

FILTER CAPSULE ASSEMBLY AND METHOD FOR ASSEMBLY THEREOF**BACKGROUND OF THE INVENTION**

[0001] A variety of filter capsules are commercially available. However, there is a need for improved filter capsules.

[0002] The present invention provides for ameliorating at least some of the disadvantages of the prior art. These and other advantages of the present invention will be apparent from the description as set forth below.

BRIEF SUMMARY OF THE INVENTION

[0003] In an embodiment, the present disclosure provides a filter assembly comprising a first housing including an inlet, and a first cavity, a second housing including an outlet, and a second cavity, and a cassette including a first planar side and a second planar side, and a cassette outlet. The first planar side and the second planar side each include an inner and outer surface, the inner surfaces of the first and second planar sides delimiting a cassette cavity. The first and second housing are configured to be joined such that the cassette is arranged within the first cavity and the second cavity. The inlet is in fluid communication with the outlet through the cassette cavity and the cassette outlet.

[0004] In an embodiment, the present disclosure provides a filter cassette configured for arrangement in a pressurized filter capsule, the cassette comprising a first planar side delimiting a first outer surface of the cassette and a first inner surface, a second planar side delimiting a second outer surface of the cassette opposite the first outer surface and a second inner surface. The first inner surface and the second inner surface further delimit a cassette cavity, and at least one of the first outer surface and the second outer surface includes a grid of openings in fluid communication with the cassette cavity. The cassette comprises an outlet protruding from the first planar side and the second planar side and in fluid communication with the cassette cavity and a membrane arranged on the grid of openings upstream of the cassette cavity.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0005] Subject matter of the present disclosure will be described in even greater detail below based on the exemplary figures. All features described and/or illustrated herein can be

used alone or combined in different combinations. The features and advantages of various implementations will become apparent by reading the following detailed description with reference to the attached drawings, which illustrate the following:

[0006] FIG. 1 illustrates a right side view of an assembled filter assembly (filter capsule) according to an embodiment of the present disclosure;

[0007] FIG. 2 illustrates a front view of an assembled filter capsule according to an embodiment of the present disclosure;

[0008] FIG. 3 illustrates a left side view of an assembled filter capsule according to an embodiment of the present disclosure;

[0009] FIG. 4 illustrates a top view of an upper housing according to an embodiment of the present disclosure;

[0010] FIG. 5 illustrates a bottom view of a lower housing according to an embodiment of the present disclosure.

[0011] FIG. 6 illustrates a right side cross-sectional view of an assembled filter capsule according to an embodiment of the present disclosure;

[0012] FIG. 7 illustrates a front cross-sectional view of an assembled filter capsule according to an embodiment of the present disclosure;

[0013] FIG. 8 illustrates a left side cross-sectional view of an assembled filter capsule according to an embodiment of the present disclosure;

[0014] FIG. 9 illustrates a top view of a cassette arranged in a lower housing according to an embodiment of the present disclosure;

[0015] FIG. 10 illustrates a top cross-sectional view of a cassette arranged in a lower housing according to an embodiment of the present disclosure;

[0016] FIG. 11 illustrates a perspective view of a cassette according to an embodiment of the present disclosure;

[0017] FIG. 12 illustrates a front view of a cassette according to an embodiment of the present disclosure;

[0018] FIG. 13 illustrates a rear view of a cassette according to an embodiment of the present disclosure; and

[0019] FIG. 14 illustrates a bottom view of a cassette according to an embodiment of the present disclosure;

[0020] FIG. 15 illustrates a side view of a cassette according to an embodiment of the present disclosure;

[0021] FIGS. 16 and 17 illustrate exploded views of a filter capsule according to an embodiment of the present disclosure;

[0022] FIG. 18 illustrates a perspective view of a lower housing of a filter capsule according to an embodiment of the present disclosure;

[0023] FIG. 19 illustrates the lower housing of FIG. 18 with an inserted cassette according to an embodiment of the present disclosure;

[0024] FIG. 20 illustrates a front view of a cassette with a membrane according to an embodiment of the present disclosure; and

[0025] FIG. 21 illustrates a rear view of a cassette with a membrane according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0026] FIG. 1 illustrates a right side view of an assembled filter assembly (filter capsule) 100 according to an embodiment of the present disclosure. The filter capsule 100 includes a first or upper housing 102 and a second or lower housing 122 that are joined together in a sealing manner to form a liquid-tight capsule configured to filter a pressurized liquid. The upper housing 102 includes an inlet 104 for receiving a liquid that is to be filtered, the inlet 104 including a fitting 106. In the illustrated embodiment, the fitting 106 comprises a clamp ferrule fitting that may be joined with a corresponding fitting to provide the liquid to be filtered to the inlet 104. It will be readily appreciated, however, that fitting 106 may comprise a variety of forms without departing from the spirit of the present disclosure. For example, the fitting 106 may comprise a barbed fitting, a threaded adapter or bushing, or various types of clamped fittings according to the needs of the particular device or system to which the filter capsule 100 is adapted. The filter capsule thereby provides for versatile connectivity to varying systems and applications.

