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AN APPARATUS AND METHOD OF USE FOR RESPIRATORY SAFETY

STATEMENT OF GOVERNMENT INTEREST

[0001] The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

CROSS REFERENCE TO OTHER PATENT APPLICATIONS

[0002] None.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0003] The invention relates to a method and apparatus for enhancing respiratory safety equipment through the addition of ultraviolet light disinfection of an air stream.

(2) Description of the Related Art

[0004] The SARS-Cov-2 pandemic has revealed significant shortcomings of known personal protective equipment (PPE). Traditional cloth masks are not necessarily effective in preventing the spread of disease, and have potentially negative consequences for the wearer. Alternatively, reusable powered air purifying respirators (PAPR) offer a more sustainable

solution with respect to comfort and effectiveness for protecting against viral transmission and infection.

[0005] The spread of respiratory virus infections occur through contact and aerosol particle transmission. To protect against respiratory virus transmission, PPE must significantly reduce the probability of virus particles from entering a human respiratory system. PPE must be capable of filtering aerosol particles, which are in the range of 10 nanometers (nm) to tens of micrometers (μm). SARS-CoV-2 virus particles are approximately 100 nanometers ($0.1 \mu\text{m}$) in diameter.

[0006] Studies have measured the probability filtration efficiency of various masks types. Cloth masks require additional layers of material to effectively filter out smaller virus particles. N95 face masks offer high levels of particle filtration efficiency, but can be in short supply.

[0007] Decreased mask effectiveness occurs due to gaps or leakage around the edges of the mask resulting from improper fitting to the face. Face masks can have negative consequences for the wearer, such as breathability, irritating exhalation into the eyes, and sores around facial contact areas. Masks also make it impossible for hearing impaired individuals to read lips, and can be psychologically dehumanizing. Lastly, masks do not protect the eyes of the wearer, which are another entry point on the body for viruses.

[0008] Industrial workers have used PAPR for years. These devices are a clear full-face mask connected with a hose to a belt mounted filter and fan assembly. Because PAPRs are powered; the filters can be much denser than is possible with lung-powered masks. Furthermore, the clean air blowing into the mask prevents contaminants from entering underneath the mask; thereby, keeping the visor or barrier from fogging with the breath of the user and protecting the eyes of the user from infiltrating contaminants. Also, because these systems are loose fitting, PAPRs do not require to be fit with the user.

SUMMARY OF INVENTION

[0009] In the present invention, novel respiratory safety equipment is provided that includes a first stage having at least one filter; a second stage having at least one ultraviolet C unit; and a third stage including a blower. The filter at the first stage is resistant to degradation by ultraviolet light when a foam filter, a N95 filter, or a combination of both is used. The second stage is a serpentine pathway through which the air and virus particles are eradicated by ultraviolet C irradiation. The third stage includes a blower that powers the air flow in the respiratory safety equipment. The first, second, and third stages are sequentially arranged wherein the

first stage is upstream of the second stage, and the second stage is upstream of the third stage.

[0010] The present invention protects the user from virus particles by inactivating the particles with ultraviolet C light rather than trying to stop the virus particles. The disclosed respiratory safety equipment has the added benefit that the equipment is easily maintainable; thereby, reducing the expense of replacement filters. Furthermore, the respiratory safety equipment permits the use of full-face masks; the users would not be dehumanized; and hearing impaired individuals would not be disadvantaged.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Features of illustrative embodiments may be understood from the accompanying drawings in conjunction with the description. The elements in the drawings may not be drawn to scale. Some elements and/or dimensions may be enlarged or minimized for the purpose of illustration and the understanding of the disclosed embodiments.

[0012] FIG. 1 is a notional layout of the respiratory safety equipment in accordance with an embodiment of the present disclosure; and

[0013] FIG. 2 is a method of use for the respiratory safety equipment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The following description relates to respiratory safety equipment and a method of use. The respiratory safety equipment includes a first stage, a second stage, and a third stage. A method of use for respiratory safety equipment in order to sanitize air is shown in FIG. 2.

