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(54) **A POLLUTION MASK AND CONTROL METHOD**

(57) A mask comprises a filter layer and disinfection unit which is integrated with the mask or connects to the mask. The mask has a filtering configuration and a cleaning configuration. In the filtering configuration, the filter layer forms a mask wall which forms an air chamber over the mouth and nose of the wearer of the mask. In the cleaning configuration, the controller is configured to operate the disinfection unit to provide a disinfection treatment of the filter layer.

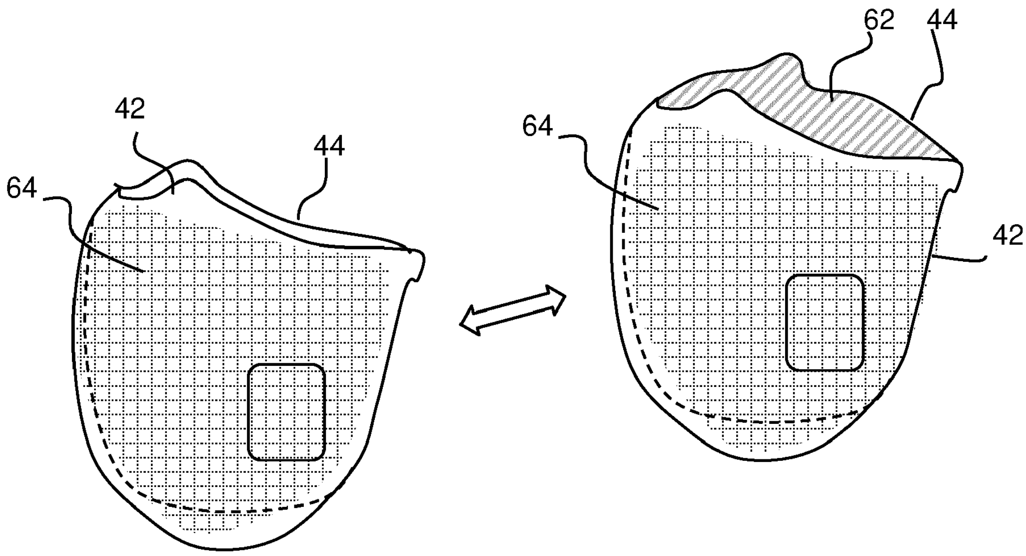

FIG. 6

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Description

FIELD OF THE INVENTION

[0001] This invention relates to a pollution mask, for providing filtered air to the wearer of the mask, with the flow assisted by 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] The spread of disease is also of increasing concern, especially with the outbreak of the Covid-19 virus. The use of a respiratory or surgical mask is thus now widespread, not only to deal with pollution in built up cities but also to prevent the spread of disease. Wearing a mask can substantially reduce the risk of exposure to pathogens born by respiratory particles.

[0004] The mask provides cleaner air by filtration. To improve comfort and effectiveness, one or two fans can be added to the mask. For efficiency and longevity reasons these are normally electrically commutated brushless DC fans.

[0005] 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.

[0006] 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.

[0007] 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 improved control of temperature and humidity as well as reducing the resistance to breathing for both inhalation and exhalation.

[0008] A powered mask also improves comfort by actively dispelling exhaled air of higher temperature and humidity, higher CO_2 concentration and lower O_2 concentration.

[0009] However, during a quickly developing epidemic or pandemic outbreak of contagious diseases (such as influenza, avian flu, SARS, COVID-19 etc.), a short supply of respiratory masks and filter replacements is expected and puts people at a higher risk of contracting the disease.

[0010] It would be desirable for a consumer to be able to resume the hygiene and filtration efficacy of a mask to enable reuse for low-risk daily protection.

[0011] Currently, the majority of medical, industrial or daily protective masks perform the filtration function using mesh materials made using melt blowing of polypropylene. The efficacy is often further enhanced by electretizing the fiber to trap particles by electrostatic adherence.

[0012] It has been proven that disinfection treatments such as UVC radiation, dry and moist heating, and microbiocidal chemicals (such as alcohol, aldehydes, and oxidant) can effectively deactivate the microbes without substantially impairing the filtration efficacy.

[0013] There is not a current solution enabling reuse of a pollution mask in a convenient and effective way for consumers.

SUMMARY OF THE INVENTION

[0014] The invention is defined by the claims.

[0015] According to examples in accordance with an aspect of the invention, there is provided a mask comprising:

> a filter layer;
> a controller; and
> a disinfection unit which is integrated with the mask or connects to the mask;
> wherein the mask has a filtering configuration and a cleaning configuration, wherein:
>
> > in the filtering configuration, the filter layer forms a mask wall which forms an air chamber over the mouth and nose of the wearer of the mask; and

in the cleaning configuration, the controller is configured to operate the disinfection unit to provide a disinfection treatment of the filter layer.

[0016] The mask is a pollution or allergen or viral/bacterial filtering mask. The mask is of the type in which the filter layer is a large area surface which covers the mouth and nose. Thus, there is a large surface area which needs to be cleaned, for example an area of at least 75cm^2 for example more than 100cm^2. It has a partially or fully integrated disinfection unit. The mask can be disinfected in open air, without needing to be placed in a disinfection chamber. The disinfection unit may be fully integrated, in which case the disinfection function is simply a setting of the mask operation. Alternatively, the disinfection unit may include some parts which are applied to the mask to place it into the cleaning configuration. Preferably, at least some parts of the disinfection unit are integrated parts of the mask design, such as a heater and/or fan.

[0017] The filtering configuration and the cleaning configuration are mutually exclusive so that the cleaning configuration is performed when the mask is not in use. In this way, the cleaning configuration is optimized for the disinfection function without needing to take into account the need for a filtering function to be performed.

[0018] The disinfection unit for example comprises a fan, wherein in the cleaning configuration, the controller is configured to operate the fan as part of the disinfection treatment of the filter layer.

