



(12)

EUROPEAN PATENT APPLICATION

- (43)

Date of publication:
03.01.2024 Bulletin 2024/01
- (51)

International Patent Classification (IPC):
A62B 18/10 (2006.01)
- (21)

Application number: 22208286.9
- (52)

Cooperative Patent Classification (CPC):
A62B 18/10
- (22)

Date of filing: 18.11.2022

(84) Designated Contracting States: AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR Designated Extension States: BA Designated Validation States: KH MA MD TN	• LIN, Fu-Lung 5656AG Eindhoven (NL) • GU, Wei 5656AG Eindhoven (NL) • LUO, Zhongchi 5656AG Eindhoven (NL) • HUANG, Haiyong 5656AG Eindhoven (NL) • CHEN, Weizhong 5656AG Eindhoven (NL) • TANG, Lijuan 5656AG Eindhoven (NL)
(30) Priority: 30.06.2022 PCT/CN2022/102933	
(71) Applicant: Koninklijke Philips N.V. 5656 AG Eindhoven (NL)	
(72) Inventors: • ZHANG, Xuan 5656AG Eindhoven (NL)	(74) Representative: Philips Intellectual Property & Standards High Tech Campus 52 5656 AG Eindhoven (NL)

(54)

A ONE-WAY VALVE FOR A FACE MASK

- (57)

A one-way valve for a face mask comprises a base and a flexible membrane structure mounted over the base. The flexible membrane structure has a plurality of valve flaps, each having a fixed portion and a free portion which can open and close. At least one of the
- valve flaps has a first edge positioned adjacent a second edge of an adjacent valve flap such that a flow through said one of the valve flaps is directed at least in part across the upper surface of said adjacent valve flap, to assist in the opening of said adjacent valve flap.

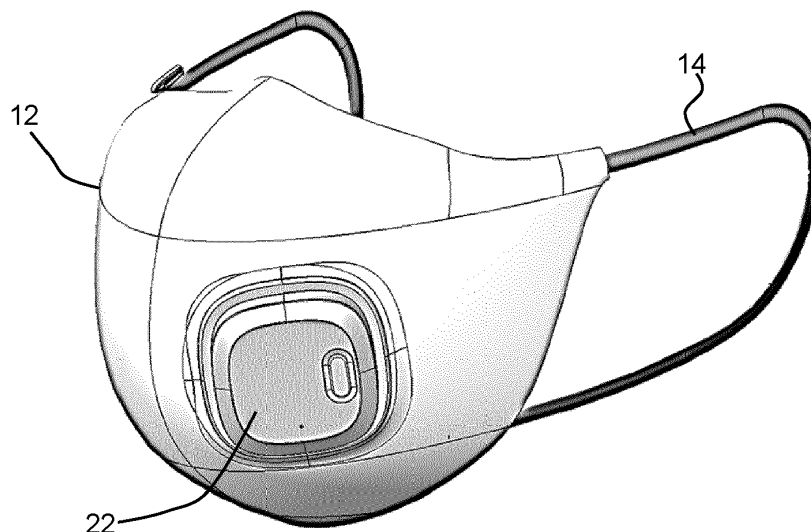


FIG. 2

Description

FIELD OF THE INVENTION

[0001] This invention relates to face masks, for providing filtering of pollutants, and in particular relates to a one-way valve for use in such face masks.

BACKGROUND OF THE INVENTION

[0002] Air pollution is a worldwide concern. The World Health Organization (WHO) estimates that 4 million people die from air pollution every year. Part of this problem is the outdoor air quality in cities. Nearly 300 smog-hit cities fail to meet national air quality standards.

[0003] Official outdoor air quality standards define particle matter concentration as mass per unit volume (e.g. $\mu\text{g}/\text{m}^3$). A particular concern is pollution with particles having a diameter less than $2.5 \mu\text{m}$ (termed "PM2.5") as they are able to penetrate into the gas exchange regions of the lung (alveoli), and very small particles ($<100 \text{ nm}$) may pass through the lungs to affect other organs.

[0004] Since this problem will not improve significantly on a short time scale, a common way to deal with this problem is to wear a mask which provides cleaner air by filtration and the market for masks in China and elsewhere has seen a great surge in recent years.

[0005] Such masks may be made of material that acts as a filter of pollutant particles, or may have a filter for only part of the mask surface, and this filter may be replaceable when it becomes clogged.

[0006] However, during use, the temperature and relative humidity inside the mask increases and, combined with the pressure difference inside the mask relative to the outside, this makes breathing uncomfortable.

[0007] This can be mitigated in part by providing an outlet valve or check valve which allows exhaled air to escape the mask with little resistance, but which requires inhaled air to be drawn through the filter. This also improves the comfort for the facial skin within the mask cavity.

[0008] To improve comfort further, a fan can be added to the mask, drawing in air through the filter and/or providing assistance when breathing out. One possible benefit to the wearer of using a fan-powered mask is that the lungs are relieved of the slight strain caused by inhalation and exhalation against the resistance of the filters in a conventional non-powered mask. Furthermore, the fan also prevents re-inhalation of exhaled air which would also negatively impact the heat and moisture in the mask cavity, as well as affecting the oxygen and carbon dioxide exchange of the respiratory system, resulting in breathing discomfort. Fan-assisted masks thus may improve the wearing and breathing comfort by reducing the temperature, humidity and breathing resistance.

[0009] In one arrangement, an inlet (i.e. inhale) fan may be used to provide a continuous intake of air. In another arrangement, an exhaust (i.e. exhale) fan may

be used to provide a continuous release of air. This provides breathing assistance when exhaling. An exhale fan may be combined with a series check valve so that no flow can enter the mask through the fan.

[0010] Thus, several types of mask for preventing daily exposure to air pollutants are available, including passive masks with an exhale valve, and masks with at least one active fan. In many cases a one-way valve is part of the mask design. The one-way valve is typically used to allow exhaled air to pass through an opened small round or square membrane to the ambient surroundings, and the valve results in reduced resistance compared to the mask filter material.

[0011] The one-way valve typically includes an opening sealed by a flexible membrane. The membrane forms a seal or opening in dependence on the airflow direction or pressure difference between the mask cavity and the ambient surroundings, caused by the inhalation and exhalation of the user of the mask.

[0012] Taking an exhalation valve as an example, when the wearer breathes in, the valve membrane will cling closely to a valve casing due to the inward airflow (i.e., negative pressure in the mask cavity). The valve is closed, and all inhaled air will pass the filter material to be filtered. When the wearer breathes out, at least part of the membrane will peel off the valve casing under the pushing force of the airflow, so that a gap or channel is generated in the valve. The valve is open so that part of the exhaled air will pass through the valve to the ambient surroundings due to the lower resistance compared with filter material.

