

NBC FILTRATION SYSTEM WITH A STATUS INDICATOR

FIELD OF THE INVENTION

5 The present invention relates to an NBC filtration system with a self powered status indicator providing indication of rate of airflow and an emergency illumination capability. More particularly to an NBC filtration system with an air turbine fitted in the air pathway of the NBC filtration system. The air turbine generating power for illumination and airflow data for a perceptible status indicator.

10 BACKGROUND OF THE INVENTION

 The regulations in Israel indicate that private living units and public constructions such as office buildings, shopping malls, industrial facilities, entertainment centers and the like, must preserve an NBC protected space for use at a state of emergency caused by warfare or natural disaster. The protected space must include an NBC filtration system
15 correctly sized to fit the volume of the protected space and the expected number of people occupying the protected space during emergency.

 The regulations specifically require that such private and public NBC filtration systems should include an NBC filter unit composed of a particulate filter and a gas adsorption filter, and an electric blower appropriate for certain rate of volumetric air
20 exchange. Furthermore, the NBC filtration system should feature a manual air exchange backup capability to be operated by human power in case of electric power failure. The air exchange backup element is usually constructed as a manually operated bellows for the small living-unit systems, and as a hand crank operated blower for the larger public systems. Typically, the manual air exchange backup unit of the larger systems includes a
25 speed increaser gear having an input shaft manually rotated by the hand crank and an output shaft engaged to rotate the electric blower.

 An intuitive indication of positive airflow is required for the small systems, while a more accurate airflow-rate meter is required for the larger systems. The main goal of the airflow-rate meter is to inform the occupants of the protected space, even when electric
30 power is available, and in particular at times of electric power failure, whether the blower motor or the hand operation introduces correct amount of fresh air into the protected

space. Insufficient amount of airflow is clearly undesirable for safety reasons, however excessive amount of air flow shortens the operation time of the adsorption filter and hence is also undesirable.

Another requirement of the regulations relating to the larger systems, enforces
5 inclusion of a light source that can be manually powered by the above mentioned hand crank at times of electric power failure.

Currently available NBC filtration systems for large collective protection shelters includes a mechanical vane type airflow sensor located in the path of the airflow. The vane is balanced by a spring or a weight which is tensioned or raised when the airflow speed
10 increases. The exposed extremity of the vane hinge pin is attached to a pointer moving in front of a scale to approximately indicate the rate of airflow passing through the filtration system. The passive pointer must be constantly observed by the occupants of the protected space or the operator of the hand crank in order to control the electric motor power or the hand crank rotation speed. The electric motor of the blower is typically slightly over-sized
15 and a throttle valve is provided in the flow path to enable reduction of the airflow when electric power is available and the blower draws excessive rate of air flow.

To facilitate the illumination requirement, a small generator is assembled on the shaft of the blower such that electric power is generated even during manual operation.

Both the illumination power generator and the passive flow rate meter are
20 relatively gentle and complex, production cost is high and reliability may decrease over time. Consequently there is a need to further optimize the above prior art systems and provide a cost effective reliable solution.

SUMMARY OF THE INVENTION

Accordingly, it is a principal object of the present invention to overcome the disadvantages and limitations of prior art systems and provide an NBC filtration system with a self powered status indicator providing accurate indication of the rate of airflow and
5 an emergency illumination capability.

According to the present invention, there is provided an NBC filtration system comprising an NBC filter unit; a blower and a self powered status indicator. The status indicator comprising: an air turbine blade fitted in the air pathway of the NBC filtration system, an electric generator mechanically coupled to the air turbine blade, a controller
10 and a human interface. The electric generator provides electric power for the controller and the human interface. The controller provides status information through the human interface, indicating at least the rate of airflow.

According to an aspect of the invention, the NBC filtration system further comprises an air exchange backup unit.

15 According to another aspect of the invention, the NBC filtration system further comprises a light source. The electric generator provides electric power for the light source as well.

According to yet another aspect of the invention, the controller further provides information regarding indoors air quality.

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BRIEF DESCRIPTION OF THE DRAWINGS

The invention and the way it may be carried out in practice, will be understood with reference to the following illustrative figures, by way of non-limiting example only, in which like reference numerals identify like elements, and in which:

25 Fig. 1 is a front view of an NBC filtration system making use of a status indicator made according to an embodiment of the present invention;

Fig. 2 is a top view of the NBC filtration system of Fig. 1;

Fig. 3 is an enlarged side view of the blower portion of an NBC filtration system;

Fig. 4 is a sectional view taken along line A-A in Fig. 3; and

30 Fig. 5 is a schematic block diagram of the components gathering the status indicator.

DETAILED DESCRIPTION OF EMBODIMENTS

The present invention discloses an NBC filtration system including a status indicator. The NBC filtration systems is typically located in safe rooms or collective protection shelters. The status indicator provides information regarding the rate of fresh
5 airflow entering the protected space. In addition to the airflow data, the status indicator may also include an emergency illumination capability. The invention will now be described in detail with reference to the figures.