[0027] The upper housing 102 also includes a vent 108 and a welding interface 112. The vent 108 allows a medium within the filter capsule 100 to be vented to an external environment, thereby purging and/or depressurizing the filter capsule, and also allows for fluid sampling. For example, if air is trapped in the filter assembly, the vent 108 may be temporarily opened to provide for venting of air, thus ensuring only non-compressible liquid remains in the filter capsule for a more stable flow and filtration within. Alternatively, or additionally, the vent 108 may be opened to allow a fluid sample to be taken. The vent 108 includes a vent fitting 110. In the illustrated embodiment, the vent fitting 110 is a Luer lock

fitting configured to provide a pressurized seal of the filter capsule in a closed position and that can be opened to an open position via rotational removal vent fitting 110. It will be readily appreciated that the vent fitting 110 may have varying shapes and/or dimensions in order to provide a user with an interface by which the vent may be selectively opened and closed without departing from the spirit of the present disclosure. The upper housing 102 and lower housing 122 each include a welding interface 112, the welding interfaces providing an increased diameter of the housing in order to ensure sufficient surface area by which the upper and lower housings 102, 122 may be joined is provided.

[0028] The lower housing 122 includes an outlet 124 with a fitting 126 by which the lower housing 122 may be connected to a corresponding fitting of another pipe, device, and/or system. In the illustrated embodiment, the fitting 126 is a barbed fitting which may be inserted into a flexible tube to form a frictional interference fit. As with the fitting 106 of the upper housing, it will be readily understood that the fitting 126 of the lower housing 122 may be of a type, shape, and/or size that varies from that of the illustrated fitting 126 without departing from the spirit of the present disclosure.

[0029] FIG. 2 illustrates a front view of the assembled filter capsule 100 according to FIG. 1. The assembled filter capsule 100 includes an upper housing 102 joined with a lower housing 122. The upper housing includes a vent with a vent fitting 110 configured to provide for selective opening and closing of the vent.

[0030] FIG. 3 illustrates a left side view of the assembled filter capsule 100 according to FIGS. 1 and 2. In the illustrated embodiment, the left side of the filter capsule 100 is symmetrical to the right side of the filter capsule (as illustrated in FIG. 1). It will be readily appreciated that minor asymmetries may be incorporated into either side of the filter capsule 100 in order to orient a user during installation, to provide identifying markings, instructions, and/or other types of printed characters with varying purposes without departing from the spirit of the present disclosure.

[0031] FIG. 4 illustrates a top view of the upper housing 102 according to FIGS. 1-3. The fitting 106 of the inlet has an opening connecting the external environment to a cavity within the upper housing 102, which includes other features that will be described hereafter.

[0032] FIG. 5 illustrates a bottom view of the lower housing 122 according to FIGS. 1-3. The fitting 126 of the outlet has an opening connecting the external environment to a cavity within the lower housing 122, which includes other features that will be described hereafter.

[0033] FIG. 6 illustrates a right side cross-sectional view of an assembled filter capsule 600 (without a membrane covering a grid on the cassette (discussed below; *see also*, Fig. 20))

according to an embodiment of the present disclosure. The cross-section is offset from a centerline of the filter capsule in order to illustrate a cassette 630 more clearly. The filter capsule 600 includes a first or upper housing 602 and a second or lower housing 622 that are joined together in a sealing manner to form a liquid-tight capsule configured to filter a pressurized liquid. The upper housing 602 includes an inlet 604 for receiving a liquid that is to be filtered, the inlet 604 including a fitting 606. In the illustrated embodiment, the fitting 606 comprises a clamp ferrule fitting that may be joined with a corresponding fitting to provide the liquid to be filtered to the inlet 604.

