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(54) **A MASK-BASED BREATHING APPARATUS**

(57) A mask uses inlet and outlet flow control based on a user's breathing pattern. The mask wall has a region with a pair of spaced membranes, with a filter material in a spacing between the membranes. At least one of the flow control devices provides a fluid coupling between

the outside of the mask and the spacing such that a transverse flow through the spacing is provided. The flow distance through the filter material and hence flow contact time with the filter material is greatly increased.

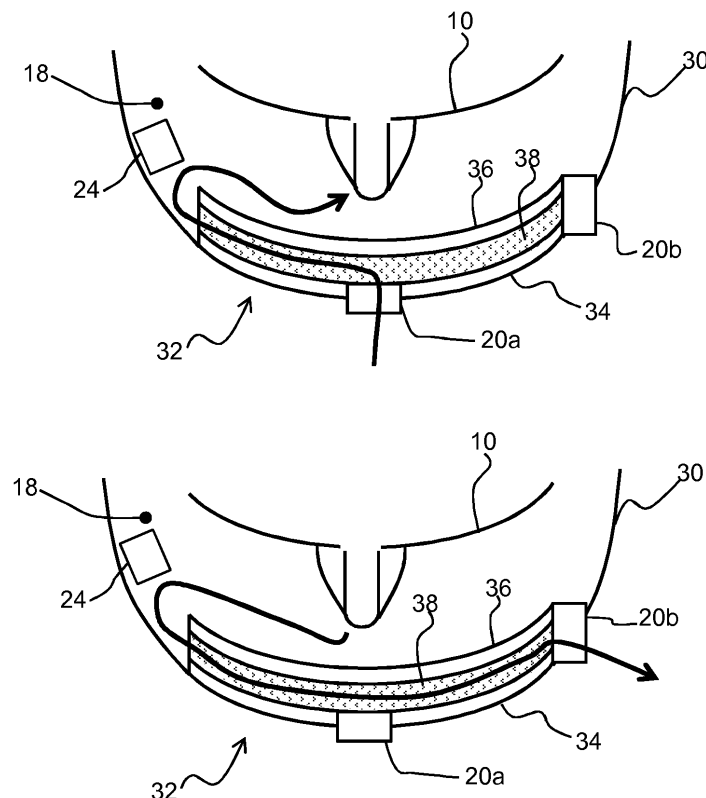


FIG. 2

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Description

FIELD OF THE INVENTION

[0001] This invention relates to a breathing apparatus in the form of a mask, for providing air to the wearer of the breathing apparatus, with the flow assisted by an air blower such as a fan.

BACKGROUND OF THE INVENTION

[0002] 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. The worst in class are Indian cities like Delhi that have an annual pollution level more than 10 times the recommended level. Well known is Beijing with an annual average 8.5 times the recommended safe levels. However, even in European cities like London, Paris and Berlin, the levels are higher than recommended by the WHO.

[0003] Since this problem will not improve significantly on a short time scale, the only way to deal with this problem is to wear a mask which provides cleaner air by filtration.

[0004] A basic mask in the form of a bulk of filter material introduces resistance to the breathing of the user, and can also result in a high temperature and humidity in the mask volume. Furthermore, in a conventional non-powered mask, inhalation also causes a slight negative pressure within the mask which leads to leakage of the ambient contaminants into the mask, which leakage could prove dangerous if these are toxic substances. A basic mask also has low filter performance because a thin filter layer is needed so that there is only a short contact time and distance with the filter material.

[0005] To improve comfort and effectiveness one or two fans can be added to the mask.

[0006] In one arrangement, an inlet (i.e. inhale) fan may be used to provide a continuous intake of air. In this way, the lungs are relieved of the slight strain caused by inhalation against the resistance of the filters in a conventional non-powered mask. A steady stream of air may then be provided to the face and may for example provide a slight positive pressure, to ensure that any leakage is outward rather than inward. However, this gives additional resistance to breathing when exhaling.

[0007] In another arrangement, an exhaust (i.e. exhale) fan may be used to provide a continuous release of air. This instead provides breathing assistance when exhaling, but has the disadvantage that a negative pressure in the mask volume may result, so that leakage around the mask edge results in polluted air leaking into the mask volume.

[0008] Another alternative is to provide both inlet and exhaust fans, and to time the control of the fans in synchronism with the breathing cycle of the user. The breathing cycle may be measured based on pressure (or differential pressure) measurements. This provides im-

proved control of temperature and humidity as well as reducing the resistance to breathing for both inhalation and exhalation.

[0009] By providing regulation of the fan operation in this way (and optionally also regulation of the fan speed) more appropriate ventilation is provided during the inhalation and exhalation sequence and the electrical efficiency is improved. The latter translates into longer battery life or increased ventilation.

[0010] The humidity level inside the mask is typically relatively high due to the breathing of the user. This presents a problem when the ambient temperature is low, e.g. in winter. The exhaled humid air in a cold mask will immediately cause the condensation of the water vapor inside the mask. This condensation may be uncomfortable or unpleasant for the user of the mask and/or it may cause damage or reduce the lifetime of the mask. Condensation may affect the operation of any sensors used to detect the breathing pattern of the user.

