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Gauthier et al.

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[54] **ENVIRONMENTAL CONTAMINATION CONTROL DEVICE**

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[52] **U.S. Cl.** ..... **128/2 R**, 98/115 LH, 128/2 F, 128/194

[51] **Int. Cl.** **A61b 10/00**

[58] **Field of Search** ..... 128/1, 2 R, 2 C, 128/2 F, 139, 132, 172, 191 R, 191 A, 194; 98/115 LH, 36

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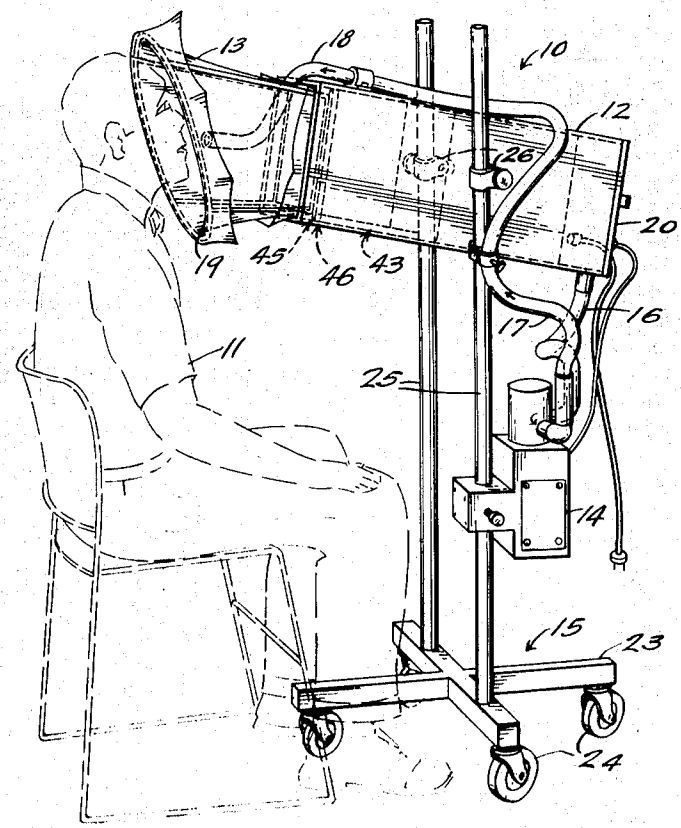
[57] **ABSTRACT**

An improved device for a medical treatment station which may include inducing and collecting sputum without contaminating the environment. A patient is positioned to inhale an aerosol from a discharge hose connected to a nebulizer. Sputum, excess aerosol and room air are drawn through an ultra-high-efficiency filter system to remove preferably at least 99.97 percent of 0.3 micron and larger particles from the air. The purified air is returned to the room, except for a controlled portion which is diverted to the nebulizer for delivering a controlled density aerosol. The filter system preferably includes a gross particle filter and a pre-filter in addition to the ultra-high-efficiency filter. The aerosol discharge hose is positioned in a cowl which directs room air, exhaled air, sputum and excess aerosol to the filter. The highly contaminated aerosol discharge hose, cowl, gross particle filter and pre-filter, and in severe contamination cases the housing and the ultra-high-efficiency filter, are all disposable.