[0034] The upper housing 602 also includes a vent 608. The vent 608 allows a medium within the filter capsule 600 to be vented to an external environment, thereby purging and/or depressurizing the filter capsule, and also allows for fluid sampling. The vent 608 includes a vent fitting 610. In the illustrated embodiment, the vent fitting 610 is a Luer lock fitting configured to provide a pressurized seal of the filter capsule in a closed position and that can be opened to an open position via rotational removal of vent fitting 610. The upper housing 602 and lower housing 622 are joined at a joining surface 611 extending circumferentially about each of the upper housing 602 and lower housing 622. The joining surface 611 may comprise an interface at which material making up the upper housing 602 and the lower housing 622 are welded together in order to form a liquid-tight and pressure-rated seal of the inner cavities of the upper housing 602 and lower housing 622. It will be readily recognized that other joining methods may be employed in order to join the upper housing 602 and lower housing 622 without departing from the spirit of the present disclosure. For example, an adhesive and/or a sealant may be used to join the upper housing 602 and lower housing 622.

[0035] The filter capsule 600 also includes a cassette 630 arranged within a cavity formed by the upper and lower housings 602, 622. The cassette 630 includes a grid 632 on at least one of the two sides of the cassette with a plurality of openings configured to allow for passage of liquid that is introduced into the cavity of the filter capsule 600 via inlet 604. The liquid passing through the grid 632 then passes through an internal cavity of the cassette 630 and out of cassette outlet 638 into the outlet 624 of the lower housing. A plurality of hold-up openings 633 are arranged between the grid 632 and the cassette outlet 638. The hold-up openings 633 provide for passage of liquid that rests outside of the cassette 630 but below the grid 632, thereby reducing hold-up volume of the filter capsule 600 by ensuring that as much liquid as possible can enter the cassette without being stuck between the cassette 630 and the lower housing 622. In the illustrated embodiment, the hold-up openings 633 include a plurality of parallel slits extending partially onto the cassette outlet 638. It will be readily

appreciated, however, that the hold-up openings may vary in shape, size, or quantity and nonetheless provide for a reduction of hold-up volume without departing from the spirit of the present disclosure. A membrane is mounted over the grid upstream of the liquid flow previously described, thus providing for filtration of the liquid as it passes through the grid, and thereby ensuring liquid that enters the inlet 604 of the upper housing is filtered before it exits the filter capsule 600 via outlet 624. The illustrated cassette outlet 638 includes an O-ring 640 to prevent unfiltered liquid from exiting via outlet 624. However, an O-ring is not required. For example, the cassette can be welded into place, with the weld acting as a seal.

[0036] FIG. 7 illustrates a front cross-sectional view of an assembled filter capsule 600 according to an embodiment of the present disclosure. The upper housing 602 includes ribs 642 and the lower housing 622 includes ribs 644. The ribs 642, 644 of each housing 602, 622 are configured to abut on either side and secure in place the cassette 630 within the internal cavity of the filter capsule. The cassette 630 includes a grid 632 and hold-up openings 633 on two opposing sides, thereby allowing for liquid to flow into an internal cavity of the cassette 630 from either side of the cavity in which the cassette 630 is arranged. Although the cassette 630 includes identical grids 632 on either side of the cassette 630 in the illustrated embodiment, it will be readily understood that a grid 632 may be included on just one side of the cassette 630 and that the grid 632 may have a variety of shapes, sizes, and dimensions according to the particular filtering needs that the filter capsule 600 is configured to address. For example, a single, smaller grid that occupies only a small proportion of the surface area of one side of the cassette 630 may be employed in applications where liquid flow rates are low and the filtration can thus be accomplished by smaller membrane. Alternatively, the cassette 630 may include a maximally sized grid 632 (as in the illustrated embodiment) in order to accommodate higher liquid flow rates, provide faster filtration, and/or increase a filter capsule's useful life. Embodiments of the present disclosure thus provide a filter capsule that can be adapted for a variety of applications or customized according to need, thus ensuring versatile utility and maximized use potential.

[0037] FIG. 8 illustrates a left side cross-sectional view of an assembled filter capsule 800 according to an embodiment of the present disclosure. The cross-section is offset from a centerline of the filter capsule in order to illustrate extension of optional guide pins 842, 844 within an internal cavity of the filter capsule 800. The filter capsule includes a vent fitting 810 that may not only seal the end of a vent, but may also include a plug 811 configured to be inserted at least partially into the vent, thereby increasing the pressure rating of the vent fitting and ensuring proper closure when closed. As noted above the vent 108 also allows for