[0019] The use of a fan for the cleaning configuration makes the cleaning treatment more uniform and assists in drying the filter layer after is has been used. The fan may be used only for the cleaning function and it may then be part of a disinfection unit which is attached to the mask. Alternatively, the fan may be an existing part of an active mask.

[0020] In the latter case, in filtering configuration the controller may be configured to operate the fan as part of the filtering function. The fan is then part of the structure of an active mask. The fan function is re-used for the cleaning function.

[0021] The disinfection unit may comprise a heater embedded into, or provided on, the filter layer, wherein in the cleaning configuration the controller is configured to operate the heater and the fan to provide heating of the filter layer and to draw air through the filter layer.

[0022] Heating is one possible way to implement the disinfection. For example, the controller may be adapted to control the heating to greater than 55 degrees, for example greater than 60 degrees during the cleaning mode.

[0023] The heater may comprise a mesh of heating wires. This provide a lightweight and low cost implementation of the heater.

[0024] The disinfection unit may comprise a support member for connection to the filter layer, wherein in the cleaning configuration, the support member and the filter layer are coupled to define a closed cavity, and the controller is configured to operate the fan to draw air between the inside and outside of the cavity through the filter layer.

[0025] The support member is used to form a cavity which is defined at least in part by the filter layer. Operating the heater provides a disinfection function for the filter layer. By forming the filter layer into a cavity, and using a fan to drive air in or out of the cavity, a heating and drying function is achieved so that the filter layer can be regenerated.

[0026] This provides an energy efficient, space efficient and cost efficient way to provide restorative cleaning by providing a closed cavity. Because the cavity is closed, air is forced through the filter layer, to provide forced convection for heating and drying. The fan drives air in or out of the cavity, and the corresponding displacement of air is drawn out or in through the filter layer.

[0027] The support member is preferably non-permeable. The fan air flow thus is all driven through the filter layer or layers.

[0028] The support member may comprise a collapsible structure. It may thus be collapsed for storage. It may even be attached to the mask so that there are no separate parts required; the mask can simply be converted from filtering mode to the cleaning mode on-the-go. The support member may comprise first and second support elements for forming opposing cavity closures.

[0029] The mask may further comprise a shell layer. The shell layer for example functions as an outer filter layer, and the filter layer functions as an inner filter layer. The shell layer may for example support a fan in normal use. The mask may thus comprise a fan fixed to the shell layer.

[0030] In the filtering configuration, the shell layer and the filter layer may be coupled together to define the mask wall and in the cleaning configuration the shell layer and the filter layer are separated to form a cavity between them.

[0031] In this design, a cavity is formed between the shell layer and the filter layer, for example by the support member mentioned above or simply by having a bistable coupling between the shell layer and the filter layer.

[0032] The shell layer may also have a heater, for example comprising a mesh of heating wires. Thus, the cleaning may be applied to the shell and the filter layer.

[0033] The mask may include a temperature sensor and optionally also a humidity sensor. These sensors may be used both for the normal operation of the mask to control the user comfort and also in the cleaning mode to control the heating and drying functions.

[0034] 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

[0035] Examples of the invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 shows a known face mask design which may be modified in accordance with the invention;
Figure 2 shows one example of the components of the mask of Figure 1;
Figure 3 shows in more detail an example of the shape and configuration of a known mask design of the type shown in Figures 1 and 2;.
Figure 4 shows the mask of Figure 3 in an assembled state;
Figure 5 shows an inner filter layer which may be used as the only filter layer of a mask;
Figure 6 shows an inner filter layer and outer shell layer;
Figure 7 shows a version with a shell layer and inner filter layer with a fan module attached to the shell layer;
Figure 8 shows a version with only an inner filter layer having an attached fan module;
Figure 9 shows a version with only an inner filter layer and with no fan; and
Figure 10 shows how an inner filter layer and shell layer may be designed to toggle between open and closed states.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0036] The invention will be described with reference to the Figures.

[0037] 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.

[0038] The invention provides a mask comprising a filter layer and disinfection unit which is integrated with the mask or connects to the mask. The mask has a filtering configuration and a cleaning configuration. In the filtering configuration, the filter layer forms a mask wall which forms an air chamber over the mouth and nose of the wearer of the mask. In the cleaning configuration, the controller is configured to operate the disinfection unit to provide a disinfection treatment of the filter layer.

[0039] Figure 1 shows a known face mask design which may be modified in accordance with the invention.

[0040] A subject 10 is shown wearing a 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 the subject. For this purpose, the mask body itself acts as an air filter 16. Air is drawn in to an air chamber 18 formed by the mask by inhalation. During inhalation, an outlet valve 22 such as a check valve is closed due to the low pressure in the air chamber 18.

[0041] Optionally, a sensing arrangement 24 is provided for measuring the temperature inside the mask chamber, or even both the temperature and humidity (e.g. relative or absolute humidity) inside the mask chamber 18.

[0042] The filter 16 may be formed only by the body of the mask, or else there may be multiple layers. For example, the mask body may comprise an external cover (i.e. an outer shell) formed from a porous textile material, which functions as a pre-filter. Inside the external cover, a finer filter layer is reversibly attached to the external cover. The finer filter layer may then be removed for cleaning and replacement, whereas the external cover may for example be cleaned by wiping. The external cover also performs a filtering function, for example protecting the finer filter from large debris (e.g. mud), whereas the finer filter performs the filtering of fine particulate matter. There may be more than two layers. Together, the multiple layers function as the overall filter of the mask.

[0043] 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. In one example, fan module 20 in the form of an exhaust fan assists in the removal of air through the outlet valve 22. Preferably, more air is removed than exhaled so that additional air is supplied to the face. This increases comfort due to lowering relative humidity and cooling. During inhalation, by closing the valve, 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 filter 16. However, it may instead be an electronically controlled valve.