[0013] A problem is that the one-way valve inherently presents an airflow resistance. Air pressure is needed to open the valve. Thus, the valve will open only when a pressure, e.g. the exhaled air pressure, exceeds an opening pressure of the valve (or equivalently an opening force). After the valve is open, the valve and mask filter material function as two resistance elements in parallel. The ratio of air passing through these two parts depends on the resistance of the opened valve and the resistance of the mask filter material.

[0014] Therefore, for improving the performance of one-way valve, it is desired to lower the air pressure necessary to open the valve, and to lower the resistance of the opened valve for the airflow as well. Meanwhile, a firm seal is needed when the valve is closed to block the reverse airflow.

[0015] Conventionally, the flexible membrane of the valve comprises a single valve flap, which may have various shapes (e.g., round, rectangle, butterfly etc.) and the center or an edge of the membrane is fixed to a base of the valve. The internal tension force inside the valve flap material means it is difficult to fully open the valve flap meaning the open valve flap still presents a significant flow resistance.

[0016] It has been proposed to provide a one-way valve as an array of valve flaps. Each individual valve flap can then be designed to open with a lower pressure,

but the combined opening area created by the multiple valve flaps enables the desired airflow to pass through the valve. Although the multi-flap structure lowers the airflow resistance of the one-way valve, it is still hard to open all the flaps fully in use, because of an uneven distribution of the airflow and the different properties of the valve flaps (e.g. uneven material hardness). The valve flaps move independently.

[0017] There remains a need for an improved one-way valve design for a face mask.

SUMMARY OF THE INVENTION

[0018] The invention is defined by the claims.

[0019] According to examples in accordance with an aspect of the invention, there is provided a one-way valve for a face mask, comprising:

a base; and
a flexible membrane structure mounted over the base,
wherein the flexible membrane structure comprises:

a support region; and
a plurality of valve flaps, each having a fixed portion connected to the support region and each extending from the support region to define a free portion which can open and close, the free portion have first and second edges,

wherein each valve flap has an upper surface facing away from the base and a lower surface facing the base,

wherein at least one of the valve flaps has the first edge positioned adjacent a second edge of an adjacent valve flap such that a flow through said one of the valve flaps is directed at least in part across the upper surface of said adjacent valve flap, to assist in the opening of said adjacent valve flap.

[0020] This valve design has multiple valve flaps. This enables each valve flap to be designed to open at a desired (low) pressure difference while providing a desired size of air flow passageway. The flow through one valve flap assists the opening of an adjacent valve flap using the flow through that one valve flap over the top of the adjacent valve flap.

[0021] The surface area of the upper surface of each valve flap is for example greater than the surface area of the lower surface, such that an airflow over the upper and lower surfaces of the valve flaps generates a lifting force to further open the valve flaps.

[0022] The difference in surface area means that a flow over the upper and lower surfaces of a valve flap (when the valve flap is open) creates a lifting force by Bernoulli's principle. In this way, the air flow over a valve when the valve starts to open assists further in the complete opening of the valve, and hence a reduced airflow resistance

of the valve is enabled.

[0023] Similarly, an air flow over one valve flap when it is initially closed (e.g. from an adjacent valve flap which is already open) assists the initial opening of the valve flap.

[0024] Each flap for example has the shape of an aerofoil. This provides an optimum lifting force.

[0025] At least one valve flap may be configured to open before the other valve flaps. This accelerates the valve opening process in that a first valve flap opens early, and it assists the opening of the other valve flaps.

[0026] A valve flap may have a lower opening force than said other valve flaps and/or a valve flap may be configured to be exposed to a greater opening force, in use, than said other valve flaps as a result of the flow conditions through the valve.

[0027] The valve flap that opens first thus may have a lower opening force, or it may be subjected to a greater force during initial opening than the other valve flaps. The flap with the lower opening force opens first, and then creates a flow which assists the opening of the other valve flaps.

[0028] The lower opening force may be achieved based on the shape or size of one valve flap being different to the others. Alternatively, or additionally, the flow conditions (e.g. a fan outlet design) may be such that one valve flap is exposed to a greater force.

[0029] The free portion of each valve flap may have a first edge and a second edge, and wherein, in the closed state of each valve flap, the upper surface of the valve flap at the first edge is higher than the upper surface of the valve flap at the second edge.

[0030] An airflow through an open valve flap flows towards the higher part of the valve flap, at the first edge. This first edge is higher than the second edge (even when closed), and is hence higher than an adjacent second edge of an adjacent valve flap. As a result, the airflow through one valve flap is directed over the top of an adjacent valve flap. In this way, a side flow is generated by one valve flap which assists the opening of an adjacent valve flap. The air flow through at one of the valve flaps is directed to an adjacent valve flap, to provide a lifting force to that adjacent valve flaps. The multiple flaps may be arranged in a line, or in a ring, or in a grid.

[0031] The lower surface of each valve flap at the first edge is for example higher than the upper surface of the flap at the second edge. Thus, the flow coming from the second edge of the valve flap is directly over the adjacent next valve flap.

[0032] The valve flaps are for example arranged along a closed path such that a flow through each valve flap is directed to a respective adjacent valve flap around the closed path.

[0033] In this design, each valve flap is adjacent to another valve flap around the closed path. The first edge and the second edge of each valve flap are preferably positioned circumferentially around the ring. Thus, the flow through the valve flaps follows a direction around

the closed path. The closed path for example is a ring.

[0034] In one design, the support region comprises a central hub, and each valve flap extends radially outwardly from the central hub, arranged in a ring around the central hub. This is a first possible design, with the valve flaps extending radially outwardly from a central hub, with a design similar to a propeller. The hub may be circular but it may oval or polygonal (e.g. square or rectangular).

[0035] In another design, the support region comprises an annular outer support and each valve flap extends radially inwardly from the annular outer support, arranged in a ring within the annular outer support. This is a second possible design, with the valve flaps extending radially inwardly from an outer annular support. Again, each valve flap is adjacent to another valve flap and the annular support may again be circular but it may oval or polygonal (e.g. square or rectangular).

[0036] The valve flaps are for example spaced apart around the ring. This prevents the valve flaps hitting each other when they open and close. There may for example be 3, 4 or 5 valve flaps arranged around a ring.

[0037] The base for example comprises a mounting area to which the support region is mounted, and an opening for each flap. The base thus defines a valve seat for each valve flap. The base preferably also comprises a sealing area around each opening. The sealing area cooperates with the valve flap when in the closed state, to ensure a desired seal to prevent flow through the valve in the unwanted flow direction.