fluid sampling. The upper housing 802 of the filter capsule 800 includes optional guide pins 842 and the lower housing 822 includes optional guide pins 844. The guide pins are configured to be inserted into a cassette 830 arranged within the filter capsule 800, thereby securing the cassette in place. The guide pins 842, 844 act as assembly and location guides with corresponding guide pin openings of the cassette 830, which will be illustrated and described in greater detail hereafter. However, guide pins and guide pin openings are optional for any embodiment of the invention. While this illustrated embodiment shows two first guide pins, two second guide pins, two first guide pin openings and two second guide pin openings, embodiments of the invention can include at least one first guide pin and at least one first guide pin opening and/or at least one second guide pin and at least one second guide pin opening; or an embodiment of the invention is without a first guide pin and a first guide pin opening and/or without a second guide pin and a second guide pin opening. Illustratively, an embodiment without guide pins and guide pin openings can be produced by, for example, using an external guide on either side of the cassette to guide the cassette into place, or, for example, inserting a pin temporarily through the cassette to guide the cassette into the housing, followed by removing the pin.

[0038] FIG. 9 illustrates a top view of a cassette 930 arranged in a lower housing 922 to form a partial assembly 900 according to an embodiment of the present disclosure. The illustrated cassette 930 includes optional guide pin openings 902 for receiving optional guide pins. The cassette 930 also includes peripheral sealing surfaces 934 configured to form a seal between the cassette 930 and the membrane. The lower housing 922 includes a joining surface 906 configured to join and form a seal with a corresponding joining surface of an upper housing. The lower housing 922 also includes a circumferential support 904 configured to provide structural rigidity to the lower housing 922 while reducing the amount of material required to form the inner surfaces and structure of the lower housing 922.

[0039] FIG. 10 illustrates a top cross-sectional view of a cassette 1030 arranged in a lower housing 1022 to form a partial assembly 1000 according to an embodiment of the present disclosure. The lower housing 1022 includes a ribs 1002 configured to abut the cassette 1030 and secure the cassette 1030 in place within a cavity 1028 of the lower housing 1022. In the illustrated embodiments, only the upper end of the ribs 1002 are shown, which have a smaller width compared to the lower end of the ribs 1002. As such, the upper ends of the ribs 1002 do not directly contact the cassette 1030, whereas other portions of the ribs 1002 will directly contact either side of the cassette 1030. The lower housing 1022 also includes circumferential supports 1004 and lateral supports 1005 to form a grid-like support

structure about the cavity 1028. The grid-like support structure is understood to provide structural rigidity to the lower housing 1022 and enables the lower housing 1022 to be manufactured using a smaller quantity of material. In some embodiments, the grid-like support structure may have a shape or configuration that varies from the illustrated embodiment. For example, a honeycomb structure may also be suitable for providing support the lower housing 1022 while reducing the weight or quantity of material of the lower housing 1022.

[0040] FIG. 11 illustrates a perspective view of a cassette 1100 according to an embodiment of the present disclosure. The cassette 1100 includes a first side 1102 and a second side 1104. An outer surface of each of the first and second sides 1102, 1104 delimit the outer periphery of the cassette 1100. An inner surface of each of the first and second sides 1102, 1104 delimit a cavity of the cassette 1100. The cassette 1100 includes a cassette outlet 1110 that protrudes from the first and second sides and is in fluid communication with the cavity of the cassette 1100 such that liquid that enters the cavity may exit through the cassette outlet 1110. The illustrated cassette outlet 1110 includes a recess or groove 1112 in which an O-ring may be arranged in order to seal a space between the cassette outlet 1110 and a lower housing when the cassette 1100 is inserted in the lower housing. However, neither a recess or groove nor an O-ring is required. For example, the cassette can be welded into place, with the weld acting as a seal.

[0041] The outer surface of the first side 1102 includes a membrane recess 1108 in which a membrane may be arranged, as will be described in greater detail hereafter. The first and second sides 1102, 1104 include flattened ends 1106 on opposing sides of the cassette 1100. The flattened ends 1106 ensure that the cassette 1100 can fit within the cavity formed by the upper and lower housings of a filter capsule and also create a void in the cavity through which liquid may flow from an upper housing inlet to grids on one or more of the first and second side 1102, 1104 of the cassette 1100. The illustrated cassette 1100 also includes optional guide pin openings 1114 through which optional guide pins of the lower housing may be inserted. Similar optional guide pin openings are also arranged on an opposing and upper end of the cassette 1100 that are configured to receive optional guide pins of the upper housing.