[0015] FIG. 1 depicts respiratory safety equipment 100 for sanitizing ambient air. Direction arrows indicate the direction of the AIR FLOW. In use, ambient air enters the respiratory safety equipment 100 at an inlet 102. A first stage 104 includes a filter (ultraviolet resistant foam or ultraviolet resistant electrostatic filter) to trap large moisture droplets or exhalation droplets which contain virus particles. In another embodiment, the first stage 104 includes a smaller sieve filter to stop large scale particulates. The smaller sieve filter may be a N95 filter. Filters used in the invention are resistant to degradation from ultraviolet light and ozone.

[0016] In yet another embodiment, the first stage 104 includes a foam or electrostatic filter and a smaller sieve filter where the foam filter and the smaller sieve filter are washable and disposable.

[0017] It is expected that aerosolized virus particles will contact the first stage 104 and will be stopped. However, as the carrier moisture dries, the 0.1 micron and smaller virus

particles will be freed and continue into the respiratory safety equipment 100 albeit at a slower rate and in a lower concentration on a per minute basis.

[0018] A second stage or housing 106 directly couples to the end of the first stage 104. The second stage 106 encloses a serpentine pathway air tube 108 and at least one ultraviolet C unit 110. The serpentine pathway air tube 108 is transparent to the ultraviolet C unit 110 yet sealed to contain air.

[0019] The housing 106 can be disassembled for cleaning and maintenance of the serpentine pathway 108 and the ultraviolet C unit 110. The housing 106 can include a belt (not shown) or at least two backpack straps so that the respiratory safety equipment 100 can be carried by the user.

[0020] The serpentine pathway air tube 108 provides a passage for the filtered air carrying the virus particles. The serpentine pathway 106 is made of material that is transparent to ultraviolet light and cannot be degraded by ultraviolet irradiation or ozone. The material is glass, clear plastic or other materials such as polyethylene terephthalate glycol. Also, the serpentine pathway 108 can be disassembled for cleaning.

[0021] The serpentine pathway 108 is arranged to maximize a surface area of the air pathway so that ultraviolet irradiation

on the virus particles is optimized. The serpentine pathway 108 is a snake-shaped pathway or can be a coil-shaped pathway.

[0022] The ultraviolet C unit 110 is powered by a battery and couples to the serpentine pathway 108 to irradiate the serpentine pathway at high luminance. The high luminance deactivates the virus particles as the particles pass through the serpentine pathway 108.

[0023] The ultraviolet C unit 110 emits light with a wavelength above 220 nanometers. For example, the wavelength of light emitted by the ultraviolet C unit 110 is 222 nanometers. Furthermore, the ultraviolet C unit 110 may produce ozone, but the ozone production level is kept below accepted environmental standards. In one embodiment, the ultraviolet C unit 110 is a light emitting diode or a mercury lamp that emits ultraviolet type C wavelengths other than 222 nm.

[0024] Preferably, the ultraviolet C unit 110 is located to maximize UV throughout the serpentine pathway 108. However, an ultraviolet C unit (not shown) may be located in an upstream portion of the serpentine pathway 108. The ultraviolet C unit 110 may mount to different locations of the second stage or housing 106.

[0025] In another embodiment, the ultraviolet C unit 110 can be located downstream of the serpentine pathway 108. The ultraviolet C unit 110 can include two ultraviolet C units,

wherein the first ultraviolet C unit is located upstream of the serpentine pathway 108 and the second ultraviolet C unit is located downstream of the serpentine pathway.

[0026] A third stage 112 directly couples to the second stage 106. The third stage 112 includes a hose connecting the end of the serpentine pathway 108 and a blower 114. The third stage 112 receives sanitized air from the second stage 106 and transfers the sanitized air to a face mask (not shown) via the blower 114.