[0038] The valve may further comprise a top cover for fixing the support region to the mounting area of the base. This provides an easy-to-assemble design, with the valve flaps (preferably formed as a single integrated component) clamped between the base and the top cover. The top cover is for example a snap fit to the base.

[0039] The flexible membrane structure for example comprises a single injection molded component, wherein the single injection molded component is manufactured by a mold with a first valve flap mold portion and a second valve flap mold portion, different from the first valve flap mold portion.

[0040] The valve flaps are defined by the outer shape of the molded component rather than being defined by cuts in a sheet. This makes it easier to control the performance of the valve flaps. The mold used to form the valve flaps creates valve flaps of different designs, e.g. different opening forces.

[0041] The invention also provides a face mask comprising:

a mask body defining a mask cavity inside the mask body when the mask is worn by a user, wherein the mask body includes the valve as defined above. A fan assembly is for example received in an opening in the mask body.

[0042] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] For a better understanding of the invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:

Fig. 1 shows one example of a mask design to which the invention may be applied;

Fig. 2 shows another example of a mask design to which the invention may be applied;

Fig. 3 shows the flexible membrane structure for a first example of the one-way valve;

Fig. 4 shows the base for receiving the membrane of Fig. 3;

Fig. 5 shows the flexible membrane structure for a second example of the one-way valve;

Fig. 6 shows the base as well as the membrane of Fig. 5;

Fig. 7 shows the closed path for the membrane design of Fig. 3 and shows a cross section around that path;

Fig. 8 shows examples with three, four and five valve flaps around a ring;

Fig. 9 shows that instead of a ring, a grid of valve flaps may be used;

Fig. 10 shows a cross section through the base of Fig. 4; and

Fig. 11 shows a cross section with a cover in place for the design of Figs. 3 and 4.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0044] The invention will be described with reference to the Figures.

[0045] It should be understood that the detailed description and specific examples, while indicating exemplary embodiments of the apparatus, systems and methods, are intended for purposes of illustration only and are not intended to limit the scope of the invention. These and other features, aspects, and advantages of the apparatus, systems and methods of the present invention will become better understood from the following description, appended claims, and accompanying drawings. It should be understood that the Figures are merely schematic and are not drawn to scale. It should also be understood that the same reference numerals are used throughout the Figures to indicate the same or similar parts.

[0046] The invention provides a one-way valve for a face mask, comprising a base and a flexible membrane structure mounted over the base. The flexible membrane structure has a plurality of valve flaps, each having a fixed portion and a free portion which can open and close. At least one of the valve flaps has a first edge positioned adjacent a second edge of an adjacent valve flap such that a flow through said one of the valve flaps is directed at least in part across the upper surface of said adjacent

valve flap, to assist in the opening of said adjacent valve flap.

[0047] Fig. 1 shows one example of a mask design to which the invention may be applied.

[0048] The mask 10 is a passive mask, comprising a mask body 12 formed of a filter material. The mask body is held in place by ear straps 14. The mask body includes a one-way valve 20.

[0049] Fig. 2 shows another example of a mask design to which the invention may be applied. The mask 10 is an active mask, again comprising a mask body 12 held in place by ear straps 14.

[0050] The mask body in this example includes a rigid or semi-rigid outer casing and the filter member is retained inside (behind) the outer casing. The outer casing is porous so that air can flow through the outer casing to the filter member.

[0051] A fan and valve module 22 combines a fan, such as a centrifugal fan, and a passive one-way valve. The fan is for example for delivering a flow out of the cavity formed by the mask body through the one-way valve.

[0052] The invention relates in particular to the design of the one-way valve. It may be applied to passive or active masks. The valve comprises a base and a flexible membrane structure mounted over the base.

[0053] Fig. 3 shows the flexible membrane structure 30 for a first example of the one-way valve.

[0054] The flexible membrane structure 30 comprises a support region 32, which in this example comprises a central hub. Valve flaps 34 extends radially outwardly from the central hub 32, arranged in a closed path around the central hub. The hub in this example is circular but it may oval or polygonal (e.g. square or rectangular). The closed path is thus a circular ring in this case, but other closed paths may be formed.

[0055] The flexible membrane structure is a thin, flexible, airtight sheet which may be made of rubber, silicone, plastic, or any other type of elastomer.

[0056] Each valve flap 34 of the membrane structure comprises a free end 36 and a fixed end 38. The fixed end 38 connects to the central hub 32 and is connected to a mounting area of the base. Each valve flap 34 has an upper surface facing away from the base (this is the surfaces shown in Fig. 3) and a lower surface facing the base.

[0057] The free end 36 has a first edge 40 and a second edge 42, positioned at different circumferential positions around the ring. The first edge 40 of each valve flap is positioned adjacent a second edge 42 of an adjacent valve flap such that a flow through said one of the valve flaps is directed at least in part across the upper surface of said adjacent valve flap, to assist in the opening of said adjacent valve flap.

[0058] The free end 36 seats against a sealing area of the base and covers a respective opening area in the base to form a tight valve seal when the valve flap is closed. The free end 36 flexes away from the sealing area to create an air path between the valve flap and the

opening area in the base when the valve flap is open. The valve flap opens and closes depending on the pressure differential between cavity formed by the mask and the ambient surroundings.

5 [0059] In this particular design, each valve flap 34 of the membrane structure is not a flat sheet as in a conventional valve membrane, but has a streamlined shape that is designed to generate a lift force to facilitate the opening of its adjacent flap. The two-dimensional cross-sectional shape of the valve flap has an aerofoil shape.

10 [0060] The closed path, i.e. the ring in this example, means that each valve flap is adjacent to two other valve flaps around the ring. The flow through one valve flap when the valve is open is directed to a respective adjacent valve flap around the ring to provide this lift force to the adjacent valve flap.

15 [0061] The use of multiple valve flaps means each valve flap can open at a desired (low) pressure difference while providing a desired combined size of air flow passageway.

20 [0062] The aerofoil design is implemented by designing the surface area of the upper surface of each valve flap to be greater than the surface area of the lower surface. An airflow over the upper and lower surfaces of the valve flaps generates a lifting force to further open the valve flaps. In this way, the air flow when the valve starts to open assists further in the complete opening of the valve, and hence a reduced airflow resistance of the valve is enabled. An air flow over one valve flap when it is initially closed (e.g. from an adjacent valve flap which is already opening) also assists the opening of the valve flap.