[0044] Figure 2 shows one example of the components of the system. The same components as in Figure 1 are given the same reference numbers. The optional sensing arrangement is shown as a separate temperature sensor 24a and humidity sensor 24b.

[0045] In addition to the components shown in Figure 1, Figure 2 shows a controller 30 and a local battery 32.

[0046] The fan module 20 comprises a fan blade 20a and a fan motor 20b. In one example, the fan motor 20b is an electronically commutated brushless motor.

[0047] If the outlet valve 22 is an electronically switched value, respiration cycle timing information may then be used to control the outlet valve 22 in dependence on the phase of the respiration cycle. This may for example be determined by a pressure sensor 36.

[0048] In addition to controlling the outlet valve, the controller may turn off the fan e.g. during an inhalation time. This gives the mask different operating modes, which may be used to save power.

[0049] For a fan used for assisting exhalation, the fan operation forces air out of the area between face and mask. This enhances comfort because exhalation is made easier. It can also draw additional air onto the face which lowers the temperature and relative humidity. Between inhalation and exhalation, the fan operation increases comfort because fresh air is sucked into the space between the face and the mask thereby cooling that space.

[0050] During inhalation, the outlet valve is closed (either actively or passively) and the fan can be switched off to save power. This provides a mode of operation which is based on detecting the respiration cycle.

[0051] The mask system as described above is known. The invention relates to disinfection of the filter layer and, if one is used, an outer shell.

[0052] Figure 3 shows in more detail an example of the shape and configuration of a known mask design of the type shown in Figures 1 and 2. The mask 12 is shown in exploded view and comprises an outer shell 42 and an inner filter member 44. The outer shell is rigid or semi-rigid with ear straps 43, whereas the filter member 44 is formed of a fabric and thus easily deforms such that an outer edge can match the shape of a wearer's face. The outer shell is porous so that air can flow through.

[0053] The inner filter member 44 is sealed around a connector module 46. The connector module 46 is for connecting to the fan module 20. In this particular example, the connector module 46 comprises a passive check valve. The connector module and the fan module may be considered together to comprise a fan assembly and the two modules may be connected together and disconnected manually. Thus, the connector module and the fan module together comprise a separable coupling to enable the inner filter member to be detached from the fan module. The wearer breathes through the inner filter member 44, in particular through the area of the inner filter member which is outside the area of the connector module. Thus, the area outside the connector module functions as the filtering system for the air breathed by the wearer. The connector module connects to a portion of the outer surface of the filter member, as shown. In particular, in this example the connector module connects to a portion at one lateral side of the filter member.

[0054] A control module 48 is coupled to the outside of the filter member 44. The control module includes the fan module 20 of the fan assembly and also a control unit 52. The control unit 52 for example comprises a battery and other control circuitry. This may include sensors. Note that the control circuitry may instead be on the fan module side. Thus, the various additional circuitry elements and battery may be divided between the fan module and the control unit in different ways.

[0055] The connector module 46 is permanently fixed to the filter member 44 so that it is discarded with the filter member 44 when there is filter replacement. The fan module 20 of the fan assembly is reusable and includes (at least) the fan drive circuitry and fan impeller.

[0056] The outer casing 42 has an opening 54 in which the fan module 20 of the fan assembly is received.

[0057] An electrical connector bridge 58 provides electrical connection between the control unit 52 and the fan module 20 of the fan assembly, for transfer of power and control signals.

[0058] The fan module 20 of the fan assembly and the control unit 52 are at opposite lateral sides of the mask, i.e. one on each side of the nose of the wearer. This provides a balanced weight distribution. By having two modules, the weight of each individual part is reduced, so that the loading at any one location is reduced.

[0059] Figure 4 shows the mask in the assembled state from one front side.

[0060] A first set of examples of the invention is based on forming a closed cavity which includes the filter layer (or multiple filter layers). By drawing air into and out of the closed cavity, a drying function is performed. A disinfection treatment is also carried out, for example by heating. However UV radiation may instead be used.

[0061] Figure 5 shows a filter layer 44 which may be used as the only filter layer of a mask. It has a generally cup-shaped profile.

[0062] A heater 60 is embedded into, or provided on, the filter layer 44. The mask has a cleaning configuration in which the control unit 52 is configured to operate the heater 60 and the fan module 20 to provide heating of the filter layer 44 and to draw air through the filter layer.

[0063] Heating is one possible way to implement the disinfection. For example, the controller may be adapted to control the heating to greater than 55 degrees, for example greater than 60 degrees during the cleaning mode. The heating is used to thermally deactivate microbes and the fan module is used to generate air convection to make the treatment uniform and carry moisture away. Such treatment can disinfect the mask while essentially retain the filtration efficacy thus extend the lifetime of the mask filter for daily protection in low risk environment.

[0064] The heater 60 for example may comprise a mesh of heating wires such as carbon fiber heating wires. This provides a lightweight and low cost implementation of the heater. The temperature can also be controlled to a lower level to aid the evaporation of moisture from the fabric of the filter layer.

[0065] To form a closed cavity, the disinfection unit in this example has a support member 62 for connection to the filter layer. The support member 62 is for example shaped to enable the opening of the cup-shaped mask layer to be closed. Preferably, the filter layer remains in place attached to the mask. When in a cleaning configuration, the support member and the filter layer are thus coupled to define a closed cavity. The fan module 20 is used to draw air between the inside and outside of that closed cavity through the filter layer 44.

[0066] Operating the heater 60 provides a disinfection function for the filter layer. By forming the filter layer into a cavity, and using a fan to drive air in or out of the cavity, a heating and drying function is achieved so that the filter layer can be regenerated.