[0027] The blower 114 is a battery-powered device that blows air. Due to the structure of the blower 114, the disassembling and cleaning of the blower is typically challenging and time consuming. However, by locating the blower 114 downstream of the filtration and sanitization stages; the blower is protected from contamination. In this way, the requirement for cleaning the blower 114 is significantly reduced.

[0028] Furthermore, by utilizing ultraviolet C irradiation at the second stage 106, the respiratory safety equipment 100 does not solely rely on the first stage 104 to protect the user from virus particles. Thus, the need for more sophisticated, denser filters in conventional respiratory safety equipment is alleviated. As such, a power requirement for the blower 114 may be reduced; thereby, resulting in a longer battery life for the blower.

[0029] FIG. 2 depicts a method 200 for operating the respiratory safety equipment 100. At step 202, air is filtered at a first stage 104. The first stage 104 includes one foam filter, one N95 filter or a combination of both. Blowing air past the first stage 104 removes large moisture droplets and other largish scale particulates which can contain virus particles. It is expected that aerosolized virus particles will hit the first stage 103 and stop; as the carrier moisture dries, the 0.1 micron and smaller virus particles will be freed and continue into the second stage 106.

[0030] At step 204, air is disinfected at the second stage by activating the at least one ultraviolet C unit. As illustrated in FIG. 1, the second stage 106 includes a long and serpentine pathway 108. The serpentine pathway 108 includes numerous turns or coils to maximize a surface area of the pathway.

[0031] As air blows pass the second stage 204, the virus particles carried in the air are exposed to ultraviolet C light for a sufficient amount of time so that the virus particles are eradicated. The ultraviolet C unit irradiates the serpentine pathway at a sufficiently high luminance known to those skilled in the art. As air leaves the second stage, the air is sanitized for the user.

[0032] At step 206, the method 200 includes blowing air past the third stage. A blower installed at the third stage provides

power for the air flow and forces air pass the entire system. The blower may be activated at the same time as the ultraviolet C unit at the second stage. The sanitized air passes the blower at the third stage and enters a face mask coupled to the blower.

[0033] At step 208, the method 200 includes determining if the air flow rate is above a predetermined threshold. The predetermined threshold is an air flow rate that not only provides a sufficient amount of air to the user, but is also high enough to prevent contaminants from entering the mask in case of loose fitting. For example: a Venturi mask has a flow rate of 4 liters/minute to 26 liters/min.

[0034] The air flow rate may be measured by a mass air flow (MAF) sensor, known to those skilled in the art, located between the first stage and the third stage. In one embodiment, the MAF sensor is located downstream the filters at the first stage. In another embodiment, the MAF sensor is located upstream of the blower at the third stage. In yet another embodiment, the MAF sensor is located downstream of the blower at the third stage and upstream of the face mask. If the air flow rate is above the predetermined threshold, the method ends.

[0035] If the air flow rate is not above the predetermined threshold; there is a possibility that the filters at the first stage are clogged or dirty. Thus, the method proceeds to step 210 in which the filters at the first stage are changed or

washed. With new or cleaned filters, the resistance is reduced, and the air flow rate should increase. Then the method ends.

[0036] The method 200 of FIG. 2 includes a use for respiratory safety equipment to include: filtering air at a first stage; disinfecting air at a second stage; and blowing air pass a third stage. By using ultraviolet C irradiation; protection of the user from virus particles does not merely depend on filters.

[0037] Also, by forcing air through a serpentine pathway, the exposure time of the virus particles under ultraviolet C light is increased and the inactivation efficiency of the virus particles is improved. Furthermore, by arranging the blower at the end of the respiratory safety equipment, the blower stays sanitized and does not require frequent cleaning.

[0038] The foregoing description of the preferred embodiments of the invention has been presented for purposes of illustration and description only. It is not intended to be exhaustive nor to limit the invention to the precise form disclosed; and obviously many modifications and variations are possible in light of the above teaching. Such modifications and variations that may be apparent to a person skilled in the art are intended to be included within the scope of this invention as defined by the accompanying claims.