[0011] Powered mask designs enable a thicker filter layer to be used so that the filtration efficiency can be increased. However, the range of pollutants that can be filtered is limited by the short flow time and distance through the filter.

[0012] There is therefore a need for a mask design which can address some or all of these problems.

SUMMARY OF THE INVENTION

[0013] The invention is defined by the claims.

[0014] According to examples in accordance with an aspect of the invention, there is provided a mask comprising:

- a mask wall which defines an air chamber;
- an inlet flow control device;
- an outlet flow control device;
- a sensor arrangement for detecting a breathing pattern; and
- a controller for controlling the inlet and outlet flow devices in dependence on the detected breathing pattern, wherein the mask wall comprises a region having a pair of spaced membranes, with a filter material in a spacing between the membranes, wherein at least one of the flow control devices provides a fluid coupling between the outside of the mask and the spacing such that a transverse flow through the spacing is provided by the at least one of the flow control devices.

[0015] This mask design makes use of assisted inhalation and exhalation. This enables the filter material to provide a significant resistance to the air flow. The spacing is designed so that the air flow is not transversely through the mask wall as in conventional filter designs. Instead, there is an air port from the ambient surroundings to the spacing (which may be an inlet port or an

exhaust port), and the air flow between that air port and the air chamber is laterally through the spacing. Thus, the flow distance through the filter material and hence flow contact time with the filter material is greatly increased. As discussed below, this presents various possibilities. In some examples, it enables more effective filtering, for example of a wider range of pollutants, and in other examples it enables a reduction in humidity to reduce condensation.

[0016] Note that the air chamber is the space between the mask wall and the face of the user, which may also be described as the mask volume, whereas the spacing is a part of the structure of the mask wall. By "transverse flow" is meant a flow in a direction predominantly perpendicular to the layer thickness direction of the membranes and hence predominantly perpendicular to the thickness direction of the spacing. Thus, the flow is not through the membranes but is parallel to the surface of the membranes through the spacing.

[0017] By "filter material" is meant a material for removing a component from the air flow, but this component may be particles or specific compounds (including water).

[0018] In one set of examples, the at least one of the flow control devices is the inlet flow control device. In this way, air to be inhaled is passed laterally through the filter material, to increase the exposure to the filter material.

[0019] The inlet flow control device may be located in a middle area of the mask wall region and the spacing is vented to the air chamber at a plurality of edge areas of the mask wall region. This "middle area" is intended to signify the middle of the surface shape of the mask wall region, rather than the middle of thickness of the mask wall region. Thus, the air is driven from the ambient surroundings into the middle of the mask wall region. From there, it follows radial flow paths towards the edge areas, thus ensuring a desired flow length through the filter material.

[0020] This has benefits for filtering but also for humidity reduction. If the spacing is used for reducing humidity (as discussed below), the stored water may be released back to dry inhaled air, since the water absorption function is typically reversible. Inhaling very dry air can cause irritation, so using the water absorbed from exhaled air to provide wetting of dry ambient air is also advantageous.

[0021] In one arrangement, the output flow control device may be located at an edge area of the mask wall region. Thus, the exhaled air passes through the filter material between edge areas. This may again provide a long path. It means that the two flow control devices are spaced apart which makes the assembly and connections easier. It would instead be possible to provide both flow control devices in the middle area.

[0022] In another arrangement, the output flow control device may be located at a part of the mask wall away from the mask wall region. In this case, the filter material is used only for processing the air to be inhaled, and the output flow control device simply functions as an exhaust

valve.

[0023] The inlet flow control device may instead be at an edge area of the mask wall region and the spacing is vented to the air chamber at one or more other edge areas of the mask wall region. This provides an edge to edge flow path, which may ensure the longest flow distance and time through the filter material.

[0024] The output flow control device may again be located at a part of the mask wall away from the mask wall region so that the filter material is used only for processing the air to be inhaled.

[0025] As mentioned above, the mask may comprise a moisture absorbent (desiccant) in the spacing. This may be used to reduce the relative humidity of exhaled air, but also reduce dryness of air to be inhaled, based on a reversible absorption function. The moisture absorbent for example comprises a modified surface layer of one or both membranes, which surface layer faces the spacing.

[0026] The filter material for example comprises a particle filter material. This performs the main filtering function of the mask. The particle filter material for example comprises a HEPA filter material.

[0027] The filter material may also comprise a volatile organic compound filter material. This extends the filtering function of the mask.

[0028] The sensor arrangement for example comprises a pressure monitoring system, and the controller is adapted to determine a respiration cycle from the pressure monitoring system. The absolute pressure in the air chamber, or the relative pressure between the inside and outside, may be used to provide a signal which enables the respiration cycle timing to be derived.

[0029] The mask wall region for example occupies an area of at least 50%, such as at least 75% of the area of the mask wall. The remainder of the mask wall is non-porous, so that substantially all inlet and/or outlet flow passes through the filter material in the spacing.