25 [0063] This particular example has a round membrane structure with five equally distributed valve flaps. There are three holes in the central hub to fix the membrane structure to the base. There is a gap between each adjacent pair of valve flaps to prevent the interference or collision between two valve flaps.

30 [0064] Fig. 4 shows the base for receiving the membrane structure of Fig. 3. The base 50 forms a rigid, light, airtight frame and is made of plastic, metal, or any other suitable material.

35 [0065] The base 50 defines opening areas 52 and a central mounting area 54 to which the central hub 32 is fixed. Sealing areas 56 are formed around the opening areas 52. The shape and configuration of the base is designed according to the shape of the valve flaps so that each valve flap of the membrane is able to form a seal over the corresponding opening area 52 along the sealing area 56.

40 [0066] A top cover (not shown) may be provided over the membrane, for example a cap made of a rigid, light, and airtight material, such as plastic or metal. The top cover for example is a snap-fit to the mounting area 54 of the base such that the membrane structure 30 is clamped between the base 50 and the top cover. This mounting function also could be realized by the base itself, so that the top cover is optional.

[0067] The top cover may be part of a frame. The frame may for example limit the opening range of the valve flaps and prevent them colliding with fan blades for examples where the valve is part of a fan module.

[0068] Fig. 5 shows the flexible membrane structure 60 for a second example of the one-way valve. In this design, the support region of the membrane comprises an annular outer support 62 and each valve flap 64 extends radially inwardly from the annular outer support 62, arranged in a ring within the annular outer support. There are three valve flaps in this design. Again, each valve flap is adjacent to another valve flap. In the same way as for Fig. 3, each valve flap 64 of the membrane comprises a free end 66 and a fixed end 68. The fixed end 68 connects to the outer annular support 62 and is connected to the mounting area of the base. Each valve flap has an upper surface facing away from the base and a lower surface facing the base.

[0069] The free end 66 has a first edge 70 and a second edge 72, positioned at different circumferential positions around the ring. The first edge of each valve flap is positioned adjacent a second edge of an adjacent valve flap such that a flow through said one of the valve flaps is directed at least in part across the upper surface of said adjacent valve flap, to assist in the opening of said adjacent valve flap.

[0070] Fig. 6 shows the base 80 as well as the membrane 60. The base 80 again defines opening areas 82 and an outer mounting area 84 to which the annular outer support is fixed. Sealing areas are also formed around the opening areas.

[0071] As mentioned above, the valve flaps are not flat, but have a streamlined shape designed to generate a lift force.

[0072] Fig. 7 shows the closed path 100 of the membrane structure design of Fig. 3, and also shows a cross section around that path. It shows that each valve flap 34 has an aerofoil shape in cross section to generate an upward lift, i.e. away from the base. The path 100 represents the flow direction of air which passes through the valve flaps. Thus, they aim to direct the flow to a circumferential direction to pass over adjacent valve flaps.

[0073] A flow through one open valve flap 34, as shown by arrow 102, passes over an adjacent valve flap to induce a lifting force to that adjacent valve flap.

[0074] Fig. 7 also shows that, at the free portion of each valve flap (through which the cross section is taken), the upper surface of the valve flap at the first edge 40 is higher than the upper surface of the valve flap at the second edge 42. The airflow through an open valve flap flows towards the highest part of the valve flap, at the first edge 40.

[0075] This first edge is higher than the second edge (even when closed), and is hence higher than the adjacent second edge of an adjacent valve flap. As a result, the airflow 102 through one valve flap is directed over the top of an adjacent valve flap as shown in Fig. 7. In this way, a side flow is generated by one valve flap which

assists the opening of an adjacent valve flap.

[0076] The lower surface of each valve flap at the first edge 40 is for example also higher than the upper surface of the flap at the second edge.

[0077] As explained above, when a valve flap is open, so that a flow can pass over and under the valve flap, a lifting force is generated. A lifting force is also generated when there is a flow over the upper surface and static pressure (with not flow) at the bottom surface. Thus, as soon as one valve flap is open, and directs a flow over the other valve flaps (around the closed path), a lifting force will be provided to assist the opening of those other valve flaps.

[0078] Thus, by ensuring fast opening of one valve flap, assistance can be provided to the opening of the other valve flaps. For this purpose, at least one valve flap may be configured to open before the other valve flaps. This accelerates the valve opening process in that a first valve flap opens early, and it assists the opening of the other valve flaps.

[0079] To provide early opening of one valve flap, it may have a lower opening force than the other valve flaps. This can be achieved by a shape design - for example that valve flap may be smaller in area or thinner. It may instead be provided by design of the flow through the membrane. For example, a fan module may have an outlet air flow which is directed towards a particular valve flap, which will therefore open first.

[0080] The valve flap that opens first thus may have a lower opening force, or it may be subjected to a greater force during initial opening than the other valve flaps.

[0081] The flexible membrane structure for example comprises a single injection molded component.

[0082] The valve flaps are thus defined by the outer shape of the molded component rather than being defined by cuts in a sheet. This makes it easier to control the performance of the valve flaps.

[0083] To create valve flaps of different designs, the single injection molded component may be manufactured by a mold with a first valve flap mold portion and a second valve flap mold portion, different from the first valve flap mold portion. The differences may be in thickness, size or shape.

[0084] The examples above make use of a closed line of valve flaps (e.g. a ring).

[0085] Fig. 8 shows examples with three, four and five valve flaps around the ring. The separating lines are for example linear gaps.

[0086] Fig. 9 shows that instead of a ring, a grid of valve flaps may be used, such as a two-dimensional grid (left image) or a one dimensional grid (right image). The free ends could be in the internal lines or at the outer boundaries. Thus, a closed path is an optional design feature.

[0087] The shape of the mounting area and sealing area of the base is designed to match the 3D shape of the valve flaps to form a good seal at the contact areas between the membrane and the base (i.e., a good seal over the opening area in the valve).

[0088] Fig. 10 shows a cross section through the base of Fig. 4 with the membrane structure 30 in place. To obtain an optimal seal, it is preferred to raise the height of the sealing area compared with the mounting area along the perpendicular direction of membrane (i.e. the y-axis direction shown, which is the height direction). Thus, the free end of the valve flap seals at a higher position than the fixed end. This slant between the free and fixed parts can be seen in the regions 110 shown in Fig. 10.

[0089] This creates a curved shape for each valve flap when the membrane is closed and seated located on the base. This curved shape in combination with the resilience of the flap material further ensures a firm seal of valve.

