temperatures (includes but not limited to temperatures below -20°C) are commonly known as cryovials, cryotubes,
25 microcentrifuge tubes or microfuge tubes. Such vials are small and usually cylindrical with an integral snap cap or screw-on cap. Different sized vials are used for various storage volumes, which generally range from 250 µl to 2 ml. For fluid samples such as blood and urine, the size of the vial used is determined by the sample volume collected. However, for solid tissue samples, such as a sample of excisional biopsy tissue, the choices are limited
30 and often, a larger than required vial would be used. A larger vial usually has a wider opening to allow easy access/deposit of the sample. The sample usually takes up less than 10% of the volume in the storage vials, with the remaining volume being unused. This remaining volume is commonly referred to as void volume. Void volume takes up wasted space in the freezers/cryotanks of biobanks. The financial implications are significant as

more freezers are needed, higher utility bills are incurred, and more space is required to house the extra freezers.

US 2014/0014550 A1 discloses a stackable cryogenic vial assembly, where a series of vials are stacked on top of one another. Each vial has an upper flange that extends and engages a lower socket portion of another vial, whereby the base of each vial serves as a cap for the vial below. The problem with such an assembly is that the separation of biological samples is not easy, and sample cross-contamination may be introduced as the vials are not fully isolated from one another, i.e. the bottom of the top vial will come in direct contact with the specimen in the adjacent bottom vial. Further, the opening of the vial is relatively narrow and the chamber is oddly shaped, thereby making access to the sample difficult. Furthermore, as there is no vial cap and each vial serves as a cap for the vial below, the uppermost vial in the assembly would usually be left empty to serve as a cap for the entire assembly, thereby creating void volume.

Therefore, there is a need for an improved vial assembly which alleviates problems in the prior art, which includes greatly reducing void volume, substantially reducing or preventing sample cross-contamination, and easily separating and accessing biological samples.

SUMMARY OF INVENTION

In a first aspect, the present invention provides a vial unit for storing a biological sample, the vial unit comprising a body comprising a chamber for containing the biological sample, the body having a top and a base, the top comprising an opening for accessing the chamber, and a cap having a first and second end, the second end is adapted to engage the body to cover the opening, wherein the base of the body is adapted to engage a first end of a cap of another vial unit.

The fact that the base of the vial unit of the first aspect of the present invention is capable of engaging the cap of another vial unit permits stacking, which optimizes the quantity of samples stored and the use of space by reducing void volume. The effect is a net reduction of storage cost as the same amount of space that is used to traditionally store a single sample can now be used to store multiple samples. Space savings will translate into lower storage and utility costs. The optimization of storage space usage is also coupled with the advantage that existing equipment/infrastructure need not be modified or upgraded that

usually comes with the changes of lab ware, when using the present invention. A cap being provided for every vial unit further prevents contamination of the sample being stored, especially when the vial units are individually handled by a user.

- 5 Preferably, the base of the body comprises a female member and the first end of the cap of the another vial unit comprises a male member, wherein the female member is capable of mating with the male member. Alternatively, the base of the body comprises a male member and the first end of the cap of the another vial unit comprises a female member, wherein the female member is capable of mating with the male member.

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Preferably, the male member is capable of engaging the female member via a snap-fit mechanism.

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Preferably, the second end of the cap is adapted to engage the body via a twist-lock mechanism, snap-fit mechanism or threaded mechanism.

Preferably, the second end of the cap and the body comprise complementary screw threads.

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Preferably, the screw threads are dual screw threads.

Preferably, the cap comprises an internal annular flange capable of sealing the chamber when the cap engages the body.

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Preferably, the internal annular flange extends into the chamber when the cap engages the body.

Preferably, the cap comprises a deformable material.

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Preferably, the cap further comprises structural ribs along an outer circumferential surface of the cap.

Preferably, the female member comprises at least one indentation along its periphery.

Preferably, the operable temperature range of the vial unit is about -196°C to about 121 °C.

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In a second aspect, the present invention provides a vial assembly for containing a plurality of biological samples, the vial assembly comprising two or more vial units, each vial unit comprising a body comprising a chamber for containing the biological sample, the body having a top and a base, the top comprising an opening for accessing the chamber, and a cap having a first and second end, the second end is adapted to engage the body to cover the opening, wherein the base of the body is adapted to engage a first end of a cap of another vial unit in the vial assembly.

Preferably, the base of the body of a vial unit comprises a female member and the first end of the cap of the another vial unit in the vial assembly comprises a male member, wherein the female member is capable of mating with the male member. Alternatively, the base of the body of a vial unit comprises a male member and the first end of the cap of the another vial unit in the vial assembly comprises a female member, wherein the female member is capable of mating with the male member.

Preferably, the male member is capable of engaging the female member via a snap-fit mechanism.

Preferably, the second end of the cap is adapted to engage the body via a twist-lock mechanism, snap-fit mechanism or threaded mechanism.

Preferably, the second end of the cap and the body comprise complementary screw threads.

Preferably, the screw threads are dual screw threads.

Preferably, the cap comprises an internal annular flange capable of sealing the chamber when the cap engages the body.

Preferably, the internal annular flange extends into the chamber when the cap engages the body.

Preferably, the cap comprises a deformable material.

Preferably, the cap further comprises structural ribs along an outer circumferential surface of the cap.

Preferably, the female member comprises at least one indentation along its periphery.

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Preferably, the operable temperature range of the vial unit is about -196 °C to about 121 °C.

Preferably, the vial units are stackable along a common central axis.

10 Preferably, the length of the vial assembly along the common central axis is 50 mm or less.

Preferably, the vial assembly has a substantially continuous outer circumferential surface.

BRIEF DESCRIPTION OF THE DRAWINGS

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The present invention will now be described, by way of example only, with reference to the accompanying drawing, in which:

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Figure 1 provides a perspective view of a first embodiment of a vial assembly of the present invention.

Figure 2 provides two side views of a first embodiment of a vial assembly of the present invention.

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Figure 3 provides two side views of a first embodiment of a vial unit of the present invention.

Figure 4a provides a view of the first end of the vial cap viewed from V_T in Figure 3 and Figure 4b provides a view of the base of the vial body viewed from V_B in Figure 3.

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Figure 5 provides a view of the interior of a first embodiment of the vial unit of the present invention.

Figure 6 provides two views of a first embodiment of the vial unit of the present invention with the vial cap and vial body disassembled.

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Figures 7a and 7b provide a perspective and side view respectively of a second embodiment of a vial assembly of the present invention, where the body is constructed from a translucent material.

- 5 Figures 8a and 8b provide a side and cross-sectional view respectively of a second embodiment of a vial assembly of the present invention, where the body is constructed from an opaque material.

- 10 Figures 9a and 9b provide a perspective and side view respectively of a second embodiment of a vial unit of the present invention, where the body is constructed from an opaque material.

Figure 9c provides a side view of a second embodiment of a disassembled vial unit of the present invention, where the body is constructed from an opaque material.

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Figure 10a provides a side view of a second embodiment of a vial unit of the present invention, where the body is constructed from a translucent material.

- 20 Figures 10b and 10c provide two perspective views of a second embodiment of a vial unit of the present invention, where the body is constructed from a translucent material.

Figure 11 provides a perspective view of a second embodiment of a vial unit of the present invention, where the body is constructed from a translucent material.

- 25 Figure 12 provides a cross-sectional view of a second embodiment of a vial unit of the present invention, where the body is constructed from an opaque material.

- 30 Figure 13a provides a perspective view of the body of a second embodiment of a disassembled vial unit of the present invention, where the body is constructed from a translucent material.

Figure 13b provides a view of the body of a second embodiment of a disassembled vial unit of the present invention viewed from V_T in Figure 13c.

Figure 13c provides a view of the interior of the body of a second embodiment of a disassembled vial unit of the present invention, where the body is constructed from a translucent material.

5 Figure 13d provides a cross-sectional view of a portion of the body of the vial unit of Figure 13c.

Figure 14a provides a view of the cap of a second embodiment of a disassembled vial unit of the present invention viewed from V_T in Figure 10a.

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Figures 14b and 14c provide a perspective and side view respectively of the cap of a second embodiment of a disassembled vial unit of the present invention.

Figure 14d provides a cross-sectional view of a cap of a second embodiment of a
15 disassembled vial unit of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Particular embodiments of the present invention will now be described with reference to the accompanying drawings. In the drawings and description hereinafter, like elements are
20 numbered with like reference numerals. The terminology used herein is for the purposes of describing particular embodiments only and is not intended to limit the scope of the present invention. Additionally, unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which this invention belongs.

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Throughout the specification, unless the context requires otherwise, the word “comprise” or variations such as “comprises” or “comprising”, are to be construed as inclusive and not exhaustive.

30 Furthermore, throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including”, are to be construed as inclusive and not exhaustive.

As used herein, the term “about” typically means +/- 5% of the stated value, more typically
35 +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically +/- 2%

of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

Throughout this disclosure, certain embodiments may be disclosed in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as a limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. Ranges are not limited to integers, and can include decimal measurements. This applies regardless of the breadth of the range.

