(19) Ministère de l'Economie et du Commerce extérieur
Office de la propriété intellectuelle

(11) Numéro du brevet d'invention : **91961**

(12) # BREVET D'INVENTION

(45) Date de délivrance du brevet d'invention : **23.09.2013**

(51) Int. Cl.: **B01D63/08**

(22) Date de dépôt : **20.03.2012**

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(54) **MEMBRANE ASSEMBLY**

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(30) Priorité :

(73) Titulaire : **UNIVERSITÉ DU LUXEMBOURG**
162a, AV. DE LA FAÏENCERIE
1511 LUXEMBOURG (LU)

(72) Inventeur : **WILMES PAUL**
CAMPUS BELVAL, 7 AVENUE DES HAUTS-FOURNEAUX
4362 ESCH-ALZETTE (LU)

(74) Mandataire : **OFFICE FREYLINGER S.A.**
234, ROUTE D'ARLON
8001 STRASSEN (LU)

91961

MEMBRANE ASSEMBLY

TECHNICAL FIELD

Embodiments of the invention relate to a membrane assembly and, in particular, a membrane assembly having a seal.

BACKGROUND

Embodiments of the invention are concerned with the use of membranes where the diffusion or flow through the membrane is to be controlled so that a culture may be established on a surface of the membrane. In such applications it is often necessary to control the environment at one or more surfaces of the membrane. To do so it is necessary to prevent the flow of fluids around an edge of the membrane.

It is known to provide a reusable seal such as an O-ring together with a disposable membrane so that the culture may be established at one surface of the membrane and nutrients may be provided to the opposing surface. However, in known arrangements, a support structure such as a retaining ring with support scaffolds is used to ensure that a seal is maintained between the O-ring and the membrane. An example of such a structure is provided at www.kareldomansky.com.

Such known arrangements have the advantage that the O-rings and supporting structures are reusable, but the disadvantage that there is a risk of cross-contamination and leakage due to compression failures of the O-ring. As the membranes and the supporting structure are reduced in size such problems, particularly that of compression failure, become more pronounced as there is an increased risk of significant impurities being located between the seal and the membrane or the supporting structure, leading to a loss of sealing properties.

In known arrangements of smaller membranes with seals, the membrane is provided between two polymer sheets. However, at smaller scales typical of microfluidic apparatus, the pressure which the membrane and the support are subject to is substantially greater than at larger scales.

SUMMARY

Aspects of the invention are set out in the accompanying claims.

It is an object of embodiments of the invention to provide a membrane assembly which is easy to remove and handle.

It is a further object of embodiments of the invention to provide a membrane assembly which is capable of withstanding the operational environment where microfluidic behaviour of fluids occurs. In particular it is desirable to provide a membrane assembly having a membrane and a seal which is capable of withstanding a greater pressure than known arrangements.

According to a first embodiment of the invention, there is provided a membrane assembly comprising a membrane , the membrane having a first surface and a second surface so that material may move from the first surface to the second surface through the membrane, the membrane further having a border defined by at least one edge, the membrane assembly further comprising a seal, wherein the seal adheres to the edge and wherein the seal is formed to encase the edge along at least a portion of the border.

The seal may adhere to the edge by chemical, mechanical or any other known methods.

The seal may encase the edge along an entire length of the border. In an alternative arrangement, the seal may encase the edge along a portion of the border only. An embodiment of such an alternative arrangement further comprises a second seal encasing a second edge along a second portion of the border. The seal and the second seal may, cumulatively, encase an edge along an entire border of the membrane.

The border may define a meeting between the first surface and the second surface.

The membrane may be a semi-permeable membrane which allows passage of material in either direction through the membrane.

The seal may be made from a polymer such as a thermoset polymer and may be injection moulded to adhere to, and encase, the edge along at least a portion of the border.

The membrane may have at least one void formed therein, the void having a void border defined by a void edge, the membrane structure comprising a further seal engaged with the void edge along at least a portion of the void border.

The further seal may be made from a polymer and may be injection moulded to engage with, and encase, the void edge along at least a portion of the void border.

The membrane assembly may further comprise more than one void formed in the membrane, each void having a seal associated with a corresponding void edge thereof.

The membrane assembly may further comprise a support scaffold for supporting the membrane, the support scaffold and the membrane forming a stack having an edge wherein the seal is formed to encase the edge along at least a portion of the void border. The stack may further comprise other structures such as a retaining ring for retaining a sample.

A further aspect of the invention extends to a plural membrane structure comprising a first membrane assembly and a second membrane assembly, wherein each membrane assembly comprises a membrane having at least one edge and a seal, wherein the seal adheres to the edge and wherein the seal is formed to encase the edge, the seal being comprised of a deformable material, the first and the second membrane assemblies being arranged so that the seal of the first membrane assembly is in contact with the seal of the second membrane assembly to thereby form a channel between the membrane of the first membrane assembly and the membrane of the second membrane assembly.

The plural membrane structure may further comprise a housing for arranging the first membrane assembly relative to the second membrane assembly and for bringing the seal of the first membrane assembly into a sealing engagement with the seal of the second sealing engagement.

The seal of the first sealing assembly and/or the seal of the second sealing assembly may be comprised of an elastomeric material such as a polymer.

A distance between the first membrane and the second membrane may be less than 500 μm, but greater than 50 μm, preferably less than 200 μm, and more preferably about 150 μm.

Either or both of the first and the second membrane assemblies may be membrane assemblies as herein described.

A further aspect of the invention extends to a method of constructing a membrane assembly comprising: providing a membrane having at least one edge; and providing a seal, wherein the method comprises: adhering the seal to the edge so that the seal encases the edge.

