SMOKE INHALATION PROTECTOR

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ABSTRACT

A respirator for removing or reducing the smoke and noxious fumes content of air comprises an outer casing having a tubular nozzle that extends through an opening formed in the top of the casing downwardly a short distance into the upper end portion of the casing. An inner conduit is disposed within the outer casing, the upper end of the conduit being spaced a short distance away from the lower end of the nozzle and the lower end of the conduit coinciding with an opening formed in the bottom of the casing. A funnel-shaped baffle is disposed within the casing so that the lower inner end of the nozzle extends into the enlarged upper end of the baffle coincides with the open upper end of the inner conduit. A filter retaining member is disposed in the casing between the casing and the upper of the inner conduit. The lower end of the outer casing and the filter retaining member are each formed with a plurality of small air passage openings, and the space between the outer casing and the inner conduit is filled with air distribution means and an air purification material. When the user of the respirator inhales through the nozzle of the device inhalation valve means automatically open and exhalation valve means automatically close so that air is drawn through the air passage openings formed in the filter retaining member, and when the user exhales the inhalation valve means automatically close and the exhalation valve means automatically open so that moisture laden air is expelled directly into the inner conduit and thence to the atmosphere.

12 Claims, 6 Drawing Figures
SMOKE INHALATION PROTECTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to respirators, and more particularly to a small mouth or hand-held respirator for removing or substantially reducing smoke and noxious fumes from air before the air is inhaled.

2. Prior Art

Devices, usually referred to as respirators, for removing smoke and noxious fumes from air before the air is inhaled are well known in the art. In general, these devices comprise a canister or other container which contains a catalyst for converting carbon monoxide to carbon dioxide, a filter for removing particulate matter (e.g. sooty smoke particles) and an adsorbent material (e.g. activated carbon) for removing organic vapors and acid gases from the air being inhaled by the user of the device. For proper operation of such devices it is necessary to provide valve means which cause the air being inhaled to be drawn through the filter and adsorbent materials and which prevent the air being exhaled from being expelled through these materials. Furthermore, these devices are commonly provided with mouthpieces, nose clips, goggles, face masks, and/or flexible tubing connecting the face mask to the canister which together comprise a relatively bulky assembly that is inconvenient to carry and that frequently requires special training to properly don and use. Military gas masks and firefighters smoke inhalation protectors are representative of this type of prior art respirator device.

Fires in office buildings, houses, subway trains, tunnels and the like are frequently very smokey and produce copious quantities of carbon monoxide and other noxious air pollutants. Such smokey fires claim hundreds of lives each year due to smoke poisoning, unconsciousness and eventual suffocation which lives might have been saved had the victims been wearing or using a respirator which removes or substantially reduces smoke particles and noxious fumes from the air before being inhaled. Conventional gas masks and smoke inhalator protectors which would serve the purpose are too bulky and inconvenient for the average person to carry with him in the unlikely event that he might be caught in an emergency that, statistically speaking, rarely occurs. Moreover, it would be impractical and unrealistic to have respirators of conventional design stored in accessible receptacles in office buildings, subway trains and other such places in sufficient numbers to provide protection for all those who might be present during the statistically unlikely event of a smokey fire.

A person caught in a smokey fire emergency can usually escape form the scene by way of a fire stairwell or elevator or tunnel relatively quickly if he can avoid being overcome by smoke in the meantime. The time required to escape from the scene, in the absence of smoke and noxious fumes, is usually only few minutes, and rarely more than 20, or perhaps 30, minutes. Therefore, an emergency smoke inhalation protective device need only have an effective service life of about one half an hour to serve the intended purpose. Herefore, however, the bulky size and inconvenience of conventional respirators have made their wide use for this purpose impossible.

As a result of an extensive investigation of the problem described, I have developed a smoke inhalation protective device that is simple and reliable in operation and yet is so small and free of encumbrances that it may be carried about at all times in a pocket or purse of the prospective user. Moreover the device may be kept in a desk drawer at home or in the office, and it may easily be stored in quantities of several dozen in comparatively small receptacles mounted in elevators, fire escape wells, subway cars and at other strategic locations. The compactness and efficiency of the device is made possible by the development in recent years of super-adsorbents for noxious gases. For example, there is available today a super adsorbent known as "Hopcalite" which not only adsorbs organic vapors and acid gases but also catalytically causes carbon monoxide to be oxidized to harmless carbon dioxide at ambient temperatures, and which has an air purifying capacity relative to its weight or volume much greater than ordinary activated charcoal. The efficiency and effectiveness of these new super adsorbents makes possible the use of smaller quantities of these materials and therefore, at least theoretically, the creation of respirators of small size. However the small size of the respirators it is now theoretically possible to construct creates other problems with respect to the design of a satisfactory respirator. Such problems include the ease of breathing through the respirator, its valving mechanism, and the manner of disposal of excessive moisture contained in exhaled air which can blanket the purifying capacity of the super-adsorbent material. The device of the present invention provides an efficient, effective and reliable solution to these problems.