[0042] FIG. 12 illustrates a front view of a cassette 1100 according to an embodiment of the present disclosure. The cassette 1100 includes a grid 1202 in the membrane recess 1108 and hold-up openings 1203 partially in the membrane recess 1108 and partially on the cassette outlet 1110. The grid 1202 includes openings that provide fluid connection of an

internal cavity of the cassette with an environment external to the cassette. The hold-up openings 1203 also provide for fluid connection of an internal cavity of the cassette with an environment external to the cassette.

[0043] FIG. 13 illustrates a rear view of a cassette 1100 according to an embodiment of the present disclosure. The cassette 1100 includes a grid 1302 and hold-up openings 1303 on at least one side, thereby providing a plurality of openings through which liquid may pass from outside of the cassette into an internal cavity of the cassette. In the illustrated embodiment, the grid is formed by a plurality of parallel linear openings. However, variations in the size, dimensions, and general shape of the grid and/or openings may be implemented without departing from the spirit of the present disclosure. For example, an array of openings with varying numbers of columns and/or rows may form the grid 1302. Regardless of the particular shape or form of the openings forming the grid 1302, the openings provide for flow of liquid into an internal cavity of the cassette 1100.

[0044] FIG. 14 illustrates a bottom view of a cassette 1100 according to an embodiment of the present disclosure. The cassette includes a circular cassette outlet 1110. In some embodiments, the cassette outlet 1110 may include flattened ends that are coplanar with the outer surface of the sides forming the cassette 1100, thereby maintaining a planar outer profile along an entire height of the cassette 1100. The cassette 1100 includes guide pin openings 1114 configured to receive guide pins of a lower housing.

[0045] FIG. 15 illustrates a side view of the cassette 1100 according to FIG. 14.

[0046] FIG. 16 illustrates an exploded view of a filter capsule assembly 1600 according to an embodiment of the present disclosure. In particular, an upper housing 1602 and internal components thereof are illustrated, as well as a cassette 1620 that is configured for arrangement within the filter capsule assembly 1600, and partially within and between the upper housing 1602 and lower housing 1622. The upper housing 1602 includes an upper housing cavity 1608 in which a plurality of ribs 1604 and optional guiding pins 1606 are arranged. The ribs 1604 are arranged in parallel to one another and extend in a direction from an inlet of the upper housing 1602 and towards an open end of the upper housing 1602. The arrangement of the ribs 1604 is configured such that when the filter capsule 1600 is fully assembled, the ribs 1604 abut against either side of the cassette 1620 and/or a membrane mounted thereon (which will be described in greater detail hereafter), thereby helping secure the cassette 1620 and/or membranes within the upper housing 1602. In addition, the ribs 1604 guide the flow and flow distribution of a liquid received into the upper housing 1602 via its inlet, thereby ensuring predictable and balanced flow of the liquid to be filtered towards the

outer surface or surfaces of the cassette 1620, which provide for filtration of the liquid. The ribs 1604 also reduce the surface area of the cassette and/or membranes mounted thereon that is directly exposed to contact with the liquid to be filtered, thereby reducing an internal wetted area. Accordingly, it will be readily appreciated that the ribs 1604 may be modified in dimension and/or shape to adapt to a particular use case or application as needed without departing from the spirit of the present invention. For example, in applications where smaller filtration area is desired, the ribs 1604 may have an increased width to further reduce the internal wetted area of the cassette.

[0047] The optional guide pins 1606 are arranged to extend in a similar manner to the ribs and serve to help secure the cassette 1620 within the upper housing 1602. The optional guide pins 1606 are configured to penetrate openings of the cassette 1620 that are sized to act as assembly and location guides with the optional guide pins 1606. When penetrating the cassette 1620, the guide pins 1606 (if present) extend into an internal cavity of the cassette 1620.

[0048] The upper housing cavity 1608 is sized and shaped to receive the cassette 1620. The upper housing 1602 also includes circumferential supports 1623 and lateral supports 1614 that provide structural rigidity for the upper housing 1602 as a whole and strengthen it for an increased pressure rating. At the same time, the circumferential supports 1623 and lateral supports 1614 allow reduction in the quantity of material required for forming the upper housing 1602 as a whole. The hemispherical shape of the upper housing 1602 further contributes to its rigidity and ability to form a pressure vessel that can withstand increased internal pressure. The upper housing 1602 includes an upper joining surface 1610 by which the upper housing 1602 may be joined to the lower housing 1622. In some embodiments, the upper and lower housing 1602, 1622 are joined by welding. The shape of the upper housing 1602 and lower housing 1622 is such that an assembled filter capsule has a generally spherical shape. As used in the present disclosure, the terms “spherical” and “hemispherical” may include exact spheres and hemispheres, and may also include slight modifications departing from perfectly spherical or hemispherical shapes. For example, some embodiments of the present disclosure provide upper and lower housings that are slightly ovular at their joining interface, thus slightly deviating from a perfectly circular interface or perfectly hemispherical overall design. The ovular nature of the deviated shape may ensure that the upper and lower housings are oriented and aligned properly when they are joined together, thereby ensuring proper manufacture of a filter capsule.