[0030] The mask wall region may be detachable from the remainder of the mask for replacement or servicing. Some of the filter functions may have a limited lifetime and the filter material may then need regenerating or replacing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Examples of the invention will now be described in detail with reference to the accompanying drawings, in which:

Fig. 1 shows a subject wearing a known face mask;
Fig. 2 shows a first example of face mask, viewed from above;

Fig. 3 shows a second example of face mask;
Fig. 4 shows a third example as a minor modification to Fig. 3;

Fig. 5 shows a perspective view of the mask wall for a design of the general type shown in Fig. 2;

Fig. 6 shows the flow paths during exhalation (top image) and inhalation (bottom image) for an arrangement of the general type shown in Fig. 2; and Fig. 7 shows the electrical components of the mask.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0032] The invention will be described with reference to the Figures.

[0033] 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.

[0034] The invention provides a mask using inlet and outlet flow control based on a user's breathing pattern. The mask wall has a region with a pair of spaced membranes, with a filter material in a spacing between the membranes. At least one of the flow control devices provides a fluid coupling between the outside of the mask and the spacing such that a transverse flow through the spacing is provided. The flow distance through the filter material and hence flow contact time with the filter material is greatly increased.

[0035] The basic operation of a known face mask, as well as various design options will first be discussed.

[0036] Fig. 1 shows a subject 10 wearing a known face mask 12 which covers the nose and mouth of the subject. The purpose of the mask is to filter air before it is breathed in by the subject and to provide active control of the flow of air into an air chamber 18 (i.e. the mask volume) and optionally also out of the air chamber. An air flow control arrangement 20 provides active flow control. The air flow control arrangement is typically a fan arrangement but any suitable fluid flow control device may be used such as a micropump.

[0037] In some known examples, the mask body itself acts as an air filter 16. In an alternative arrangement, the mask body is not gas permeable, and a filter 21 is provided in series with the fan arrangement 20.

[0038] Air is drawn in to the air chamber 18 by inhalation with assistance provided by the fan arrangement. During inhalation, an outlet valve 22 such as a check valve is closed due to the low pressure in the air chamber 18.

[0039] When the subject breathes out, air is exhausted through the outlet valve 22. This valve is opened to enable easy exhalation, but is closed during inhalation.

[0040] The fan arrangement 20 is provided at least for

providing a flow of air into the air chamber 18 during inhalation, thus providing assisted breathing. The fan arrangement may also provide a flow during exhalation (with the outlet valve open). During exhalation, more air may be removed from the air chamber 18 than is exhaled so that additional air is supplied to the face. This increases comfort due to lowering relative humidity and cooling. For example, a minimum exhaust flow rate may be provided for reducing the relative humidity inside the air chamber

[0041] During inhalation, by closing the valve 22, it is prevented that unfiltered air is drawn in. The timing of the outlet valve 22 is thus dependent on the breathing cycle of the subject. The outlet valve may be a simple passive check valve operated by the pressure difference across the mask. However, it may instead be an electronically controlled valve.

[0042] It is known for the operation of the fan arrangement also to be timed with the breathing cycle of the user. For this purpose, a pressure sensor 24 is provided either for measuring the pressure inside the air chamber 18 or for measuring a differential pressure between the inside and outside of the air chamber.

[0043] It is also known to have separate inlet and exhaust fans, in which case the outlet valve is instead a second fan. Thus, there is then assisted inhalation and exhalation.

[0044] This invention relates in particular to a mask design with both inlet and exhaust flow devices (e.g. fans or other pumps) and it relates to a particular design of the mask wall. The mask may be a mouth and nose mask as shown in Fig. 1, or it may be a full face mask.

[0045] Fig. 2 shows a first example, viewed from above.

[0046] The mask comprises a mask wall 30 which defines the air chamber 18. There is an inlet fan 20a (or other flow control device such as a micropump) and an outlet fan 20b (or other flow control device). As in the example of Fig. 1, a sensor arrangement 24 is for detecting a breathing pattern and a controller (not shown in Fig. 2) is provided for controlling the inlet and outlet fans in dependence on the detected breathing pattern.

[0047] The mask wall 30 comprises a region 32 having a pair of spaced membranes 34, 36. An outer membrane 34 forms the outer surface of the mask (although there may be a further outer covering) and an inner membrane 36 forms the boundary of the air chamber 18. A filter material 38 is provided in the spacing between the membranes.

[0048] The filter material 38 in preferred examples is for filtering the air to be inhaled. However, in its broadest sense, the filter material may be provided for the inhalation air flow (for filtering) or for the exhalation air flow (for removing i.e. filtering out water) or for both. Thus, in some examples the inlet fan may be associated with an in-line filter and not with the filter material in the spacing.

[0049] Fig. 2 shows a preferred example in which the inlet fan 20a provides a fluid coupling between the outside

of the mask and the spacing. The top image shows the inhalation air flow, and it shows that a transverse flow is provided through the spacing by the inlet fan 20a.

[0050] The inlet fan provides assisted inhalation so that the filter material 38 in the spacing can provide a significant resistance to the air flow. The flow distance through the filter material and hence flow contact time with the filter material is greatly increased by providing a flow in the direction parallel to the membranes.