SUMMARY OF THE INVENTION

The small emergency respirator device of my invention comprises an outer casing having top and bottom closure portions and a filter retaining member disposed within the outer casing a short distance below the top closure portion. The top and bottom closure portion and the filter retaining member are each formed with a generally axially aligned opening. An inner conduit is disposed within the outer casing, the upper end of the conduit coinciding with the opening formed in the filter retaining member and the lower end of the conduit coinciding with the opening formed in the bottom closure portion of the casing. A funnel-shaped baffle member is disposed within the outer casing immediately above the filter retaining member, the relatively small opening at the lower end of the baffle member coinciding with the upper end of the inner conduit. A generally tubular nozzle or mouthpiece extends through the opening formed in the top closure portions and downwardly part way into the enlarged open upper end of the funnel shaped baffle member. The lower end of the outer casing is formed with a plurality of circumferentially-spaced air inlet openings and the filter retaining member is formed with a plurality of circumferentially-spaced air outlet openings.

Air distribution means, advantageously a layer of fibrous material, is disposed in the space between the outer casing and inner conduit adjacent the air inlet openings formed in the lower end of the casing, and a layer of said fibrous material is disposed in said annular space adjacent the air outlet openings formed in the filter retaining member. The purpose of said fibrous
layers is to evenly distribute the airflow into the air purification material from the air inlet openings, and out of the air purification material into the air outlet openings, with a minimum of resistance to airflow while at the same time assuring that the air will flow throughout the entire cross section of the body of air purification material.

A body of granular material, purification material, advantageously a combined catalyst for the oxidation of carbon monoxide to carbon dioxide and an adsorbent for organic vapors and acid gases, is disposed in the annular space between said layers of fibrous material.

The catalyst and adsorbent material, particularly when a material such as "Hopcalite" is used, may be protected against any moisture content of the inhaled air by placing a small amount of desiccant material, such as anhydrous calcium chloride, at the bottom (that is, air inlet end) of the body of catalyst and adsorbent material. This is a precaution because the catalytic effect of this material which causes the conversion of carbon monoxide to carbon dioxide is adversely affected by moisture even in low concentrations.

Inhalation check valve means are associated with the air outlet openings formed in the filter retaining member and exhalation check valve means are associated with the opening at the lower end of the inner conduit, said valve means may advantageously comprise flapper-type check valves of resilient sheet material. As a result of the aforesaid construction, when the user inhales through the nozzle or mouthpiece of the device the inhalation valve means automatically opens and the exhalation valve means automatically closes so that air is drawn in through the air inlet openings formed in the outer casing, through the air purification materials in the casing, through the air outlet openings formed in the filter retaining member, by the funnel-shaped baffle and thence into the mouthpiece. When the user of the device exhales through the nozzle or mouthpiece, the inhalation valve means automatically closes and the exhalation valve means automatically opens so that moisture laden air is expelled directly into the inner conduit and thence to the atmosphere.

It should be noted that the device need not necessarily attain complete purification of the air being inhaled, its purpose being to reduce the dangerous pollutants to a sufficiently low level to enable the user to escape from the emergency area with reasonable comfort and without serious harm. Also, when the device is intended to be kept in desk drawers, or stored in boxes suitably located in such places as stairwells, elevators, or subway cars, its dimensions may be made somewhat larger, particularly with respect to the diameter (cross-sectional area) and length of the section containing the absorbent materials, since this will, of course, provide additional protection and in these locations the very smallness of the device is not quite as crucial a consideration as in the case where the device is specifically intended to be carried in the user's purse or coat pocket.