[0067] The inlet of the fan module for example faces the inside of the cavity and its outlet faces outward. The exhaust check valve (if present) for example faces away from the fan module to prevent air being driven through the check valve. Ambient air is thus is drawn into the cavity, passing the heating element and the mask filter layer, and flows over the filter layer by convection. The air exits the cavity via the fan, carrying away moisture and residual heat.

[0068] Figure 6 shows an inner filter layer 44 (which will however simply be referred to as "the filter layer") and an outer shell layer 42.

[0069] In the filtering configuration, the shell layer 42 and the filter layer 44 may be coupled together to define the mask wall. In the cleaning configuration, the shell layer 44 and the filter layer 42 are separated to form a cavity between them. A support member 62 again may be used to hold the shell layer and the filter layer apart.

[0070] However, a bistable coupling may instead be provided between the shell layer and the filter layer so that it may be pulled into a cavity shape or closed, without needing any additional support member.

[0071] The shell layer may also have a heater 64. Thus, the cleaning may be applied to the shell layer and the filter layer. The filter layer and shell layer will have different mass and thermal properties, so the heaters may have different designs, e.g. different resistance and/or be driven by different voltage, current, or pulse mode. They may thus generate heat at different rates but achieve the same temperature (with the aid of air convection) or achieve same level of disinfection and drying.

[0072] Figures 7 to 9 show various possible configurations. The shape of the filter layer and shell layer (when present) are represented as a cylinder, for simplicity.

[0073] Figure 7 shows a version with a shell layer 42 and filter layer 44 with the fan module attached to the shell layer. A support member is used to hold the shell layer and filter layer open and to close the cavity. The support member is shown as a pair of supports 70 for forming opposing cavity closures. These may be collapsible so that they occupy a small space when not used and they may be stored with the mask itself. They may for example comprise a rim that is held open by a transverse strut that engages at its ends with opposing fixtures on the rim. The rim may be closed with the fixture disengaged and the strut pivoted away about its hinge. The rim is for example made of semi-rigid material and may have two limbs connected at their ends by hinges.

[0074] The cavity closures defined by the support member is for example a flexible soft material but which is essentially non-permeable to air and heat. Thus, when placed at the intended locations, they complete the closure and create a cavity for effective convection. When not in use, they can be folded and stored easily.

[0075] The support member may comprise a pair of be narrow straps or bands to implement the closure and optionally also provide electrical connections. Of course in other designs a single support member element is needed.

[0076] Figure 8 shows a version with only an single filter layer 44 having an attached fan module 20. The support member 62 forms a closed cavity.

[0077] Figure 9 shows a version with only a single filter layer 44 and with no fan as part of the mask. Instead, the fan module 20 is part of the support member 62 which couples to the filter layer.

[0078] The fan module 20 includes a battery, and the support member 62 provide an electrical connection 90 from the battery to the heater of the filter layer. Thus, the fan does not need to be the fan of an active mask. It may be part of the disinfection unit. This version is thus for a passive mask with no fan and no electrical components. The powering of the heater may be a simple DC driving scheme or it may be a pulse width modulation scheme or other driving approach.

[0079] Figure 10 shows that an inner filter layer 44 and a shell layer 42 may be designed to toggle between open and closed states without needing external support. For example, the fan module may deliver air into the cavity and thereby maintain it as inflated balloon during the cleaning treatment. The outlet check valve in such a case may need to be closed off if is a passive device.

[0080] The example of heating has been given above. The heating and drying treatment is timed and preferably monitored using at least a temperature and humidity sensor in the air flow path to estimate the state of the regeneration process. The heating power can be tuned (via voltage, current and pulse mode) to speed up the treatment while avoid causing thermal damage to the device.

[0081] For thermal deactivation of microbes, it has been shown that 55 °C dry heating for 30 minutes can deactive all influenza virus, and for the same duration, 60 °C is need to deactive all staphylococcus aureus. For safety, the later time-duration or greater is needed but should not exceed the thermal tolerance of any mask filter material.

[0082] For drying the mask, assuming the clenaing treatment is conducted in an ambient environment of temperature

T_e (°C) and relative humidity of H_{re} (%) at 1 bar (100kPa) atmosphic pressure, then the absolute humidity H_{ae} (milibar) of ambient air can calculated as:

$$H_{ae}=H_{re}*0.06137*\exp(17.5*T_e/(241+T_e))$$

[0083] If a heated air flow temperature T_d(°C) is used for drying the mask to an equilibrium moisture level (H_{ae}) with the air, then the target relative humidity of the heated air flow H_{rd}(%), i.e. the drying treatment, can be calculated as:

$$H_{rd}= H_{re}*\exp\{17.5*[T_e/(241+T_e)-T_d/(241+T_d)]\}$$

[0084] Thus, for instance, if the ambient conditions are T_e=25 °C and H_e=60%, then the absolute humidity is 19.07 milibar. To reach equilibrium with this humidity, the target relative humidity would need to reach H_{rd}=9.49% in the cavity if a drying air flow of 60 °C is used, or reach H_{rd}=7.55% if a drying air flow of 65 °C, or reach H_{rd}=12.03% if a drying air flow of 55 °C is used.

[0085] The drying time will depend on the environment temperature and humidity, and moisture level of the mask fabric, so it is preferably monitored in real time. An empirical model or just a constant can also be used for the drying time.

[0086] An array of UV LEDs may instead be integrated onto the filter layer or the shell layer, or provided between them.

[0087] The use of a fan to provide drying and uniform cleaning treatment is preferred. However, other examples may not use fan assisted drying, although the cleaning function may then require a longer time duration.

[0088] For consumer (non-medical) masks, the pressure inside the air chamber preferably remains below 2 cmH_2O, or even below 1 cmH_2O or even below 0.5 cmH_2O, above the external atmospheric pressure. The pollution mask in such a case is not for use in providing a continuous positive airway pressure, and is not a mask for delivering therapy to a patient. In such consumer applications, the mask is preferably battery operated so the low power operation is of particular interest.

