

## TRANSMITTAL

Electronic Version v1.1

Stylesheet Version v1.1.0

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                             |                |               |             |                |                                                |                     |          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|----------------|---------------|-------------|----------------|------------------------------------------------|---------------------|----------|
| <b>Title of<br/>Invention</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Method and Apparatus for Sterilizing and Conditioning Air and Surfaces<br>and Protecting a Zone from External Contamination |                |               |             |                |                                                |                     |          |
| Application Number :                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                             |                |               |             |                |                                                |                     |          |
| Date :                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                             |                |               |             |                |                                                |                     |          |
| First Named Applicant:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | S. Edward Neister                                                                                                           |                |               |             |                |                                                |                     |          |
| Confirmation Number:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                             |                |               |             |                |                                                |                     |          |
| Attorney Docket Number:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | NEI.US.1                                                                                                                    |                |               |             |                |                                                |                     |          |
| <p>I hereby certify that the use of this system is for OFFICIAL correspondence between patent applicants or their representatives and the USPTO. Fraudulent or other use besides the filing of official correspondence by authorized parties is strictly prohibited, and subject to a fine and/or imprisonment under applicable law.</p> <p>I , the undersigned, certify that I have viewed a display of document(s) being electronically submitted to the United States Patent and Trademark Office, using either the USPTO provided style sheet or software, and that this is the document(s) I intend for initiation or further prosecution of a patent application noted in the submission. This document(s) will become part of the official electronic record at the USPTO.</p> |                                                                                                                             |                |               |             |                |                                                |                     |          |
| <table border="1"><tr><td>Submitted By:</td><td>Elec. Sign.</td><td>Sign. Capacity</td></tr><tr><td>Phillip E. Decker<br/>Registered Number: 39,163</td><td>/Phillip E. Decker/</td><td>Attorney</td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                             |                | Submitted By: | Elec. Sign. | Sign. Capacity | Phillip E. Decker<br>Registered Number: 39,163 | /Phillip E. Decker/ | Attorney |
| Submitted By:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Elec. Sign.                                                                                                                 | Sign. Capacity |               |             |                |                                                |                     |          |
| Phillip E. Decker<br>Registered Number: 39,163                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | /Phillip E. Decker/                                                                                                         | Attorney       |               |             |                |                                                |                     |          |

| Documents being submitted: | Files                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| us-request                 | nei1-usrequ.xml<br>us-request.dtd<br>us-request.xsl                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| us-fee-sheet               | nei1-usfees.xml<br>us-fee-sheet.xsl<br>us-fee-sheet.dtd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| application-body           | heiprva.xml<br>application-body.dtd<br>Image1.tif<br>Image10.tif<br>Image11.tif<br>Image12.tif<br>Image13.tif<br>Image2.tif<br>Image3.tif<br>Image4.tif<br>Image5.tif<br>Image6.tif<br>Image7.tif<br>Image8.tif<br>Image9.tif<br>isoamsa.ent<br>isoamsb.ent<br>isoamsc.ent<br>isoamsn.ent<br>isoamso.ent<br>isoamsr.ent<br>isobox.ent<br>isocyr1.ent<br>isocyr2.ent<br>isodia.ent<br>isogr1.ent<br>isogr2.ent<br>isogr3.ent<br>isogr4.ent<br>isolat1.ent<br>isolat2.ent<br>isomfrk.ent<br>isomopf.ent<br>isomscr.ent<br>isonum.ent<br>isopub.ent<br>isotech.ent<br>mathml2.dtd<br>mathml2-qname-1.mod<br>mmlalias.ent<br>mmlextra.ent<br>soextblx.dtd<br>us-application-body.xsl |

|                           |                      |
|---------------------------|----------------------|
| application-body-pdf-wrap | wipo.ent             |
| abstract-pdf              | heiprva-pdf-wrap.xml |
| claims-pdf                | heiprva-abst.pdf     |
| description-pdf           | heiprva-clms.pdf     |
| drawings-pdf              | heiprva-desc.pdf     |
| <b>Comments</b>           |                      |

## APPLICATION DATA SHEET

Electronic Version v14

Stylesheet Version v14.1

### ***Applicant Information:***

Inventor 1:

**Applicant Authority Type:** Inventor  
**Citizenship:** US  
**Given Name:** S.  
**Middle Name:** Edward  
**Family Name:** Neister  
**City of Residence:** New Durham  
**State of Residence:** NH  
**Country of Residence:** US  
**Address-1 of Mailing Address:** 152 Brackett Road  
**Address-2 of Mailing Address:** P.O. Box 61  
**City of Mailing Address:** New Durham  
**State of Mailing Address:** NH  
**Postal Code of Mailing Address:** 03855  
**Country of Mailing Address:** US  
**Phone:**  
**Fax:**  
**E-mail:** eneister@worldpath.net

### ***Correspondence Information:***

**Customer Number:** 24111



### ***Application Information:***

**Title of Invention :** Method and Apparatus for Sterilizing and Conditioning Air and Surfaces and Protecting a Zone from External Contamination  
**Application Type :** provisional, utility  
**Attorney Docket Number :** NEI.US.1

**Botanic Information:**

Publication Information:

**Suggested Figure for Publication -**

**Suggested Classification -**

**Suggested Technology Center -**

**Total Number of Drawing Sheets -**

***Representative Information:***

practitioner(s) at Customer Number:

24111



as my attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith.

***Domestic Priority Information:***

***Foreign Priority Information:***

***Assignee Information:***

## ABSTRACT

This invention relates to both a method and apparatus for sterilizing breathable air and then using this air to protect a confined space from external contamination. The apparatus consists of a new ultra-violet (NUV) source that is more effective than mercury based 254 nm light for destroying DNA of virus, bacteria, spores and cists. It is most effective in breaking chemical bonds in toxic gases that are useful to terrorists. It is combined with other apparatus that remove byproducts caused by the NUV source and maintains positive pressure of the confined space so as to prevent the influx of air from outside the protected zone. The apparatus includes a humidification system to provide and maintain minimum moisture content at predetermined and controllable levels. In addition, the apparatus contains baffles and zone restriction devices that enhance the zone protection and minimize the positive pressure required to maintain the protected zone. Furthermore, this invention relates to a process for treating surfaces contaminated with microorganisms and toxic substances to render both inactive. These surfaces include material objects such as tables, counter tops, trays, hand railings, floors, chairs and clothing and food and all associated handling equipment.