As used herein, the terms "vial" and "container" are used interchangeably and are defined as a vessel having a space suitable for holding, transporting, containing and/or storing an object, preferably a biological sample.

As used herein, the term "cryogenic storage" when used in the context of tissues and cells refers to the storage of such tissues and cells at less than 0°C to about -196°C.

As used herein, the term "low temperatures" refers to temperatures below -20°C, while the term "very low temperatures" or "ultra low temperatures" refers to temperatures which are generally lower than -80°C.

As used herein, the term "overall dimensions" when used in the context of a vial assembly refers to the height H1 and diameter W1 of a vial assembly.

As used herein, the term "void volume" refers to volume which is not utilized or effectively utilized for storage.

Importantly, the vial assembly of the present invention leads to a significant reduction in void volume. This is because a standard cryovial that is typically used by a person skilled in the art is now segregated to two or more vial units. For instance, a vial assembly 100 of the present invention having a height (H1) of 48 mm may be comprised of vial units 110a,

110b, 110c, each vial unit capable of containing a different sample. In contrast, a standard cryovial that is typically used by a person skilled in the art having a height of 48 mm can only contain one sample, which typically takes up less than 10% of the volume of the cryovial, with the remaining 90% of the volume being void volume. Consequently, the vial assembly of the present invention effectively increases the storage space of a standard cryovial by reducing void volume.

It would be appreciated that generally, vial assembly 100, 200 and vial units 110a, 110b, 110c, 210a, 210b, 210c may be subjected to low or very low temperatures without experiencing any damage (e.g. damage to its structural integrity), and they can also be used at room temperature or higher temperatures. It would also be appreciated that vial assembly 100, 200 and vial units 110a, 110b, 110c, 210a, 210b, 210c are adapted to tolerate and withstand multiple freeze-thaw cycles without experiencing any damage (e.g. damage to their structural integrity). It would be understood by those having ordinary skill in the art that one freeze-thaw cycle comprises one step of freezing the relevant article (e.g. vial assembly 100 and/or vial units 110a, 110b, 110c), and one step of thawing the said relevant article.

Exemplary, non-limiting embodiments of the present invention will now be disclosed.

A first embodiment of the present invention is shown in Figures 1 and 2, which provide a vial assembly 100 comprising vial units 110a, 110b, 110c. The vial assembly 100 and vial units 110a, 110b, 110c are suitable for cryogenic storage and the operable temperature of the vial assembly 100 and vial units 110a, 110b, 110c is preferably about -196 °C to about 121 °C. It is contemplated that the operable temperature range of the vial assembly 100 and vial units 110a, 110b, 110c may vary depending on the type of material used to construct vial assembly 100 and vial units 110a, 110b, 110c. However, it is preferable that the material selected to construct the vial assembly 100 and vial units 110a, 110b, 110c will make them suitable for cryogenic applications, such as cryogenic storage.

Vial assembly 100 and vial units 110a, 110b, 110c are suitable for cryogenic storage and cryopreservation, which is commonly understood to be a process where cells, tissues or organic material are preserved by freezing to very low temperatures, thereby effectively reducing or stopping any enzymatic or chemical reactions which may cause damage to the cells, tissue or organic material. Vial assembly 100 is made up of vial units 110a, 110b,

110c, and the dimensions of vial assembly 100 make it compatible with the infrastructure of current biorepositories or biobanks. Vial units 110a, 110b, 110c are stackable on top of one another along a common central axis X (Figure 2). The use of multiple vial units 110a, 110b, 110c to form vial assembly 100 segregates the space commonly utilized by a standard vial, thereby effectively increasing the storage space by reducing void volume, without the need for equipment/infrastructure upgrade that usually accompanies changes of laboratory equipment.

The inventors of the present invention have found an optimum range of dimensions for vial assembly 100 and vial units 110a, 110b, 110c. Compared to existing cryovials which are well known in the art and are typically used by a person skilled in the art, the dimensions of each vial unit 110a, 110b, 110c provide maximal storage capacity. As such, vial assembly 100 having identical or similar overall dimensions as for instance, a standard 2 ml cryovial having a height of 48 mm, may contain for example, three different biological samples.

The height of vial assembly 100 can be customized to suit a storage box by changing the height of the individual vial units 110a, 110b, 110c or the number of vial units 110a, 110b, 110c. For example, three vial units 110 may make up a vial assembly 100 for storage in a standard rack (as shown in Figure 1), while more than three vial units 110 may make up a vial assembly 100 for storage in a specially fabricated storage rack. The height of vial assembly 100 (as indicated by H1 in Figure 2) may range from about 24 mm to about 50 mm, about 30 mm to about 50 mm, about 40 mm to about 50 mm, preferably about 48 mm to about 50 mm, preferably about 24 mm, about 25 mm, about 30 mm, about 35 mm, about 40 mm, about 42 mm, about 45 mm, about 46 mm, about 48 mm, about 48.5 mm, about 49 mm, or about 50 mm. Preferably, the height H1 of vial assembly 100 will not exceed 51 mm so that the vial assembly 100 may be used with existing storage systems. In a preferred embodiment, the height of vial assembly 100 is about 48.5 mm. Advantageously, the height of the vial assembly 100 facilitates efficient use of space in freezers by minimizing void volume and maximizing storage capacity.

The height of each vial unit 110a, 110b, 110c may be from about 12 mm to about 25 mm, about 12 mm to about 20 mm, about 12 mm to about 16 mm, about 14 mm to about 18 mm or about 16 mm to about 17 mm. In a preferred embodiment, when the vial assembly 100 comprises three vial units, the height of each vial unit is preferably about 16 mm to about 17 mm. Therefore, depending on the application, the dimensions of vial assembly 100 may

vary. Further, depending on the application, vial units 110a, 110b, 110c need not be of the same height within the vial assembly 100. It is preferable for vial assembly 100 to have a substantially continuous outer circumferential surface so that it can be easily, preferably smoothly fitted into or retrieved from existing storage equipment.

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As shown in Figure 1, each vial unit 110a, 110b, 110c may comprise a body 120a, 120b, 120c and a cap 130a, 130b, 130c, respectively. As shown in Figures 1 to 6, the body 120 comprises a base 121, a top 123 and a chamber 140. The base 121 includes a recessed portion 128 having a discontinuous periphery and two opposing indentations 122 along said periphery (as shown in Figures 4b and 5). More than one indentation 122 may be contemplated and such indentations 122 may be arranged anywhere along the periphery of the recessed portion depending on the application, i.e. they need not be opposing. As such, each vial unit 110a, 110b, 110c may comprise indentations 122a, 122b, 122c, respectively. The top 123 includes an opening for accessing the chamber 140, external screw threads 124 and an external annular flange 125.

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As shown in Figure 3, the cap 130 comprises a first end 131, a second end 133 and internal screw threads 134, which are complementary to the external screw threads 124 of body 120. Advantageously, the cap 130 reduces or prevents cross-contamination between the object stored in each vial unit 110a, 110b, 110c by providing a physical barrier between two adjacent vial units. The cap 130 has a height H2, wherein H2 may range from about 4 mm to about 10 mm, preferably about 4 mm, about 6 mm, about 8 mm, or about 10 mm. In a preferred embodiment, the cap 130 has a height H2 of about 8 mm. The cap 130 has a diameter W1, wherein W1 may range from about 12.4 mm to about 13.7 mm, preferably about 12.40 mm, about 12.45 mm, about 12.50 mm, about 12.60 mm, about 12.80 mm, about 13.00 mm, about 13.10 mm, or about 13.20 mm. In a preferred embodiment, the cap 130 has a diameter W1 of about 12.40 mm. It would be appreciated that the diameter W1 may be dependent on the dimensions of the container that it is to be stored in, such as a cryobox. For instance, diameter W1 should be less than 13.7 mm if a standard 9 x 9 cryobox having a grid width of 13.7 mm is used so that the vial assembly 100 would be placed too closely to an adjacent vial assembly 100 thereby making the retrieval/removal of the vial assembly 100 difficult. Similarly, diameter W1 should be less than 12.45 mm if a standard 10 x 10 cryobox having a grid width of 12.45 mm is used.

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As shown in Figure 4a, the first end 131 has a boss (male member) 132, which is sized to fit into the recessed portion (female member) 128 of a body 120 of a vial unit 110. The boss 132 has a height H3 (Figure 3), wherein H3 may range from about 1 mm to about 3 mm, preferably about 1 mm, about 2 mm, or about 3 mm. In a preferred embodiment, the boss 132 has a height H3 of about 2 mm. The boss 132 has a diameter W2, wherein W2 may range from about 6 mm to about 11 mm, preferably about 6 mm, about 7 mm, about 8 mm, about 9 mm, about 10 mm or about 11 mm. In a preferred embodiment, the boss 132 has a diameter W2 of about 9 mm. Advantageously, the diameter W2 of the boss 132 of a vial unit, for instance, boss 132b of vial unit 110b, allows the boss 132b to fit into and substantially engage the recessed portion (female member) 128 of another vial unit, for instance, recessed portion 128a of the vial unit 110a, such that a reasonable amount of force, which will be understood by a skilled person, would be required to break or separate such engagement, i.e. to separate the boss 132b and the recessed portion 128.