[0051] The inlet fan 20a is shown located in a middle area of the mask wall region 32. The spacing is vented to the air chamber 18 at a plurality of edge areas of the mask wall region 32, even though only one flow path is shown in Fig. 2. The air is driven from the ambient surroundings into the middle of the mask wall region 32 and then follows radial flow paths towards the edge areas.

[0052] The outlet fan 20b is provided at an edge area of the mask wall region 32. Flow of exhaled air is shown in the bottom image of Fig. 2, and it passes through the filter material between edge areas, which again provides a long path through the filter material.

[0053] The example of Fig. 2 is for example of particular interest for a mask to be used for standard particle filtering but in cooler weather, so that water condensation should be avoided. In many areas, temperatures drop below freezing in the winter, and it is then common to experience condensation on the inner surface of the mask, where the exhaled air with high relative humidity meets the cold mask. The condensation usually flows down to the interface between the face and the mask and this causes discomfort. In an active mask, the condensation may cause damage or reduce the usage life time of the mask.

[0054] To address the condensation problem, a moisture absorbent is provided in the spacing, in particular on the inner surface of one or both of the membranes 34, 36. There are many possible moisture absorbing materials such as hydrogels, desiccants, and superabsorbent polymers such as polyacrylamide copolymer, ethylene maleic anhydride copolymer, cross-linked carboxymethylcellulose, polyvinyl alcohol copolymers, cross-linked polyethylene oxide, and starch grafted copolymers of polyacrylonitrile.

[0055] The moisture absorbent may be provided as a modified inner surface layer. The moisture absorbent is designed to reduce quickly the humidity in the surrounding moist air, as well as releasing water vapor when the surrounding air is dry.

[0056] The exhaled air passes through the spacing between the two membranes and hence passes over the membranes which reduce the moisture in the exhaled air.

[0057] By way of example, the spacing between the membranes is typically less than 5 mm and for example between 0.1 mm and 1 mm. The preferred spacing depends on the capability of the absorbing materials, and the concentration of the target components to be absorbed.

[0058] The double wall region 32 is generally in front

of the central breathing area (i.e. the nose and mouth). The shape and size will be designed depending on the location of the inlet and/or outlet fans, in order to realize a balanced wind resistance from all directions. A typical surface area would be in the range 50 to 150 cm².

[0059] The membranes and the other part of the mask housing are generally air-impermeable. The functional materials would be filled between the spacing or provided as a modified surface of the membranes.

[0060] The filter material could for example be made from a HEPA (high efficiency particulate air) filter, cotton, or other materials for example designed to filter PM2.5 particulates. The thickness could be from several μ m to 1mm.

[0061] The position of the inlet fan in the middle area of the region 32 provides several benefits. Normally, in cold weather, the absolute humidity is relatively low, so when the ambient air is driven through the moisture absorbent during inhalation, some moisture is taken up by the drier flow, which moisture is released from the material. This provides a wetting function before inhalation, which can improve user comfort.

[0062] Thus, placing the inlet fan in the middle area of the region 32 also extends the usage lifetime of the component before it needs to be regenerated for further use.

[0063] In this way, the cyclic reversal of the flow direction results in regeneration whenever the ambient humidity is not extremely high.

[0064] Fig. 3 shows a second example in which the mask is designed to provide filtering of a greater range of pollutants. Additional functional materials are provided in the spacing for this purpose.

[0065] The inlet fan 20a is at one edge of the region 32 and one or more openings are provided to the air chamber 18 at or near an opposite edge region. This maximizes the flow distance through the filter material. For example, to filter volatile organic compounds, an activated carbon filter is integrated into the filter material. The outlet fan 20b is in the mask wall 30 away from the region 32. Thus, this example does not make use of humidity reduction but focuses on improving filtering efficiency.

[0066] Fig. 4 shows a third example as a minor modification to Fig. 3 in which the inlet fan 20a is again in the middle region (as in Fig. 2) and the one or more openings are provided to the air chamber 18 around the edge region. This makes the flow distance through the filter material more uniform and uses the full volume of the filter material. The outlet fan 20b is again in the mask wall 30 away from the region 32.

[0067] The transverse flow in these two examples again means that instead of passing directly through a filter layer (which may for example be 2 mm thick) a much longer contact time and distance is provided.

[0068] For directed flow through a 2 mm thick filter layer in a basic non-powered mask, a typical average tidal breathe volume of 500 ml and inhalation time of 2s may be assumed. The surface area of a typical basic mask is

around 180 cm². The linear velocity for the inhaling air flow is around 2.1 cm/s which means the time period in contact with the filter layer is around 0.09 s.

[0069] If an active mask is used, the maximum flow velocity is for example 18 L/min. The cross-sectional area of the fan is for example a circle with diameter of 4 cm, so the linear velocity for the inhaling air flow is then around 24 cm/s. The time during which the air remains in the filter layer is then only around 0.008 s.