## Method and Apparatus for Sterilizing and Conditioning Air and Surfaces and Protecting a Zone from External Contamination

### DESCRIPTION

[Para 1] This invention teaches a new method for sterilizing air and decontaminating surfaces and food from microorganisms and toxic chemical substances. More particularly, it relates to a process and apparatus for protecting closed or captured environments and zones from external sources of contamination in an efficient and cost effective process. These zones can be large volumes such as high rise buildings, cruise ships and jet airliners, or small volumes such as surgical operation zones whether in a hospital operating room or on the battle field.

### Description of Related Art

[Para 2] All prior art for sterilizing air has been based on using commercially available ultra-violet (UV) lamps or by using magnetic fields. These lamps are either pulsed or continuous. Continuous lamps are mercury based and emit principally at 254 nm. A number of companies are presently producing UV light based apparatus for the destruction of virus, spores and pathogens (VSP) in room air. This is an effective treatment because it continually exposes room air currents to the treatment light and over time has sufficient exposure time to VSP's. The required exposure times range from 10's to 100's of seconds, depending on the light absorption capability of the different virus and bacteria at the 254 nm. While this is effective for treating the room air of individual

rooms, it is not practical for treating large flowing volumes of air that pass quickly down large ducts.

[Para 3] Magnetic based apparatus also require time to deactivate or destroy these VSP's. Two such inventions are directed to specific applications. Wesley, U.S. Pat. No. 4,458,153 is directed specifically towards liquid like substances enclosed in pipes, but does not discuss any test results. Sangster, U.S. Pat. No. 5,750,072 requires an injection of a sterilizing fluid as a mist or vapor for the magnetic field to produce radicals that in turn are used to kill the VSP's. He does not discuss any test results. Hofmann, U.S. Pat. No. 4,524,079 is directed specifically to treating food stuffs. He speaks of requiring up to 100 pulses at frequencies ranging from 5 to 500 kHz. Although the action time would be short, the power required to treat large areas and the apparatus design limit its practical application.

[Para 4] During the past few years, new UV emitting lamps based on the excitation of excimers are becoming commercially available. These emitters produce single line emission at a wavelength determined by the gas composition of the lamp. If the treatment lamp's wavelength is chosen to match the peak of the VSP absorption, then a lethal dosage can be delivered to the VSP's in a shorter time. There has not been found any patent that teaches the use of new ultra-violet (NUV) sources coupled with supporting equipment that can effectively and efficiently treat large volumes of air, large and small surfaces, and food stuffs in various stages of preparation.

## NUV Background

[Para 5] The genetic makeup of all living organisms is contained in their DNA molecule. Replication occurs by the splitting of the DNA molecule, which duplicates itself through a transformation of its structure. Parts of the DNA molecule have been given names such as pyrimidine bases, cytosine, thymine or uracil that form a group of biochemicals that sustain life. The long DNA molecule holds itself together by using simple bonds like those found in sugars.

[Para 6] Researchers believe that the energy of the UV photon causes the formation of a strong (covalent) bond to develop between specific biochemicals. However, the bond strength of the covalent bond is very dependent on the relative position of the participating atoms. When the bond is symmetrical on both sides of a hydrogen atom in the bond, it is referred to as a dimer. A dimer is a very strong bond and is not generally broken during the vaporization of the liquid. UV light is known to produce Thymine, cytosine–thymine, and cytosine dimers. After the formation of the dimer, further replication of the DNA stops. Figure 8 shows the concept of the dimer formation in a DNA molecule.

[Para 7] The DNA molecule absorbs light from about 180 nm to about 300 nm. The most effective wavelength in water is about 254 nm because water absorption increases steadily as the wavelength decreases below 235nm. DNA absorption also increases with lower wavelength. Figure 9 graphically shows

this relationship (Von Sonntag; Disinfection by free radicals and UV-radiation. Water Supply 4, 11–18 (1986)).

[Para 8] The commercial light source for UV irradiation near a principal absorption peak of DNA has been produced by using mercury as the source for generating photons. The mercury gas and its pressure in the lamp determine the wavelength of the emitting light. For low-pressure (LP) and low-pressure high output (LPHO) lamps, the emitting wavelength is 254 nm. For medium pressure lamps, the emission ranges from 200 nm to above 300 nm. However, the strength of the emitted light is not effective below 245 nm for the continuous emitting lamps and below 235 nm for medium pressure lamps. Xenon gas in pulsed lamps produces a similar emission as the medium pressure mercury lamps.

[Para 9] DNA action spectra show that absorption increases as the wavelength decreases, with a relative maxima at 260 nm and largest at 200 nm. Many articles indicate the principal action spectra of the DNA absorption is from 245 to 280 nm range and do not address the 200 nm peak. Since water absorption significantly increases below 235 nm, it becomes apparent that DNA effectiveness curves that omit the 200 nm peak apply only to organisms in water.

[Para 10] MS-2 Phage is a marker virus that is used to measure reproduction viability after UV irradiation. Figure 10 is DNA absorption without the influence of water (Gates, F.L. A study of the bactericidal action of ultra violet

light III...Jour. General Physiology 14, 31–42 (1930)). Absorption is more than doubled at 222 nm.

[Para 11] A recent technical paper (Peak et al, UV action spectra for DNA dimmer induction.., Photochemistry and Photobiology, 40, 5 (613–620), 1984) suggests that dimmer formation is not the only requirement to inactivate DNA. Absorption of other molecular groups in the long DNA chain increase as the wavelength is reduced from 254 nm. Damaging or destroying these bonds may be more effective in deactivating the DNA than compared to the 254 nm band. No one has done a detailed study of the effectiveness of inactivation for the different single line UV emitters that are produced by the new UV source (NUV) excimer lamps. Reports show that damage caused by 254 nm light can be reversed by longer wavelength UV and blue light. 222 nm photons with their higher energy are not expected to cause this 'photo-reactivation' phenomenon. However, this theory needs to be confirmed.