With reference to Fig. 1, there is shown a front view of a simple NBC filtration system generally referenced 10, typically used in large collective protection shelters. Fig. 2
10 depicts a top view of the NBC filtration system of Fig. 1. The NBC filtration system comprises a prefilter 12 of a coarse mesh fitted to an outer concrete wall 28 of the shelter, a flexible inlet conduit 14, an NBC filter unit 16 typically including a particulate filter and a gas adsorption filter, a flexible outlet conduit 18, a blower 20 powered by an electric motor 26 and a manual air exchange backup 22. The NBC filtration system draws external
15 fresh air through a conduit 29 embedded in the concrete wall 28, into the filtration system 10 and through an outlet tunnel 33 of blower 20 to the protected space. The airflow direction at the inlet and outlet are marked by arrows 31. The manual air exchange backup 22 is typically a speed increasing gear operated with a hand crank 24 or a foot pedal (not shown) to power the blower 20 during electric power failure. The flexible conduits 14 and
20 18 may be connected directly to each other in order to bypass the NBC filter unit 16 when the shelter is populated but NBC protection is not needed. Newer NBC filtration systems may include a changeover valve (not shown) for changing the NBC filtration system 10 mode of operation, between a ventilation mode effective during normal times or conventional hazard and an NBC protection mode effective during NBC hazard.

25 According to the present invention there is provided an NBC filtration system 10 with a self powered status indicator generally referenced 30. The status indicator 30 is positioned in two main locations circled and marked B and C in fig. 1. The circle marked B highlights a partial sectional view of the blower 20, and the circle marked C highlights a user panel visible or otherwise perceptible to the occupants of the protected space. The
30 user panel is also visible or otherwise perceptible to an operator of the hand crank 24 at times of electric power failure. The status indicator 30 comprises (in the circle marked B), an air turbine blade 32 fitted in the air pathway of the NBC filtration system and an

electric generator 34 mechanically coupled to the air turbine blade 32. The status indicator 30 further comprises (in the circle marked C), an optional light source 36, a controller 38 and the user panel comprising at least a human interface 40. The electric generator 34 provides electric power for the light source 36 if fitted, the controller 38 and the human interface 40. The controller 38 provides status information through the human interface 40, the status information comprising at least a rate of airflow formed by the blower 20 whether operated electrically as preferable or manually as a result of electric power failure.

It will be understood that the components shown in circle C may be positioned in close proximity to the components shown in circle B to form a single unit. Furthermore, the components gathering the status indicator may be positioned separately or in different groups as long as the turbine blade 32 is positioned in the air pathway of the NBC filtration system and the human interface 40 is visible or otherwise perceptible by the operator and the shelter occupants.

With reference to Fig. 3, there is shown according to another implementation of the present invention, a side view in larger scale of a blower 20, fitted to an NBC filtration system, incorporating the status indicator generally referenced 30. Fig. 4 depicts a sectional view taken along line A-A in fig. 3. As shown in Figs. 3 and 4, the manual air exchange backup 22 is an increaser speed gear transmission remotely operated, in an event of power failure, using a belt or chain drive 25. The remote operation permits placement of the NBC filtration system at a high position thus saving floor space. Accordingly the human interface 40 is located below the blower 20 for convenient visibility. The hand crank (not shown) is located at an accessible height for proper operation by the occupants of the protected space.

The partial section shown in Fig. 3 exposes the air turbine blade 32 fitted in the outlet tunnel 33 of the blower 20, and the electric generator 34 carrying the air turbine blade 32. The electric generator 34 is attached to the wall of the blower with several fins 52 lying substantially in the direction of the airflow to prevent restriction of the opening.

The human interface 40 may use a liquid crystal display (LCD) providing visual indication of the rate of airflow. The visual indication may be represented by numerals indicating an airflow-rate value, or as a variable vector represented by dots extending along the LCD with the vector length varying according to the rate of airflow. Optionally,

the human interface may use a series of light emitting diodes (LEDs) providing visual indication of the rate of airflow by the number of LEDs or the position of a LED being turned on at a given rate of airflow. The light emitting diodes may be of different colors to identify more clearly the status of the rate of airflow.

5 As explained above, the NBC filtration system 10 has two operating modes, a ventilation mode effective during normal times or conventional hazard and an NBC protection mode effective during NBC hazard. At NBC protection mode the air entering the protected space flows through the NBC filter unit 16, while at ventilation mode the incoming air bypasses the NBC filter unit 16. The NBC filter unit 16 has a certain
10 noticeable resistance to airflow, therefore at ventilation mode, where the NBC filter unit is bypassed, the blower 20 introduces a larger rate of airflow into the protected space.

