professional installation, are not accessible to the general public *per se*, and have not been used to kill COVID-19. Moreover, filtration in an HVAC system can be ineffective. COVID-19 measures between 0.05 to 0.2 microns, but HEPA filters can filter particulate larger than 0.3 microns so additional protection is needed against the spread of COVID-19.

[0011] For these reasons, the subject matter of the present disclosure is directed to overcoming, or at least reducing the effects of, one or more of the problems set forth above.

SUMMARY OF THE DISCLOSURE

[0011a] According to a first aspect of the present invention, there is provided an apparatus used with supplied power for treating air flow of an air handling system for a pathogen, the apparatus comprising:

a frame having a plenum with an inlet and an outlet, the frame being configured to position in the air flow of the air handling system for passage of the air flow therethrough;

a filter disposed across the plenum and comprising a first material, the filter being configured to filter the air flow therethrough up to a filtration threshold; and

a heater disposed across the plenum and comprising a permeable barrier having a metal material, the permeable barrier of the heater being configured to allow the air flow therethrough up to a porosity threshold, the metal material of the permeable barrier of the heater connected in electrical communication to the supplied power, the permeable barrier having an active surface area being configured to interact with the pathogen, the active surface area being heated by the supplied power to a surface temperature directed to at least damage the pathogen,

wherein the active surface area heated to the surface temperature and the porosity threshold of the permeable barrier are configured to produce heating that is localized and is dissipated in the air flow downstream thereof.

[0011b] According to a second aspect of the present invention, there is provided an apparatus for use with supplied power for treating air flow of an air handling system for a pathogen, the apparatus comprising:

a heated filter comprising a filter media and a permeable barrier disposed adjacent one another, the filter media being configured to filter the air flow therethrough up to a filtration threshold and comprising a first material, the permeable barrier comprising a metal material, the permeable barrier exposed to the air flow and being configured to allow the air flow therethrough up to an porosity threshold, the metal material of the permeable barrier connected in electrical communication to the supplied power, the permeable barrier having an active surface area being configured to interact with the pathogen and being heated by the supplied power to a surface temperature directed to at least damage the pathogen,

wherein the active surface area heated to the surface temperature and the porosity threshold of the permeable barrier are configured to produce heating that is localized and is dissipated in the air flow downstream thereof.

[0011c] According to a third aspect of the present invention, there is provided a method for treating air flow of an air handling system for a pathogen, the method comprising:

positioning a frame in the air handling system for passage of the air flow therethrough;

filtering the air flow up to a filtration threshold through a filter disposed across a plenum of the frame between an inlet and outlet;

allowing the air flow up to a porosity threshold through a permeable barrier of a heater disposed across the plenum, the permeable barrier having a metal material and an active surface area, the active surface area being configured to interact with the pathogen; and

heating the active surface area of the permeable barrier of the heater to a surface temperature directed to at least damage the pathogen by supplying a voltage potential across the permeable barrier, wherein the active surface area heated to the surface temperature and the porosity threshold of the permeable barrier are configured to produce heating that is localized and is dissipated in the air flow downstream thereof.

[0012] The subject matter of the present disclosure is directed to a purification device that filters air and seeks to destroy viruses, bacteria, mold, pollens, volatile organic compounds, allergens, and pollutants. The purification device is intended to be affordable, easily installed, accessible and useable in both residential and commercial settings. The purification device can be applied to real world solutions to best reduce viruses, such as COVID-19, and other pathogens in the circulating air, and the purification device can be deployed as a specialized heated filter for use in commercial, residential, mass transit, and public venues.

[0013] For example and as discussed below, the purification device includes a barrier heater or heated filter that uses targeted thermal conduction of high efficiency nickel foam/mesh raised to temperatures proven to kill pathogens, such as corona viruses (such as COVID-19). The purification device also includes an ultraviolet (UV) light source that uses UV-C light to destroy the virus. The UV light source and the barrier heater are combined together in a flame retardant and resistant filtration system, which can then be directly integrated into air returns, furnace intakes, and other parts of an air handling system of a facility or populated environ, such as an airport terminal, church, hospital, workshop, office space, residence, transit vehicle, school, hotel, cruise ship, recreational venue, etc. As there is no current cure for COVID-19 and many other pathogens, environmental purification strategies can help slow the spread of the virus, and the air purification provided by the disclosed device can provide a primary defense against transmission.

[0014] In one configuration, an apparatus is used with supplied power for treating air flow of an air handling system of a facility. The apparatus comprises a frame, a filter, and an UV light source, and a heater. The frame has a plenum with an inlet and an

outlet and is configured to position in the air flow of the air handling system for passage of the air flow therethrough.