BRIEF DESCRIPTION OF THE DRAWINGS

The respirator device of my invention will be better understood from the following description in conjunction with the accompanying drawings of which:

FIG. 1 is a side elevation partly in section of an advantageous embodiment of the respirator of the invention showing the passage of air therethrough when the user is inhaling through the device;

FIG. 2 is a side elevation partly in section of the device shown in FIG. 1 showing the passage of air therethrough when the user is exhaling through the device;

FIG. 3 is a sectional view along line 3—3 of FIG. 2 showing an advantageous form of inhalation valve means partly broken away;

FIG. 4 is a sectional view along line 4—4 of FIG. 1 showing an advantageous form of exhalation valve means;

FIG. 5 is a plan view from below of the lower end of the device shown in FIG. 1 and 2; and

FIG. 6 is a side elevation in section of the lower end of the respiratory device showing an elaboration of the moisture-laden exhaling discharge feature of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As previously mentioned, the present invention provides a small, effective and convenient to use smoke inhalation protective device that is inexpensive to manufacture, convenient to carry or store and that may be discarded after use. An important consideration in the design of such a respirator device is the fact that during an emergency situation people tend to breathe at an increased rate as compared to normal breathing under relaxed circumstances. As a result the respirator must be so designed that inhaling and exhaling through the device can be easily accomplished at the higher breathing rates without requiring undue suction during inhaling or pressure during exhaling. If the device is not specifically designed to provide for this relatively easy inhaling and exhaling, the increased suction and pressure required is apt to increase the feeling of alarm or panic which is always present during emergency situations. Special attention must therefore be paid to the arrangement of the valving mechanism (in this very small device) to take maximum advantage of the limited space available and thus obtain the minimum resistance to airflow as possible. Preferably the inhalation suction and exhalation pressure should not be more than 4 inches of water differential as measured by a water manometer, and in any event should not exceed about 6 to 7 inches water differential.

The respirator device of the invention is preferably designed to be inserted in the mouth of the user, simply held in place more or less like a cigar or pipe. (In this connection it should be noted that nature has provided man with a positive, almost automatically applied mechanism in the back of the nose that closes off the airflow through the nose while breathing in and out through the mouth; for example, the breathing action one automatically adopts when swimming. When the device is so used, a particular problem presents itself - namely, that when exhaling there is not only the usual high moisture content of the exhaled breath, but considerable amounts of saliva charged into the device as well. The device must therefore be so designed as to provide for constant, automatic discharge of the excessive liquid carried by the exhaling breath, and this liquid should be discharged from, or
near, the bottom of the device to prevent it contacting either the indrawn air which is being inhaled or the absorbent materials which remove noxious fumes from this indrawn air. In actual experiments under simulated emergency conditions I have found that when a respirator device does not have adequate provisions for constant drainage of considerable amounts of liquid, the whole device becomes too wet, and as a result inoperative, in a matter of a few minutes.

In accordance with the foregoing considerations and design criteria, the preferred embodiment of the respirator of my invention that is shown in FIGS. 1 and 2 of the drawings comprises an outer casing 10 having a top closure portion 11 and a bottom closure portion 12. The casing 10 is advantageously in the form of an elongated tube having a circular cross section of at least about 1 inch in diameter, could be somewhat larger or smaller and could have a rectangular or oblong cross section. The top closure portion 11 and the bottom closure portion 12 may be separate parts that are adhesively secured to the top and bottom ends of the casing, or they may be integrally formed with the casing 10 in which case the casing is advantageously fabricated in two parts which are joined together approximately along line 3—3 of FIG. 2. A filter retaining member 13 is disposed in the casing 10 a short distance (e.g., about one-half inch) below the top closure portion 11, the top and bottom closure portions 11 and 12 and the filter retaining member 13 each being formed with an axially aligned opening 11a, 12a, and 13a respectively. An inner conduit 14 is disposed axially within the outer casing 10, the open upper end of the conduit 14 coinciding with the opening 13a formed in the filter retaining member 13 and the open lower end of the conduit coinciding with the opening 12a formed in the bottom closure portion 12. A cup or funnel-shaped baffle 15 is disposed in the casing 10 within the space between the top closure portion 11 and the filter retaining member 13. The relatively small opening at the lower end of the baffle 15 coincides with the open upper end of the inner conduit 14, the enlarged upper end of the baffle 15 being spaced a short distance (e.g., about one-eighth inch) from the top closure portion 11. A nozzle or mouthpiece 16 extends through the opening 11a in the top closure portion 11 downwardly a short distance into the enlarged upper end of the baffle 15 as clearly shown in FIGS. 1 and 2 of the drawing. As noted, the baffle 15 is positioned a small but sufficient distance below the top closure portion 11 and the lower end of the nozzle 16 is spaced a small but sufficient distance radially inwardly from the baffle 15 to provide free passage for air being inhaled as indicated by the arrows in FIG. 1. Moreover, the baffle 15 serves the essential function of guiding moisture-laden air exhaled through the nozzle 16 directly into the open upper end of the inner conduit 14 as indicated by the arrows in FIG. 2.