[Para 12] An excimer lamp emitting at 222 nm is considered the most effective source because DNA chains and biochemical's have greater absorption at this wavelength. The steep rise in absorption below 250 nm is exhibited by all proteins. It has been fairly well established that peptide bond absorption is responsible for the steep rise in absorption exhibited by all proteins. This occurs as well for nucleo-proteins, aromatic amino-acids, diglycine, triglycine, and bovine albumin (McLaren, et al, Photochemistry of Proteins and Nucleic Acids, Pergamon Press, Macmillan Company, 1964). An organic chemist suggests that this lower wavelength is more effective in breaking bonds and

producing dimers in the purine bases and sugar phosphates instead of the pyrimidines. The 222 nm is not strongly absorbed by water vapor and oxygen in the air. A shorter wavelength would be most certainly rendered ineffective by water vapor and oxygen absorption for long irradiation distances in air.

## Tests

[Para 13] Using a lamp that emits 222 nm, a comparison test with and without water was made to determine the effect of this radiation on organisms. The organism used in all tests was the MS-2 virus, which has become a standard indicator of mutation effectiveness. The EPA report (811-R-96-002) reports a 4.3 average log reduction of the MS-2 virus using mercury light 254nm at an irradiance greater than 128 mj /cm<sup>2</sup>.

[Para 14] Three wavelengths were tested; 222, 253, 259 nm. The 222 nm lamp was tested at three levels of irradiance with the virus in a thin layer of water in order to reduce the absorption effect of water. A separate test was also done with the virus in water. The 253 and 259 nm lamps were tested at the identical irradiance levels with the virus in water. Controls were made on all tests and a single test dish on each lamp was made to check experimental error.

[Para 15] The 222 nm lamp (Figure 11) produced log 5 reductions at 40 mj/ cm<sup>2</sup> and log 6.5 reductions at 60 mj/ cm<sup>2</sup>. The water test produced a 3.2 log reduction, which matched the equivalent calculated irradiance in air. The 253 and 259 nm lamps produced about log 4 reductions at 60 mj/cm<sup>2</sup>. A 3 million

reduction in population is about 10 to 100 times more effective than reported mercury 254nm results at the same irradiance.

## Analysis

[Para 16] The results of the test indicate that 222 nm light is very effective in causing mutations in airborne organisms. These tests indicate an improvement of between 10 to 1000 times, depending on the intensity of the lamp. It is important to note the improvement of the 259 nm source compared to the 254 nm source. This produced a 10 times improvement in the test sample even in water. It illustrates the importance in using a UV photon emitter that is near the absorption peak of the DNA or targeted chemical such as proteins, nucleic acids, or amino-acids.

[Para 17] It is important to note that DNA biochemical's will have different absorption spectra and the peak absorption will be shifted by water, ph, temperature, previously absorbed light and surrounding contaminates in the air. The presence of ozone can significantly reduce the resistance to damage and shorten the action kill time.

[Para 18] For example, tyrosine has a relative maximum at 275 nm, a red shift of 20 nm from the normal DNA curve. The tobacco mosaic virus peaks at 265 nm, but its X-protein at pH 7.3 peaks at 280 nm while the RNA peak occurs at 260 nm. Critical to the destruction of the organism is targeting the proper biochemical so the critical dosage can be delivered in the shortest time. The

critical dosage is that dosage that destroys or deactivates the organism and also prevents its replication.

[Para 19] The excimer lamp is a coaxial design that can be made as small as a pencil to as large as 1 meter long. Lamp efficiency is about the same as mercury at 10–25% wall power to UV emission. The design has several advantages over mercury lamps. Most important is that its gas can be chosen to maximize its absorption to the targeted biochemical. Unlike the mercury lamp, the excimer intensity can be varied from near zero to maximum. It will produce 10 to 1000 time more intensity than mercury, depending on the lamp dimensions, and it does not use mercury which will soon become regulated by the EPA.

[Para 20] The energy of the emitted photon is determined by its wavelength. Photon energy is about 5ev at 250nm, and increases for shorter wavelengths. Different bonds in the DNA will be affected with photons of different energy.

[Para 21] Figure 12 illustrates the 254 nm dose required for deactivation of different VSP's. The bars represent with (open) and without (solid) photo-reactivation. Note that a dose of 75 mj/cm<sup>2</sup> is required to deactivate the MS2 Phage virus and prevent photo-reactivation. In the tests shown in Figure 11, half the dose at 222 nm was just as effective as the higher dose at 254 nm. Even though the sample was under water, the 222 nm radiation was still more effective than 254 nm radiation.

[Para 22] The 222 nm photon has more energy and is absorbed by S-N, S-O, O-O, O-H, and many carbon bonds that do not absorb 254 nm. This suggest that 222 nm light may also prevent DNA repair that has been reported for low level 254 nm UV sources.

### Toxic Gas Weapons

[Para 23] Biotoxins and nerve agents can be used by terrorists as weapons against groups of people. Nothing economical has been developed that could mitigate an attack and prevent the loss of life and incapacitation at the point of attack. While government agencies of the US have developed detectors that could be used in the future to warn people in the confined areas that are under attack, nothing would prevent the attack from being effective.

[Para 24] Biotoxins and nerve agents are organic molecules that contain either DNA or are chemicals that involve long chain carbon molecules. Both of these are susceptible to destruction using NUV light sources. 222 nm will destroy the C=C and C=O bonds causing the destruction of the chemical.

[Para 25] The most effective means for delivery of these agents is to spread them in a gas phase through the air ventilation system. A detector would be used to turn on sufficient NUV sources so that the agents are destroyed before exiting the ventilation system into the confined area where the captured population is present. Tests still need to be done in regulated and controlled laboratories to develop the criteria for these sources to be effective and become the first line

of defense. However, the concept of using the NUV source as well as the associated support equipment used for treating VSP's is valid and is also contained in the scope of this patent.

### **High E field electrostatic precipitator (ESP)**

[Para 26] Important to the sterilization apparatus is the use of a high E field ESP.