 According to the present invention, the controller 38, may be provided with an input recognizing the current mode of operation of the NBC filtration system 10. The controller 38 may electronically adjust the rotation speed of the electric motor 26 running
15 the blower 20. Alternately, the controller 38 may provide the human interface 40 with the correct reading at both modes of operation. The occupants of the protected space will yet have to control the airflow but without the need to interpret the reading of the human interface 40. Optionally in a simpler embodiment, the LED array may have two rows of LEDs or two zones of colored LEDs each one being marked as appropriate for one mode
20 of operation. The occupants of the protected space will have to control the airflow with interpretation of the reading of the human interface 40 according to the actual mode of operation.

 For example with reference to Fig. 5, showing a schematic block diagram of the status indicator 30, the human interface 40 may include six LEDs 42 organized in a row
25 and lighting one by one in a sequence. The first pair of LEDs, for example on the left side of the human interface 40 may be for instance red LEDs indicating when one of them is lighting that insufficient rate of airflow is introduced into the protected space. The second pair of LEDs, in the middle position, may be for instance green LEDs indicating when one of them is lighting that the rate of airflow is correct. The third pair of LEDs, on the left
30 side of the human interface 40, may be for instance blue LEDs indicating when one of them is lighting that an excessive rate of airflow is introduced into the protected space. When one of the blue LEDs is lighting, the operator may reduce the speed of rotation of

the hand crank 24 thus extending the operation time of the adsorption filter and saving physical effort to allow longer manual operation of the hand crank.

Optionally as indicated above, the LED array may have two zones of colored LEDs each one being marked as appropriate for one mode of operation. In such case for instance the three LEDs on the left side of status indicator 40, will indicate the status of flow rate during filtration mode while the three LEDs on the right side of status indicator 40, will indicate the status of flow rate during ventilation mode. The central LED of each of the groups indicates the correct flow rate for the relevant mode of operation. The occupants of the protected space will have to control the airflow with interpretation of the reading of the human interface 40 according to the actual mode of operation. It will be understood that other implementations of the LEDs array are possible, such as a clock like circular array or a plurality, or even a single, color-changing LED. Yet in another implementation, the human interface 40 may be a voice synthesizer announcing a status message periodically or at least when the rate of airflow is insufficient.

Yet with reference to fig. 5, the schematic block diagram includes principal and optional components of the air filtration system 10 and status indicator 30. The block marked 74 includes the components which are subject to line voltage such as blower 20, blower motor speed control 76 and main power switch 78. The dotted arrow marked 80 represents the air flow coupling between the blower 20 and the turbine blade 32. The generator 34 may be a permanent magnet brushed direct current (DC) generator or a permanent magnet brush-less alternating current (AC) generator. If an AC generator is used, a rectifier 62 is needed to translate the AC current to DC current, otherwise the rectifier 62 may be omitted. The rectifier 62 may be a diode type full bridge rectifier as shown in fig. 5, or a half bridge rectifier as known in the art. Modern active rectifiers using controlled FET transistors instead of diodes may also be used, in order to reduce power losses on the rectifier.

Preferably the wave frequency at the outlet of the generator 34 is transmitted to a counter input of the controller 38 through conductor 66. Optionally, the voltage at the outlet of the generator 34 or the rectifier 62, if used, is transmitted by optional conductor 72 and conductor 66 to an analog input of the controller 38 for processing and determining the rate of airflow. A DC to DC converter 64 is used to translate the input variable voltage to a fixed voltage suitable for proper operation of the light source, the controller and the

human interface 40. When sufficient airflow is introduced into the protected space, the controller 38 turns on the light source 36 using a field effect transistor (FET) switch 70, or any other electronic switching device. The light source 36 is typically a high efficiency power saving light emitting diode (LED) providing 50 lumen (lm) of emitted visible light.

- 5 Currently available illumination LEDs have efficiency of above 150lm/W, thus only a third of a watt is required for the light source 36. A manual switch 68 may be provided to enable override of the controller decision and turn the light source on or off at will.

An optional feedback bus or line 82 connecting the controller 38 and the motor speed control 76, may be used if the controller 38 is set to control the blower 20 rotational speed by the motor speed control 76. The feedback line 82 may also provide the controller
10 with an input, recognizing the mode of operation of the NBC filtration system. Such input allows the controller to electronically adjust the rotation speed of the blower at both ventilation mode and filtration mode. If the above options are implemented, then as long as line power is available, the air-flow rate may be automatically adjusted without
15 intervention of the shelter occupants. Otherwise as mentioned above, the blower rotational speed may be adjusted manually using control knob 84 of motor speed control 76, to change the rotational speed until a correct reading of airflow-rate is obtained by the status indicator 30. The motor speed control 76 may be a dimmer using phase angle control technique as known in the art to adjust the electric power introduced to the blower motor.