[0089] As discussed above, embodiments make use of a controller, which can be implemented in numerous ways, with software and/or hardware, to perform the various 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.

[0090] 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).

[0091] 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.

[0092] 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 filter layer (44);
a controller (52); and
a disinfection unit which is integrated with the mask or connects to the mask;
wherein the mask has a filtering configuration and a cleaning configuration, wherein:

in the filtering configuration, the filter layer forms a mask wall which forms an air chamber over the mouth

and nose of the wearer of the mask; and
in the cleaning configuration, the controller is configured to operate the disinfection unit to provide a disinfection treatment of the filter layer.

2. The mask of claim 1, wherein the disinfection unit comprises a fan (20), wherein in the cleaning configuration, the controller (52) is configured to operate the fan as part of the disinfection treatment of the filter layer.

3. The mask of claim 2, wherein in the filtering configuration, the controller (52) is configured to operate the fan as part of the filtering function.

4. The mask of claim 2 or 3, wherein the disinfection unit comprises a heater (60) embedded into, or provided on, the filter layer (44), wherein in the cleaning configuration, the controller (52) is configured to operate the heater (60) and the fan (20) to provide heating of the filter layer and to draw air through the filter layer.

5. The mask of claim 4, wherein the controller (52) is adapted to control the heating to greater than 55 degrees, for example greater than 60 degrees during a cleaning mode in the cleaning configuration.

6. The mask of claim 4 or 5, wherein the heater (60) comprises a mesh of heating wires.

7. The mask of claim 4, 5 or 6, wherein the disinfection unit comprises a support member (62) for connection to the filter layer, wherein in the cleaning configuration, the support member (62) and the filter layer (44) are coupled to define a closed cavity, and the controller is configured to operate the fan to draw air between the inside and outside of the closed cavity through the filter layer.

8. The mask of claim 7, wherein the support member (62) is non-permeable.

9. The mask of claim 7 or 8, wherein the support member (62) comprises a collapsible structure.

10. The mask of any one of claims 7 to 9, wherein the support member (62) comprises first and second support elements (70) for forming opposing cavity closures.

11. The mask of any one of claims 1 to 10, further comprising a shell layer (42).

12. The mask of claim 11, comprising a fan (20) fixed to the shell layer (42).

13. The mask of claim 11 or 12, wherein:

in the filtering configuration, the shell layer (42) and the filter layer (44) are coupled together to define the mask wall; and
in the cleaning configuration, the shell layer (42) and the filter layer (44) are separated to form a cavity between them.

14. The mask of claim 13, wherein the shell layer (42) has a heater (64), for example comprising a mesh of heating wires.

15. The mask of any one of claims 1 to 14, further comprising a temperature sensor (24a) and optionally also a humidity sensor (24b).