The method may further comprise: providing a die having a support for the membrane and a void corresponding to the seal; placing the membrane on the support; and moulding the seal to the edge of the membrane.

The method may further comprise injecting a polymer into the die to form the seal.

The method may further comprise forming one or more voids in the membrane, each void having a void edge, providing a further seal corresponding to each void, and adhering each further seal to the void edge of the corresponding void.

A further aspect of the invention extends to a method of constructing a plural membrane structure, the method comprising:

providing a first membrane assembly and a second membrane assembly, wherein each membrane assembly comprises a membrane having at least one edge and a seal, wherein the seal adheres to the edge and wherein the seal is formed to encase the edge, the seal being comprised of a deformable material;

arranging the first and the second membrane assemblies so that the seal of the first membrane assembly is in contact with the seal of the second membrane assembly to form a channel between the membrane of the first membrane assembly and the membrane of the second membrane assembly.

DESCRIPTION OF ACCOMPANYING FIGURES

Embodiments of the invention are described with reference to the accompanying schematic diagrams where:

Figure 1 is a plan view of a membrane assembly according to an embodiment of the invention;

Figure 2 is a cross-section of the membrane assembly of Figure 1 along the line A-A;

Figure 3 is an enlarged view of a portion of the membrane assembly of Figure 1, shown in cross-section;

Figure 4 is a plan view of a membrane assembly according to a further embodiment of the invention;

Figure 5 is a cross-section of the membrane assembly of Figure 4 along the line B-B;

Figure 6 is a plan view of a membrane assembly according to a further embodiment of the invention;

Figure 7 is a plan view of a membrane assembly according to a further embodiment of the invention;

Figure 8 is a cross-section of the membrane assembly of Figure 7 along the line C-C;

Figure 9 is an enlarged side view of the membrane assembly of Figure 7;

Figure 10 is a plan view of a membrane assembly according to a further embodiment of the invention;

Figure 11 is a cross-section of a membrane assembly according to a further embodiment of the invention;

Figure 12 is a cross-sectional view of a plural membrane structure according to an embodiment of the invention;

Figure 13 is a plan view of a die for moulding a membrane assembly according to an embodiment of the invention;

Figure 14 is a cross-sectional view of a mould for moulding a membrane incorporating the die of Figure 13; and

Figure 15 is a flow diagram of a method for constructing a membrane assembly according to an embodiment of the invention.

DESCRIPTION OF EMBODIMENTS

Embodiments of the invention are described hereafter with reference to the accompanying diagrams.

Figure 1 illustrates a membrane assembly 10 according to an embodiment of the invention. The membrane assembly 10 comprises a membrane 14 and a seal 12. As illustrated in Figure 1, the membrane 14 is formed as a disc having a border 15 defined, in this embodiment, by the circumferential edge of the disc. The seal 12, here in the form of an O-ring, completely surrounds the membrane along the border 15. It is to be realised however that embodiments of the invention are not limited to disc-shaped membranes; embodiments of the invention may take many other forms.

Figure 2 illustrates the membrane assembly 10 of Figure 1 in cross-section along the line A-A of Figure 1. In this embodiment, the seal 12 is formed in as a part-circle (in cross-section) encasing an edge of the membrane 14. The membrane 14 has an upper surface 18 and a lower surface 20. The membrane permits the movement of certain material between the upper surface 18 and the lower surface 20. In certain embodiments of the invention, the membrane permits movement of material in both directions, and disallows the movement of some material in either direction.

It is to be realised however that embodiments of the invention are not limited to the shape of the seal in cross-section.

Figure 3 illustrates a cut-away of the right-hand edge of the membrane assembly 10 of Figures 1 and 2. As shown in this Figure, the membrane 14 comprises an edge formed by the disc of the membrane 14. In this embodiment, the circumferential edge 16, as shown in cross-section, is formed by the perpendicular surface 16 and a portion of the upper surface 18, as well as a portion of the lower surface 20 of the membrane. In this embodiment, the edge 16 defines the border 15 of the membrane 14.

In certain embodiments of the invention, an edge of a membrane comprises a surface with one or more discontinuities (e.g. one or more corners when viewed in cross-section). In embodiments of the invention, the edge may be any portion of the membrane allowing the passage of material (i.e. movement of material from one surface of the membrane to another along a path which is not through the membrane) when the seal is operational.

As illustrated in Figure 3, the seal 12 encases the edge 16 of the membrane 14 by forming a partial circle (when viewed in cross-section) which is in contact with the upper surface 18, and with the lower surface 20. In this embodiment the seal 12 encases the edge along the entire border 15 formed by the circumference of the seal 12. A portion of the seal stands proud of the upper surface and a portion of the seal stands proud of the lower surface (which may be true for seals having shapes other than partial circles, in cross-section, too). In this manner, the seal 12 serves to prevent any material from flowing around the membrane edge. Although this is usually applied to fluids such as gasses and liquids, it is to be realised that embodiments of the invention are equally applicable to solids, as well as mixtures of solids and fluids.

In embodiments of the invention, the seal 12 and the membrane 14 are constructed so that the seal 12 adheres with membrane. This helps to ensure that the seal formed by the seal 12 is more reliable and able to withstand greater pressures than a seal which is mechanically engaged with the membrane. A method of manufacturing the membrane structure 10 is illustrated in Figure 15 and described in greater detail below. In this method, the bond between the seal 12 and the membrane 14 is formed during the solidification of the polymer seal. However, embodiments of the invention are not so limited and other methods of establishing a bond may be used instead. For example, in one embodiment, adhesive may be used as a seal.