20 In operation, the controller 38 calculates the rate of airflow as a function of an output signal generated by the generator 34. The output signal may be the generated voltage, suitable for DC and AC generators, or the generated wave frequency suitable in case of an AC generator. Since the light source 36 typically consumes more power than both the controller 38 and the human interface 40, the load on the generator significantly
25 increases when the light source is turned on. As a result, for a given rate of airflow, a different voltage or frequency is generated by the generator 34 when the light source is turned on or off. To overcome the influence of the load on the measured voltage or frequency, two different functions are used for calculation of the airflow by the controller. A first function is used when the light source is turned off and a second function is used
30 when the light source is turned on. Optionally, the calculated values of the two functions may be stored as a data array in an internal memory of the controller, thus eliminating the need to constantly repeat the calculations.

The switch 68 or an optional additional switch may also be used for calibration of the system during production. The calibration may be performed by applying an accurate airflow through fan blade 32, reading the measured result from the controller, and setting that result as the correct airflow for further use, by pressing switch 68. The operation may
5 be repeated twice, first for setting the correct reading of airflow-rate during ventilation mode and second for setting the correct reading of airflow-rate during filtration mode.

With an addition of some environmental sensors, the controller 38 may further provide information regarding indoors air quality. The air quality data may include humidity, temperature, contents of CO₂ and contents of CO. The collected data may be
10 processed along with the rate of airflow to determine more precisely the required flow of air into the protected space, thus saving physical effort required by the operator of the hand crank in cases of power failure.

Optionally, the status indicator may further comprise a USB socket electrically connected to the electric generator 34 through the DC-DC converter 64 or a different DC-
15 DC converter adjusted to provide a 5 volts output. The USB socket powered by the electric generator 34, may be used for providing power or charging instruments such as flashlights and smart-phones.

It will be appreciated that the specific embodiments of the present invention described above and illustrated in the accompanying drawings are set forth merely for
20 purposes of example. Other variations, modifications, and applications of the present invention will readily occur to those skilled in the art. It is therefore clarified that all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

CLAIMS:

1. An NBC filtration system comprising an NBC filter unit; a blower and a self powered status indicator, said status indicator comprising: an air turbine blade airflow coupled to said blower, fitted in the air pathway of said NBC filtration system; an electric generator mechanically coupled to said air turbine blade; a controller; and a human interface, wherein said electric generator provides electric power for at least said controller and said human interface, and wherein said controller provides a status information through said human interface, said status information comprising at least a rate of airflow.
2. The NBC filtration system as claimed in claim 1, further comprising an air exchange backup unit.
3. The NBC filtration system as claimed in claim 1, further comprising a light source, wherein said electric generator provides electric power for said light source as well.
4. The NBC filtration system as claimed in claim 1, wherein said human interface comprises a liquid crystal display providing visual indication of said rate of airflow.
5. The NBC filtration system as claimed in claim 1, wherein said human interface comprises a series of light emitting diodes providing visual indication of said rate of airflow.
6. The NBC filtration system as claimed in claim 5, wherein said light emitting diodes are of different colors.
7. The NBC filtration system as claimed in claim 1, wherein said human interface is a voice synthesizer announcing a message at least when said rate of airflow is insufficient.
8. The NBC filtration system as claimed in claim 3, wherein said light source is a power saving light emitting diode with efficiency of above 150lm/W.
9. The NBC filtration system as claimed in claim 1, wherein said controller calculates said rate of airflow as a function of an output signal generated by said generator.
10. The NBC filtration system as claimed in claim 9, wherein said output signal is selected between said generator frequency and said generator voltage.

11. The NBC filtration system as claimed in claim 9, wherein said controller uses two different functions for calculation of the airflow, a first function is used when said light source is turned off and a second function is used when said light source is turned on.
12. The NBC filtration system as claimed in claim 9, wherein said function values are stored as a data array in a memory of said controller.
13. The NBC filtration system as claimed in claim 1, wherein said controller further provides information regarding indoors air quality.
14. The NBC filtration system as claimed in claim 13, wherein said information regarding indoors air quality comprises data selected from the group of: humidity; temperature; contents of CO₂; and contents of CO.
15. The NBC filtration system as claimed in claim 1, wherein said controller is provided with an input, recognizing a mode of operation of said NBC filtration system, said controller electronically adjusts the rotation speed of said blower.
16. The NBC filtration system as claimed in claim 1, further comprising a USB socket, wherein said electric generator provides power for instruments connected to said USB socket.
17. The NBC filtration system as claimed in claim 1, further comprising a switch, wherein said switch is used for calibration of the system.