13 Claims, 5 Drawing Figures



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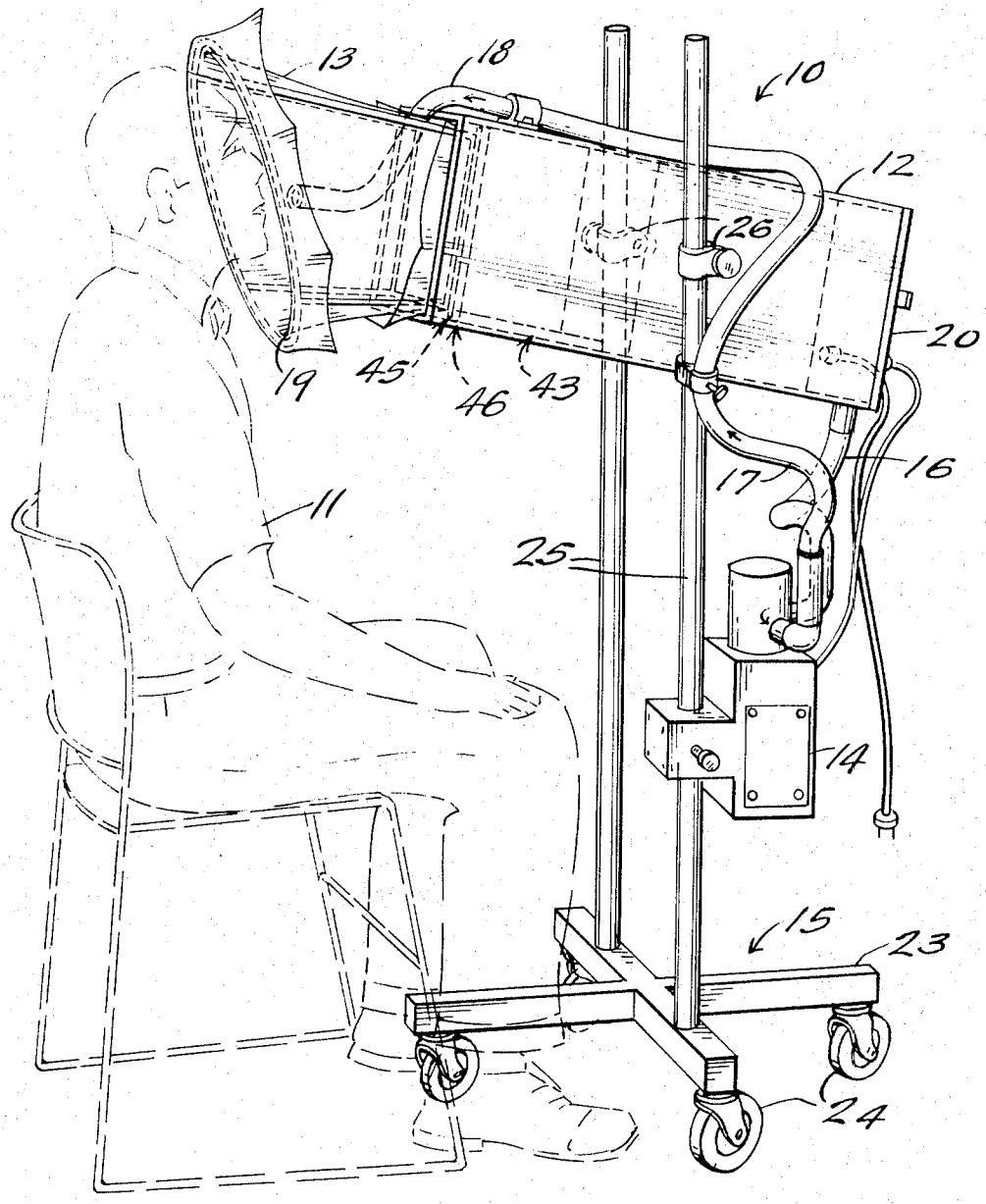