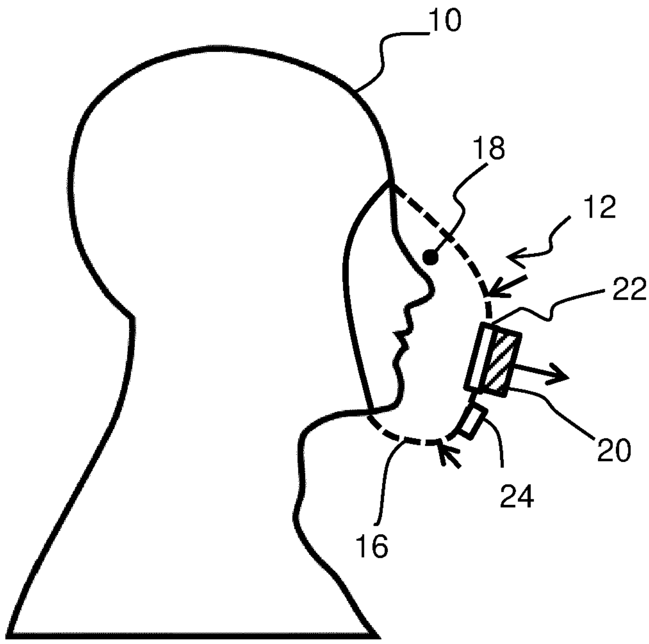

FIG. 1

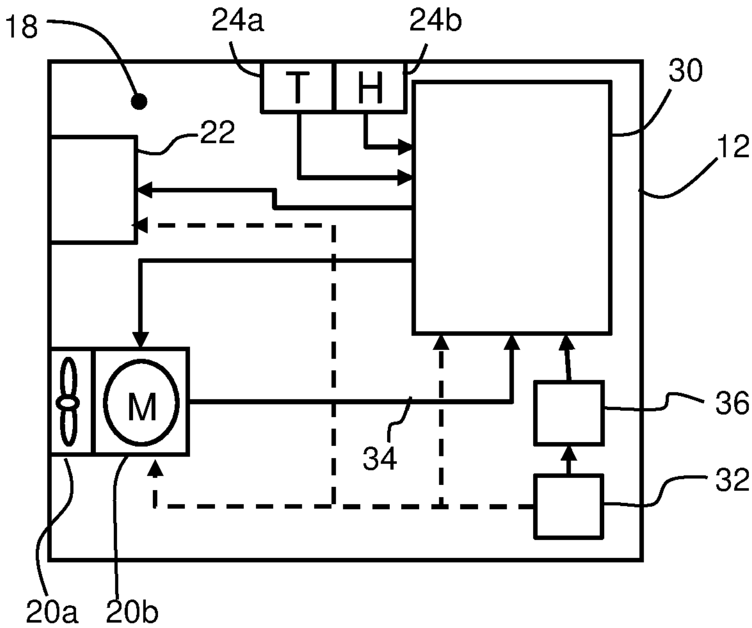

FIG. 2

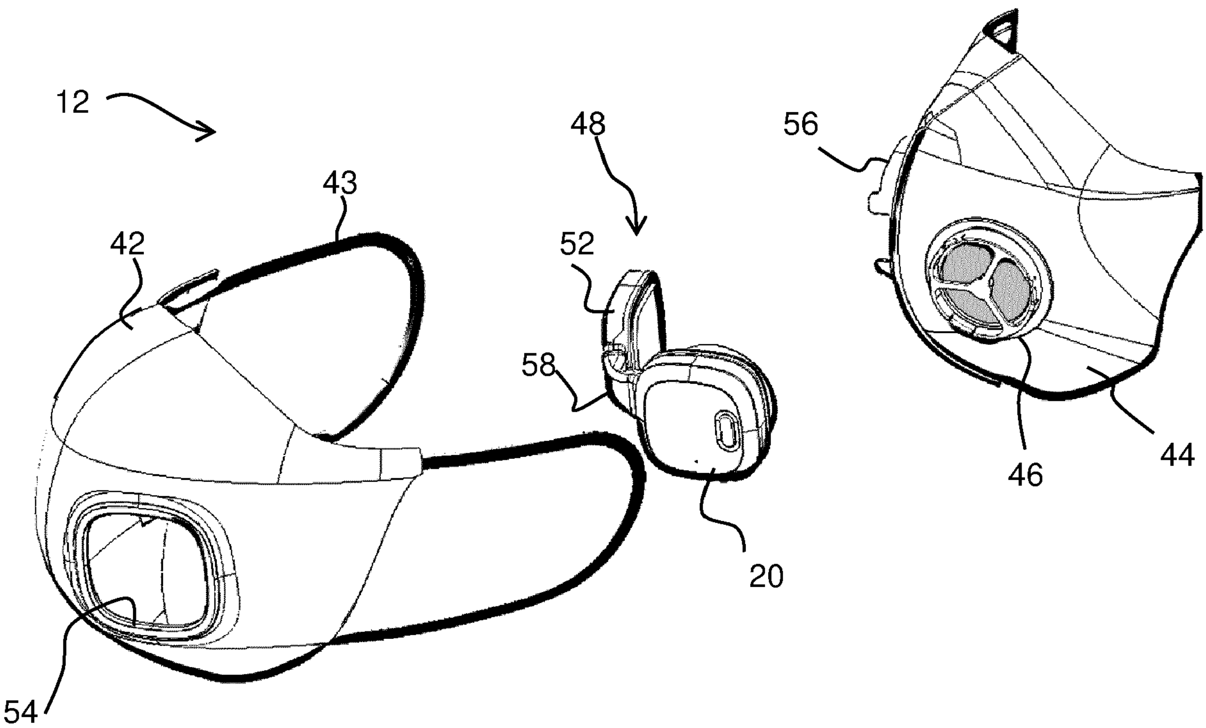

FIG. 3

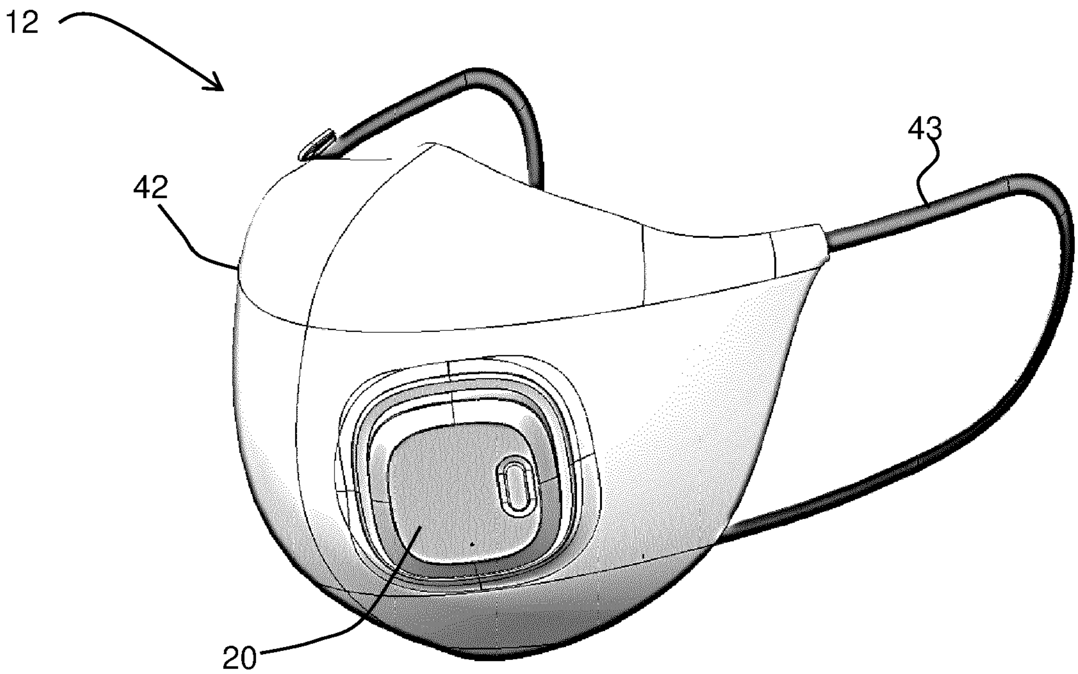

FIG. 4

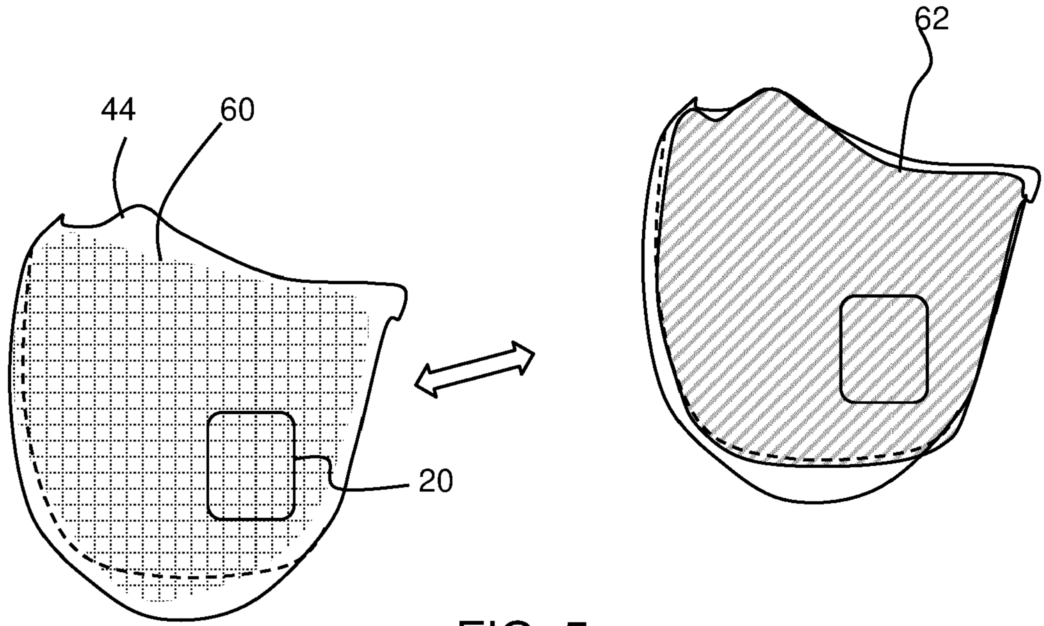