The body 120 and cap 130 are made from a suitable material, which includes a polymeric material. Preferably, this material is polypropylene and even more preferably, the vial unit 110 is made from medical grade IV polypropylene. Advantageously, medical grade IV polypropylene is sturdier and more durable than other grades of polypropylene. Consequently, the vial unit 110 may be capable of withstanding low temperatures. The cap 130 preferably comprises a deformable material, more preferably a soft material, such as other types of polypropylene. Advantageously, the use of a soft material for the cap 130 facilitates easy manipulation of the cap 130, for example providing an easier disengagement of the cap 130, for instance, cap 130a of vial unit 110a, from the body 120, for instance, body 120a of vial unit 110a. Even more preferably, the cap 130 is made from a softer material than the body 120, and the cap 130 is preferably constructed from a material different from that of the body 120. Traditionally, O-rings are used in cryovials to effectively seal a sample in a chamber from the external environment. The cap 130 comprising a deformable soft material which is preferably softer than that of the body 120, dispenses the need for O-rings because the internal surface of the cap 130 may also function like an O-ring to effectively seal a sample in chamber 140 from the external environment. Biological samples for storage in vial unit 110 include, but are not limited to liquids (e.g. serum or plasma) or solid (e.g. tissue) samples, which include small solid samples of about 1 cm³ or smaller.

As shown in Figures 5 and 6, external screw threads 124 on body 120 and internal screw threads 134 on cap 130 are complementary to one another. When the cap 130 is screwed onto body 120, the screw threads 124, 134 are arranged in close proximity and tight contact with one another so as to prevent frosting when vial unit 110 or vial assembly 100 is subjected to low or very low temperatures. Further, as cap 130 is screwed onto body 120, the second end 133 of the cap 130 abuts tightly against the external annular flange 125 so as to prevent frosting when vial unit 110 or vial assembly 100 is subjected to low or very low temperatures.

Vial units 110a, 110b, 110c form vial assembly 100 via inter-vial unit fitting engagement with one another. In operation and with reference to vial units 110a, 110b, the first end 131b of cap 132b of vial unit 110b (bottom vial unit), engages the base 121a of body 120a of vial unit 110a (top vial unit), via a snap-fit mechanism where the boss 132b of vial unit 110b is urged to fit into recessed portion 128a of vial unit 110a. When boss 132b of vial unit 110b is snap-fitted within recessed portion 128a of vial unit 110a, sides 129a of vial unit 110a exert a force substantially in a lateral direction against the sides of boss 132b of vial unit 110b to hold boss 132b within the recessed portion 129a of vial unit 110a. When vial unit 110a is snap-fitted via base 121a to cap 130b and when cap 130b is screwed onto body 120b, vial units 110a and 110b are considered to be engaged or interlocked. Indentations 122 separate sides 129 and provide for easy dismantling of the vial assembly 100 and the separation of vial units 110a, 110b, 110c (Figure 4b). Further, indentations 122a, 122b and 122c provide grip to a user to separate the vial units 110a, 110b, 110c, respectively. A snap-fit mechanism is the preferred mechanism to form vial assembly 100 because it is a fast and efficient method, especially when a user has to handle multiple vial assemblies, and the viability of samples stored within the vial units 110a, 110b, 110c is dependent on surrounding temperatures. A skilled person would appreciate that freezing and thawing samples will damage them and reduce their viability. A snap-fit mechanism is also preferred over screwing or twist-lock mechanisms for inter-vial engagement because the intra-vial unit engagement mechanism by which the cap 130 engages the body 120 of vial unit 110 is preferably via a screwing mechanism. Therefore, a screwing or twist-lock inter-vial unit engagement mechanism to attach vial units 110a, 110b, 110c together can cause cumbersome handling for a user because a user may inadvertently disassemble vial assembly 100 when attempting to unscrew the cap 130 from the body 120 of a vial unit 110. Preferably, when a vial unit 110a is engaged via base 121a to cap 130b of another vial unit 110b, such engagement will provide sufficient force to prevent disengagement of

the base 121a from cap 130b when a user is unscrewing for example, the cap 130a from the body 120a of vial unit 110a.

A second embodiment of the present invention is shown in Figures 7 to 14, which provide
5 a vial assembly 200 having vial units 210a, 210b, 210c. The vial assembly 200 and vial units 210a, 210b, 210c are suitable for cryogenic storage and the operable temperature of the vial assembly 200 and vial units 210a, 210b, 210c is preferably about -196 °C to about 121 °C. It is contemplated that the operable temperature range of the vial assembly 200 and vial units 210a, 210b, 210c may vary depending on the type of material used to construct
10 vial assembly 200 and vial units 210a, 210b, 210c. However, it is preferable that the material selected to construct the vial assembly 200 and vial units 210a, 210b, 210c will make them suitable for cryogenic applications, such as cryogenic storage.

As shown in Figure 7a, each vial unit 210a, 210b, 210c may comprise a body 220a, 220b, 220c and a cap 230a, 230b, 230c, respectively. Compared to existing cryovials which are
15 well known in the art and are typically used by a person skilled in the art, the dimensions of each vial unit 210a, 210b, 210c is designed to maximize storage capacity. As such, vial assembly 200 having identical or similar overall dimensions as for instance, a standard 2 ml cryovial having a height of 48 mm, may for example contain three different biological
20 samples. The height of vial assembly 200 (as indicated by H1' in Figure 7b) may range from about 24 mm to about 50 mm, about 30 mm to about 50 mm, about 40 mm to about 50 mm, preferably about 48 mm to about 50 mm, preferably about 24 mm, about 25 mm, about 30 mm, about 35 mm, about 40 mm, about 42 mm, about 45 mm, about 46 mm, about 48 mm, about 48.5 mm, about 49 mm, or about 50 mm. Preferably, the height H1' of
25 vial assembly 200 will not exceed 51 mm so that the vial assembly 200 may be used with existing storage systems. In a preferred embodiment, the height of vial assembly 200 is about 48.5 mm. Advantageously, the height of the vial assembly 200 facilitates efficient use of space in freezers by minimizing void volume and maximizing storage capacity.

30 The height of each vial unit 210a, 210b, 210c may range from about 12 mm to about 25 mm, about 12 mm to about 20 mm, about 12 mm to about 16 mm, about 14 mm to about 18 mm, preferably about 12 mm, about 14 mm, about 16 mm, about 17 mm. In a preferred embodiment, when a vial assembly comprises of three vial units, the height of each vial unit is preferably about 16 mm to about 17 mm. Therefore, depending on the application, the

dimensions of vial assembly 200 may vary. Further, depending on the application, vial units 210a, 210b, 210c need not be of the same height within the vial assembly 200.

As shown in Figures 7 to 12, the body 220 comprises a base 221, a top 223 and a chamber 240. The base 221 includes a recessed portion 228 having a discontinuous periphery and two opposing indentations 222 along said periphery (Figure 10c). More than one indentation 222 may be contemplated and such indentations 222 may be arranged anywhere along the periphery of the recessed portion 228 depending on the application, i.e. they need not be opposing. As such, each vial unit 210a, 210b, 210c may comprise indentations 222a, 222b, 222c, respectively (Figure 7a). The top 223 includes an opening for accessing the chamber 240, external screw threads 224 and an external annular flange 225.

It is contemplated that the operable temperature range of the vial assembly 200 and vial units 210a, 210b, 210c may vary depending on the type of material used to construct vial assembly 200 and vial units 210a, 210b, 210c. However, it is preferable that the material selected to construct the vial assembly 200 and vial units 210a, 210b, 210c will make them suitable for cryogenic applications, such as cryogenic storage. Consequently, the body 220 and cap 230 are made from a suitable material, which includes a polymeric material. Preferably, this material is polypropylene and even more preferably, the vial unit 210 is made from medical grade IV polypropylene. Advantageously, medical grade IV polypropylene is sturdier and more durable than other grades of polypropylene. Consequently, the vial unit 210 may be capable of withstanding low temperatures. The cap 230 preferably comprises a deformable material, more preferably a soft material, such as other types of polypropylene. Advantageously, the use of a soft material for the cap 230 facilitates easy manipulation of the cap 230, for example providing an easier disengagement of the cap 230, for instance, cap 230a of vial unit 210a, from the body 220, for instance, body 220a of vial unit 210a. Even more preferably, the cap 230 is made from a softer material than the body 220, and the cap 230 is preferably constructed from a material different from that of the body 220. Traditionally, O-rings are used in cryovials to effectively seal a sample in a chamber from the external environment. The cap 230 comprising a deformable soft material which is softer material than that of the body 220, dispenses the need for O-rings because the internal surface of the cap 230 may also function like an O-ring to effectively seal a sample in chamber 240 from the external environment. Biological samples for storage in vial unit 210 include, but are not limited to

liquids (e.g. serum or plasma) or solid (e.g. tissue) samples, which include small solid samples of about 1 cm³ or smaller.