FIG-1-

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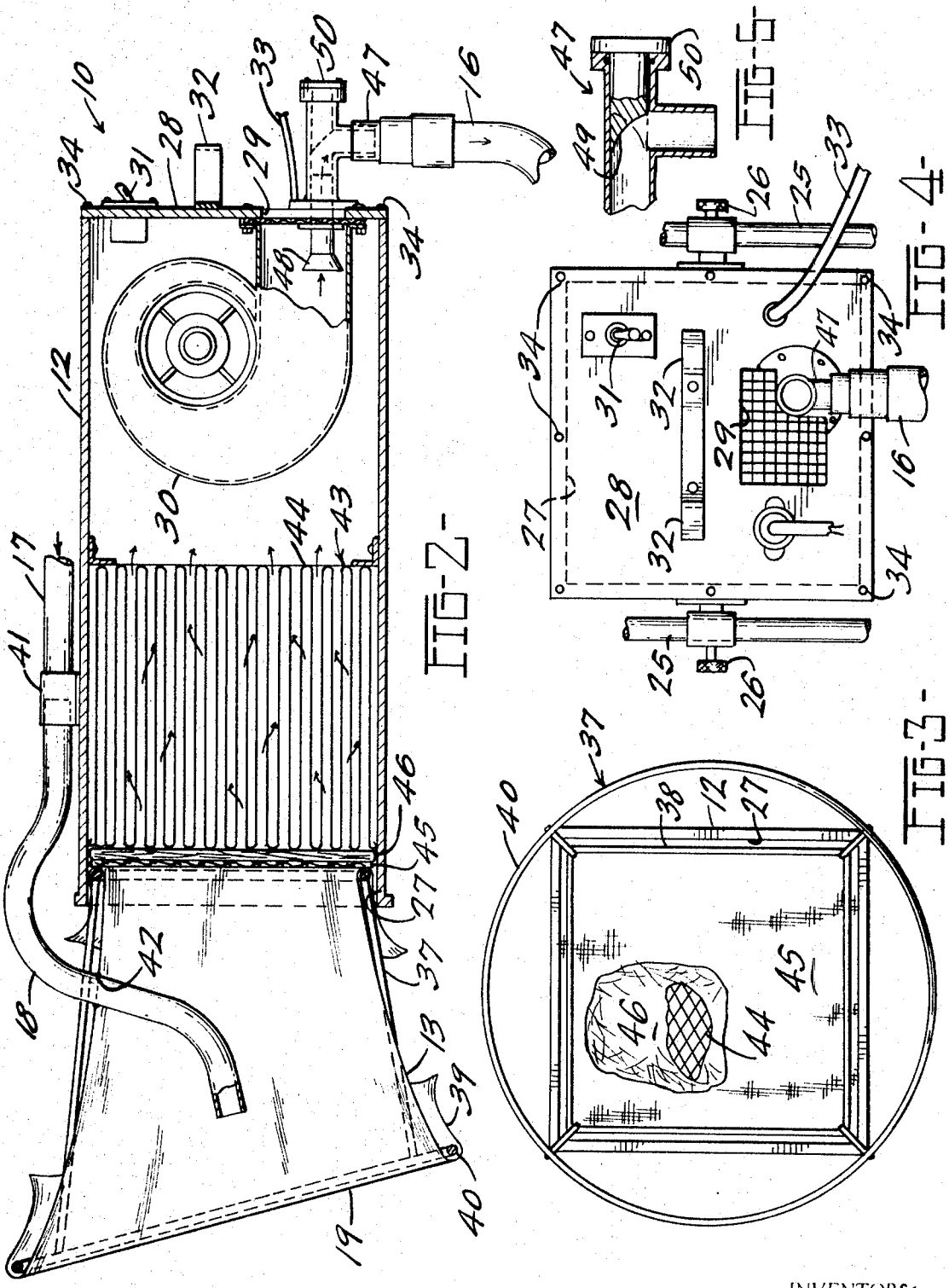

ENVIRONMENTAL CONTAMINATION CONTROL DEVICE

BACKGROUND OF THE INVENTION

This invention relates to a device for use in medical diagnosis and treatment and, more particularly, to an improved device for administering medical aerosols to a patient without contaminating the environment.

It is sometimes desirable for a physician to cause a patient to expectorate sputum. However, precautions must be taken not to contaminate the environment, since the patient may have a communicable disease. In some cases, a sample of the sputum must be collected. Sputum samples may, for example, be required for bacteriologic, cytologic and mycologic diagnosis. Sputum induction may also follow treatment progress in tuberculosis and other infectious pulmonary diseases. When a patient is induced to expectorate sputum and for some treatments, it is also desirable to administer an aerosol without contaminating the environment. Aerosols may be used, for example, for tracheo bronchial particle deposition and cleansing or for administering anesthesia.