Figure 13 compares the range of effectiveness with mechanical filters for different pollutant sizes. As illustrated in the fourth column, it is capable of removing VSP's. However, since it can also capture fog and mist, it has the ability to breakdown ozone O<sub>3</sub> into oxygen. Its use prevents levels of ozone from exceeding the EPA safe level of 0.5 ppm.

### **Summary of Invention**

[Para 27] Critical to this method is the development of a new ultra-violet (NUV) source that emits single line photons that correspond to the maximum absorption band for DNA. The preferred embodiment is a NUV source at 222 nm, but other lines can also be used. This spectral emission is 10<sup>4</sup> times more effective than standard 254 nm photons for destroying DNA. Kill action times are reduced from 10's to 100's of seconds to times less than 0.1 seconds. Photon energy of the NUV source is sufficiently high to break carbon bonds of chemical toxic substances with similar action times. Unique to obtaining short

action (kill) times is a determination of the specific wavelength required to destroy the targeted organism or chemical. The NUV source is chosen to supply the single line emission that matches the peak absorption of the targeted organism or chemical.

[Para 28] This makes for a cost effective method for sterilizing air, clothing, surfaces and food during normal daily activity, preventing the previous need to restrict occupation and use of areas that are being treated. Furthermore, the apparatus is capable of effectively and efficiently decontaminating floors, hand rails, clothing and objects that are in constant contact with transient populations for the purpose of preventing transmission of disease and toxic substances that can cause injury or illness to these populations.

[Para 29] Normal breathable air contains many contaminants including moisture droplets, dust, lint, bacteria, virus, cists, spores and possible toxic gases. Sterilization requires the removal of all particles to the smallest possible size. The NUV source also produces byproducts that must be removed for some treatment applications. These byproducts include oxidized air (ozone), condensable chemical byproducts, and damaged microorganisms. Critical to the apparatus is the removal of these contaminants and byproducts. In some special applications, ozone is added to make treatment more effective. Consequently, the apparatus includes high E field precipitators, ozone generators and ozone destroying light and apparatus to make effective use of the combination of these technologies.

**[Para 30]** Sterilized air is then used to prevent contamination of a protected zone by preventing the influx of air from outside this zone. The apparatus includes pressurizing equipment and zone baffles that provide sufficient outflow from the protected zone so no contamination can occur. Protected zones can be as small as a wound area on a battlefield operating table to a cruise ship, airplane, or high rise building with thousands of inhabitants.

**[Para 31]** A major source of infection and terrorist's activity is food and material handling. Photon emitters have been used to effectively clean food stuffs and surfaces for many years. However, this invention uses the NUV source that makes it cost effective in treating surfaces of food and materials since the action time is almost immediate. The apparatus of this invention is capable of irradiating food stuffs in conveyor assemblies, stationary carts and in handling routes during the movement from storage to food preparation processes.

#### **Brief Description of Drawings**

**[Para 32]** Figure 1 is a perspective schematic view of a preferred embodiment of the present invention defining the location of important components of the NUV source therein;

**[Para 33]** Figure 2 is a perspective schematic view of a preferred embodiment of the present invention defining the location of important components for treating large volumes of air therein;

**[Para 34]** Figure 3 is a perspective schematic view of a preferred embodiment of the present invention defining the location of important components for treating floor surfaces and other surfaces such as chairs, hand rails, counter tops, trays, table tops and the like therein;

**[Para 35]** Figure 4 is a perspective schematic view of a preferred embodiment of the present invention defining the location of important components for treating food prior to handling by kitchen or cooks and prior to serving therein;

**[Para 36]** Figure 5 is a perspective schematic view of a preferred embodiment of the present invention defining the location of important components for treating air that is used to cover and protect the zone around a surgical operation or procedure independent of the location of the operation therein;

**[Para 37]** Figure 6 is a perspective schematic view of a preferred embodiment of the present invention illustrating the zone air sterilization apparatus in conjunction with the remote protected operation zone therein;

**[Para 38]** Figure 7 is a CFD view of a preferred embodiment of the present invention defining the emitted air flow pattern from the sterilization apparatus that is used to cover and protect the zone around a surgical operation or procedure independent of the location of the operation therein;

## **Description of Preferred Embodiments**

[Para 39] The drawings illustrate the invention in its different forms and the apparatus required for sterilization of air and surfaces that contain VAR's. FIG. 1 illustrates the NUV light source. FIG. 1a shows the NUV source that would be installed inside an air duct. The high voltage electrode 1 is located inside the inner tube of the annular lamp. The ground electrode screen 2 is located on the outside of the annular lamp. The gas that produces the UV photons is located in the annular region 3 between the inner and outer tubes 4. The gas type is chosen so that the emitted UV photons are at 222nm. UV radiation is emitted radially outward 5. Changing the voltage between the two electrodes changes the amount of UV radiation. FIG. 1b illustrates the NUV light source used to direct the UV photons towards a specific location. The NUV source is shown in the center of the drawing as an end view. The specialized reflector 6 end view incorporates a specialized 'gull wing' design so that >90% of the emitted light is directed to the planar surface below. The specialized reflector 6 also incorporates barium sulfate ( $\text{Ba}_2\text{SO}_4$ ) as the reflective material in order to maximize the number of photons that are reflected onto the planar surface. In some cases, a cover 6a is necessary to protect the NUV source and reflector from dirt. This cover is transparent to 222nm light.

[Para 40] In use, the NUV source can be made to any size and length. In air ducts, the preferred embodiment FIG. 2–6b would have the NUV source supported from the side, top or bottom of the duct so that its irradiation travels parallel to the air flow. For unique applications, a second embodiment FIG. 5 – 16 would have the NUV source and cylinder reflector supported inside the duct so that irradiation is perpendicular to the air flow. An example of this embodiment

would be a NUV source positioned in the center of a tumbling dryer. All garments would be irradiated during the drying process for a length of time that would guarantee sterilization.