FIG. 5

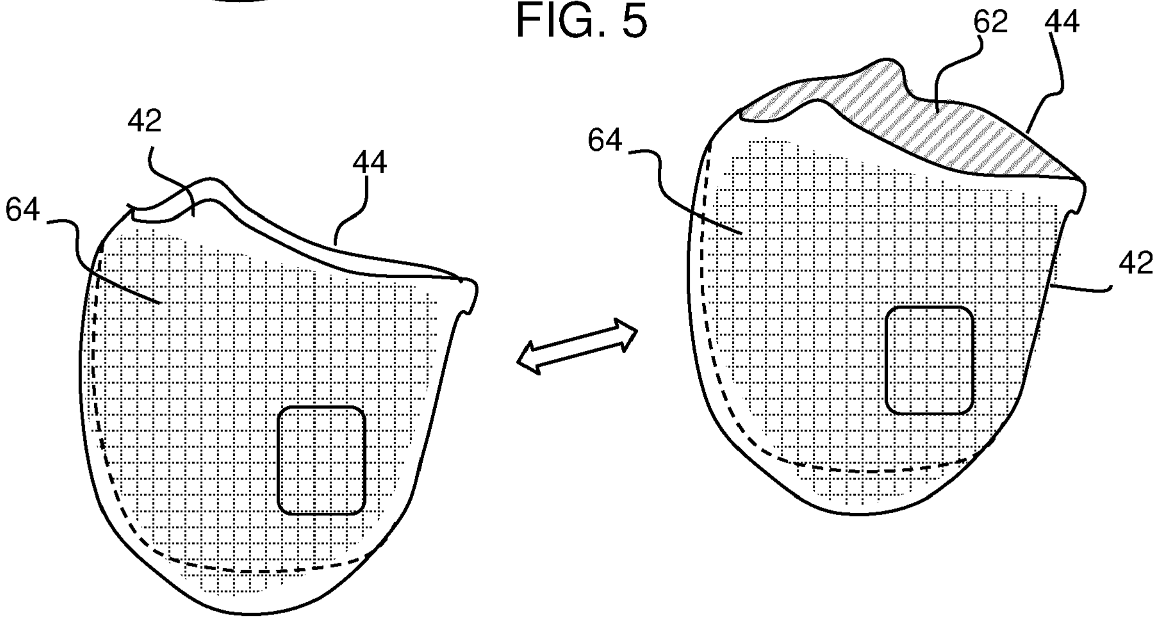

FIG. 6

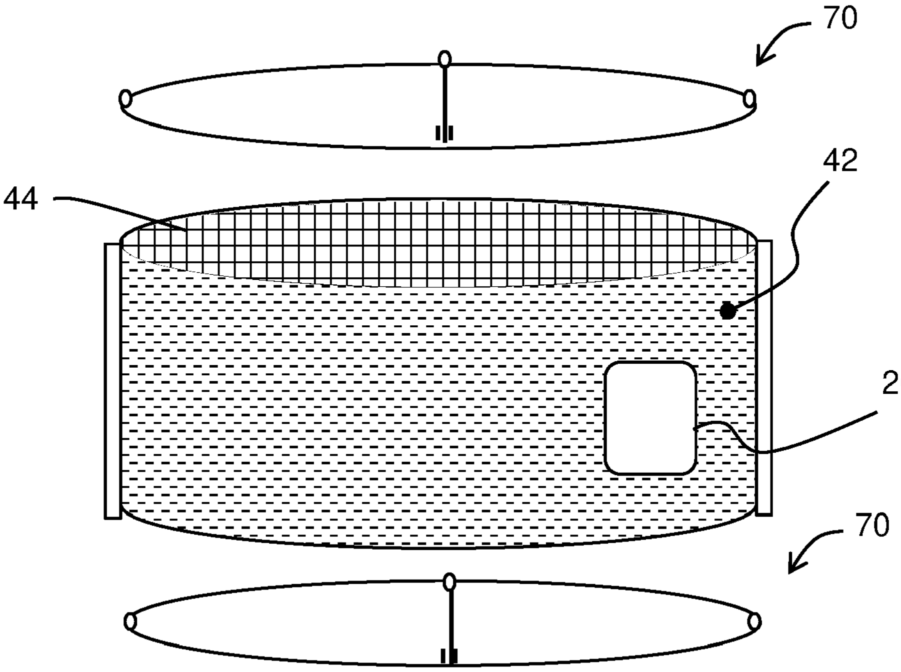

FIG. 7

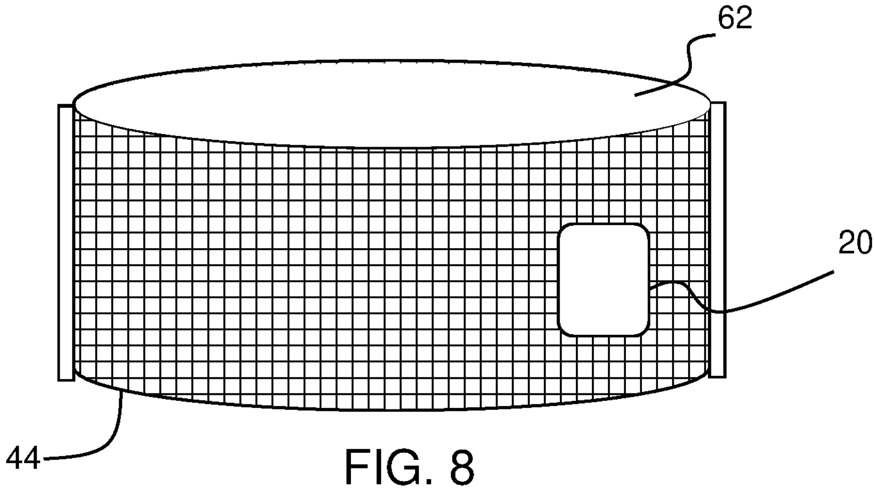

FIG. 8

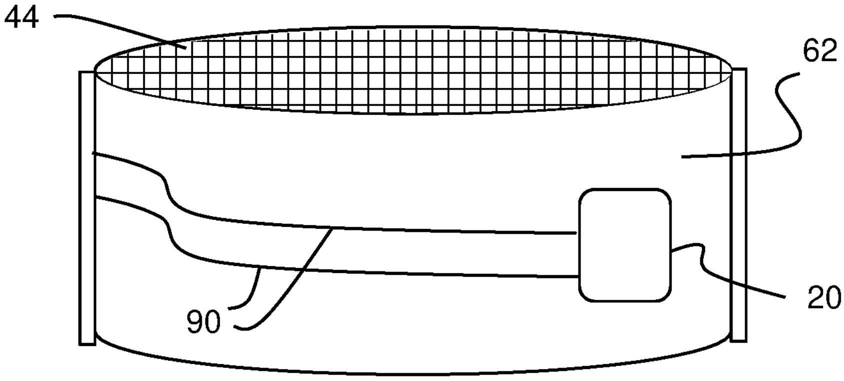

FIG. 9