[0015] The filter is disposed across a surface area of the plenum and comprises a first material, such as a metal. The filter is configured to filter the air flow therethrough up to a filtration threshold. The ultraviolet light source is disposed in the plenum. The ultraviolet light source is connected in electrical communication with the supplied power and is configured to generate an active field of ultraviolet radiation in the plenum. The heater is disposed across the surface area of the plenum and comprises a permeable barrier of metal material. The permeable barrier of the heater is configured to impede the air flow therethrough up to an impedance threshold. Moreover, the permeable barrier of the heater is connected in electrical communication to the supplied power and is heated to a surface temperature.

[0016] In another configuration, an apparatus is used with an air filter and supplied power for treating air flow of an air handling system in a facility. The apparatus comprises a frame, a UV light source, and a heater similar to that disclosed above. The filter can be mounted adjacent the frame or separately in the air handling system.

[0017] In yet another configuration, a method is used for treating air flow of an air handling system in a facility. A frame is positioned in the air handling system for passage of the air flow therethrough. The air flow is filtered up to a filtration threshold through a filter disposed across a surface area of a plenum of the frame between an inlet and outlet. An active field of ultraviolet radiation is produced in the plenum by powering an ultraviolet light source disposed in the plenum. The air flow is impeded up to an impedance threshold through a permeable barrier of heater disposed across the surface area the plenum and having a metal material. The permeable barrier of the heater is heated to a surface temperature by supplying a voltage potential across the permeable barrier.

[0018] The foregoing summary is not intended to summarize each potential embodiment or every aspect of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Fig. 1 illustrates a facility having an air handling system having a purification device according to the present disclosure.

[0020] Figs. 2A, 2B, 2C, 2D, and 2E illustrate other arrangements of the disclosed purification device used with various air handling systems.

CLAIMS:

1. An apparatus used with supplied power for treating air flow of an air handling system for a pathogen, the apparatus comprising:

a frame having a plenum with an inlet and an outlet, the frame being configured to position in the air flow of the air handling system for passage of the air flow therethrough;

a filter disposed across the plenum and comprising a first material, the filter being configured to filter the air flow therethrough up to a filtration threshold; and

a heater disposed across the plenum and comprising a permeable barrier having a metal material, the permeable barrier of the heater being configured to allow the air flow therethrough up to a porosity threshold, the metal material of the permeable barrier of the heater connected in electrical communication to the supplied power, the permeable barrier having an active surface area being configured to interact with the pathogen, the active surface area being heated by the supplied power to a surface temperature directed to at least damage the pathogen,

wherein the active surface area heated to the surface temperature and the porosity threshold of the permeable barrier are configured to produce heating that is localized and is dissipated in the air flow downstream thereof.

2. The apparatus of claim 1, wherein the permeable barrier of the heater comprises a mesh, a foam, a screen, or a tortuous media.

3. The apparatus of claim 1, wherein the metal material of the permeable barrier comprises nickel, nickel-based alloy, iron-based alloy, titanium, or steel alloy.

4. The apparatus of claim 1, wherein the first material of the filter comprises a metal material.

5. The apparatus of claim 1, further comprising an ultraviolet light source disposed in the plenum, the ultraviolet light source connected in electrical communication with the

supplied power and configured to generate an active field of ultraviolet radiation in the plenum.

6. The apparatus of claim 5, further comprising one or more structures disposed in the frame and supporting the ultraviolet light source.

7. The apparatus of claim 5, wherein the one or more structures comprises one or more strips or one or more fixtures.

8. The apparatus of claim 5, wherein the ultraviolet light source comprises one or more UV-C lamps or a plurality of UV-C light emitting diodes disposed in the plenum.

9. The apparatus of claim 5, wherein the ultraviolet light source is configured to produce the ultraviolet radiation with at least 611 $\mu J/cm^2$ dose of ultraviolet germicidal irradiation.

10. The apparatus of claim 5, further comprising a controller disposed in electrical communication with the ultraviolet light source and a barrier heater and being configured to control (i) the heating of the permeable barrier by the supplied power and (ii) the radiation of the ultraviolet light source powered by the supplied power.

11. The apparatus of claim 10, wherein the controller is disposed in electrical communication with drive circuitry connected to the ultraviolet light source, the controller being configured to control the ultraviolet radiation of the ultraviolet light source with the drive circuitry powered by the supplied power.

12. The apparatus of claim 10, further comprising a light sensor disposed adjacent the ultraviolet light source and disposed in electrical communication with the controller, the light sensor being configured to measure the ultraviolet radiation associated with the ultraviolet light source.

13. The apparatus of claim 1, wherein to allow the air flow up to the porosity threshold, the permeable barrier of the heater is configured to impede the air flow therethrough up to an impedance threshold of 20 percent, giving the permeable barrier the porosity threshold of at least 80%.

14. The apparatus of claim 1, wherein the permeable barrier of the heater is heated to the surface temperature of at least greater than about 56°C (133°F).

15. The apparatus of claim 1, wherein the frame comprises a plurality of sidewalls enclosing the plenum between an open side for the inlet and an opposing open side for the outlet.

16. The apparatus of claim 1, further comprising electrical insulation disposed between an edge of the permeable barrier and the frame.