**[Para 41]** FIG. 2 illustrates the apparatus required for the sterilization of air flow inside a large duct. NUV sources 7 precede an electrostatic precipitator (ESP) 9 by some distance 8 that permits a short action time to complete the destruction of the toxic gases or VSP's. A humidifier 10 may follow the precipitator with control sensors 11 so that the humidity of the exiting air can be selected and maintained. A fan(s) 12 may also be used to pressurize the exiting air so that a slight pressurization can be applied to a protected zone to prevent contaminated air from entering. Depending on the nature of the zone, restricting baffles (not shown) are used to assist in maintaining a positive pressure inside the protective zone.

**[Para 42]** FIG. 3a illustrates the NUV source located inside the forward compartment 13 of a vacuum cleaner or floor cleaning machines. This vacuum cleaner can be either a standup floor model or a canister model. It could also be any device that would support and carry the NUV source close to the floor, like a Segway. The significant part is that the NUV source with reflector 6 consists of the components as described in FIG. 1b. FIG. 3b illustrates a preferred embodiment with the NUV source contained in a hand held wand. Included in this embodiment are sensing switches 14 that shut off the NUV source when the wand is not directed in the treatment direction.

**[Para 43]** FIG. 4a illustrates the NUV source(s) located above a conveyor that carries raw and unprepared food prior to kitchen preparation. The conveyor assembly 14 is designed to maximize the surface area exposed to the NUV source(s). In some cases, several sources 13 are required because the exposed surface of the food can not be changed to expose the entire surface during the illumination time of one NUV source. Tumblers or vibrators are typically used to change the orientation of the food stuffs as they move along the conveyor. FIG. 4b illustrates the NUV source(s) 13 located beside heat lamps 15 or other heating surfaces used to keep the food hot on a serving counter prior to being delivered from the kitchen to the customer. In another embodiment, the NUV source is used to irradiate cool or cold foods, so heat lamps 15 are not used.

**[Para 44]** FIG. 5 illustrates the NUV source located inside an air sterilization apparatus that provides air for remote and separate operation tables. The NUV source 16 is located inside a UV reflector chamber 17 in order to reduce the loss of UV photons. A light trap 18 stops the UV light prior to the turning veins 19 that direct the air flow vertically downward onto the operation site. A diffuser 20 ensures that the airflow is uniform across the duct. A high E field electrostatic precipitator (ESP) 21 follows the diffuser to remove particulates and reduce ozone to oxygen. The airflow then passes through a second diffuser and humidifier 22 to ensure that the airflow is uniform across the duct and that the humidity level is controlled to some preset value. FIG. 6 illustrates how the air sterilization apparatus would be used in conjunction with a remote operation site, where the doctor is using remote controlled surgical instruments that are inside the sterilized air zone. FIG. 7 illustrates the air flow pattern

using CFD computational fluidic design to ensure that the air above the operation zone is uniform and prohibits contaminated air from entering the protected zone.

**[Para 45]** While the invention has been described with reference to at least one preferred embodiment, it is to be clearly understood by those skilled in the art that the invention is not limited thereto. Rather, the scope of the invention is to be interpreted in conjunction with the appended claims and their intent.

**What is claimed is:**

- [Claim 1] A NUV source that emits photons at 222 nm and other discrete UV wavelengths.
- [Claim 2] A NUV source as defined in claim 1 used for destroying DNA of viral and bacterial agents, spores and cists.
- [Claim 3] A NUV source as defined in claim 1 used for destroying chemical bonds in toxic, biochemical and chemicals.
- [Claim 4] A high E field precipitator (ESP) to remove all particles.
- [Claim 5] An ozone generator.
- [Claim 6] An ozone destructive light emitter such as 254 nm light.
- [Claim 7] An ozone destructive precipitator to remove all ozone.
- [Claim 8] A humidifier and controls to maintain controllable amounts of water vapor in the processed air.
- [Claim 9] Apparatus that consists of a NUV source, ESP, ozone generator, mercury lamps, and humidifier with controls as defined in claims 3–8 and any combination therein.
- [Claim 10] Apparatus as defined in claim 9 that provide a zone of sterilized air and free of contaminated air.
- [Claim 11] Apparatus as defined in claim 9 that sterilizes air, objects, surfaces, clothing and food stuffs in a cost effective method using NUV and/or ozone in combination or separately.
- [Claim 12] Apparatus that is specifically designed to treat air, objects, surfaces, clothing and food stuffs using NUV and/or ozone in combination or separately.

[Claim 13] Apparatus as defined in claim 9 that facilitate the use and control of the NUV source direction and area of coverage including the use of zone baffles, curtains and drapes.

[Claim 14] Apparatus and controls as defined in claim 9 that provide adjustment and control of the intensity of the NUV sources.

[Claim 15] Apparatus and controls as defined in claim 9 that provide adjustment and control of the pressure of the processed air including the use of zone baffles, curtains and drapes.

[Claim 16] Controls as defined in claim 9 that monitor the effectiveness of the process and informs operators of marginal or ineffective treatment potential.

[Claim 17] Apparatus and controls as defined in claim 9 that maintain equipment effectiveness and provide for self cleaning processes when necessary.

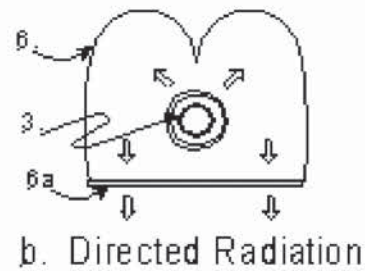
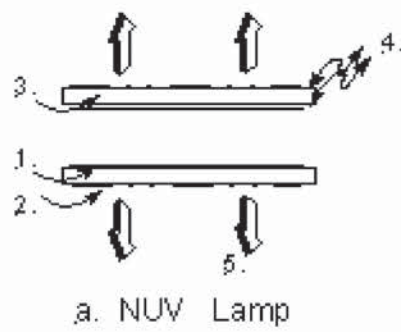