[0049] FIG. 17 illustrates the filter capsule assembly 1600 of FIG. 16 from a different perspective that more clearly shows features of the cassette 1620 and internal features of the lower housing 1622. The cassette 1620 includes a grid 1616 formed by a plurality of openings that provide fluid communication between an internal cavity of the cassette 1620 and an external environment or, in an assembled state of the filter capsule, between an internal cavity of the cassette 1620 and the internal volume of the filter capsule configured to receive a liquid to be filtered. The illustrated cassette 1620 further includes an optional O-ring 1618 configured to seal against an internal surface of the lower housing 1622 and thereby prevent liquid that is to be filtered from bypassing the cassette 1620 and exiting the filter capsule without first being filtered. However, as noted above, an O ring is not required. For example, the cassette can be welded into place, with the weld acting as a seal.

[0050] In similar fashion to the upper housing 1602, the lower housing 1622 may include a plurality of ribs 1624 and optional guide pins 1626 in a lower housing cavity 1628. The upper housing cavity 1608 and the lower housing cavity 1628 are configured to be joined to form a larger unitary cavity within which the cassette 1620 is arranged. The lower housing 1622 also includes circumferential supports 1632 and lateral supports 1634 that provide structural rigidity for the lower housing 1622 as a whole and strengthen it for an increased pressure rating. The hemispherical shape of the lower housing 1622 further contributes to its rigidity and ability to form a pressure vessel that can withstand increased internal pressure. The lower housing 1622 includes a lower joining surface 1630 by which the lower housing 1622 may be joined to the upper housing 1602.

[0051] FIG. 18 illustrates a perspective view of a lower housing 1622 of a filter capsule according to an embodiment of the present disclosure. The lower housing 1622 includes a lower housing cavity 1628 in which a plurality of ribs 1624 are arranged. In the illustrated embodiment, ten ribs separated in two groups of five equidistantly arranged ribs are arranged on either side of the lower housing cavity 1628, providing for a total of 20 ribs. It will be readily appreciated, however, that the number or particular arrangement of the ribs within the housing cavity 1628 may be modified without departing from the spirit of the present disclosure. The ribs 1624 each include a chamber 1625 to facilitate guided insertion of a cassette into the lower housing cavity 1628. In the illustrated embodiment, two guide pins 1626 are also arranged in the lower housing cavity 1628 to act as assembly and location guides. The guide pins 1626 are configured to be inserted into a cassette to help secure the cassette in place together with the ribs 1624. In some embodiments, the guide pins 1626 may be arranged on ribs 1624. In some embodiments, the guide pins 1626 may be formed of an

entirely separate structure than ribs 1624. The guide pins 1626 each include chambers 1627 to facilitate guided insertion of a cassette into the lower housing cavity 1628.

[0052] FIG. 19 illustrates the lower housing 1622 of FIG. 18 with an inserted cassette 1620 according to an embodiment of the present disclosure. The cassette 1620 is seated within the lower housing by insertion into the lower housing cavity 1628. The arrangement of the cassette 1620 can be precisely controlled due to the arrangement of ribs 1624 in the lower housing 1622, which abut either outer side of the cassette 1620, and due to the penetration of the guide pins 1626 into corresponding guide pin openings 1902 of the cassette. Although if guide pins and guide pin openings are present, the guide pin opening 1902 visible in FIG. 9 is configured to receive a guide pin of an upper housing, not the illustrated lower housing 1622, it will be readily appreciated that a similar opening may be arranged at a lower end of the cassette to mate with a guide pin 1626 of the lower housing 1622. The illustrated cassette 1620 includes a grid for enabling liquid to be filtered to enter an internal cavity of the cassette. By providing a filtering membrane on the grid 1908, liquid to be filtered can thus be guided through the filtering membrane before it enters the internal cavity of the cassette 1620 and exits an outlet of the lower housing 1622. The cassette 1620 generally has a paddle-like shape with a circular planar surfaces that form the sides of the cassette 1620 that interface with a liquid to be filtered. The outer periphery of the circular planar surfaces can include peripheral sealing surfaces 1906 that are configured to abut an internal and corresponding surface of the upper housing, thereby forming a liquid-tight seal along each peripheral sealing surface 1906. The cassette also can include similar peripheral sealing surfaces on an opposing lower end of the cassette to form a liquid-tight seal with one or more internal surfaces of the lower housing 1622. In some embodiments, the cassette may also include flattened ends 1910 that interrupt the circular profile of the peripheral sealing surfaces 1906. The flattened ends 1910 provide a space through which liquid to be filtered may flow around the cassette 1620 so that it can be filtered. Specifically, the peripheral sealing surfaces 1906, if present, guide liquid to be filtered from the inlet of the upper housing down towards the lower housing 1622 between the peripheral sealing surfaces 1906.