As shown in Figure 13c, the body 220 (with a central axis A-A) has an external diameter W3 of about 12 mm, which represents the maximum width of the body 220, measured from one side of the external annular flange 225 to the opposite side of the external annular flange 225, a diameter W4 of about 11 mm, measured from one side of the body 220 to the opposite side of the body 220, a diameter W5 of about 9 mm, measured from one side of an interior surface of recessed portion 228 to the other side of an interior surface of the recessed portion 228. Indentation 222 has a width W6 of about 4 mm. The range of external diameter W3 may be from about 12 mm to about 13.7 mm, the range of diameter W4 may be about 5 mm to about 13.7 mm, the range of diameter W5 may be about 5 mm to about 11.7 mm. Importantly, the base of the body 220 may be sized, i.e. the measurements W3, W4 and W5 may be varied so that the base 221 will sufficiently engage a boss 232 when the vial assembly 200 is assembled.

As shown in Figures 14a to 14d, the cap 230 comprises a first end 231, a second end 233 and internal screw threads 234, which are complementary to the external screw threads 224 of body 220. Advantageously, the cap 230 reduces or prevents cross-contamination between the object stored in each vial unit 210a, 210b, 210c by providing a physical barrier between two adjacent vial units. The cap 230 has a height H2', wherein H2' may be about 4 mm, about 6 mm, about 8 mm, about 10 mm. In a preferred embodiment, the cap 130 has a height H2' of about 8 mm. The cap 230 has a diameter W1', wherein W1' may be about 12.40 mm to 13.70 mm, preferably about 12.40 mm, about 12.45 mm, about 12.50 mm, about 12.60 mm, about 12.80 mm, about 13.00 mm, about 13.10 mm, or about 13.20 mm. In a preferred embodiment, the cap 230 has a diameter W1' of about 12.40 mm. The first end 231 has a boss (male member) 232, which is sized to fit into the recessed portion (female member) 228 of a body 220 of a vial unit 210. The boss 232 has a height H3', wherein H3' may be about 1 mm, about 2 mm, about 3 mm. In a preferred embodiment, the boss 232 has a height H3' of about 2 mm. As shown in Figure 14c, the boss 232 (with a central axis B-B) has a diameter W2', wherein W2' may be about 6 mm, about 7 mm, about 8 mm, about 9 mm, about 10 mm or about 11 mm. In a preferred embodiment, the boss 232 has a diameter W2' of about 9 mm.

The vial units 210a, 210b, 210c are attached to one another via a snap-fit mechanism described above in the first embodiment. Cap 230 also engages body 220 via a screwing mechanism as described above in the first embodiment. Cap 230 includes structural ribs 235 along its external circumferential surface which provides grip of the cap 230 by a user to unscrew the cap 230 from the body 220 and also for secure handling of vial unit 210 (Figures 9a to 9c, 10a to 10c). As shown in Figures 13c and 13d, chamber 240 has a wall having a thickness W7 of about 0.5 mm to about 2.0 mm. The inventors of the present invention have found that a thickness W7 of more than 2.0 mm would result in a smaller opening, thereby making it difficult to access the object contained in the chamber 240 and/or smaller chamber 240 to house the object. The inventors of the present invention have also found that a thickness W7 of less than 0.5 mm would compromise on the structural integrity of the vial unit 210 i.e. when subjected to low or very low temperatures, the vial unit 210 will likely experience significant physical damage. The body 220 may be constructed from an opaque or a translucent material, where the latter will allow a user to view the contents of chamber 240, which is useful in that the cap 230 need not be unscrewed from the body 220 in order to identify the contents of chamber 240. Unscrewing of the cap 230 from body 220 to identify a sample may unnecessarily and inadvertently cause contamination of the sample within the chamber 240. As shown in Figure 11, the bottom of the chamber 240 is provided a distance away from the recessed portion 228 to provide a catch for the boss 232 of a cap 230 of another vial unit 210.

Cap 230 is also provided with an internal annular flange 238, which extends substantially vertically from an inner surface of the cap 230. As shown in Figures 8b and 12, the internal annular flange 238 extends into chamber 240 and abuts against an internal surface of the top end 223 of body 220 which forms the start of chamber 240 when the cap 230 engages the body 220. This internal annular flange 238 acts as an O-ring which seals the contents of chamber 240 from the external environment and prevents and reduces contamination of such contents. It would be appreciated that such an internal annular flange can also extend in a substantially horizontal manner from an inner surface of the cap 230, such that it abuts against the top flange of top end 223 of body 220 (not shown). Suitable modifications may be made to internal annular flange 238 depending on its applications, so long as internal annular flange 238 is capable of sealing the contents of chamber 240 from the external environment and prevents and reduces contamination of such contents. The flange 238 is preferably constructed from a deformable material such that when the cap 230 engages the body 220, the deformable material will advantageously allow the internal annular flange

238 to substantially, and more preferably, completely seal the chamber 240 from the external environment so as to maintain a sterile environment in the chamber 240. More preferably, the internal annular flange 238 is constructed from a soft material and even more preferably, the internal annular flange 238 is constructed from a material softer than the material of the body 220.

Throughout the specification, it would be understood that the body 120, 220 and cap 130, 230 may comprise either internal or external screw threads, so long as the corresponding component which it is intended to engage has complementary screw threads – for example, the body 120, 220 can comprise internal screw threads and the cap 130, 230 can comprise external screw threads, such that the cap 130, 230 is screwed into the body 120, 220. It is also appreciated that the screw threads can be right- or left-handed screw threads, and can also be dual screw threads. It would also be understood that the measurements H1, H2, H3, H1', H3', W1, W2, W1', W2', W3, W4, W5, W6, W7, disclosed in the first embodiment or second embodiment would similarly be applicable to the other embodiment(s). Further, it would be understood that other suitable engaging means may be used instead of screw threads and snap-fit mechanisms, so long as the various components of vial units 110, 210 are capable of engaging. Together, the engaging means will cause vial units 110, 210 to interlock and form vial assembly 100, 200. It is desirable that such engaging means provide a resistive force which needs to be overcome for the various components in vial assembly 100, 200 to be separated from one another. Such engaging means include, but are not limited to twist-lock mechanisms.

The above is a description of an embodiment of the present invention. It is envisioned that those skilled in the art may design alternative embodiments(s) without departing from the scope of the present invention.

It should be further appreciated by the person skilled in the art that features and modifications as discussed in the embodiment above, not being alternatives or substitutes unless expressly stated, may be combined to form yet other embodiments that fall within the scope of the invention described. In particular, the following modifications and improvements may be made without departing from the scope of the present invention:

- The height of the vial unit, e.g. distance from the end of the base 121 to the boss 132 may vary depending on the application of the present invention. It is also

contemplated that the vial units need not be identical in height and may be different from one another depending on the application of the present invention.

- 5 • The shape of the chamber will depend on the application of the present invention, and may, for example, be tapered towards the base of the body of the cryovial, to facilitate collection of samples within the chamber.
- 10 • The female member need not comprise any indentation along a peripheral surface to facilitate mating of the female member with the male member. Advantageously, the absence of any indentation along a peripheral surface of the female member will lead to a better engagement between the female member and the male member than one with indentation.
- 15 • The measurements W1, W2, W1', W2', W3, W4, W5, W6, W7 may be varied so that there would be good grip.
- The diameter of the recessed portion need not be the same as the diameter of the chamber.
- 20 • The body and cap may be constructed from translucent or opaque materials.
- The cap and/or body may be of different colours such that a user can categorize the types of samples by using caps and/or body of certain colours.
- 25 • The intra-vial unit engagement means may be the same or different from the inter-vial unit engagement means, for example in an intra-vial unit engagement of a vial unit, its cap may be screwed into its body, while in the inter-vial unit engagement of that vial unit, its base of its body may engage the cap of another vial unit via a twist-lock mechanism.
- 30 • Depending on the application, the boss (male member) may be located at the base of the body, while the recessed portion (female member) may be located at the first end of the cap.

CLAIMS

1. A vial unit for storing a biological sample, the vial unit comprising:
a body comprising a chamber for containing the biological sample, the body
5 having a top and a base;
the top comprising an opening for accessing the chamber; and
a cap having a first and second end, the second end is adapted to engage
the body to cover the opening,
wherein the base of the body is adapted to engage a first end of a cap of another
10 vial unit.
2. The vial unit of claim 1, wherein the base of the body comprises a female member
and the first end of the cap of the another vial unit comprises a male member, wherein the
female member is capable of mating with the male member.
15
3. The vial unit of claim 1, wherein the base of the body comprises a male member
and the first end of the cap of the another vial unit comprises a female member, wherein
the female member is capable of mating with the male member.
- 20 4. The vial unit of claim 2 or 3, wherein the male member is capable of engaging the
female member via a snap-fit mechanism.
5. The vial unit of any one of the preceding claims, wherein the second end of the cap
is adapted to engage the body via a twist-lock mechanism, snap-fit mechanism or threaded
25 mechanism.
6. The vial unit of claim 5, wherein the second end of the cap and the body comprise
complementary screw threads.
- 30 7. The vial unit of claim 6, wherein the screw threads are dual screw threads.
8. The vial unit of any one of the preceding claims, wherein the cap comprises an
internal annular flange capable of sealing the chamber when the cap engages the body.