Figure 1: NUV Source

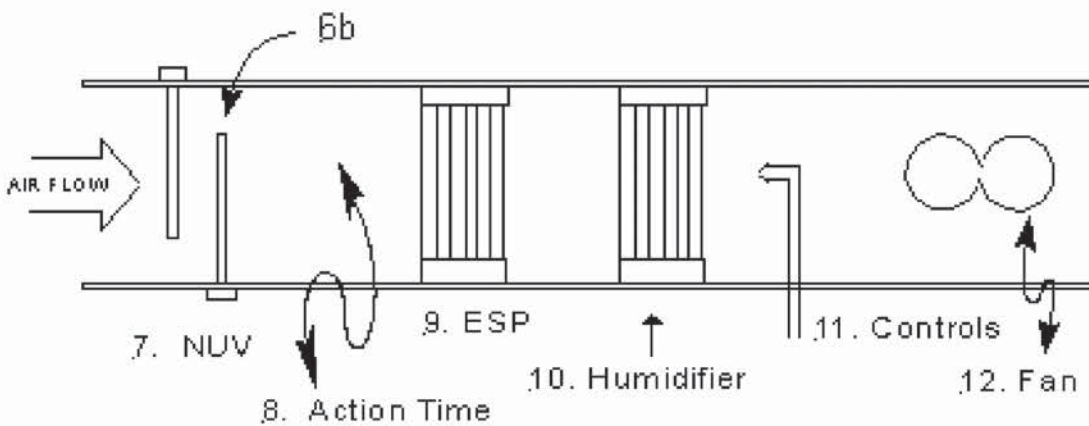
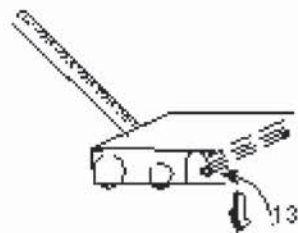
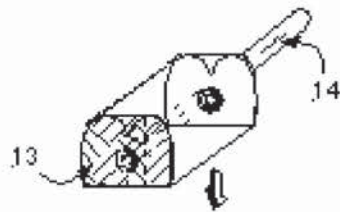