[0053] FIG. 20 illustrates a front view of a cassette 2000 according to an embodiment of the present disclosure. The cassette 2000 includes a first planar side 2002. The first planar side 2002 is generally circular shape with flattened ends 2004 that interrupt the circular circumference of the first planar side 2002. A membrane 2006 is welded to the first planar side 2002. In some embodiments, the first planar side 2002 includes a recess sized to fit the membrane 2006, thus allowing the membrane 2006 to be welded in the recess at a depth

offset to outward-facing periphery of the first planar side 2002. The membrane 2006 is generally circular in shape and includes a protrusion 2008. The cassette 2000 includes an outlet 2010 that extends away from the first planar side 2002 and that provides for a fluid connection between an outside of the cassette 2000 and an internal cavity of the cassette 2000. As a result, only liquid that has been filtered (e.g., through one or more membranes 2006) may exit the cassette 2000 via outlet 2010. The protrusion 2008 of the membrane 2006 is configured to be secured to the outlet 2010. The protrusion 2008 ensures coverage of hold-up openings (such as the hold-up openings 633 of FIGS. 6 and 7) by the membrane 2006, thereby ensuring that hold-up volume of a filter capsule may be reduced and ensuring that even liquid that flows too far below the grid of a cassette 2000 can still be filtered and expelled from the filter capsule. In some embodiments, the membrane 2006 is welded to the cassette. In some embodiments, the membrane 2006 may include at least two membrane layers that are laminated together, the membrane layers each configured for filtering liquid that passes through. Support layers may also be included in the membrane 2006 upstream and/or downstream of the membrane layers, thereby providing structural support for the membrane 2006 as a whole and/or facilitating attachment of the membrane to the cassette 2000. The illustrated outlet 2012 includes an optional circumferential groove 2012 in which an optional O-ring is arranged (see, e.g., FIG. 17), thereby ensuring that the outlet 2012 of the cassette provides the exclusive means for liquid that has entered into a filter capsule to exit the filter capsule, though instead of an O-ring and groove, the cassette can be welded into place, the weld acting as a seal.

[0054] FIG. 21 illustrates a rear view of a cassette 2100 with a membrane 2102 according to an embodiment of the present disclosure. The membrane 2102 includes a protrusion 2104 extending onto a cassette outlet 2110 of the cassette 2100. The illustrated cassette outlet 2110 includes an O-ring 2114 configured to seal against a lower housing, though instead of an O-ring, the cassette can be welded into place, the weld acting as a seal.

[0055] Aspect of the invention include filtering fluid using aspects of the filter assembly to remove undesirable material such as, for example, endotoxins, microbial contaminants, microorganisms, soluble and insoluble impurities and/or contaminants, bacteria and/or solid particles, from an aqueous fluid and/or gasses, in a wide variety of filtration applications, for example, but not limited to, the food and beverage industry, and the biopharmaceutical and pharmaceutical industries. Embodiments of the invention are particularly useful as “single use” filters for filtering fluids used in the biopharmaceutical and pharmaceutical industries at all process stages, such as, but not limited to final drug formulations, such as

nanosuspensions including liposomes, emulsions, exosomes and nanospheres; recombinant proteins including monoclonal antibodies, antibody fragments, bispecific antibodies and antibody-drug conjugates; blood products including IVIG and Human Serum Albumin; small molecule drugs, for example, Doxorubicin; viruses for gene therapies including as Adeno Associated virus and Adenovirus; and RNA drugs.

[0056] A variety of filter media such as porous membranes such as microporous membranes are suitable for use in filter assemblies according to aspects of the invention.