9. The vial unit of claim 8, wherein the internal annular flange extends into the chamber when the cap engages the body.

10. The vial unit of any one of the preceding claims, wherein the cap comprises a deformable material.

11. The vial unit of any one of the preceding claims, wherein the cap further comprises structural ribs along an outer circumferential surface of the cap.

12. The vial unit of any one of the preceding claims, wherein the female member comprises at least one indentation along its periphery.

13. The vial unit of any one of the preceding claims, wherein the operable temperature range of the vial unit is about -196 °C to about 121 °C.

14. A vial assembly for containing a plurality of biological samples, the vial assembly comprising two or more vial units, each vial unit comprising:

a body comprising a chamber for containing the biological sample, the body having a top and a base;

the top comprising an opening for accessing the chamber; and

a cap having a first and second end, the second end is adapted to engage the body to cover the opening,

wherein the base of the body is adapted to engage a first end of a cap of another vial unit in the vial assembly.

15. The vial assembly of claim 14, wherein the base of the body of a vial unit comprises a female member and the first end of the cap of the another vial unit in the vial assembly comprises a male member, wherein the female member is capable of mating with the male member.

16. The vial assembly of claim 14, wherein the base of the body of a vial unit comprises a male member and the first end of the cap of the another vial unit in the vial assembly comprises a female member, wherein the female member is capable of mating with the male member.

17. The vial assembly of claim 15 or 16, wherein the male member is capable of engaging the female member via a snap-fit mechanism.

5 18. The vial assembly of any one of claims 14 to 17, wherein the second end of the cap is adapted to engage the body via a twist-lock mechanism, snap-fit mechanism or threaded mechanism.

10 19. The vial assembly of claim 18, wherein the second end of the cap and the body comprise complementary screw threads.

20. The vial assembly of claim 19, wherein the screw threads are dual screw threads.

15 21. The vial assembly of any one of claims 14 to 20, wherein the cap comprises an internal annular flange capable of sealing the chamber when the cap engages the body.

22. The vial assembly of claim 21, wherein the internal annular flange extends into the chamber when the cap engages the body.

20 23. The vial assembly of any one of claims 14 to 22, wherein the cap comprises a deformable material.

25 24. The vial assembly of any one of claims 14 to 23, wherein the cap further comprises structural ribs along an outer circumferential surface of the cap.

25. The vial assembly of any one of claims 15 to 24, wherein the female member comprises at least one indentation along its periphery.

30 26. The vial assembly of any one of claims 14 to 25, wherein the operable temperature range of the vial unit is about -196 °C to about 121 °C.

27. The vial assembly of claim 14, wherein the vial units are stackable along a common central axis.

28. The vial assembly of claim 26, wherein the length of the vial assembly along the common central axis is 50 mm or less.

29. The vial assembly of any one of claims 14 to 28, wherein the vial assembly has a
5 substantially continuous outer circumferential surface.

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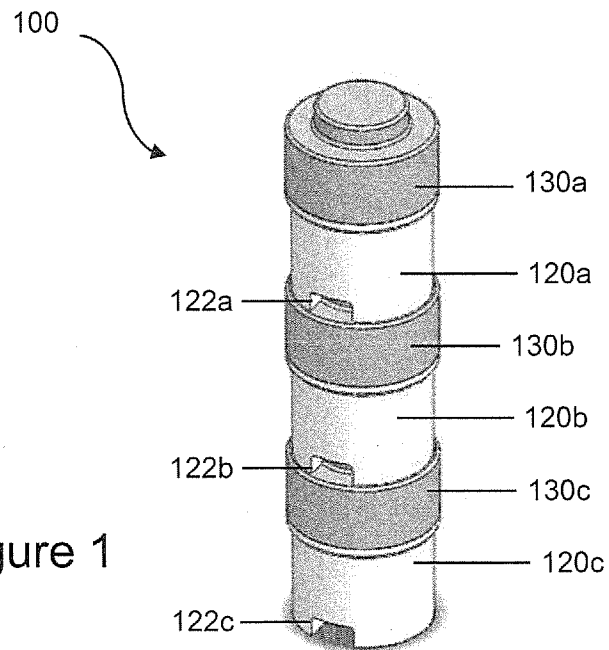


Figure 1

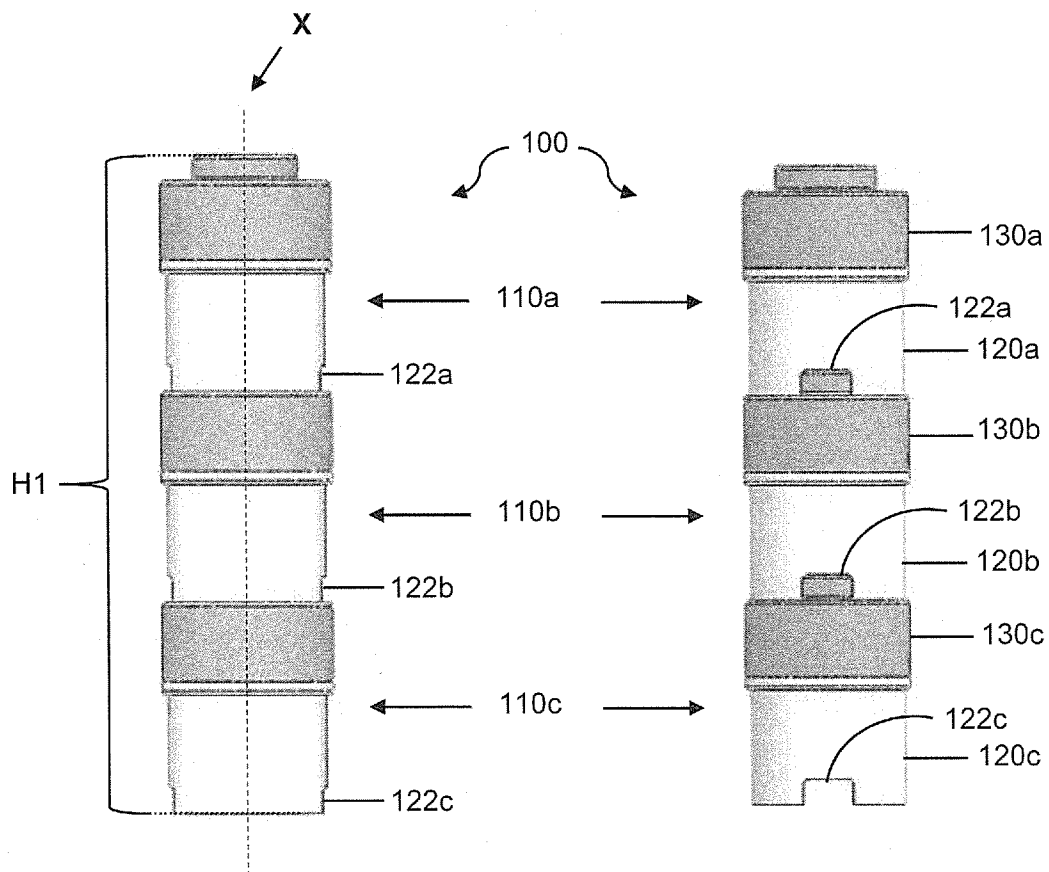


Figure 2

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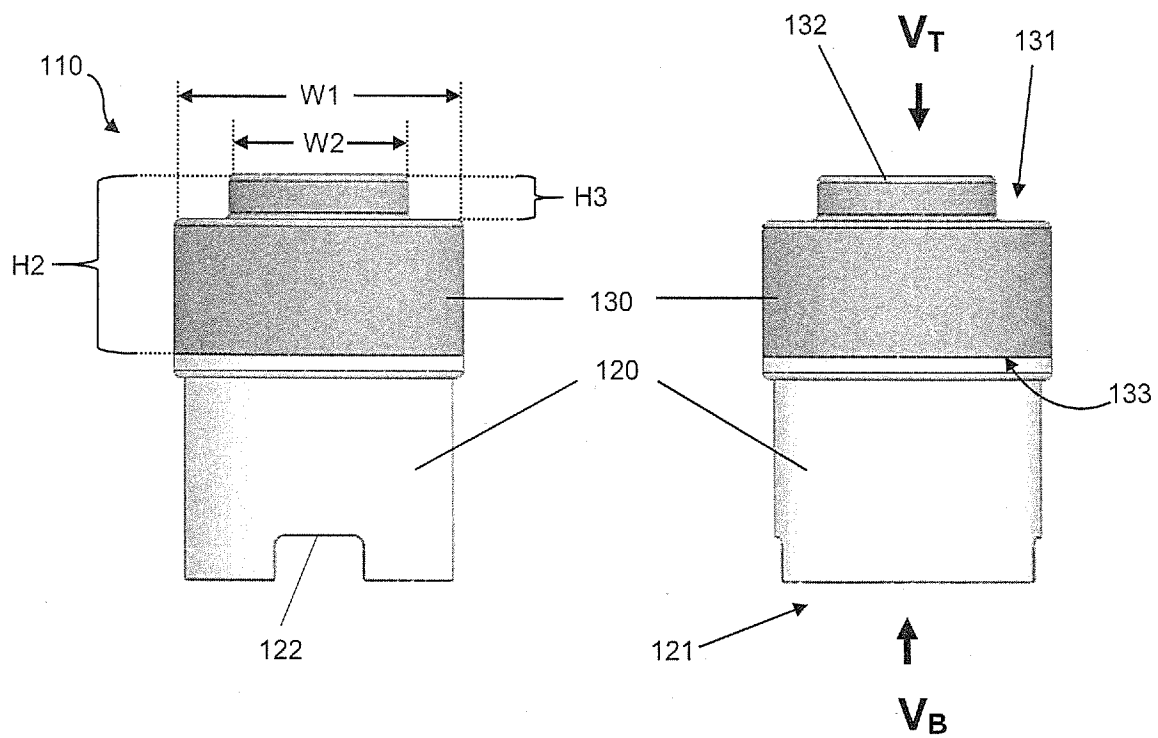