[0070] In one example, activated carbon fills the spacing. By way of example, 80% of the mask area may be occupied by the region 32, and the inlet fan may be placed in the middle of the spacing (as in Fig. 4) with a distance between the inlet fan and the surrounding openings of 6.7 cm. A linear velocity for the inhaling air flow of 24 cm/s allows a time period of around 0.3 s.

[0071] The longer time that the air has contact with the filtration materials, the better the purification efficiency. In the traditional basic mask, the duration of exposure of 0.09 s is sufficient to remove the pollutants with low concentration, but when an active mask is used to reduce the breathing resistance, the duration of exposure to the traditional filtration layer of 0.008 s, may be insufficient to remove the pollutant.

[0072] The mask design of the invention allows a longer duration of exposure to the filtration materials, which will increase the filtration effect, which is especially significant when an active mask solution is adopted.

[0073] Activated carbon filters also perform a reversible function. Thus, the activated active carbon may also be regenerated by the exhaled air.

[0074] Fig. 5 shows a perspective view of the mask wall for the design of Fig. 2. It shows that there is an array of openings 50 between the spacing and the air chamber around the edge of the region 32. This example shows three openings 50.

[0075] Fig. 6 shows the flow paths during exhalation (top image) and inhalation (bottom image) for an arrangement with six openings 50.

[0076] Fig. 7 shows the electrical components of the mask. The mask has a pressure sensor 24 or any other sensor arrangement (e.g. a flow sensor) for detecting the breathing pattern. A controller 60 receives the sensor input and controls the two fans 20a, 20b. As shown, each fan comprises a motor which drives a fan blade.

[0077] The controller and the two fans are powered by a local battery 62.

[0078] The mask wall region for example occupies an area of at least 50%, such as at least 75% of the area of the mask wall.

[0079] The mask wall region may be detachable from the remainder of the mask for replacement or servicing. Some of the filter functions may have a limited lifetime and the filter material may then need regenerating or replacing.

[0080] As discussed above, embodiments make use of a controller, which can be implemented in numerous ways, with software and/or hardware, to perform the var-

ious functions required. A processor is one example of a controller which employs one or more microprocessors that may be programmed using software (e.g., microcode) to perform the required functions. A controller may however be implemented with or without employing a processor, and also may be implemented as a combination of dedicated hardware to perform some functions and a processor (e.g., one or more programmed microprocessors and associated circuitry) to perform other functions.

Examples of controller components that may be employed in various embodiments of the present disclosure include, but are not limited to, conventional microprocessors, application specific integrated circuits (ASICs), and field-programmable gate arrays (FPGAs). In various implementations, a processor or controller may be associated with one or more storage media such as volatile and non-volatile computer memory such as RAM, PROM, EPROM, and EEPROM. The storage media may be encoded with one or more programs that, when executed on one or more processors and/or controllers, perform the required functions. Various storage media may be fixed within a processor or controller or may be transportable, such that the one or more programs stored thereon can be loaded into a processor or controller.

[0081] Other 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. 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. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A mask comprising:

- a mask wall (30) which defines an air chamber (18);
 - an inlet flow control device (20a);
 - an outlet flow control device (20b);
 - a sensor arrangement (24) for detecting a breathing pattern; and
 - a controller (30) for controlling the inlet and outlet flow devices in dependence on the detected breathing pattern,
- wherein the mask wall (30) comprises a region (32) having a pair of spaced membranes (34, 36), with a filter material (38) in a spacing between the membranes, wherein at least one of the flow control devices provides a fluid coupling between the outside of the mask and the spacing

such that a transverse flow through the spacing is provided by the at least one of the flow control devices.

50%, such as at least 75% of the area of the mask wall.

2. A mask as claimed in claim 1, wherein the at least one of the flow control devices is the inlet flow control device (20a). 5
3. A mask as claimed in claim 2, wherein the inlet flow control device is located in a middle area of the mask wall region and the spacing is vented to the air chamber at a plurality of edge areas of the mask wall region. 10
4. A mask as claimed in claim 3, wherein the output flow control device is located at an edge area of the mask wall region. 15
5. A mask as claimed in claim 3, wherein the output flow control device is located at a part of the mask wall away from the mask wall region. 20
6. A mask as claimed in claim 2, wherein the inlet flow control device is at an edge area of the mask wall region and the spacing is vented to the air chamber at one or more other edge areas of the mask wall region. 25
7. A mask as claimed in claim 6, wherein the output flow control device is located at a part of the mask wall away from the mask wall region. 30
8. A mask as claimed in any preceding claim, comprising a moisture absorbent in the spacing. 35
9. A mask as claimed in claim 8, wherein the moisture absorbent comprises a modified surface layer of one or both membranes, which surface layer faces the spacing. 40
10. A mask as claimed in any preceding claim, wherein the filter material comprises a particle filter material. 45
11. A mask as claimed in any preceding claim, wherein the filter material comprises a HEPA filter material. 50
12. A mask as claimed in any preceding claim, wherein the filter material comprises a volatile organic compound filter material. 55
13. A mask as claimed in any preceding claim, wherein the sensor arrangement comprises a pressure monitoring system, wherein the controller is adapted to determine a respiration cycle from the pressure monitoring system. 55
14. A mask as claimed in any preceding claim, wherein the mask wall region occupies an area of at least
15. A mask as claimed in any preceding claim, wherein the mask wall region is detachable from the remainder of the mask for replacement or servicing.