[0090] Fig. 11 shows a cross section with a cover 120 in place for the design of Figs. 3 and 4. The cover 120 has a central bush 122 which pushes down on the central hub part of the membrane and pushed it against the base. The central bush 122 of the top cover has a snap-fit relationship with the mounting area of the base to clamp the membrane structure 30 in the middle. The outer circumferential areas of the top cover and base also have a snap-fit relationship. Beams 124 on the top cover are used to limit the opening range of the valve flaps and prevent them colliding with the fan blades when the one-way valve is combined with an electric fan.

[0091] It will be understood by those skilled in the art that there are various design features which assist the valve in achieving the function using the flow through one valve flap to assist in the opening of said adjacent valve flap.

[0092] These design features may be summarized as:

- (i) an aerofoil shape of the valve flaps;
- (ii) the opening of one flap first to provide a flow to assist the initial opening of the other valve flaps;
- (iii) a slanted (rather than planar) arrangement of the valve flaps when closed
- (iv) a closed path e.g. ring of valve flaps.

[0093] These design features may be used alone or in any combination. Each may be considered as a separate independent design concept. Thus, concepts (ii) to (iv) may for example each be implemented with a planar membrane design.

[0094] Variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality.

[0095] The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

[0096] If the term "adapted to" is used in the claims or

description, it is noted the term "adapted to" is intended to be equivalent to the term "configured to". If the term "arrangement" is used in the claims or description, it is noted the term "arrangement" is intended to be equivalent to the term "system", and vice versa.

[0097] Any reference signs in the claims should not be construed as limiting the scope.

10 Claims

1. A one-way valve for a face mask, comprising:

abase (50); and
a flexible membrane structure (30) mounted over the base, wherein the flexible membrane structure comprises:

a support region (32); and
a plurality of valve flaps (34), each having a fixed portion connected to the support region and each extending from the support region to define a free portion which can open and close,

wherein each valve flap has an upper surface facing away from the base and a lower surface facing the base, the free portion have first and second edges (40,42), wherein at least one of the valve flaps has its first edge (40) positioned adjacent a second edge of an adjacent valve flap such that a flow (102) through said one of the valve flaps is directed at least in part across the upper surface of said adjacent valve flap, to assist in the opening of said adjacent valve flap.

2. The valve of claim 1, wherein the surface area of the upper surface of each valve flap is greater than the surface area of the lower surface, such that an airflow over the upper and lower surfaces of the valve flaps generates a lifting force to further open the valve flaps.

3. The valve of claim 2, wherein each flap has the shape of an aerofoil.

4. The valve of any one of claims 1 to 3, wherein at least one valve flap is configured to open before the other valve flap(s).

5. The valve of claims 1 to 3, wherein:

said at least one valve flap has a lower opening force than the other valve flap or flaps; and/or
said at least one valve flap is configured to be exposed to a greater opening force, in use, than

the other valve flap or flaps as a result of the flow conditions through the valve.

6. The valve of any one of claims 1 to 5, wherein, in the closed state of each valve flap, the upper surface of the valve flap at the first edge is higher than the upper surface of the valve flap at the second edge. 5
7. The valve of claim 6, wherein the lower surface of each valve flap at the first edge is higher than the upper surface of the flap at the second edge. 10
8. The valve of any one of claims 1 to 6, wherein the valve flaps are arranged along a closed path (100) such that a flow through each valve flap is directed to a respective adjacent valve flap around the closed path. 15
9. The valve of claim 8, wherein the support region comprises a central hub (32), and each valve flap extends radially outwardly from the central hub, arranged in a ring around the central hub. 20
10. The valve of claim 8, wherein the support region comprises an annular outer support (62) and each valve flap extends radially inwardly from the annular outer support, arranged in a ring within the annular outer support. 25
11. The valve of any one of claims 9 to 10, wherein the valve flaps are spaced apart around the ring. 30
12. The valve of any one of claims 1 to 11, wherein the base comprises a mounting area (54) to which the support region is mounted, and an opening for each flap. 35
13. The valve of any one of claims 1 to 12, further comprising a top cover (120) for fixing the support region to the base. 40
14. The valve of any one of claims 1 to 13, wherein the flexible membrane structure comprises a single injection molded component, wherein the single injection molded component is manufactured by a mold with a first valve flap mold portion and a second valve flap mold portion, different from the first valve flap mold portion. 45
15. A face mask comprising: 50
a mask body defining a mask cavity inside the mask body when the mask is worn by a user, wherein the mask body includes the valve of any one of claims 1 to 14. 55

