

Sept. 24, 1968

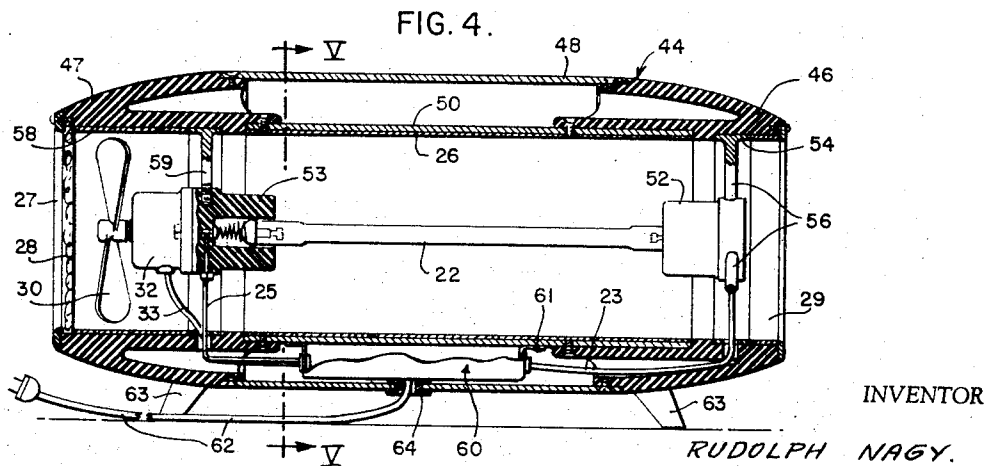
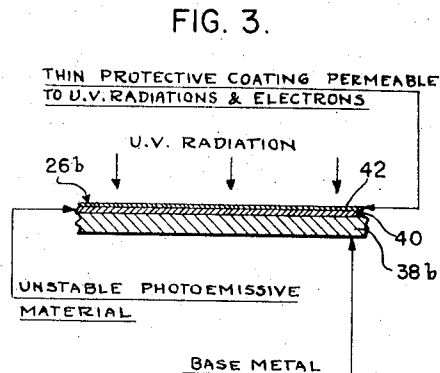
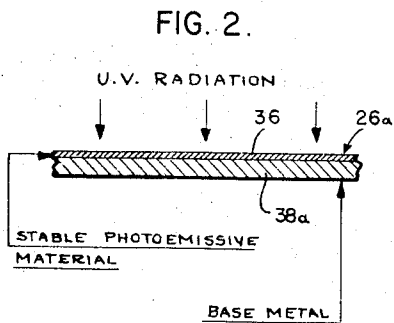
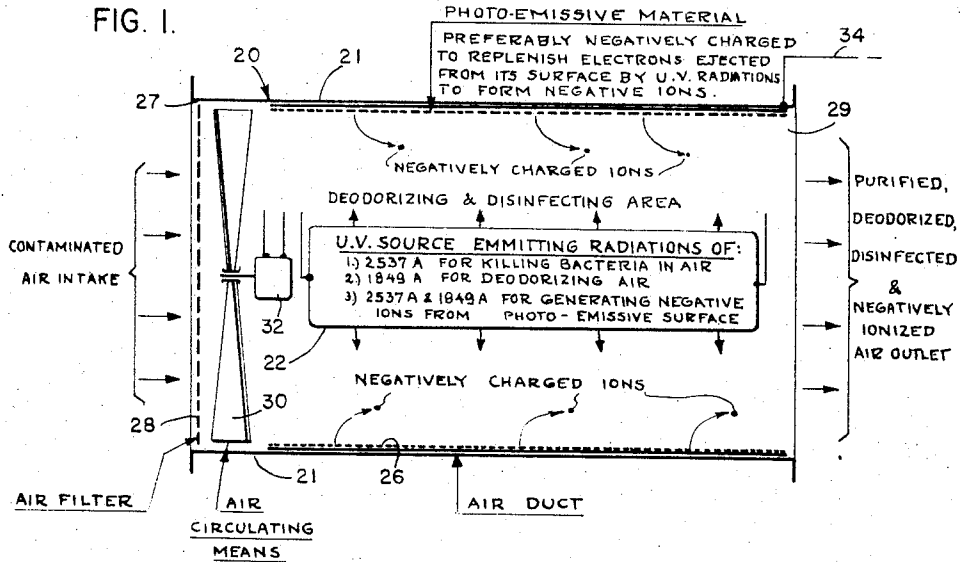
R. NAGY

3,403,252

AIR PROCESSING APPARATUS AND ION GENERATOR
COMPRISING AN ELECTROMAGNETIC RADIATION
SOURCE AND A STABLE ELECTRON EMITTING
PHOTOSENSITIVE MEMBER