In certain embodiments of the invention, the seal encases the edge of the membrane along at least a portion of the border of the seal. This helps to ensure that the membrane assembly is capable of establishing a sealed environment. It is to be realised that the interface between the membrane of the membrane assembly and the surrounding environment (such as the edge of the illustrated embodiments) will depend on the shape of the membrane, the shape of any supporting structure and the use to which the membrane assembly is to be put. Therefore, in this context, it is not always necessary that the seal completely encase the relevant edge of the membrane. In certain embodiments, the seal may cover a corner (when viewed in cross-section), or a rounded portion, of the border of the membrane. However, it has been found that the discontinuous meeting of surfaces of an edge provide a useful bonding point for the seal and thereby strengthen the interface between the seal and the membrane.

Whether the seal is bonded to the membrane by injection moulding or otherwise, embodiments of the invention comprise a seal and a membrane forming a unitary body. In certain embodiments, the seal is integral with the membrane. Having the seal bonded to the membrane has the advantage that the membrane assembly of embodiments of the invention is easy to handle; the seal and the membrane may be simultaneously removed from a holder by engaging with either the seal or the membrane.

Furthermore, because the seal is bonded to the membrane, embodiments of the invention are able to withstand greater pressures than known arrangements having a mechanical join between the membrane and the seal. In one comparative test carried out by the inventors, a membrane assembly according to an embodiment of the invention was able to withstand pressures over 20 times greater than known assemblies (tested at up to 50 μl/min flow rates through 0.45 μm membranes).

Figure 4 illustrates a membrane assembly 30 according to a further embodiment of the invention. The membrane assembly 30 comprises a membrane 34 in a disc-shape having a border 33 defined by a circumference of the membrane 34. The edge of the disc membrane 30 is encased by a seal 32 along the entire border 33. However, this membrane assembly differs from the membrane assembly 10 illustrated in Figure 1 in that there is a void 36 formed in the centre of the disc-shaped membrane 34. The void 36 has a circumferential void edge 37 which forms a border which is covered by a further seal 38.

The membrane assembly 30 is illustrated in cross-section along line B-B in Figure 5. As illustrated in this Figure, the outer circumferential edge of the disc-shaped membrane 34 is encased by seal 32 whereas the inner circumferential edge (or void edge) is encased by the further seal 38. Further seal 38 therefore encompasses the void 36.

Similarly to the embodiment of Figure 1, the seal 32 and the further seal 38 are bonded to the outer circumferential edge and the void edge, respectively and encase the edge along the entire borders formed by the outer circumferential edge 33 and the void edge 37, respectively.

It is to be realised that embodiments of the invention are not limited to a single void being formed in the membrane. Figure 6 illustrates a membrane assembly 50 according to a further embodiment of the invention. The membrane assembly 50 includes a membrane 52 having an outer circumferential edge 51 encased by a seal 54 along the entire length of the border formed by edge 51. Furthermore, the membrane 52 has two voids 56 and 60 formed therein. Each of the voids 56 and 60 have respective void edges 57 and 51, and each void edge is encased by a corresponding seal. Therefore, void 56 has seal 58 and void 60 has seal 62. As in other embodiments, the seals 54, 58 and 62 are bonded to the membrane 52.

It is to be realised that the seals of embodiments of the invention may be bonded to, and encase the edge of, more than a membrane along a border, or a portion of that border, formed by that edge. Figure 11 illustrates a cross-section of a membrane assembly 70 according to a further embodiment of the invention. The membrane assembly 70 comprises a support scaffold 75, a membrane 77 and a retaining ring 74 for holding a sample thereon. The support scaffold 75, membrane 77 and retaining ring 74 are stacked one upon the other to form a stack and a seal 72 is formed to encase the edge of the stack in the manner described above with reference to Figure 2.

Figure 7 illustrates a membrane assembly 120 according to a further embodiment of the invention. The membrane assembly 120 comprises a membrane 122 having a border 130 defined by an outer circumferential edge of the membrane. A seal 126 encases the circumferential edge along an entire length of the border 130. The seal is formed with two depressions 124 which are shown in greater detail in the cross-section of Figure 8 and the side view of Figure 9.

The membrane assembly 120 illustrated in Figures 7, 8 and 9 may be used for cross-filtration applications. Therefore, the sealing provided by the seal of the membrane assembly may be partial, at least with respect to one of the surfaces of the membrane of that assembly. In a further embodiment, the seal 126 does not encase the membrane edges in that portion of the border 130 corresponding to the depressions 124.

Figure 10 illustrates a membrane assembly 140 according to a further embodiment of the invention. The membrane assembly 140 includes a membrane 142 having a border 148 formed by a circumferential edge of the membrane. A first portion of the border 148 is encased by a first seal of a first type 144a. A second portion of the border 148 is encased by a first seal of a second type 146a. A third portion of the border is encased by a second seal of the first type 144b and a fourth portion of the border is encased by a second seal of the second type 146b.

In this embodiment, different portions of the border of the membrane are encased by different seals made from different materials. In the embodiment illustrated the different seals are of two different types, but in other embodiments, there may be seals of three or more different types. Different seals have different characteristics, and therefore may be used for varying applications. In the embodiment illustrated in Figure 10, seals of the first type 144a and 144b are less deformable than the seals of the second type 146a and 146b. This allows the different portions of the seal to effectively seal to a support structure (not shown) having an appropriately varied geometry and composition of engaging parts.