Figure 3

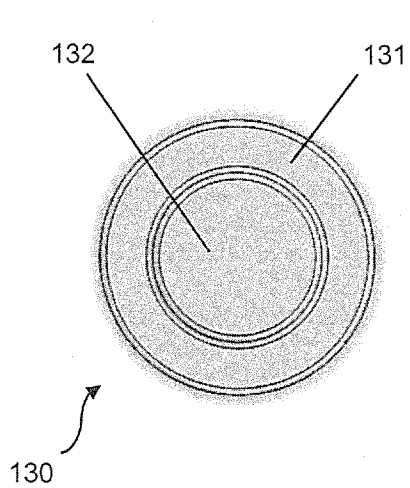


Figure 4a

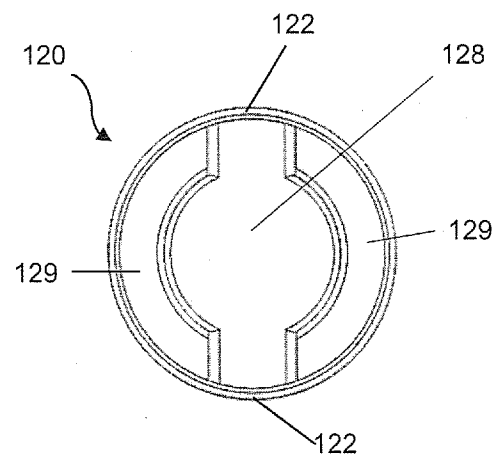


Figure 4b

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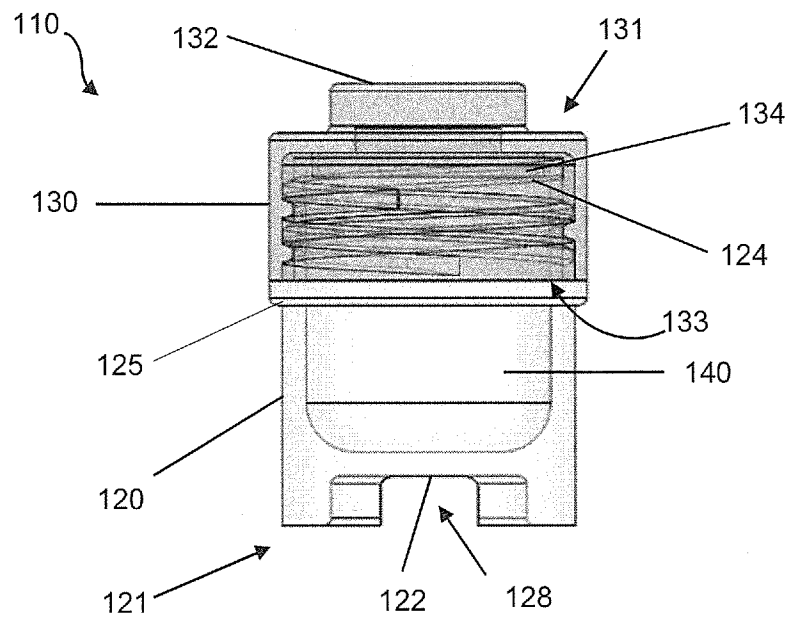


Figure 5

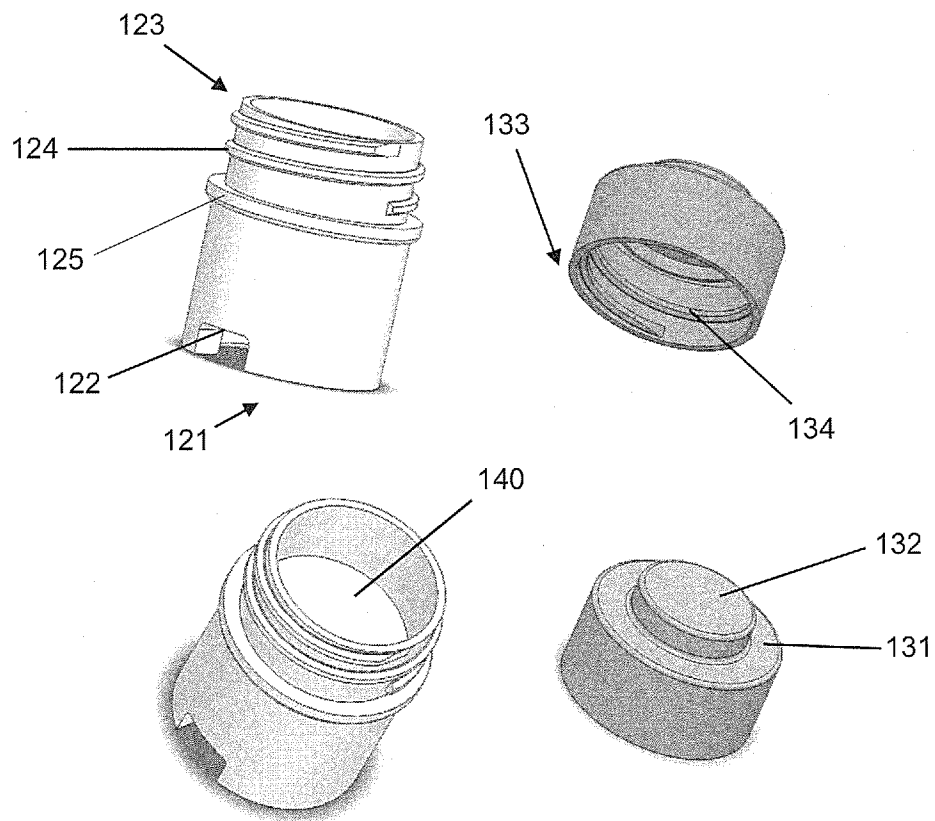


Figure 6

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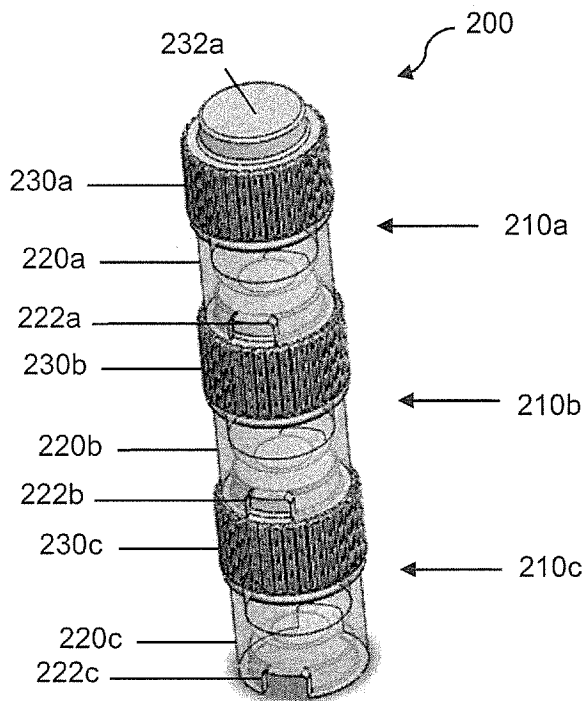