The outer casing 10, top and bottom closure portions 11 and 12, filter retaining member 13, inner conduit 14, baffle 15 and mouthpiece 16 may be formed of any suitable material such as plastics. As the respirator is intended to be discarded after use, these parts are advantageously molded by injection molding techniques from inexpensive thermoplastic molding resins.

The lower end of the casing 10 is formed with a plurality of circumferentially spaced air inlet openings 18 as shown in FIGS. 1 and 2, and the filter retaining member 13 is formed with a plurality of circumferentially spaced air outlet openings 19 as shown best in FIG. 3. Air distribution means, advantageously a layer 20 of a fibrous material, is disposed in the space between the outer casing 10 and the inner conduit 14 adjacent the air inlet openings 18, and another layer 21 of fibrous material is disposed within this space adjacent the air outlet openings 19. The space within the outer casing 10 between the layers 20 and 21 is filled with granular air purification material 22. The fibrous material 20 and 21 serves to distribute the air uniformly and to retain the granular air purification material 22 in place within the casing 10. The fibrous material must be sufficiently porous to permit air to pass easily through the material. Suitable fibrous materials include lambs wool or coarse or kinky synthetic fibers and the like. Alternatively, the air distribution means may comprise an open space maintained by a suitably placed screen. The air purification material 22 serves to remove noxious fumes from the air being inhaled. The air purification material is preferably in the form of discrete granules which permit air to be drawn easily through a body of the material and advantageously is one of the newly developed super adsorbents which have markedly improved adsorbent capacity as compared with older adsorbent materials. Specifically I prefer to use one of the more recent versions of the carbon monoxide oxidation catalyst and adsorbent material known commercially as "Hopcalite" (a mixture of oxides of copper, cobalt, manganese and silver on activated carbon or charcoal), used either as such or in conjunction with other materials such as caustite, super activated charcoal, etc. The lower portion 22a of the air purification material, just above the air distributing section containing lamb's wool or whatever or consisting of an open space maintained by a screen, advantageously comprises a desiccant such as calcium chloride or silica gel for moisture absorption while the remainder, the larger portion 22b of the adsorbent material is particularly suited to adsorb noxious gases and convert carbon monoxide into carbon dioxide.

An inhalation check valve 23 is associated with the air outlet openings 19 formed in the filter retaining member 13 and is disposed immediately above these openings, and an exhalation check valve 24 is associated with the open lower end of the inner conduit 14 and is disposed immediately below this opening. A protective cover 25 for the exhalation check valve 24 is secured to the lower end of the casing 10, the protective cover 25 being formed with a plurality of air exhaust openings 26, through which the exhauling air and its moisture content are discharged below the air inlet openings 18, and are directed downward away from the inlet openings, in order to assure that the moisture content of the inhaled air is discharged as low as possible under the circumstances. The check valves 23 and 24 are advantageously of the flapper type and are fabricated from thin sheet material that is both pliant and resilient. Suitable materials include thin pliant sheets of rubber, plastic, rubber or plastic coated fabric, or the like. The inhalation check valve 23 is advantageously annular in shape, the inner periphery of
the valve being secured in contact with the inner periphery of the filter retaining member 13 advantageously by means of the baffle 15. The exhalation valve 24 as shown has a generally oblong configuration one end of which is secured to the bottom closure portion 12 by means of the rivet-like fasteners 30, but various alternative arrangements are possible, and may be more desirable depending on the assembling steps employed in the manufacturing procedure used for quantity production of the device.

The nozzle 16 may be designed for insertion into the user's nostrils. However, in the preferred embodiment of the invention the nozzle 16 is in the form of a curved mouthpiece that is inserted in and held by the user's mouth. The tubular nozzle or mouthpiece 16 is advantageously provided with a soft rubber or plastic cover 28 which may be comfortably held in the user's mouth, or easily gripped by the user's teeth.

In the event of an emergency the person using the device inhales and exhales through the nozzle or mouthpiece 16. When the user inhales the exhalation valve 24 automatically closes and the inhalation valve 23 automatically opens, thereby causing air to be drawn in through the air inlet openings 18 upwardly through the air distributing and adsorbent materials, 20, 21 and 22, through the air outlet openings 19, by the baffle 15, and thence upwardly through the mouthpiece 16 as indicated by the arrows shown in FIG. 1. When the user exhalates through the mouthpiece 16, the inhalation valve 23 automatically closes and the exhalation valve 24 automatically opens, thereby causing the moisture-laden air being exhaled to be expelled through the inner conduit 14 and the air exhaust openings 26 directly into atmosphere as indicated by the arrows shown in FIG. 2.