Embodiments of the invention are particularly well suited to establishing cultures in environments having relatively small dimensions. A particular application of embodiments of the invention relates to microfluidics. Microfluidics concerns the study of fluid behaviour in small channels where a channel is an enclosed space in which a fluid is constrained. In these applications, the membrane of embodiments of the invention forms a portion of such a channel and, for this reason, in certain embodiments of the invention, the dimensions of the components of membrane assemblies are constrained.

In many applications of embodiments of the invention, the membrane assembly is compressed in a supporting structure so that the seal or seals of the membrane assembly contact with one or other portions of the supporting structure so that the contact helps to seal the membrane. However, when dealing with small dimensions, such as in microfluidic environments comprising a single membrane having a supporting structure, the supporting structure adds significantly to the size of any channel which can be formed by the membrane assemblies.

Figure 12 is a schematic cross-sectional view of a plural membrane structure 80 according to an embodiment of the invention. The plural membrane structure includes a first membrane assembly 82 and a second membrane assembly 84. The membrane assembly 82 comprises a membrane 82a and a seal 82b. Similarly, the membrane assembly 84 comprises a membrane 84a and a seal 84b. Both membrane assemblies 82 and 84 are of the type illustrated in Figure 1 and described above.

The membrane assembly 84 further comprises an upper support structure 86 and a lower support structure 88. The upper and lower support structures 86 and 88 are shaped so as to retain the first 82 and second 84 membrane assemblies in position and thereby form a housing for the first and second membrane assemblies. Furthermore, the first 82 and second 84 membrane assemblies are located so that the seal 82b of the first membrane assembly is in contact with the seal 84b of the second membrane assembly. In the illustration of Figure 12, the various components are shown with spacing therebetween, to illustrate the distinct components. However, in use, the seal 82b is in contact with the seal 84b, and the upper support structure 86 is in contact with the lower support structure 88 thereby forming a sealed environment in a channel 90 located between membrane 82a and membrane 84a.

In the embodiment illustrated in Figure 12, there are three channels created by the arrangement of the support structures 86 and 88, and the two membranes 82a and 84a: between the upper support structure 86 and the upper membrane 82a a channel 92 is formed; between the upper membrane 82a and the lower membrane 84a a channel 90 is formed; and between the lower membrane 84 and the lower support structure 88 a channel 94 is formed.

In an embodiment, the upper membrane 82a may be of the type illustrated in Figure 6 whereas the lower membrane 84a may be of the type illustrated in Figure 4. In such an embodiment, the upper membrane has two ports and the lower membrane has a single port, the ports being formed by voids in the respective membranes. These ports allow the relatively free movement of material into and out of the channels 90, 92 and 94 (compared to the movement permitted through the membrane).

In embodiments of the type illustrated in Figure 12, the seals of consecutive membrane assemblies contact one another directly. Therefore, the membranes are able to be located significantly closer to one another than in known structures where supports for the seals are needed, in addition to supports for the membranes. It is to be realised that this too is an advantage of having a seal directly bonded to the edge of the membrane in the constituent membrane assemblies.

The seals of membrane assemblies according to embodiments of the invention, and of plural membrane structures, are composed of a deformable material. This ensures that the sealing properties of these assemblies and structures are improved, and provides for a more robust seal in those arrangements where the seals are brought into contact with one another such as the plural membrane structure 80 of Figure 12.

In a preferred embodiment, the distance 'C' between membrane 82a and membrane 84a, is 150 μm. In further embodiments, the distance C is less than 500 μm, but greater than 50 μm, preferably less than 200 μm. It is to be realised however, that the distance C will be chosen in dependence on the application to which the membrane structure is put. In a particular application, microfluidic behaviour is encouraged by selection of the various dimensions of the structures, including the distance C which defines the operational characteristics of channel 90 when microfluidic behaviour is considered. The chosen dimensions will depend on the physical characteristics of the fluids which the structure is intended to retain.

Plural membrane structures of the sort illustrated in Figure 12 are particularly well-suited to having a sample stored in the channel 90. Using this arrangement, it is possible to perfuse across the sample at higher flow rates compared to known arrangements.

In alternate embodiments, the upper and/or lower membranes of the arrangement of Figure 12 may be replaced with grids or support structures for holding a sample. In yet further embodiments, the support structure may be incorporated into the membrane assemblies in the manner discussed above with reference to Figure 11.

Membrane assemblies according to the embodiments of Figures 1 to 10 may also be used, in conjunction with appropriate support structures, to form plural membrane structures of the type illustrated in Figure 12.

The membrane of embodiments of the invention is formed from a polycarbonate material and the seal from a thermoset polymer. Polycarbonates and thermoset polymers (as well as many other known materials from which the seal and the membrane could be constructed) have the advantage of being cheap so that the membrane assembly may be disposed of once its intended function has been fulfilled.

Therefore, in of the embodiments illustrated in Figures 1 to 12 may be formed by a process of injection moulding a seal to bond with the edge of a provided membrane.

A further embodiment of the invention relates to a method of forming a membrane assembly. Figure 13 is a schematic plan view of a die 100 for moulding a membrane assembly according to an embodiment of the invention. The die 100 is shaped from a suitable material such as polycarbonate. The die 100 includes four holes 102 through which screws are threaded to form a mould. The die 100 further comprises a membrane support 106 around which is formed an annular channel 108 having an inlet 104 and an outlet 110.

The die illustrated in Figure 13 is one half of a mould. In use liquid pre-polymer is injected through the inlet 104. At the same time, air is expelled through the outlet 110.

Figure 14 illustrates a cross-section through mould 160 for forming membrane assemblies according to embodiments of the invention. The mould comprises a lower die 100 (as illustrated in Figure 3) and an upper die 110 placed above the lower die 100. The upper die 110 and the lower die 100 are held together by screws not shown in this diagram.