Figure 7a

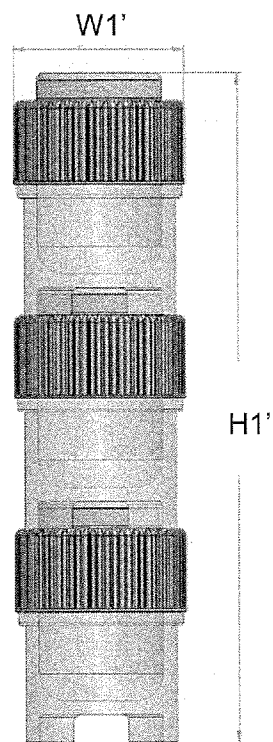


Figure 7b

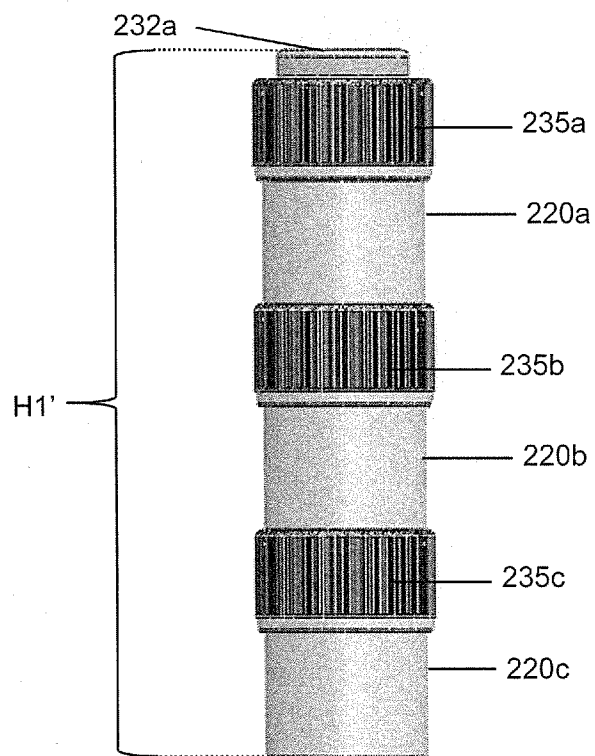


Figure 8a

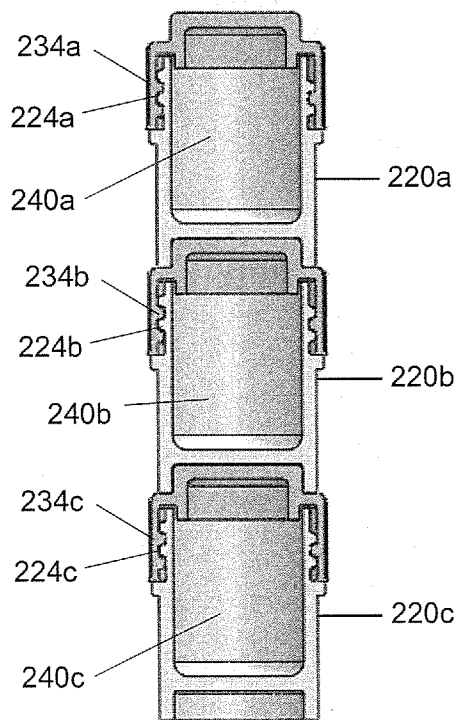


Figure 8b

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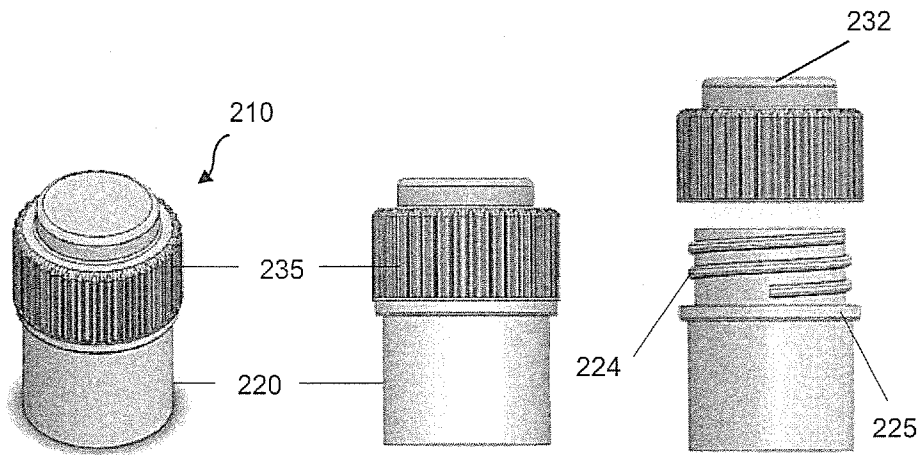


Figure 9a

Figure 9b

Figure 9c

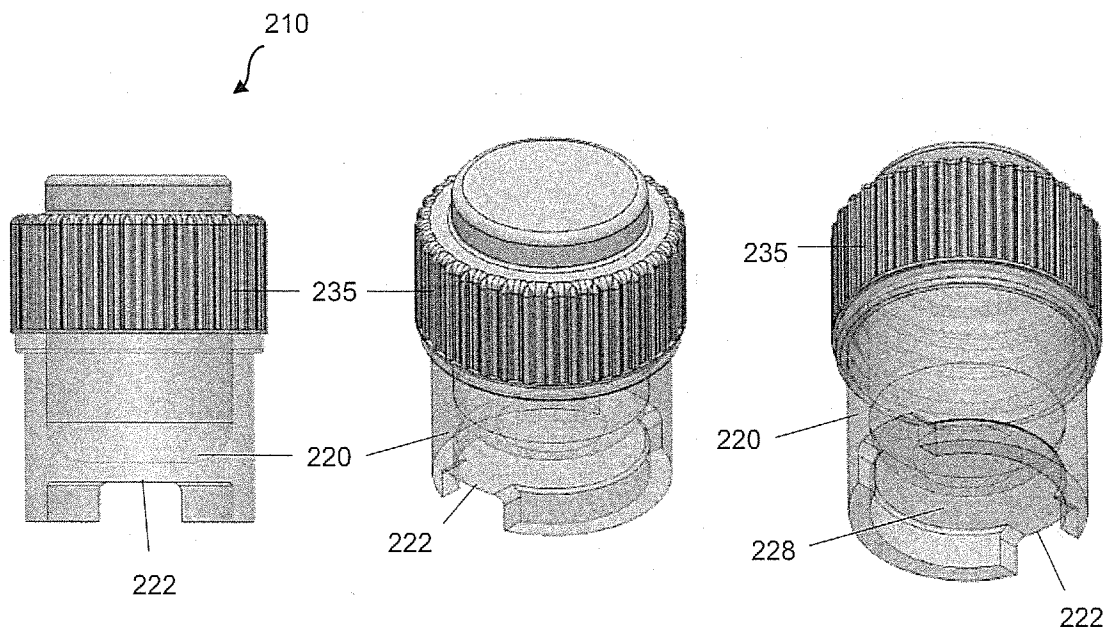


Figure 10a

Figure 10b

Figure 10c

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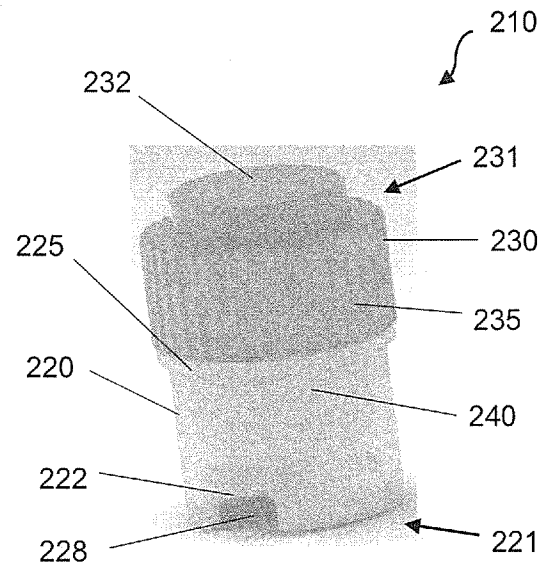


Figure 11

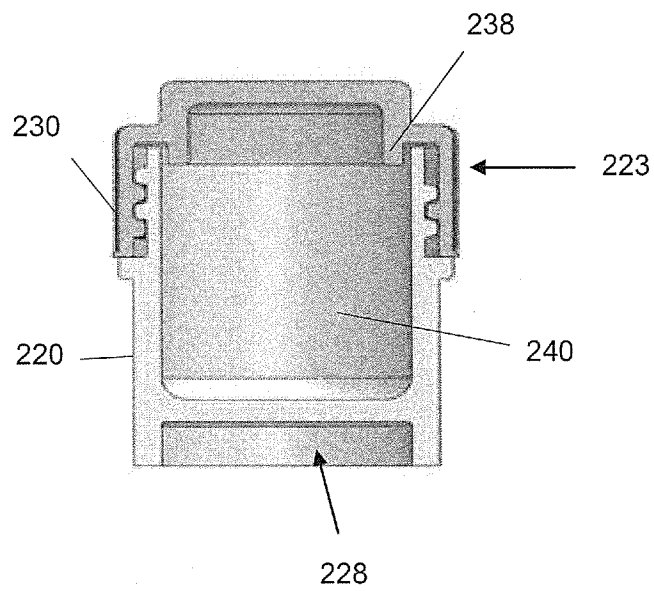


Figure 12

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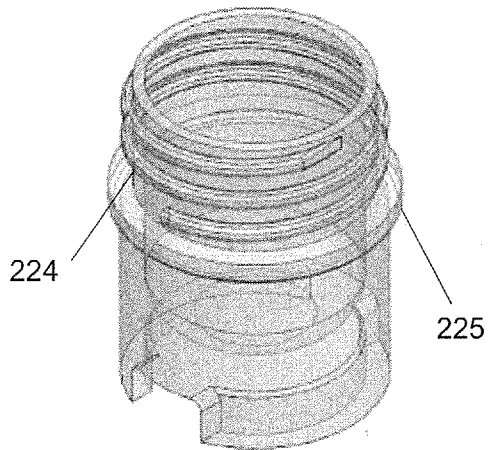