There is a growing professional concern regarding the spread of infections in limited but potentially dangerous environments. Cross-contamination, be it physically disseminated by a device or humanly dispersed, is often a topic of discussion in professional journals and circles. With certain strains of organisms becoming resistant to treatment through a bio-physical process of mutation, breaking the cross-infection—re-infection cycle in certain critical but vulnerable environments is becoming increasingly difficult. Evolution of this infection phenomenon is as broad as ones recognition of man and his instruments' ability to harbor and transmit the organisms unconsciously through daily routine.

There has also been increased concern for protecting personnel working in critical environments from infection and from inhaling aerosol disseminated particles. If, for example, an aerosol is used during treatment of a tuberculosis patient, there is a hazard that attending personnel will breathe excess aerosol or will become infected from sputum expectorated by the patient. Further problems may be caused by the deposition of sputum and aerosol particles on walls, ceilings, floors and furnishings in hospital, home and clinic environments. It is therefore desirable to have a portable device for administering an aerosol to a patient without contaminating the environment with sputum and excess aerosol.

SUMMARY OF THE INVENTION

According to the present invention, an improved device is provided for administering therapeutic or cough inducing aerosols and for collecting sputum samples without contaminating the environment with excess aerosol medicament or expectorated sputum. As used herein, "sputum" is intended to include not only expectorated matter, mucus, or the like, but exhaled contaminated aerosols and particulate matter. The device generally comprises an enclosed housing having an air inlet and an air outlet. An ultra-high-efficiency filter capable of removing **99.95** percent of 1 micron and larger particles from air and preferably capable of removing at least **99.97** percent of 0.3 micron and larger particles from air is placed between the air inlet and the air outlet in the housing. A blower is mounted between the filter and the air outlet to cause air to flow through the air inlet, the filter and the air outlet. A cowl is releasably attached to the housing to direct air, sputum and aerosol particles to the air inlet.

In a preferred embodiment, the filter comprises a disposable gross particle filter, a disposable pre-filter and a disposable ultra-high-efficiency filter. Contaminated air is sequentially filtered by the gross particle filter, the pre-filter and the ultra-high-efficiency filter. The gross particle filter is designed for replacement after each use of the environmental contamination control device, while the pre-filter is replaced periodically at relatively short intervals, e.g., every 30 days, and the ultra-high-efficiency filter is replaced periodically at longer intervals, e.g., every year. When required, sputum samples are expectorated into a disposable container positioned adjacent the filter inlet.

The housing of the environmental contamination control device is adjustably mounted on a portable carriage. The position of the housing is adjustable for use with a patient while lying or sitting on a bed, or while sitting in a chair. A conventional nebulizer, preferably an ultrasonic nebulizer, is also mounted on the carriage. A portion of the filtered air leaving the air outlet is diverted through an adjustable control valve to the nebulizer and an aerosol supply hose is attached from the nebulizer to a clamp on the housing. An aerosol discharge hose is removably attached to the supply hose and extends to within the confines of the cowl. The control valve is used to adjust the density of the aerosol delivered to the cowl.

During normal use, the cowl, the aerosol discharge hose and the gross particle filter are contaminated by aerosol, exhaled air and sputum. Each of these parts is constructed from inexpensive materials and each is designed to be readily replaceable and disposable by incineration. The pre-filter and the ultra-high-efficiency filter are usually not replaced after each use. However, where highly toxic aerosols or highly infectious organisms are involved, the pre-filter, the ultra-high-efficiency filter and the housing are also disposable. In such cases, the blower, the carriage and the nebulizer are the only parts saved. These parts may be cleaned by gas sterilization, but are not contaminated in normal use.