The complete process 150 of manufacturing a membrane assembly using a mould such as the mould 160 is illustrated in Figure 15. In a first step, step 152, the mould is prepared. This will depend on the type of assembly to be constructed, but generally involves cleaning the mould from impurities. In the following step, step 154, a provided membrane is positioned in the mould. Where the mould comprises a die such as die 100 illustrated in Figure 13, the membrane is placed on membrane support 106 so that the edges of the membrane are located over the annular channel 108.

In the following step, step 156, the mould is fastened. Where the mould comprises die 100 this step includes fastening the mould by locating and tightening screws in the holes 102.

In step 158 liquid prepolymer is injected into the mould. In embodiments of the invention, the seal (which is formed by the liquid polymer once it has set) encases the edge of the membrane. Therefore, the mould is formed so that the liquid polymer injected into the die is able to flow around the relevant edge of the membrane. In the die 100 of Figure 13, the liquid polymer is injected into one of the ports 104 so that it encases the edge of the membrane located in the channel 108.

Once the liquid prepolymer has been injected into the mould in step 158, it is cured in step 160. This will depend on the type of polymer used. In this embodiment polydimethylsiloxane is used and the curing involves exposing the mould to a temperature of 80° C for a period of two hours.

Once the polymer of the seals has set, the assembly is removed in step 162. For example, where the die 100 is used, this involves removing the screws located in holes 102.

At a final step, step 164, the stays are removed with an appropriate cutting edge and the membrane assembly undergoes final preparation appropriate to the use to which it will be put. Such final preparation may include sterilization and packaging.

This process may also be adapted to manufacture the membrane assemblies described and illustrated here. Where the membrane assemblies have a void formed therein, this is manufactured by forming a void in the corresponding membrane, prior to step 154. The mould for these assemblies is then formed so that the seal is injection moulded to encase the edge of the void formed in the membrane. More than one void may be formed in the membrane, and a seal provided for each void.

The process described above and illustrated in Figure 15 has been selected to manufacture membrane assemblies in a laboratory environment. It has the advantage that curing does not require complex or expensive equipment and the process can be adapted to design changes relatively easily. However, the process is relatively material and time intensive. Therefore, for mass production of membrane assemblies, the production process and materials used for the production would be altered. Many different types and forms of injection moulding are known and many may be applied to embodiments of the invention. For example, the dies may be constructed from mild steel and held together during the manufacturing process by applied pressure instead of screws. Known bio-compatible thermoset and thermoplastic resins and polymers may be used for the seal and the membrane.

In the embodiments described herein the bonding between the seal and membrane occurs by chemical means. In further embodiments of the invention, the bonding may be mechanical. In a particular example, the material of the seal engages with pores formed in the material of the membrane. In such an example, the seal is made from PDMS and the membrane from Teflon®.

It will be appreciated by the person skilled in the art that various modifications may be made to the above described embodiments without departing from the scope of the present invention.

CLAIMS

1. A membrane assembly (10, 30, 50, 70, 82, 84, 120, 140) comprising a membrane, the membrane having a first surface and a second surface so that material may move from the first surface to the second surface through the membrane, the membrane further having a border (15, 33, 51, 130, 148) defined by at least one edge (16), the membrane assembly further comprising a seal (12, 32, 54, 72, 82b, 84b, 126, 144a) , wherein the seal adheres to the edge and wherein the seal is formed to encase the edge along at least a portion of the border.

2. The membrane assembly according to claim 1 wherein the seal encases the edge along an entire length of the border.

3. The membrane assembly according to claim 1 wherein the seal encases the edge along a portion of a length of the border.

4. The membrane assembly according to claim 3 further comprising a second seal encasing a second edge along a second portion of the border.

5. The membrane assembly according to any preceding claim wherein the membrane is a semi-permeable membrane which allows passage of material in either direction through the membrane.

6. The membrane assembly according to any preceding claim wherein the seal is made from a polymer and wherein the seal is injection moulded to adhere to, and encase, the edge along at least a portion of the border.

7. The membrane assembly according to any preceding claim wherein the membrane has at least one void (36, 56, 60) formed therein, the void having a void border defined by a void edge, the membrane structure comprising a further seal (38, 58, 62) engaged with the void edge along at least a portion of the void border.

8. The membrane assembly according to claim 7 wherein the further seal is made from a polymer and is injection moulded to engage with, and encase, the void edge along at least a portion of the void border.

9. The membrane assembly according to claim 7 or claim 8 further comprising more than one void formed in the membrane, each void having a seal associated with a corresponding void edge thereof.

10. The membrane assembly according to any preceding claim further comprising a support scaffold (75) for supporting the membrane, the support scaffold and the membrane forming a stack having an edge wherein the seal is formed to encase the edge along at least a portion of the void border.

11. The membrane assembly according to claim 11 wherein the stack further comprises a retaining ring (74) for retaining a sample.

12. A plural membrane structure (80) comprising a first membrane assembly (82) and a second membrane assembly (84), wherein each membrane assembly comprises a membrane (82a, 84a) having at least one edge and a seal (82b, 84b), wherein the seal adheres to the edge and wherein the seal is formed to encase the edge, the seal being comprised of a deformable material, the first and the second membrane assemblies being arranged so that the seal of the first membrane assembly is in contact with the seal of the second membrane assembly to thereby form a channel (90) between the membrane of the first membrane assembly and the membrane of the second membrane assembly.

13. The plural membrane structure according to claim 12 further comprising a housing (86, 88) for arranging the first membrane assembly relative to the second membrane assembly and for bringing the seal of the first membrane assembly into a sealing engagement with the seal of the second sealing engagement.