Figure 13a

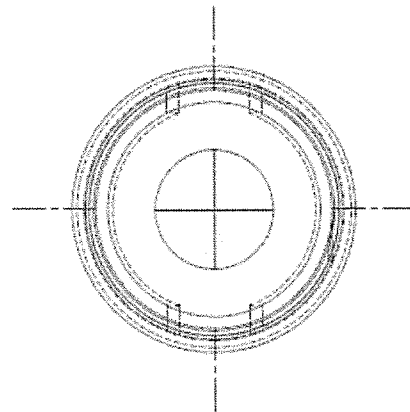


Figure 13b

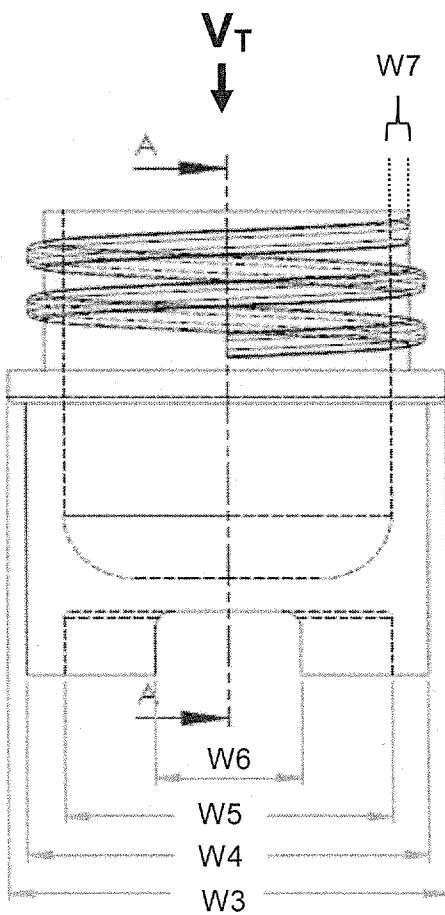


Figure 13c

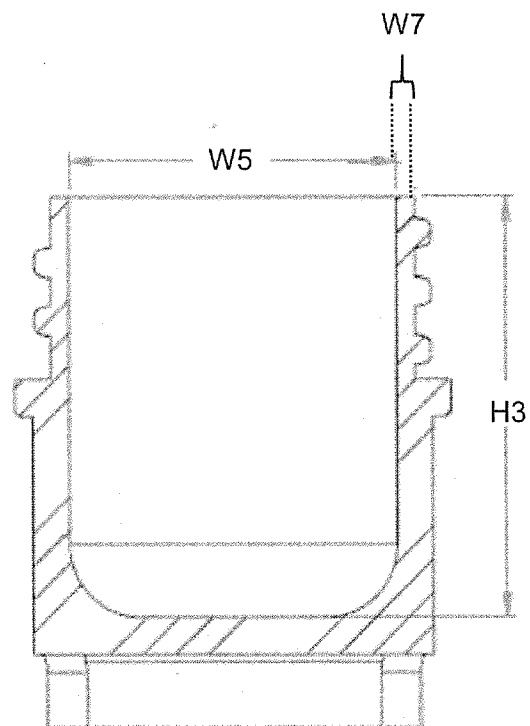


Figure 13d

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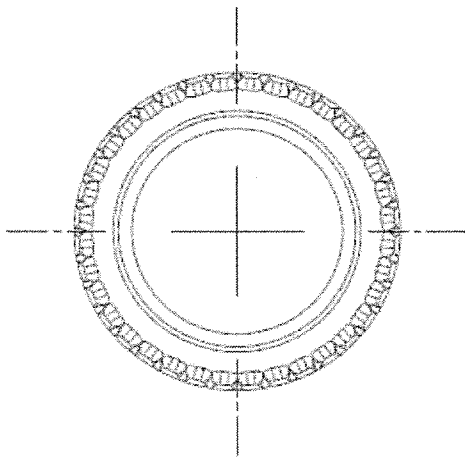


Figure 14a

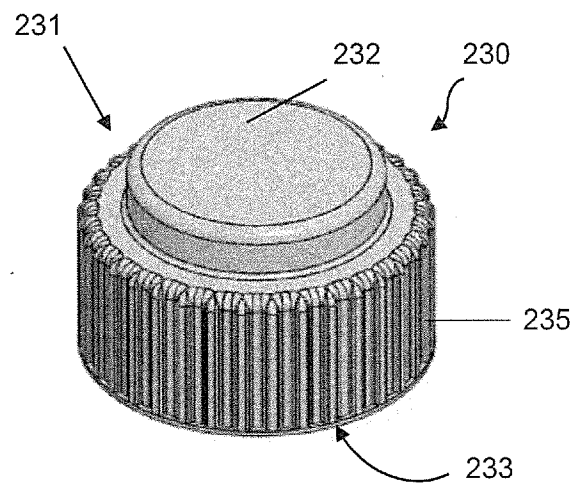


Figure 14b

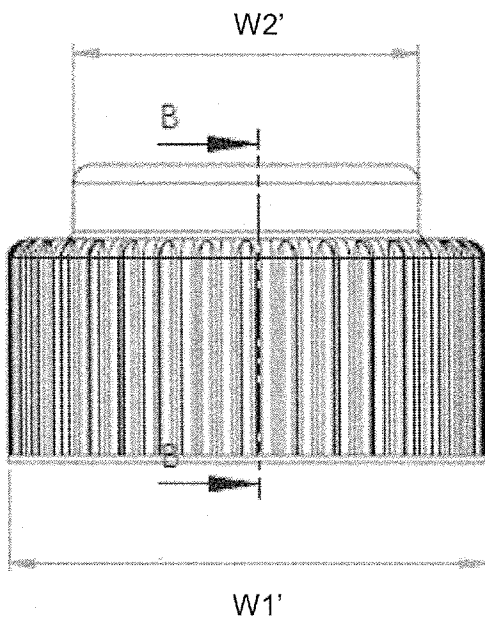


Figure 14c

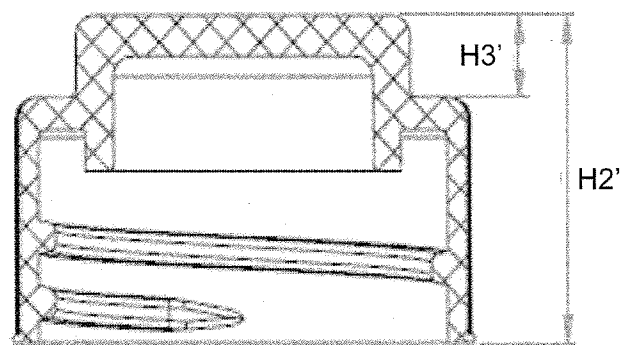


Figure 14d

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2016/050212

A. CLASSIFICATION OF SUBJECT MATTER

A01N 1/02 (2006.01) B01L 3/00 (2006.01)

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A01N, B01L

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)

FamPat: vial, container, cryopreservation, stackable, cap, lid, cover, engage and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/0226719 A1 (PARK J. S.) 22 September 2011 figures 9-10 & 14; para.[0002], [0052]-[0053]	1-29
X	CN 203732300 U (LANZHOU INST ANIMAL SCIENCE & VETERINARY PHARMACEUTICS CAAS) 23 July 2014 figure 1; page 1, paragraph 1; page 5, paragraph 3 of the machine translation	1-29
X	CN 201224536 Y (YE S.) 22 April 2009 figures 3-4; page 2, paragraph 1; page 5, paragraph 2 of the machine translation	1-29
X	US 2014/0360908 A1 (SORENSEN S. M. ET AL.) 11 December 2014 figures 1-3; para.[0044]-[0067]	1-29
X	EP 1702854 A1 (TECHNE TECHNIPACK ENGINEERING ITALIA S.P.A.) 20 September 2006 figures 1-3; para.[0001], [0003]-[0006]	1-29

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

☒ See patent family annex.

*Special categories of cited documents:

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"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

Date of the actual completion of the international search

24/06/2016

(day/month/year)

Date of mailing of the international search report

21/07/2016

(day/month/year)

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2016/050212**C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/0095009 A1 (HUET S. ET AL.) 18 April 2013 figures 1-19; para.[0002]&[0022]-[0030]	1-29
X	US 2014/0014550 A1 (BARROW D. A.) 16 January 2014 figures 11-17; para.[0003], [0006], [0042]-[0043]&[0062]-[0075]	1-29

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG2016/050212

Note: This Annex lists known patent family members relating to the patent documents cited in this International Search Report. This Authority is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US2011226719 (A1)	22/9/2011	US2014061086 (A1) US2014061150 (A1)	6/3/2014 6/3/2014
CN203732300 (U)	23/07/2014	NONE	
CN201224536 (Y)	22/04/2009	NONE	
US2014360908 (A1)	11/12/2014	WO2014197817 (A1)	11/12/2014
EP1702854 (A1)	20/9/2006	ITBO20050011 (U1)	16/9/2006
US2013095009 (A1)	18/4/2013	EP2585576 (A1) ES2490992 (T3) FR2961525 (A1) JP2013529460 (A) WO2011160911 (A1)	1/5/2013 4/9/2014 23/12/2011 22/7/2013 29/12/2011
US2014014550 (A1)	16/1/2014	WO2012094114 (A2)	12/7/2012