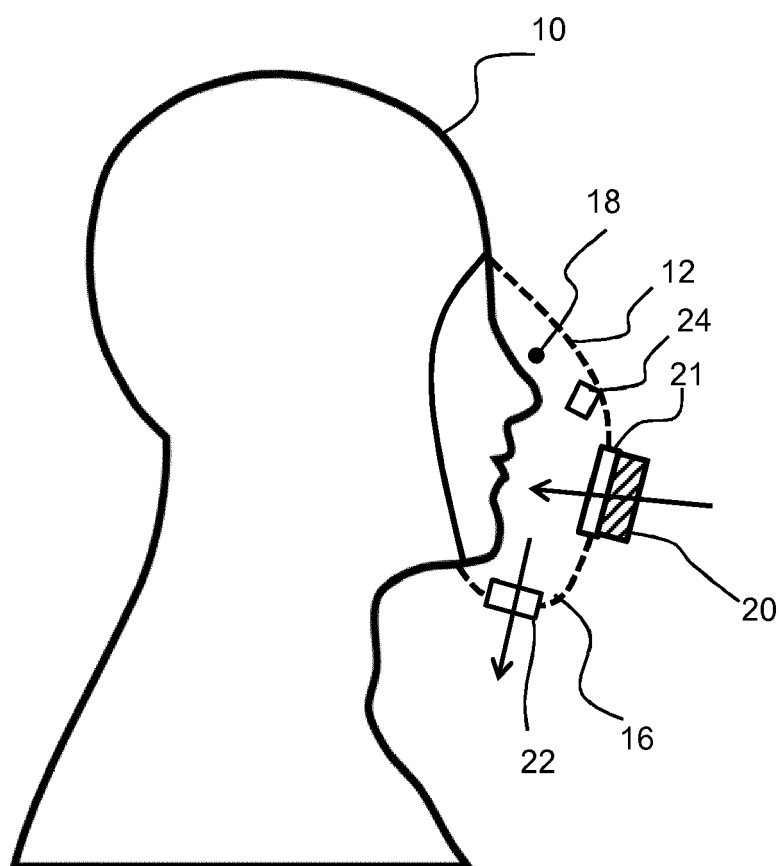


FIG. 1

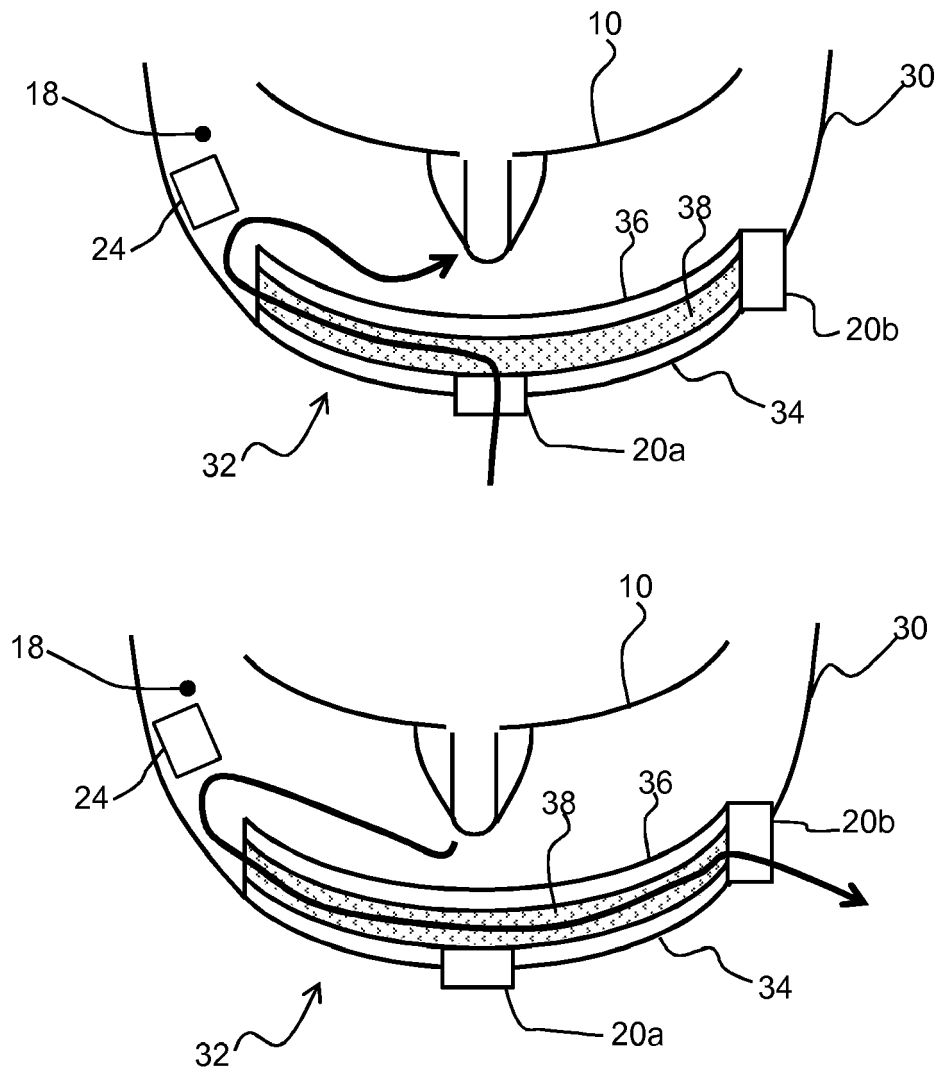


FIG. 2

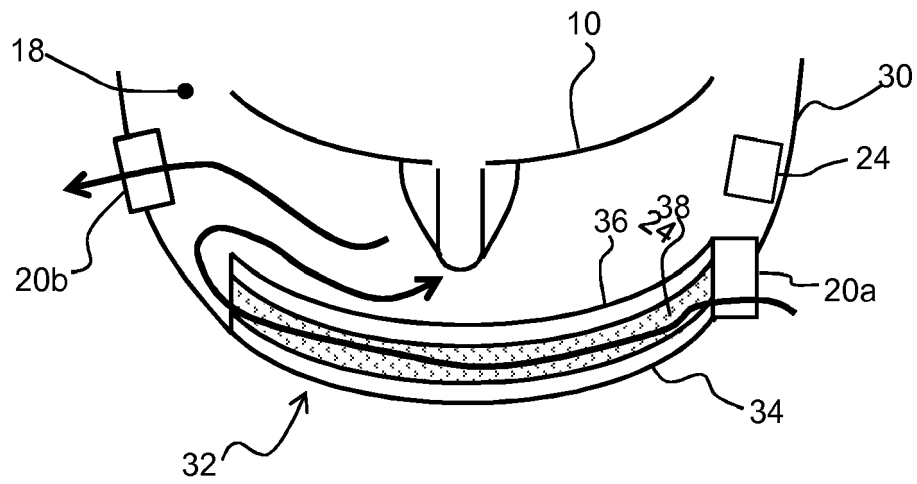


FIG. 3

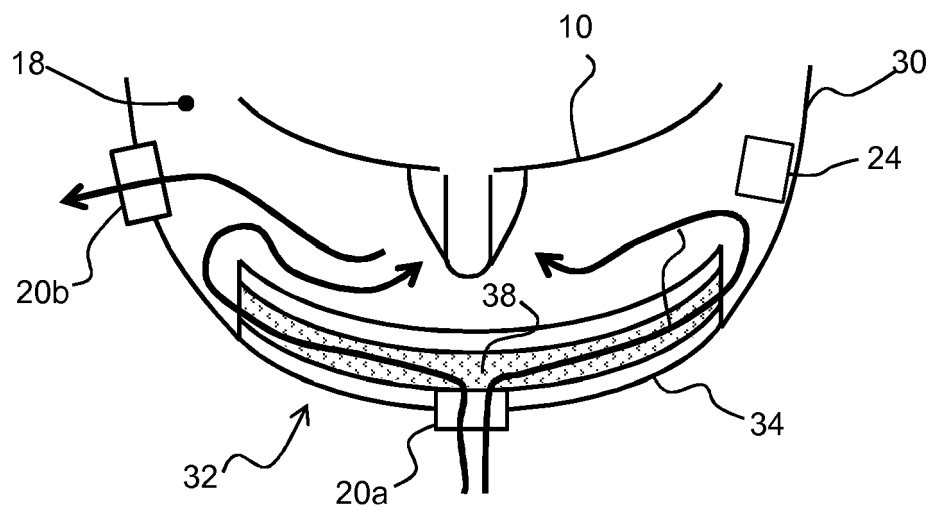


FIG. 4

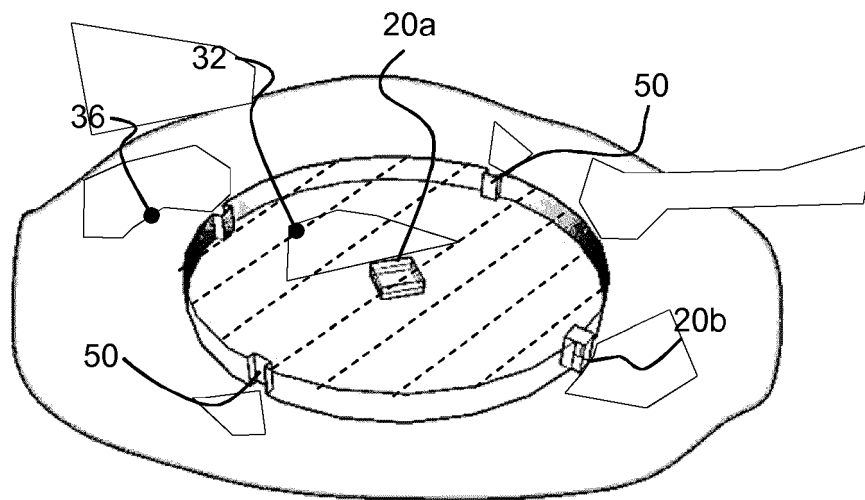


FIG. 5