Figure 2: Volumetric Air Treatment

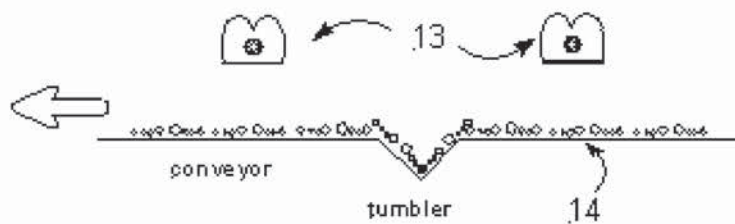


a. Floor Treatment & Cleaner

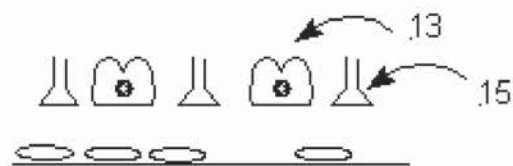


b. Handheld Surface Treatment

Figure 3: Surface Treatment



a. Unprepared food



b. Serving Counter

Figure 4: Food Treatment

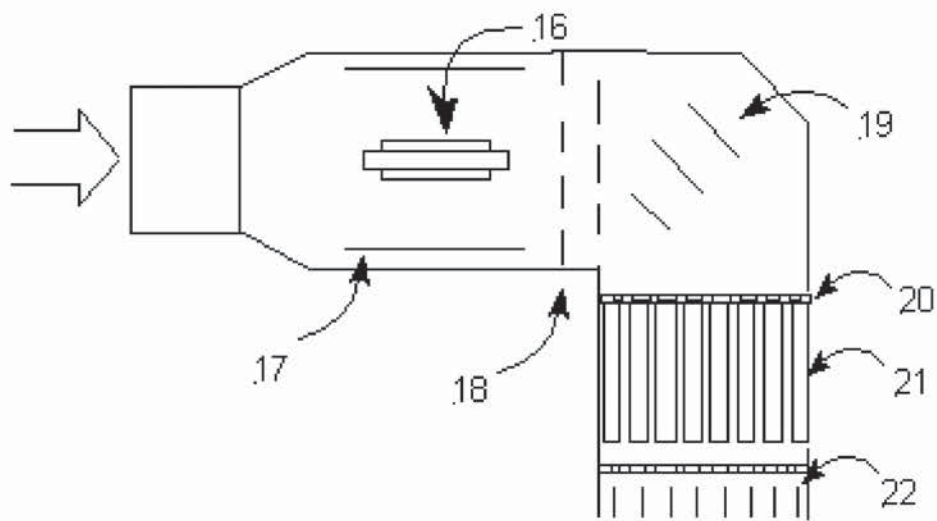


Figure 5: Zone Air Purifier & Sterilizer

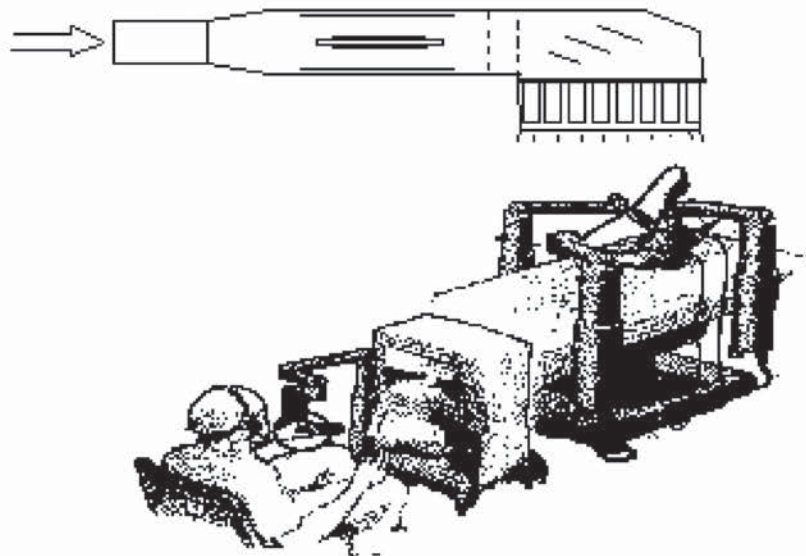


Figure 6: Operating zone with Sterilizer

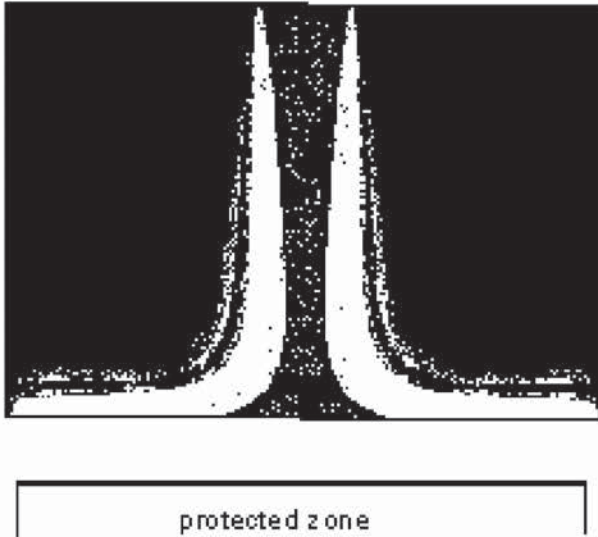
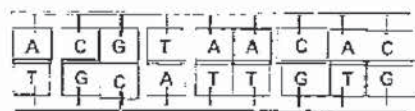
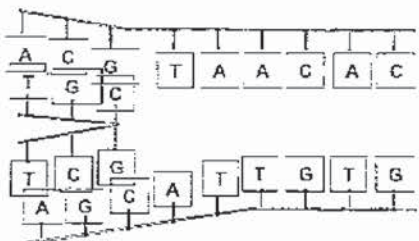


Figure 7: CFD Air Flow



HYPOTHETICAL  
DNA DOUBLE  
STRAND



REPLICATING DNA



DIMERIZATION  
OF THYMINE  
NUCLEOTIDES

Figure 8: Dimer formation by UV photon  
(by permission of ERG at UNH)