Accordingly, it is a primary object of the invention to provide an improved device for controlling environmental contamination from aerosols being administered to a patient or from similar medical procedures.

Another object of the invention is to provide an improved device for inducing sputum and reducing environmental contamination from the induced sputum.

Another object of the invention is to provide an improved device for reducing environmental contamination during inhalation therapy in which all contaminated parts of the device are disposable.

Still another object of the invention is to provide an improved air filtering device for reducing environmental contamination while applying an aerosol to a patient and in which filtered exhaust air from the device is used in delivering the aerosol.

Other objects and advantages of the invention will become apparent from the following detailed description, reference being made to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in perspective of an improved device according to the present invention for delivering an aerosol to a patient and for preventing environmental contamination from sputum, exhaled air and excess aerosol;

FIG. 2 is a side elevational view in section of an improved environmental contamination control device according to the present invention;

FIG. 3 is a front end elevational view of an improved environmental contamination control device according to the present invention;

FIG. 4 is a rear end elevational view of an improved environmental contamination control device according to the present invention; and

FIG. 5 is a fragmentary cross-sectional view of a control valve for diverting a portion of the filtered exhaust air to a nebulizer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, an improved device 10 is shown according to the present invention for administering medical aerosols to a patient 11 without contaminating the environment. The device 10 generally comprises a filter and blower housing 12, a cowl 13 and a nebulizer 14 mounted on a carriage 15. During operation, highly filtered, and thus clean, exhaust air from the housing 12 is supplied through a hose 16 to the nebulizer 14. The nebulizer 14 delivers an aerosol through a supply hose 17 and a discharge hose 18 to within the confines of the cowl 13.

The patient 11 is positioned with his face adjacent a flared or enlarged opening 19 defined by the cowl 13. The patient 11 inhales a concentrated aerosol discharged from the hose 18, which may induce a coughing spasm. When the patient 11 is induced to cough, he exhales violently and may discharge sputum into the cowl 13. Room air, exhaled air, sputum and excess aerosol are drawn into the housing 12 wherein the air is highly filtered and cleaned. The filtered air is discharged at a rear end 20 of the housing 12, with a portion of the air being diverted into the hose 16.

The carriage 15 includes a base 23 which is mounted on wheels 24 for mobility. A pair of parallel, vertical support members 25 are attached to the base 23. The housing 12 is positioned between and adjustably attached to the support members 25 by means of trunnions 26. The trunnions 26 permit a vertical and an angular adjustment of the position of the housing 12 to facilitate using the device 10 with patients in various positions, for example, lying or sitting on a bed or sitting on a chair. The nebulizer 14 is also attached to one of the support members 25.

The nebulizer 14 may be any suitable commercially available unit. One type of nebulizer found to be particularly suitable is that shown in U.S. Pat. No. 3,387,607 entitled Apparatus for Inhalation Therapy. In some cases where an aerosol is not required for causing a coughing spasm to induce sputum, the nebulizer 14 may be omitted.

Referring now to FIGS. 2–4, the environmental contamination control device 10 is shown in greater detail. The housing 12 generally comprises a box constructed from a relatively inexpensive disposable material, such as plywood. An air inlet 27 is formed in one end of the housing 12 while a rigid plate 28 closes the other end of the housing 12. An opening 29 in the plate 28 defines an air outlet. A conventional blower 30, such as a squirrel cage blower, is mounted on the plate 28 to draw air through the cowl 13 and the housing 12 and exhaust such air through the outlet 29. A switch 31 is mounted on the plate 28 for controlling the blower 30. A bracket 32 is also mounted on the back plate 28 for storing a power cord 33 for the device 10 when it is not in use. The back plate 28 is removably attached to the housing 12 by means of screws 34 such that the back plate 28 and the blower 30 may be removed as a unit for maintenance, gas sterilization or attachment to a new housing 12. All permanent parts of the device 10 are mounted either on the carriage 15 or on the back plate 28.