17. The apparatus of claim 5, wherein the filter is disposed in the plenum toward the inlet, the permeable barrier is disposed in the plenum toward the outlet, and the ultraviolet light source is disposed between the filter and the barrier heater.

18. The apparatus of claim 1, further comprising a controller disposed in electrical communication with the permeable barrier and being configured to control the heating of the permeable barrier by the supplied power.

19. The apparatus of claim 18, wherein the controller is disposed in electrical communication with heater circuitry connected to the permeable barrier, the controller configured to control the heating of the permeable barrier with the heater circuitry powered by the supplied power.

20. The apparatus of claim 19, further comprising a temperature sensor disposed adjacent the permeable barrier and disposed in electrical communication with the controller, the temperature sensor being configured to measure a temperature associated with the heating of the permeable barrier.

21. The apparatus of claim 18, wherein the controller comprises a communication interface disposed in communication with the air handling system and being configured to receive a signal indicative of the passage of the air flow through the apparatus, the controller configuring the control based on the signal received.

22. The apparatus of claim 18, further comprising a flow sensor disposed adjacent the plenum and disposed in electrical communication with the controller, the flow sensor being configured to measure the air flow passing through the plenum, the controller configuring the control based on the measured air flow.

23. The apparatus of claim 1, wherein the frame is configured to position in at least one of:

a return of the air handling system in a facility;

an intake of a furnace of the air handling system in a facility;

an outlet of the air handling system in a facility; and

a mixing chamber of the air handling system of a vehicle.

24. An apparatus for use with supplied power for treating air flow of an air handling system for a pathogen, the apparatus comprising:

a heated filter comprising a filter media and a permeable barrier disposed adjacent one another, the filter media being configured to filter the air flow therethrough up to a filtration threshold and comprising a first material, the permeable barrier comprising a metal material, the permeable barrier exposed to the air flow and being configured to allow the air flow therethrough up to a porosity threshold, the metal material of the permeable barrier connected in electrical communication to the supplied power, the permeable barrier having an active surface area being configured to interact with the pathogen and being heated by the supplied power to a surface temperature directed to at least damage the pathogen,

wherein the active surface area heated to the surface temperature and the porosity threshold of the permeable barrier are configured to produce heating that is localized and is dissipated in the air flow downstream thereof.

25. The apparatus of claim 24, further comprising a frame having a plenum disposed between an inlet and an outlet, the frame being configured to position in the air flow of the air handling system, the heated filter disposed in the plenum of the frame.

26. The apparatus of claim 24, further comprising:

an ultraviolet light source connected in electrical communication with the supplied power and being configured to generate an active field of ultraviolet radiation in the air flow.

27. The apparatus of claim 26, further comprising a frame having a plenum disposed between an inlet and an outlet, the frame being configured to position in the air flow of the air handling system, the ultraviolet light source and the heated filter disposed in the plenum of the frame.

28. The apparatus of claim 24, the pathogen being a virus, wherein the active surface area of the permeable barrier is heated to the surface temperature of up to 200°C directed to at least damage the virus.

29. A method for treating air flow of an air handling system for a pathogen, the method comprising:

positioning a frame in the air handling system for passage of the air flow therethrough;

filtering the air flow up to a filtration threshold through a filter disposed across a plenum of the frame between an inlet and outlet;

allowing the air flow up to a porosity threshold through a permeable barrier of a heater disposed across the plenum, the permeable barrier having a metal material and an active surface area, the active surface area being configured to interact with the pathogen; and

heating the active surface area of the permeable barrier of the heater to a surface temperature directed to at least damage the pathogen by supplying a voltage potential across the permeable barrier, wherein the active surface area heated to the surface temperature and the porosity threshold of the permeable barrier are configured to produce heating that is localized and is dissipated in the air flow downstream thereof.

30. The method of claim 29, further comprising producing an active field of ultraviolet radiation in the plenum by powering an ultraviolet light source disposed in the plenum.

31. The method of claim 29, wherein allowing the air flow up to the porosity threshold through the permeable barrier comprises impeding the air flow up to an impedance threshold of 20 percent, giving the permeable barrier the porosity threshold of at least 80%.

32. The apparatus of claim 24, wherein the permeable barrier comprises one or more layers of porous foam having a thickness, the active surface area comprising a latticework of tortuous channels defined through the thickness of the porous foam.

33. The apparatus of claim 32, wherein the one or more layers are corrugated.

34. The apparatus of claim 24, further comprising a controller being configured to control heating of the active surface area of the permeable barrier intermittently, when the air flow is passing through the permeable barrier, and/or when the air flow is not passing through the permeable barrier.

35. The apparatus of claim 24, wherein to allow the air flow therethrough up to the porosity threshold, the permeable barrier of the heater is configured to impede the air flow therethrough up to an impedance threshold of 20 percent, giving the permeable barrier the porosity threshold of at least 80%.

36. The apparatus of claim 24, wherein the metal material of the permeable barrier is different than the first material of the filter media.