14. The plural membrane structure according to claim 12 or claim 13 wherein the seal of the first sealing assembly and/or the seal of the second sealing assembly is comprised of an elastomeric material, preferably a polymer.

15. The plural membrane structure according to any of claims 12 to 14 wherein a distance (C) between the first membrane and the second membrane is less

than 300 μm, but greater than 50 μm, preferably less than 250 μm, and more preferably about 200 μm.

16. The plural membrane according to any of claims 12 to 15 wherein either or both of the first and the second membrane assemblies are membrane assemblies according to any of claims 1 to 8.

17. A method of constructing a membrane assembly comprising:

providing a membrane having at least one edge; and

providing a seal, wherein the method comprises:

adhering the seal to the edge so that the seal encases the edge.

18. The method according to claim 17 further comprising:

providing a die having a support for the membrane and a void corresponding to the seal;

placing the membrane on the support; and

moulding the seal to the edge of the membrane.

19. The method according to claim 18 further comprising the step of injection moulding a polymer into the die to form the seal.

20. The method according to any one of claims 17 to 19 further comprising forming one or more voids in the membrane, each void having a void edge, providing a further seal corresponding to each void, and adhering each further seal to the void edge of the corresponding void.

21. A method of constructing a plural membrane structure comprising:

providing a first membrane assembly and a second membrane assembly, wherein each membrane assembly comprises a membrane having at least one edge and a seal, wherein the seal adheres to the edge and wherein the seal is formed to encase the edge, the seal being comprised of a deformable material;

arranging the first and the second membrane assemblies so that the seal of the first membrane assembly is in contact with the seal of the second membrane assembly to form a void between the membrane of the first membrane assembly and the membrane of the second membrane assembly.

Abstract

Embodiments of the invention extend to a membrane assembly having a membrane and a seal. Further embodiments extend to a method of manufacturing a membrane assembly and a plural membrane structure comprising at least two of the aforementioned membrane assemblies.

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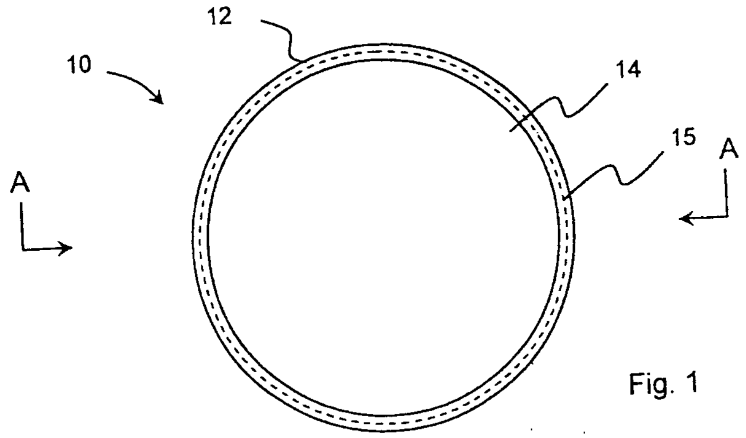