AN APPARATUS AND METHOD OF USE FOR RESPIRATORY SAFETY

ABSTRACT OF THE DISCLOSURE

Respiratory safety equipment and a method of use are provided which include a first stage including at least one air filter resistant to ultraviolet C radiation, a second stage including a serpentine pathway and at least one ultraviolet C unit, and a third stage including a blower powering air flow in the system. The first stage, the second stage, and the third stage form a continuous air pathway for filtration and radiation.

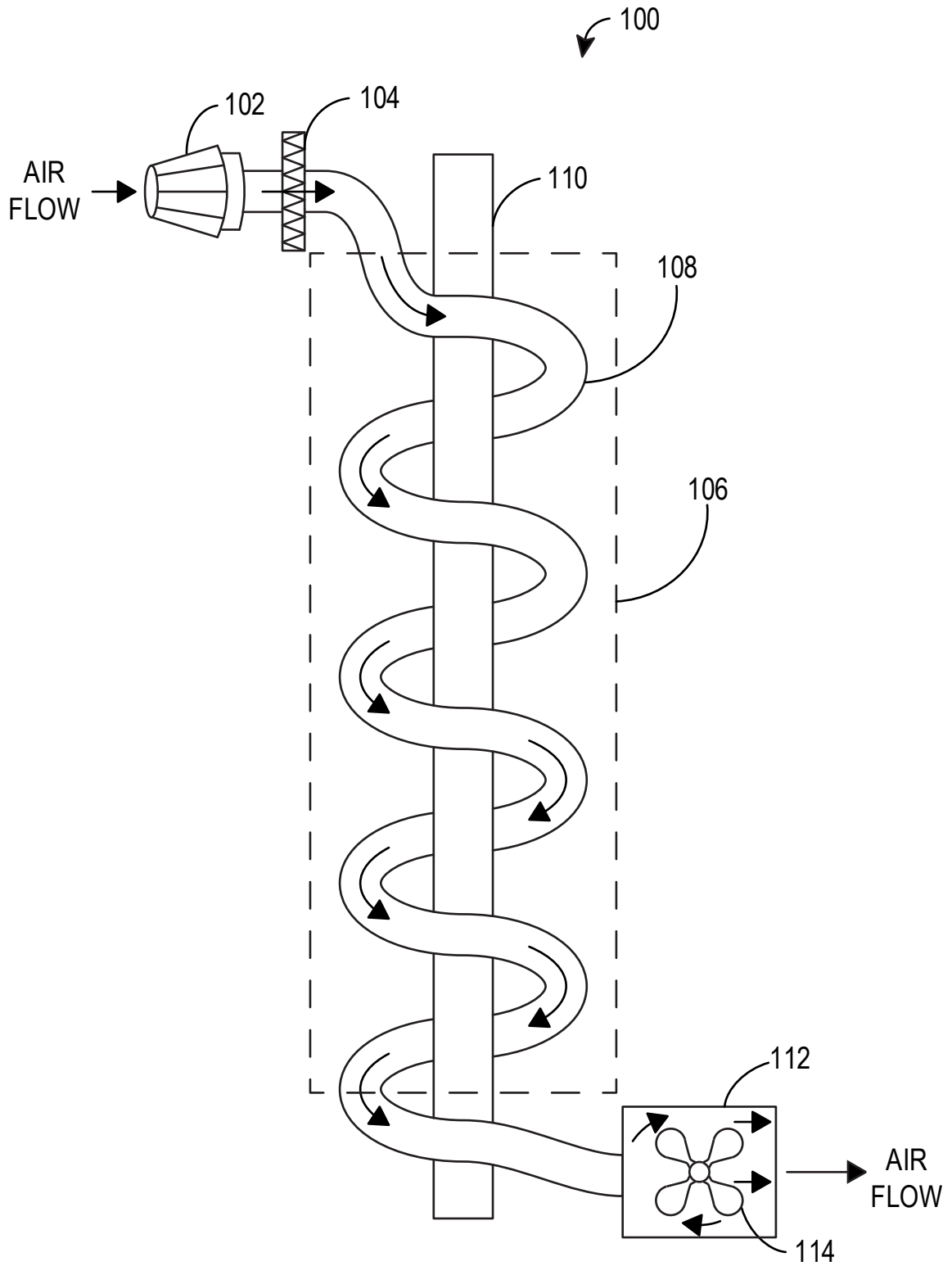


FIG. 1

200

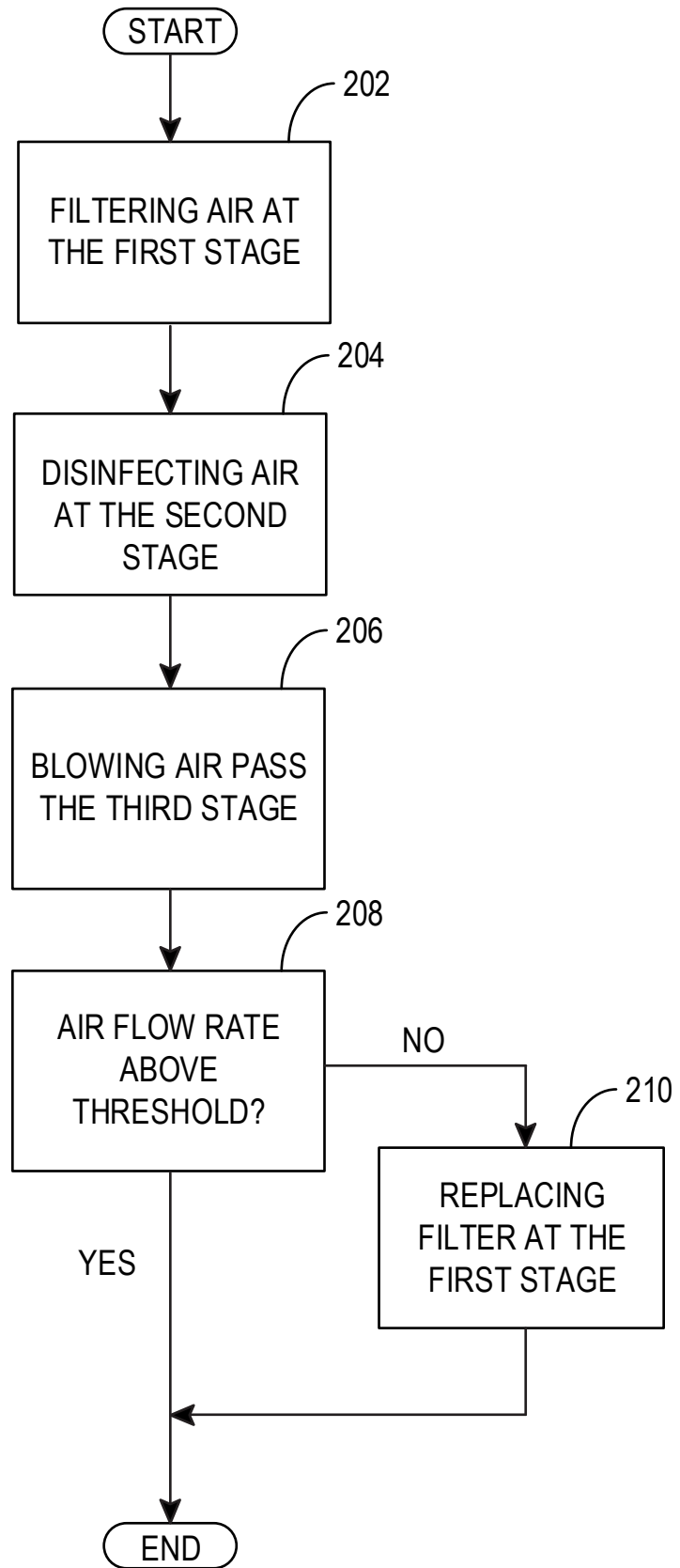


FIG. 2