A wire cowl frame 37 is provided with an end 38 which snaps or tightly fits into the air inlet 27 of the housing 12. The cowl 13 preferably comprises a thin sheet of a transparent synthetic resinous material. The cowl 13 is attached to the housing 12 by folding over the end 38 of the frame 37 and inserting the end 38 into the air inlet 27, where it is held in place by friction and compression. An extended end 39 of the cowl 13 is folded over an enlarged wire loop 40 which forms a projecting end of the frame 37 and defines the opening 19. The frame 37 is preferably constructed from rigid wire and is coated with a synthetic resin which prevents corrosion and is easily cleaned and disinfected. The aerosol discharge hose 18 is releasably held in place by a connector 41 which is attached to the housing 12 and the hose 17. The hose 18 extends through a sized opening 42 in the cowl 13. The aerosol discharge hose 18 is also constructed from an inexpensive disposable material, such as a synthetic resin, formed into a desired shape to direct the discharged aerosol. A disposable clip may also be used to give the hose 18 a desired shape and to retain it in position. The hose 18 is removable from the connector 41 and disposable with the cowl 13 after each use of the device 10.

A filter system 43 is positioned within the housing 12 to remove particles from air flowing through the housing 12. The heart of the filter system 43 is an ultra-high-efficiency filter element 44 which removes substantially all particles from air passing through the housing 12. In its preferred form, the filter element 44 removes at least 99.95 percent of 1 micron and larger particles from air, while in its most preferred form, the filter element 44 will remove at least 99.97 percent of 0.3 micron and larger particles. Filters of this type are commercially available and are typically constructed from cellulose-asbestos-fiber paper, glass and glass-asbestos fiber papers, ceramic fiber paper, compressed glass fibers, or composite beds of glass wool pads. Since ultra-high-efficiency filters of this type have a higher resistance to air flow than less efficient filters, the filter is usually pleated to provide an increased filter surface area in a small frontal area. The ultra-high-efficiency filter 44 is disposable and must be replaced when it becomes loaded with particles from the air. To reduce loading of the filter 43, a gross particle filter 45 and a pre-filter 46 are placed upstream of the ultra-high-efficiency filter 44. The gross particle filter 45 may, for example, comprise a relatively thin mat of rayon fiber, while the pre-filter 46 may comprise a thicker glass fiber screen. The gross particle filter 45 is designed for replacement after each use of the device 10, while the

pre-filter **46** is only periodically replaced, for example, every 30 days.

Referring now to FIGS. **2, 4** and **5,** a control valve **47** is shown for diverting a selected or controllable portion of the clean air exhausted from the blower **30** to the air hose **16** which connects to the nebulizer **14.** The control valve **47** includes an inlet member **48** which is positioned to open into the airstream from the blower **30.** Air passes through the inlet **48** and through the valve **47** directly into the hose **16.** The valve **47** also includes a closure member **49** which is rotated by means of a knob **50.** The closure member **49** rotates between an open position shown in solid in FIG. **5** and a closed position shown in dashed lines in FIG. **5.** The closure member **49** may be positioned with the knob **50** to give a controlled air flow in the hose **16** to deliver a predetermined aerosol concentration to the cowl **13.** When the aerosol is not required and the nebulizer **14** is omitted, the valve **47** may of course be omitted.

It will be appreciated that although a single preferred embodiment of the improved environmental contamination control device has been described, various modifications and changes may be made without departing from the spirit and the scope of the invention hereinafter claimed.

What we claim is:

1. An improved device for reducing environmental contamination during medical treatment or diagnosis of a problem of a patient comprising, in combination, an enclosed housing having an air inlet and an air outlet, a cowl constructed from a thin film such that it is disposable after a single use of said device, wire-like frame means releasably attaching said cowl to said housing, means releasably mounting said wire-like frame means on said housing adjacent said air inlet, said cowl being positioned on said frame means to extend completely around said air inlet to direct an aerosol and sputum from the patient to said air inlet, filter means positioned in said housing between said air inlet and said air outlet, said filter means removing substantially all particles larger than one micron from air passed through said housing, blower means positioned in said housing between said filter means and said air outlet for causing air to flow sequentially through said cowl, said air inlet, said filter means and said air outlet, and means on said device for supplying an aerosol to within the confines of said cowl to be breathed by the patient.