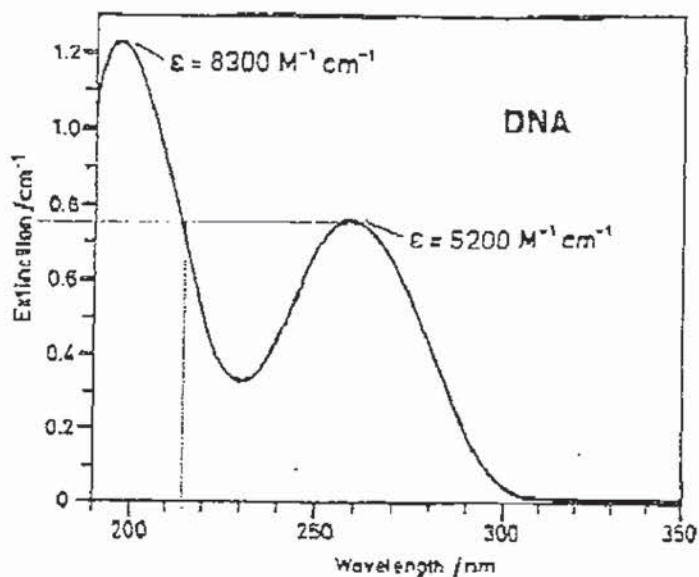


Figure 9: UV absorption of DNA

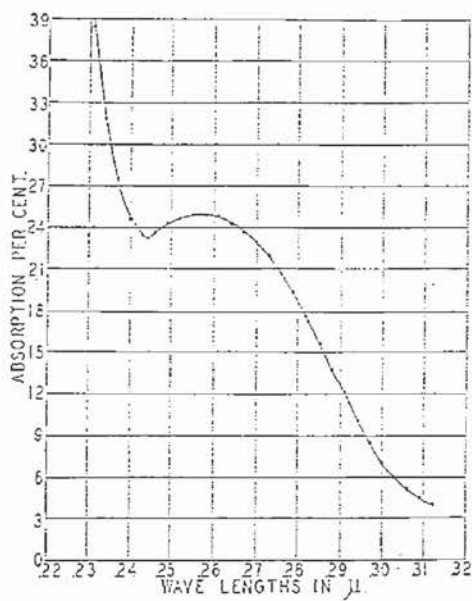


Figure 10: B. coli @ 0.8u absorption

## MS-2 Reduction vs. Irradiance

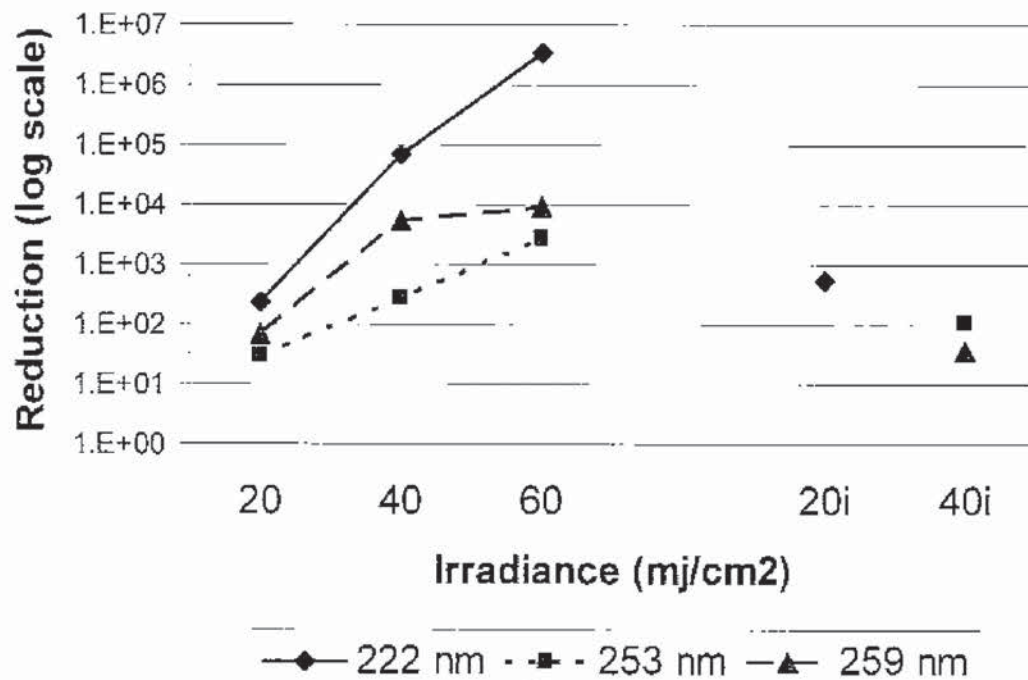


Figure 11: UV irradiation test on MS2

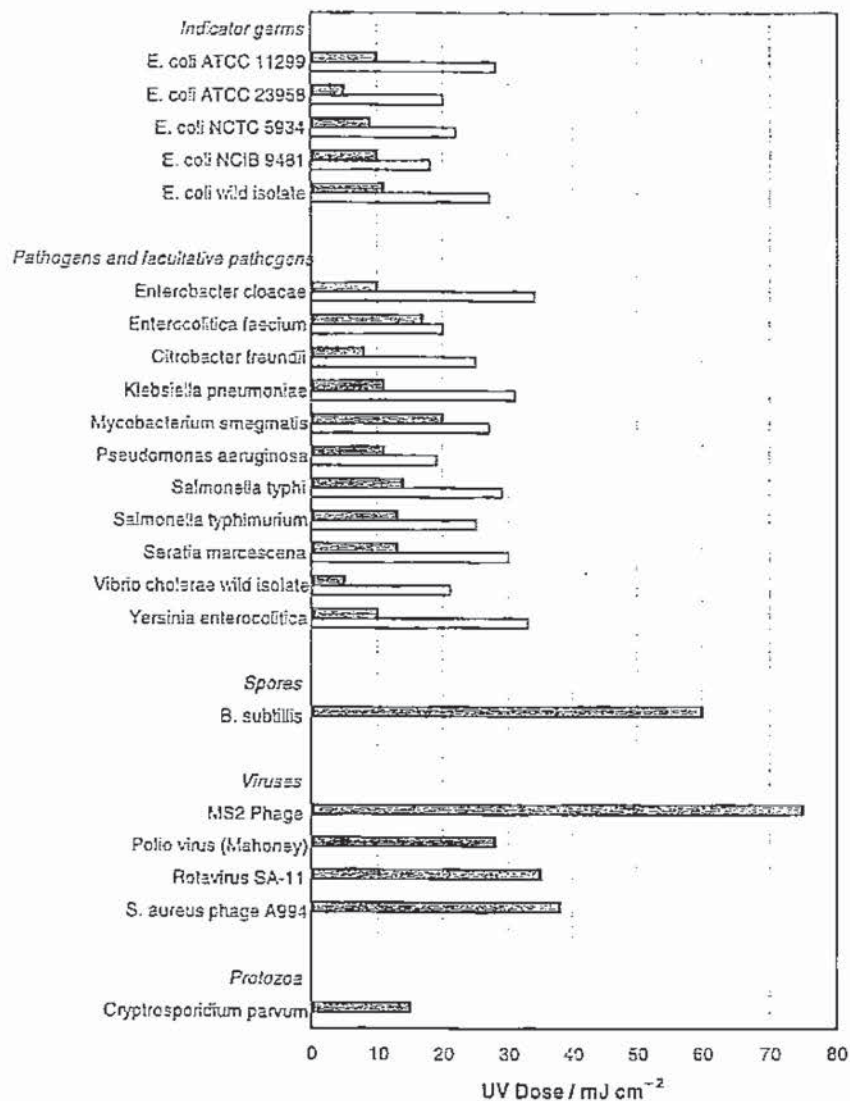


Figure 12: UV Dose Required for 4 log (99.99%) Deactivation

**THE SIZE OF AIRBORNE PARTICLES IN MICRONS**  
(1 micron = 1/25,400th of an inch)

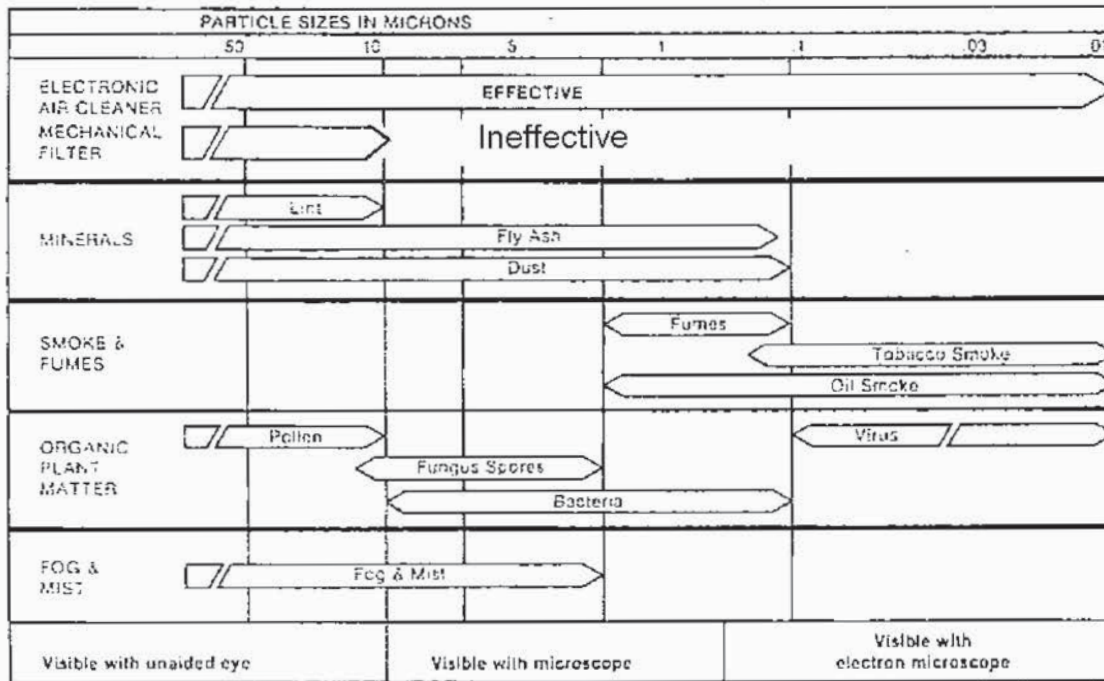


Figure 13: ESP Range of Effectiveness