Fig. 1

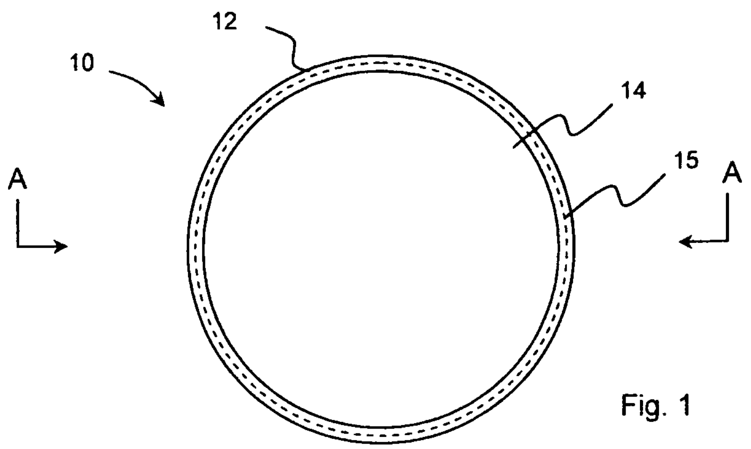

Fig. 1

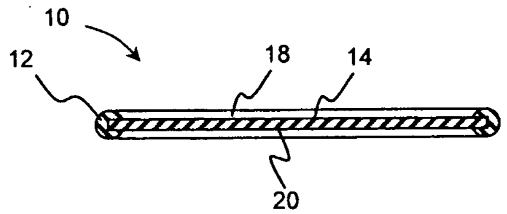

Fig. 2

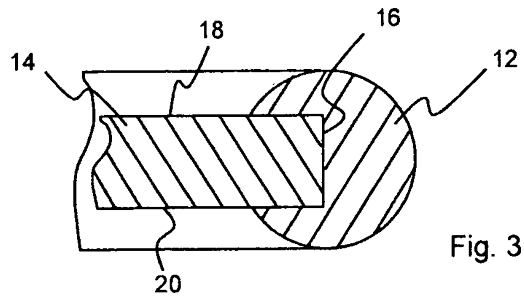

Fig. 3

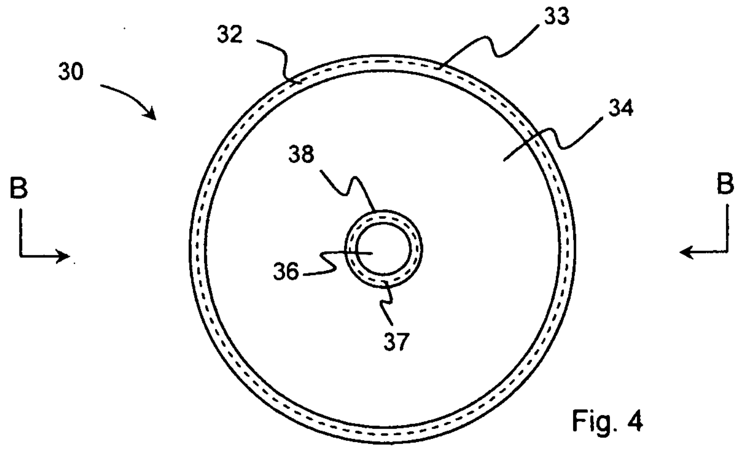

Fig. 4

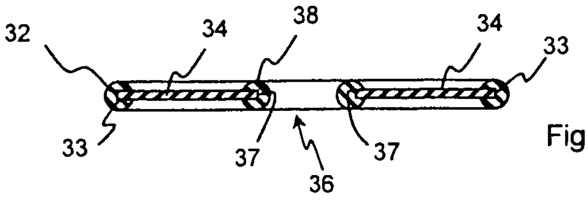

Fig. 5

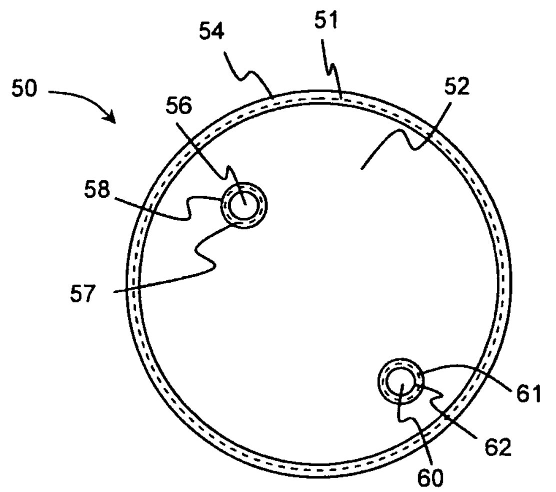

Fig. 6

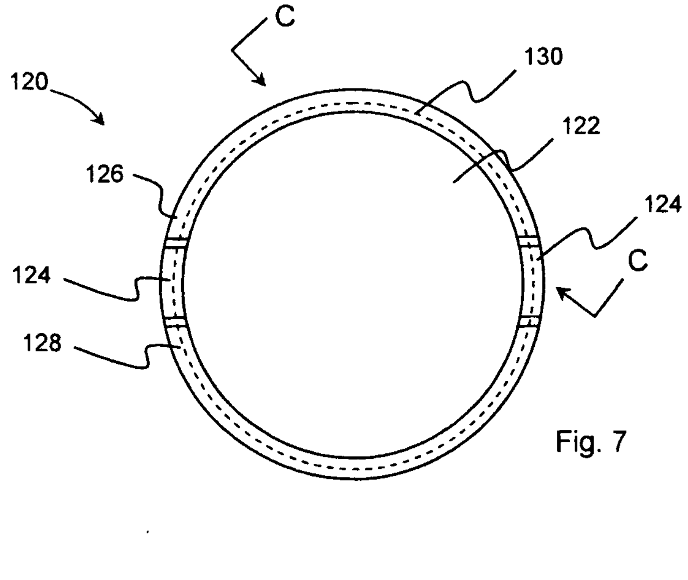

Fig. 7

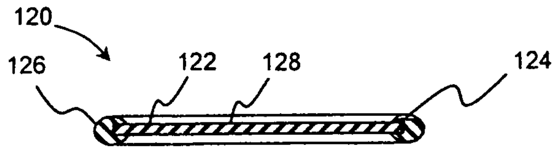

Fig. 8

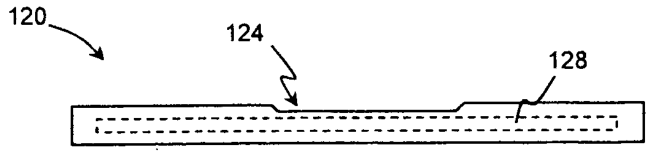

Fig. 9

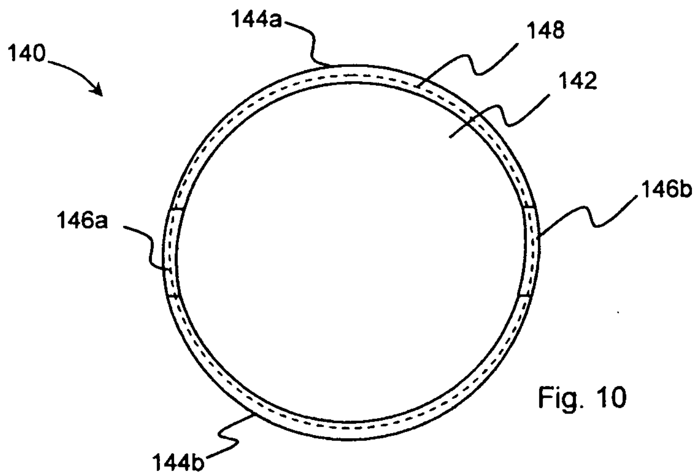

Fig. 10

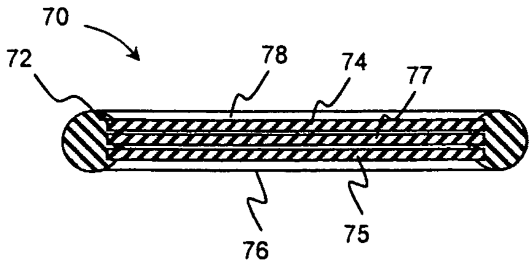

Fig. 11

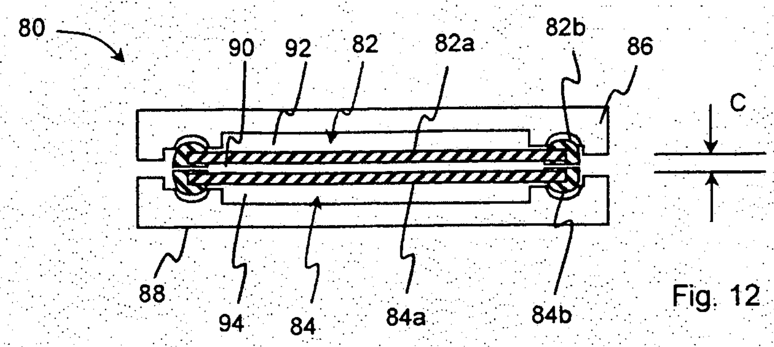

Fig. 12

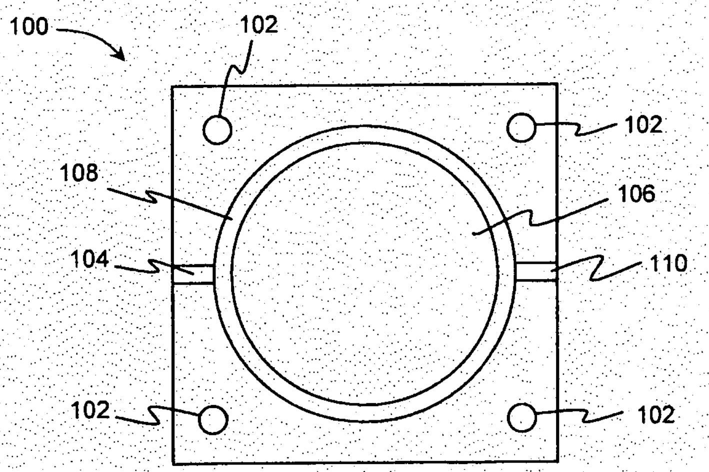

Fig. 13

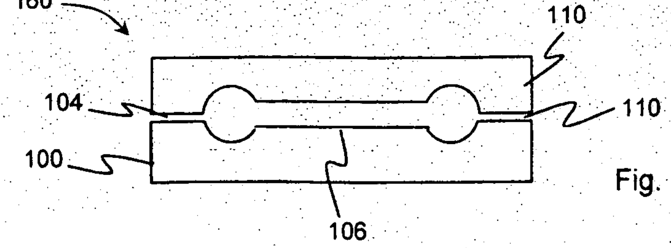

Fig. 14

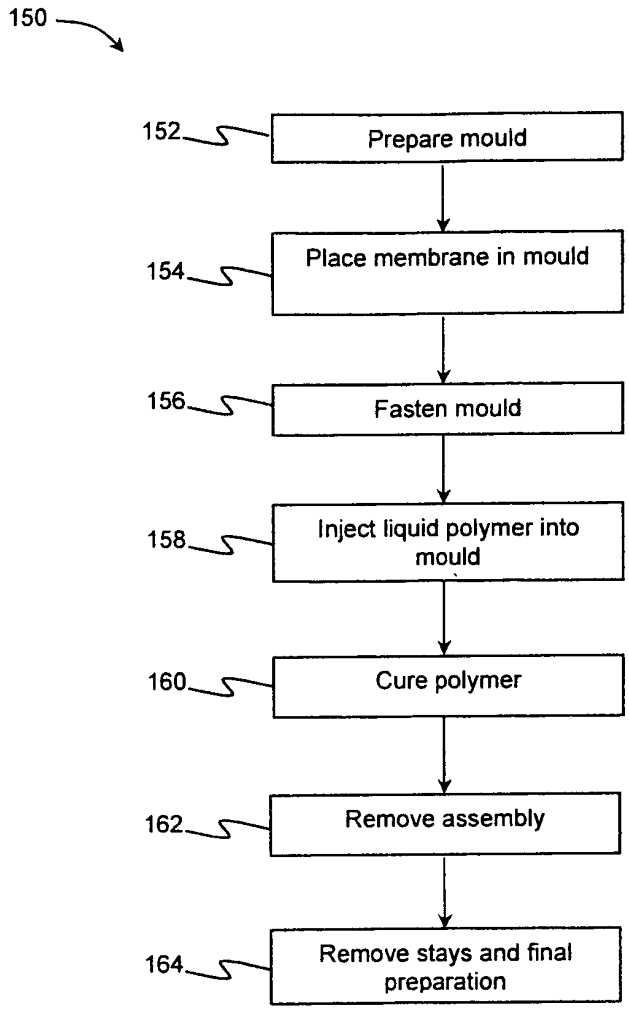
150
152
Prepare mould
154
Place membrane in mould
156
Fasten mould
158
Inject liquid polymer into mould
160
Cure polymer
162
Remove assembly
164
Remove stays and final preparation

Fig. 15

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Économie
et du Commerce extérieur

SEARCH REPORT

in accordance with Article 35.1 a)
of the Luxembourg law on patents
dated 20 July 1992

National Application Number

LO 701
LU 91961

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The present search report has been drawn up for all claims

	Date of completion of the search	Examiner
	2 August 2012	Marti, Pedro

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LO 701
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