2. An improved device for reducing environmental contamination, as defined in claim **1,** wherein said means for supplying an aerosol includes an aerosol supply hose located exterior to said cowl, an aerosol hose section disposable after a single use having an outlet positioned within the confines of said cowl and an inlet exterior to said cowl, and coupler means releasably connecting said disposable aerosol hose section inlet to said aerosol supply hose.

3. An improved device for reducing environmental contamination, as defined in claim **2,** and including means for adjusting said disposable aerosol hose to direct the aerosol in a predetermined direction within the confines of said cowl.

4. An improved device for reducing environmental contamination during an induced sputum, as defined in claim **1,** wherein said filter means includes an ultra-high-efficiency filter means for removing at least 99.97 percent of 0.3 micron and larger particles from air passed through said housing.

5. An improved device for reducing environmental contamination during an induced sputum, as defined in claim **4,** wherein said filter means further includes a gross particle filter disposable after a single use, and means removably mounting said gross particle filter between said air inlet and said ultra-high-efficiency filter, whereby said gross particle filter reduces loading of said ultra-high-efficiency filter.

6. An improved device for reducing environmental contamination during an induced sputum, as defined in claim **1,** wherein said means for supplying an aerosol includes an ultrasonic nebulizer, and means for supplying a controlled flow of air to said ultrasonic nebulizer.

7. An improved device for reducing environmental contamination during an induced sputum, as defined in claim **6,** wherein said means for supplying a controlled flow of air to said ultrasonic nebulizer includes an adjustable valve, an air hose connecting said valve to said nebulizer, and means mounting said adjustable valve to divert a controlled portion of the filtered air leaving said blower means into said hose.

8. An improved device for reducing environmental contamination, as defined in claim **7,** wherein said means for supplying an aerosol further includes an aerosol supply hose positioned exterior to said cowl, means connecting said supply hose to said nebulizer, an aerosol hose section disposable after a single use having an outlet positioned within the confines of said cowl and an inlet exterior to said cowl, and coupler means releasably connecting said disposable hose section inlet to said aerosol supply hose.

9. An improved device for reducing environmental contamination, as defined in claim **1,** and further including a mobile carriage, means attaching said housing to said carriage, and means for adjusting the position of said housing on said carriage to direct said cowl to receive sputum from a patient.

10. An improved device for reducing environmental contamination, as defined in claim **1,** wherein said housing is disposable after said housing becomes contaminated.

11. An improved device for reducing environmental contamination, as defined in claim **1,** wherein said disposable cowl comprises a thin film of synthetic resinous material.

12. An improved device for reducing environmental contamination during medical treatment or diagnosis of a problem of a patient comprising, in combination, an enclosed housing having an air inlet and an air outlet, filter means positioned in said housing between said air inlet and said air outlet for removing at least 99.97 percent of 0.3 micron and larger particles from air passed through said housing, blower means positioned in said housing between said filter means and said air outlet for causing air to flow through said air inlet, said filter means and said air outlet, aerosol generating means, means mounting said aerosol generating means on said device for supplying an aerosol to adjacent said air inlet, cowl means attached to said housing for directing air, sputum from the patient and the aerosol to said air inlet, and means for supplying a flow of filtered air from said air outlet to said aerosol generating means, said air supplying means including an adjustable valve, an air hose connecting said valve to said aerosol generating means, and means connecting said adjustable valve to said housing to divert a controlled portion of the filtered air from said blower means to said hose.

13. An improved device for reducing environmental contamination, as defined in claim **12,** wherein said aerosol generating means includes an ultrasonic nebulizer.

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