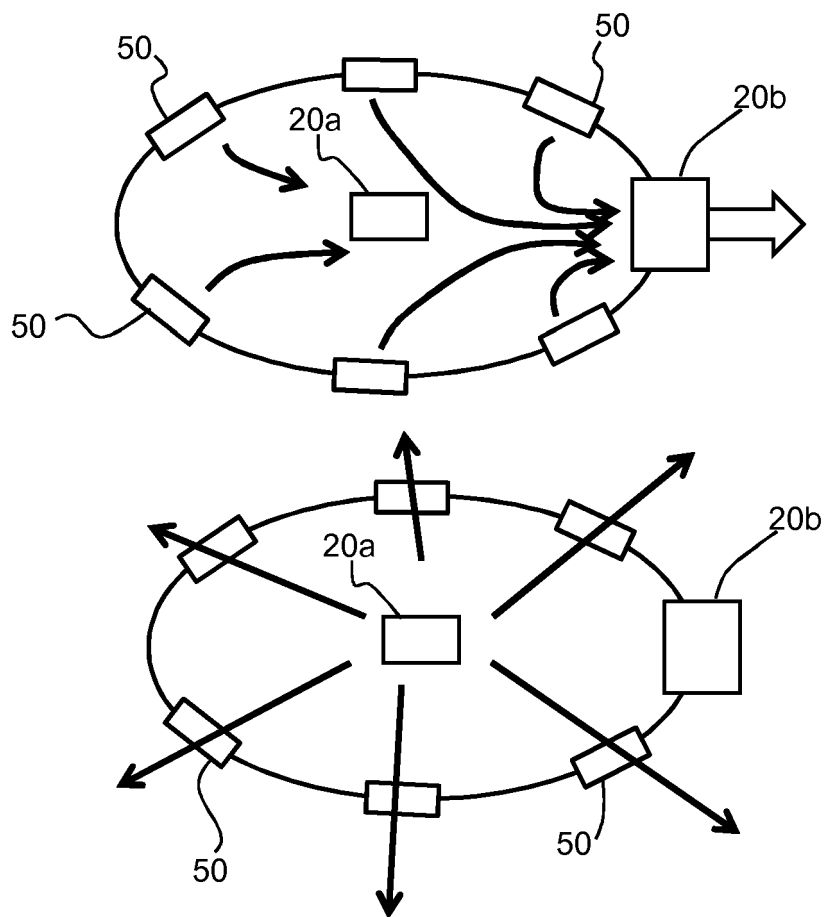


FIG. 6

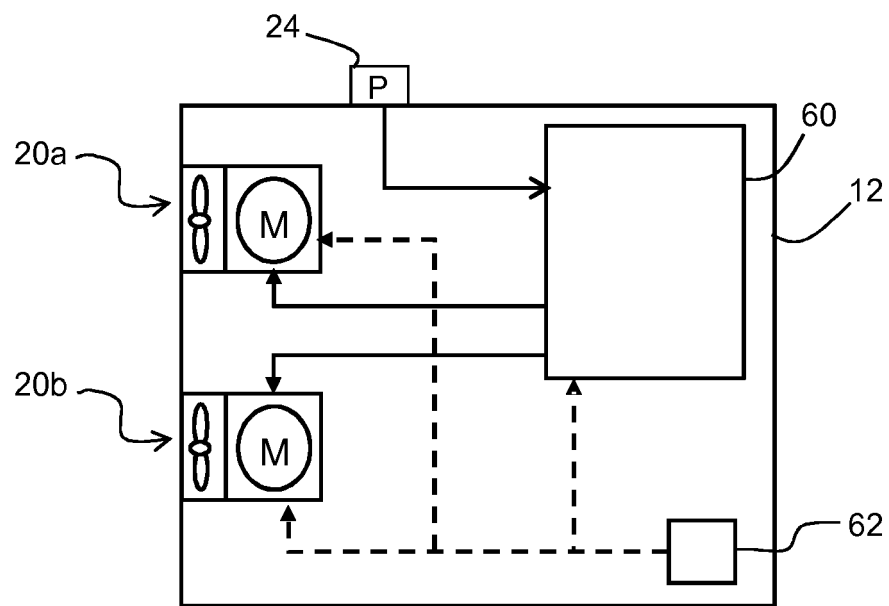


FIG. 7



EUROPEAN SEARCH REPORT

Application Number
EP 18 16 2452

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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 205 460 549 U (BEIJING SHANGHONG HENGYUAN TECH CO LTD) 17 August 2016 (2016-08-17) * paragraphs [0006] - [0017] * * paragraphs [0041] - [0055] * * figures 1-3 *	1-15	INV. A62B7/10 A62B9/00 A62B18/00 A62B18/02 A62B23/02
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