By positioning the inhale valve mechanism 23 within the main body or casing 10 of the device (rather than in the nozzle 16), it is possible to obtain the maximum air flow through the valve, the valve openings being limited only by the cross sectional area of the device. This is of extreme importance in keeping the suction required for inhaling as low as possible. Moreover, the exhaling path is a straight-through flow that does not require the exhaled air (and its liquid contents) to flow around corners or through awkwardly restricting passages. Thus, the exhaled air encounters a minimum pressure and, with the aid of gravity, propels its liquid contents directly out of the bottom of the device and away from the air intake openings.

FIG. 6 shows an addition to the protective cover 25 which serves to further insure that the moisture in the exhaling breath is discharged from the device as far away from its air inlet openings as is reasonably possible. In FIG. 6 the cover 25 is provided with a funnel like extension 25a to which is attached an open ended sock or flexible tube 31, held in place by a ring 32. The sock or flexible tube may be folded together when the device is stored or placed in a suitable air-tight container (to protect the adsorbent material against gradual deterioration due to moisture, etc. when stored for long periods of time), thus taking up but little room, while it will, of course, be automatically extended when the user exhales through the device, thereby moving the moisture discharge end of the sock or tube as far away from the air inlet openings 18 as the length of the sock or tube will permit.

I claim:

1. Disposable respirator for reducing the smoke, noxious fumes and carbon monoxide content of air prior to inhalation which comprises an elongated outer casing having top and bottom closure portions and a filter retaining member disposed within said outer casing a short distance below said top closure portion, said closure portions and said filter retaining member each being formed with a generally axially aligned opening, the lower end of the outer casing being formed with a plurality of circumferentially-spaced air inlet openings and the filter retaining member being formed with a plurality of circumferentially-spaced air outlet openings, an inner conduit disposed essentially concentrically within said outer casing, the upper end of said conduit coinciding with the opening formed in the filter retaining member and the lower end of said conduit coinciding with the opening formed in the bottom closure portion of the casing, a funnel-shaped baffle member disposed within the outer casing immediately above the filter retaining member, the relatively small opening at the lower end of the baffle member coinciding with the open upper end of the inner conduit, a generally tubular mouthpiece extending through the opening formed in the top closure portion of the casing and downwardly part way into the enlarged open upper end of the funnel-shaped baffle member, air distributing means and air purification material disposed in the space between the outer casing and the inner conduit, inhalation check valve means associated with the air outlet openings formed in the filter retaining member whereby the flow of air downwardly through said air outlet openings into the space between the outer casing and the inner conduit is prevented, and exhalation check valve means associated with the lower end of the inner conduit whereby the flow of air upwardly into said inner conduit is prevented.

2. The respirator according to claim 1 in which a layer of fibrous material is disposed in the space between the outer casing and the inner conduit adjacent the air inlet openings formed in the lower end of the casing, a layer of said material is disposed in said space adjacent the air outlet openings formed in the filter retaining member, and a body of granular air purification material disposed in said space between said layers of fibrous material.

3. The respirator according to claim 1 in which the air purification material comprises a catalyst for the oxidation of carbon monoxide to carbon dioxide at room temperature and an adsorbent for organic vapors and acid gases.

4. The respirator according to claim 1 in which the air purification material comprises a desiccant for removing moisture from inhaled air, a catalyst for the oxidation of carbon monoxide to carbon dioxide at room temperature and an adsorbent for organic vapors and acid gases.

5. The respirator according to claim 4 in which the desiccant comprises a layer of calcium chloride or silica gel disposed between the air inlet openings of the
The respirator according to claim 4 in which the adsorbent material is activated carbon.

7. The respirator according to claim 1 in which the inhalation check valve means comprises an annular disc of thin flexible sheet material that overlies and cooperates with the air outlet openings formed in the filter retaining member.

8. The respirator according to claim 7 in which the inner periphery of the annular disc is held in close proximity to the inner periphery of the filter retaining member by means of the lower end portion of the funnel-shaped baffle.

9. The respirator according to claim 1 in which an extended flexible tube is attached to the respirator at a point below the exhalation check valve.

10. The respirator according to claim 1 in which the external portion of the tubular mouthpiece is configured to be received comfortably in the mouth of the user and to be gripped by the user's teeth while the casing hangs downward from the mouth in a substantially vertical position.

11. The respirator according to claim 1 in which the outer casing comprises an elongated cylindrical tube having the inner tube disposed concentrically therewithin.

12. The respirator according to claim 4 in which the outer casing comprises an elongated cylindrical tube having the inner tube disposed concentrically therewithin.