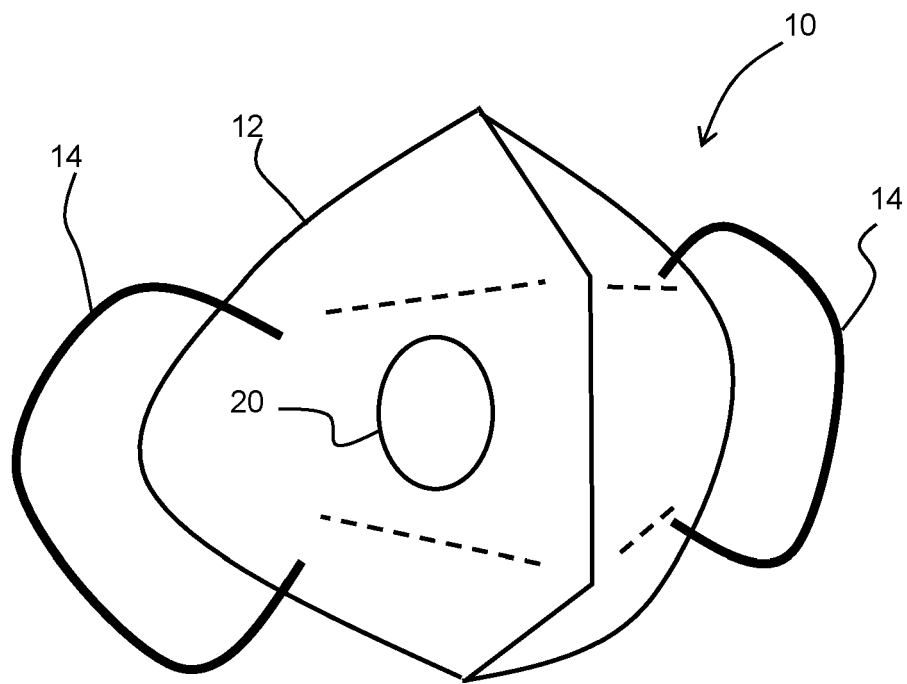


FIG. 1

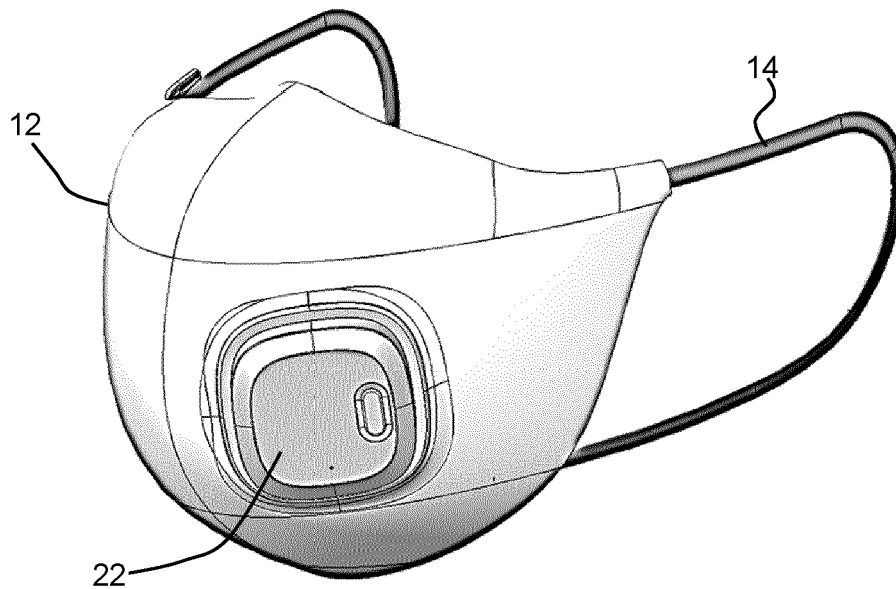


FIG. 2

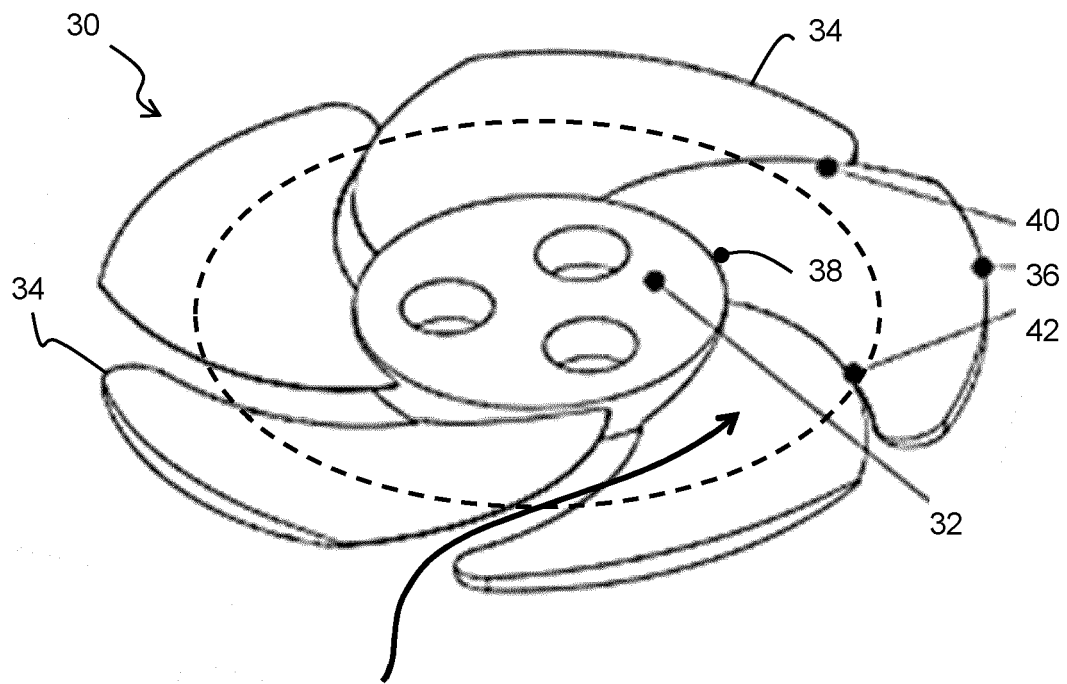


FIG. 3

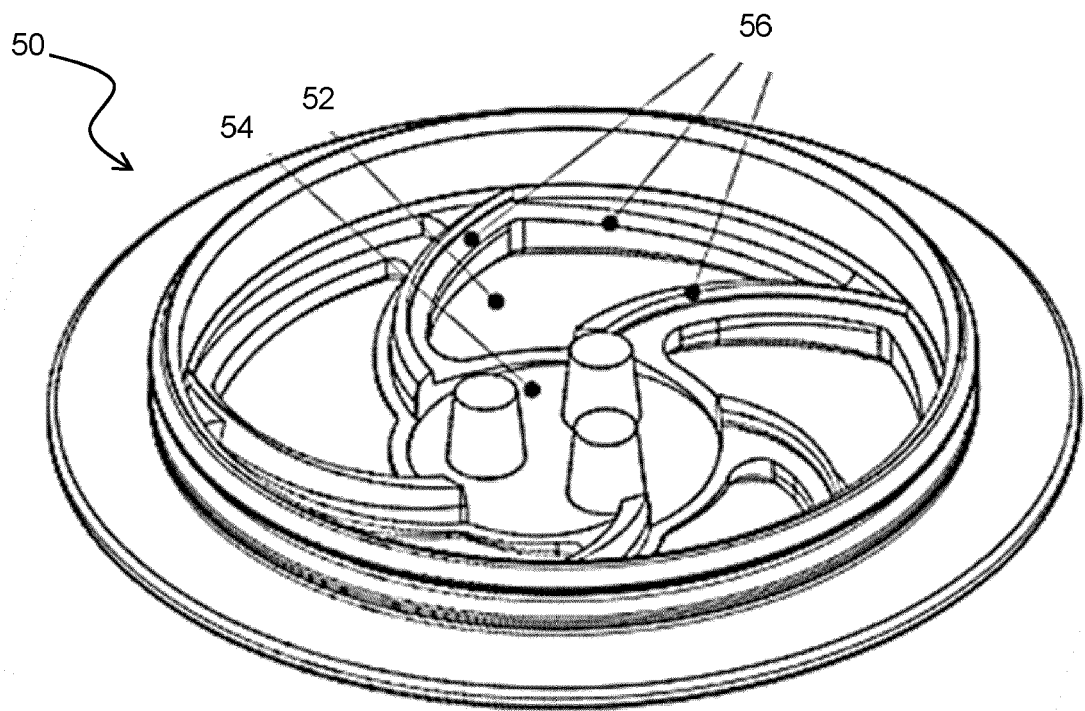


FIG. 4

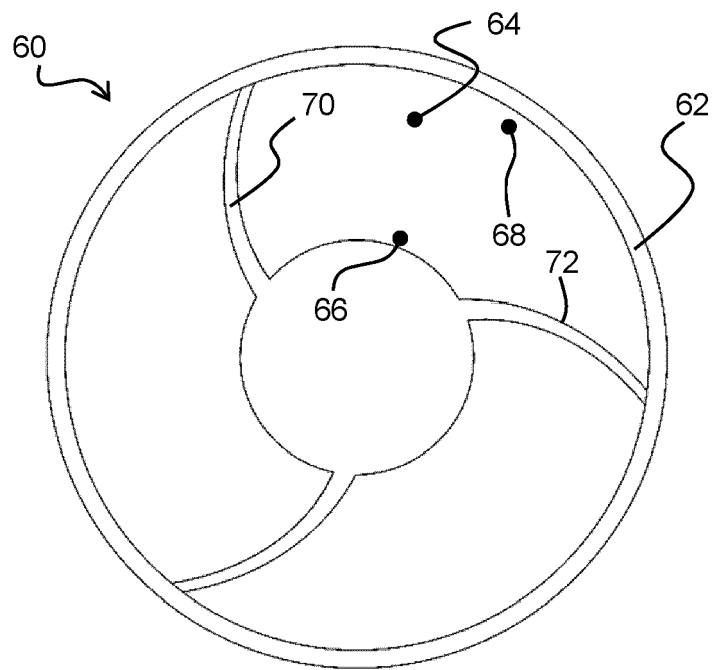


FIG. 5

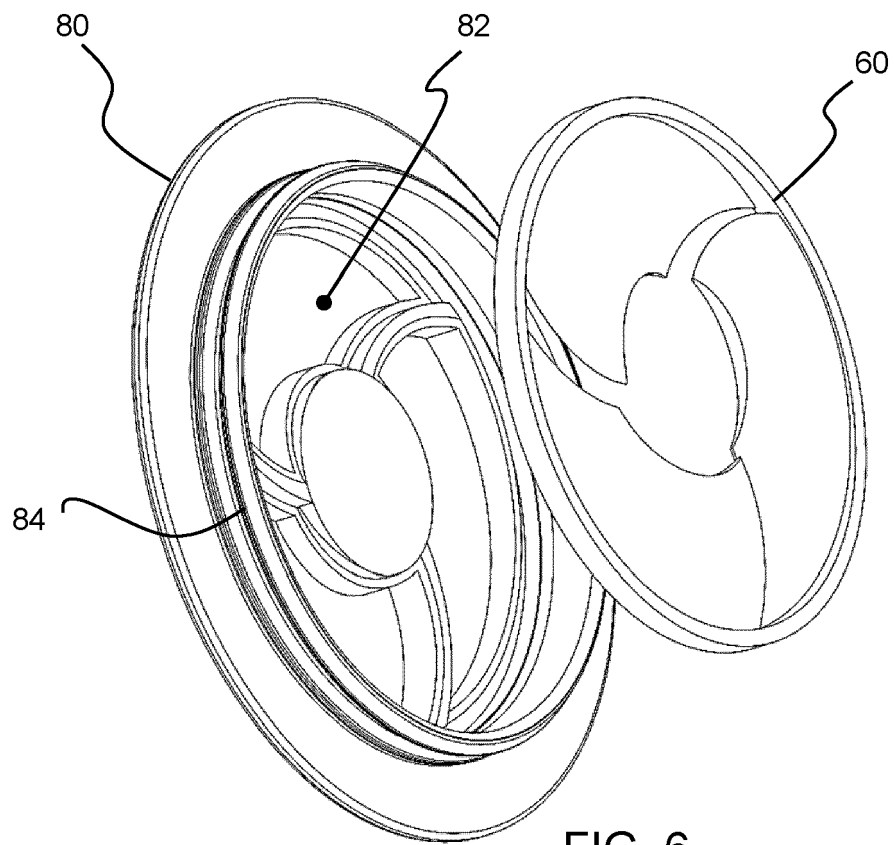


FIG. 6

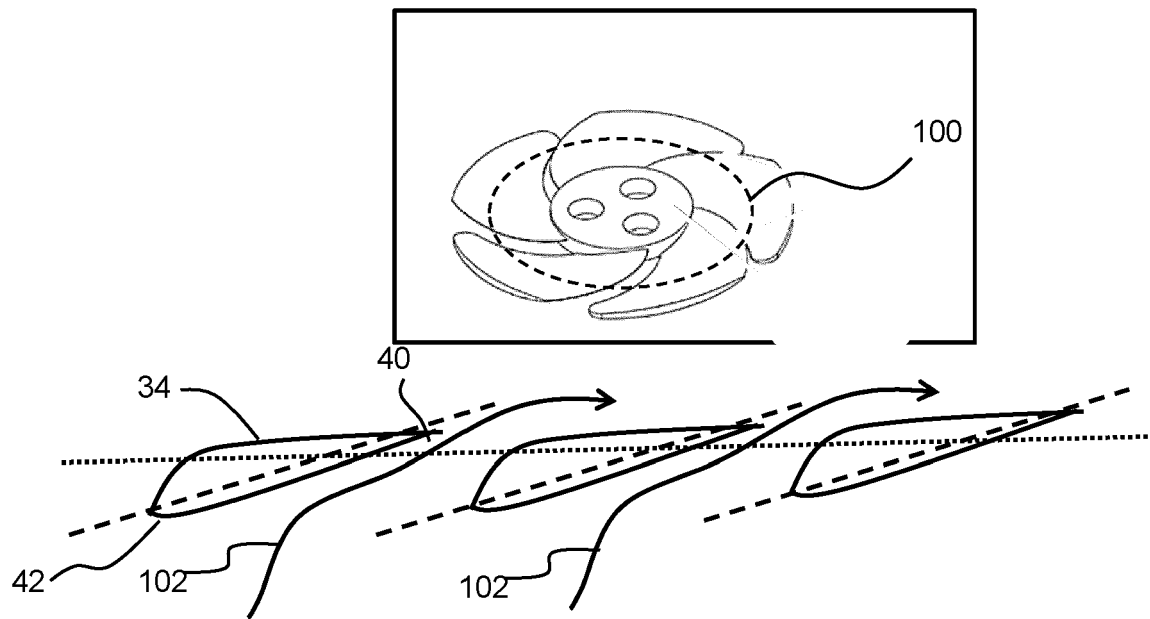


FIG. 7

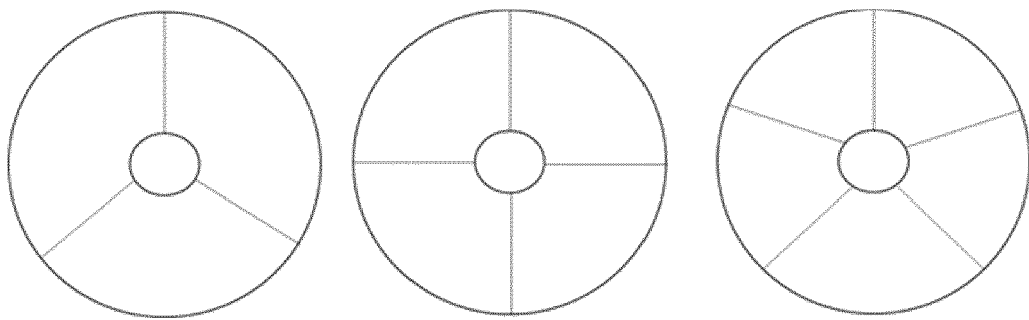


FIG. 8

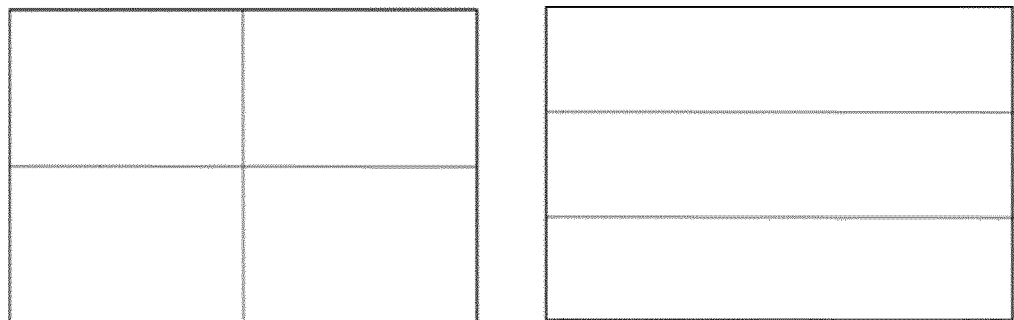


FIG. 9

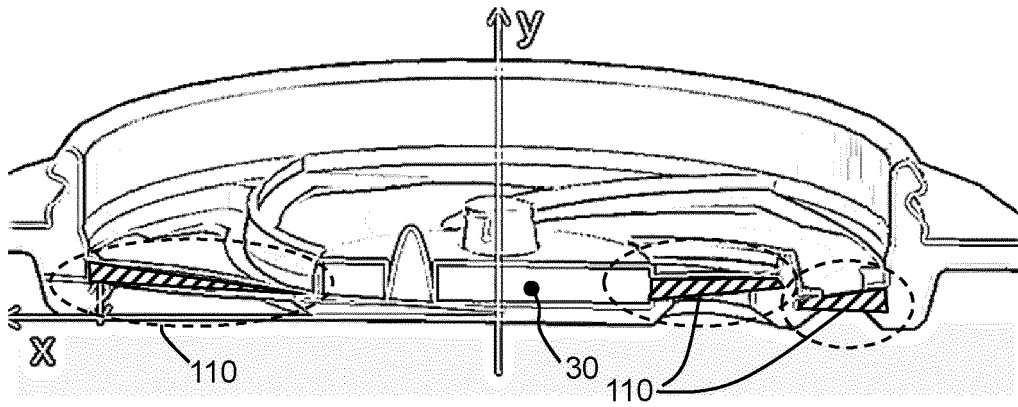


FIG. 10

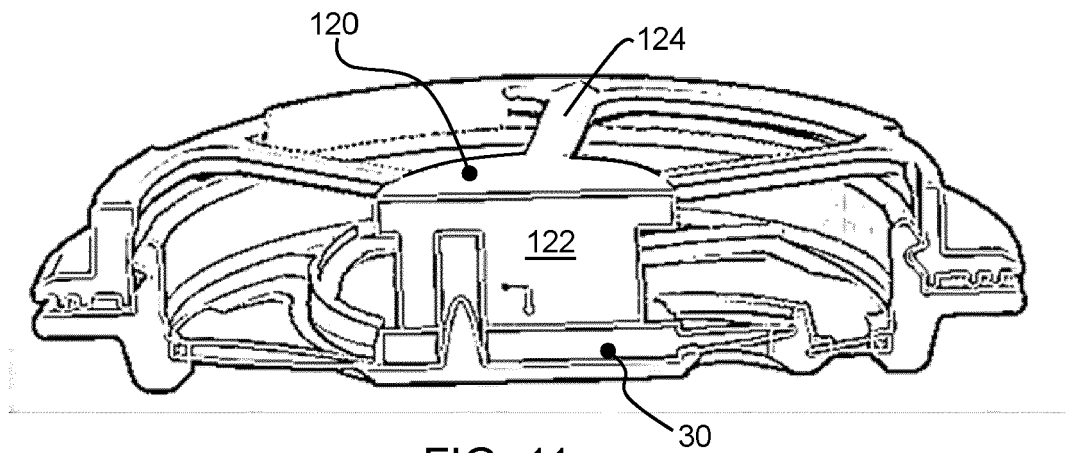


FIG. 11



EUROPEAN SEARCH REPORT

Application Number

EP 22 20 8286

5

10

15

20

25

30

35

40

45

50

55

1

EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 112 675 448 A (GAO ZHIQI) 20 April 2021 (2021-04-20)	1, 3-5, 12, 13, 15	INV. A62B18/10
A	* paragraph [0025] * * paragraph [0034] * * figures 1-4 *	2, 6-11, 14	
X	GB 825 659 A (P B COW & COMPANY LTD; ARTHUR CHARLES WILLIAM HOOKER) 16 December 1959 (1959-12-16)	1, 3-6, 8, 12, 14, 15	
A	* page 1, line 54 - line 76 * * figures 1-3 *	2, 7, 9-11, 13	
			TECHNICAL FIELDS SEARCHED (IPC)
			A62B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 4 May 2023	Examiner Ong, Hong Djien
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 22 20 8286

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-05-2023

10	Patent document cited in search report	Publication date	Patent family member(s)	Publication date
	CN 112675448 A	20-04-2021	NONE	
15	GB 825659 A	16-12-1959	NONE	
20				
25				
30				
35				
40				
45				
50				
55				

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82