[0057] The use of the terms “a” and “an” and “the” and “at least one” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The use of the term “at least one” followed by a list of one or more items (for example, “at least one of A and B”) is to be construed to mean one item selected from the listed items (A or B) or any combination of two or more of the listed items (A and B), unless otherwise indicated herein or clearly contradicted by context. The terms “comprising,” “having,” “including,” and “containing” are to be construed as open-ended terms (i.e., meaning “including, but not limited to,”) unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., “such as”) provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

[0058] Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible

variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

CLAIMS:

Claim 1: A filter assembly comprising:
a first housing including an inlet, and a first cavity;
a second housing including an outlet, and a second cavity; and
a cassette including a first planar side and a second planar side, and a cassette outlet,
wherein the first planar side and the second planar side each include an inner and outer surface, the inner surfaces of the first and second planar sides delimiting a cassette cavity,
wherein the first and second housing are configured to be joined such that the cassette is arranged within the first cavity and the second cavity, and
wherein the inlet is in fluid communication with the outlet through the cassette cavity and the cassette outlet.

Claim 2: The filter assembly of claim 1, wherein at least one of the first and second planar sides includes filter openings, and wherein the cassette includes a membrane arranged over the filter openings on the outer surface of the first and/or second planar side that includes the filter openings.

Claim 3: The filter assembly of claim 2, wherein first housing, the second housing, and the cassette are configured to be joined such that liquid entering the inlet at pressure is configured to pass from the first and/or second cavity into the cassette cavity through the membrane.

Claim 4: The filter assembly of any one of claims 1-3, wherein the first housing includes at least one first guide pin and the second housing includes at least one second guide pin, and the cassette includes at least one first guide pin opening and at least one second guide pin opening, and the first and second guide pins are configured to penetrate a respective first and second guide pin opening.

Claim 5: The filter assembly of any one of claims 1-4, wherein the cassette outlet is cylindrical and protrudes from the first and second planar sides of the cassette, and wherein the cassette outlet is inserted into the outlet of the second housing.

Claim 6: The filter assembly of any one of claims 1-5, wherein each of the first housing and the second housing include a plurality of ribs arranged in the first cavity and second cavity, respectively, the ribs being configured to abut the first and second planar sides of the cassette.

Claim 7: The filter assembly of any one of claims 1-6, wherein first housing and the second housing each have a joining surface, the joining surfaces being non-circular and identical in shape to one another, and wherein the joining surfaces are joined to one another to join the first housing and the second housing.

Claim 8: The filter assembly of any one of claims 1-7, wherein the cassette outlet includes a circumferential groove, and wherein an O-ring is arranged in the circumferential groove.

Claim 9: The filter assembly of any one of claims 1-8, wherein the first housing and the second housing are joined to form a sphere, and wherein the inlet and the outlet protrude from and extend away from the sphere.

Claim 10: The filter assembly of any one of claims 1-9, wherein the inlet and the outlet each include a barbed fitting or a clamp ferrule fitting.

Claim 11: The filter assembly of any one of claims 1-10, wherein the first housing assembly includes a vent.

Claim 12: A filter cassette configured for arrangement in a pressurized filter capsule, the cassette comprising:

- a first planar side delimiting a first outer surface of the cassette and a first inner surface;

- a second planar side delimiting a second outer surface of the cassette opposite the first outer surface and a second inner surface, wherein:

- the first inner surface and the second inner surface further delimit a cassette cavity, and

- at least one of the first outer surface and the second outer surface includes a grid of openings in fluid communication with the cassette cavity;

an outlet protruding from the first planar side and the second planar side and in fluid communication with the cassette cavity; and
a membrane arranged on the grid of openings upstream of the cassette cavity.

Claim 13: The filter cassette of claim 12, wherein the cassette is paddle-shaped, the first planar side and the second planar side being circular.

Claim 14: The filter cassette of claim 12 or 13, wherein both the first outer surface and the second outer surface include grid openings.

Claim 15: The filter cassette of any one of claims 12-14, comprising at least one first guide pin, at least one second guide pin, at least one first guide pin opening, and at least one second guide pin opening wherein the at least one first and second guide pins are received respectively in the at least one first and second guide pin openings.

Claim 16: The filter cassette of any one of claims 12-15, wherein the membrane is arranged in a recess of the first and/or second outer surface.

Claim 17: The filter cassette of any one of claims 12-16, wherein the membrane is configured to at least partially extend along a flattened outer periphery of the outlet.

Claim 18: The filter cassette of any one of claims 12-17, wherein the outlet includes a circumferential groove, and wherein an O-ring is arranged in the circumferential groove.