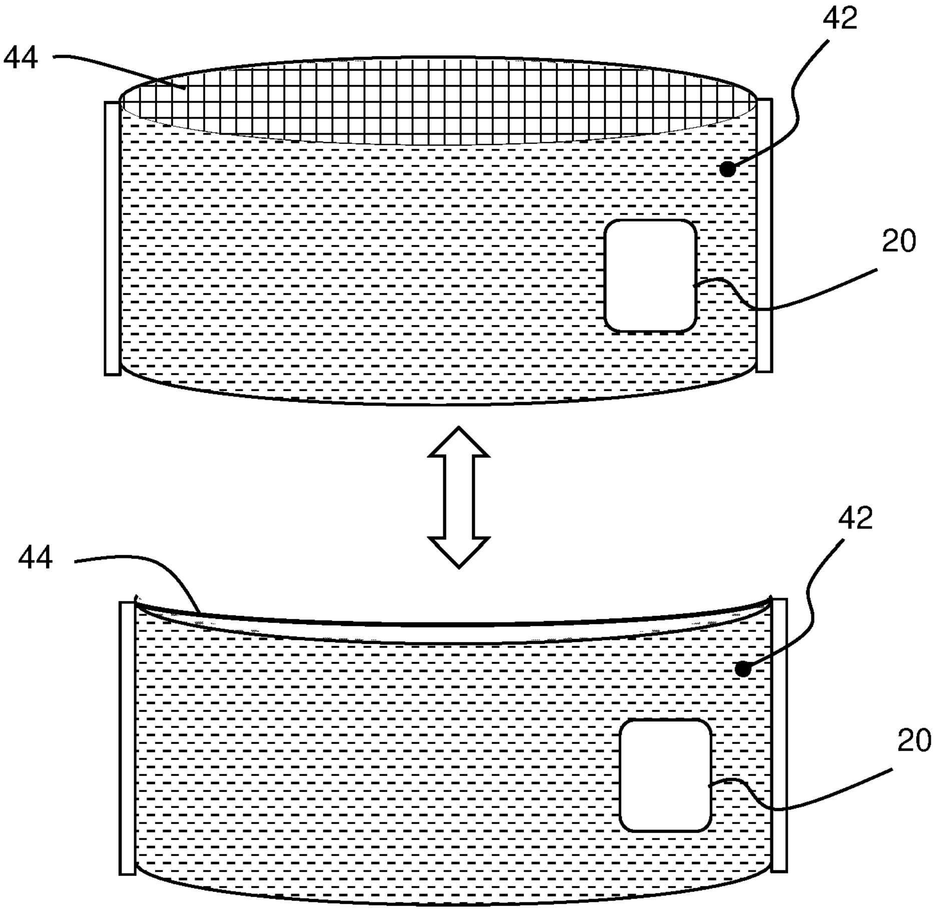

FIG. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 20 19 8336

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 February 2021	Andlauer, Dominique

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