Filed Feb. 29, 1960

4 Sheets-Sheet 1



BY *[Signature]*
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Sept. 24, 1968

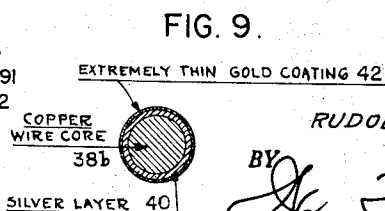
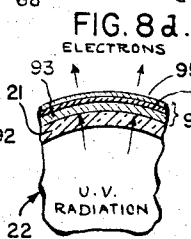
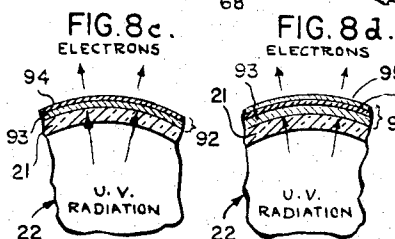
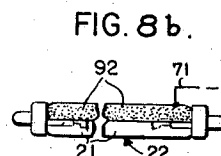
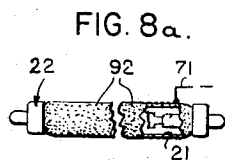
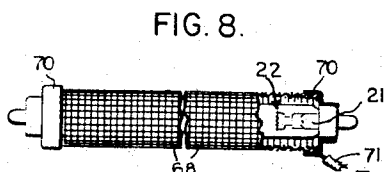
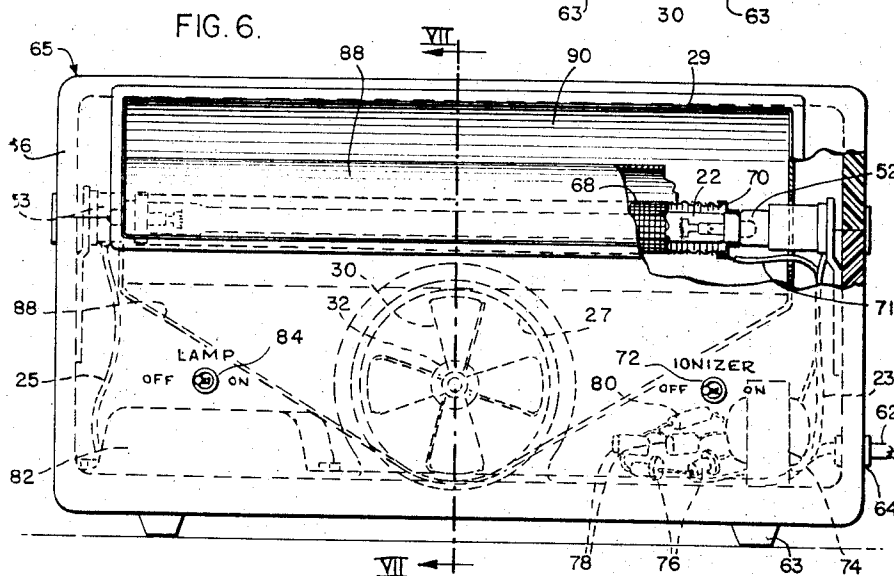
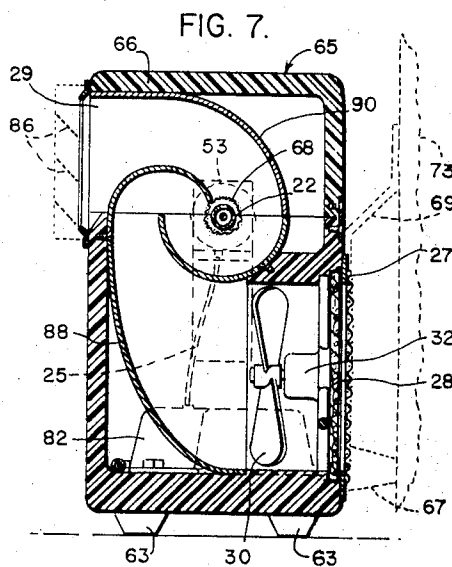
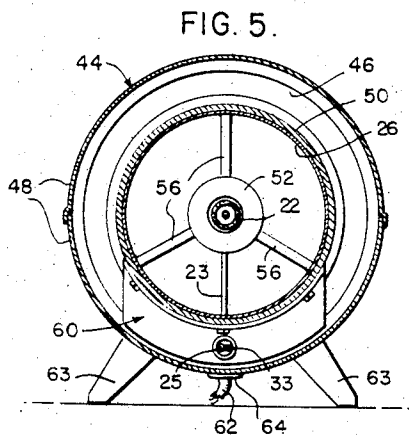
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4 Sheets-Sheet 2



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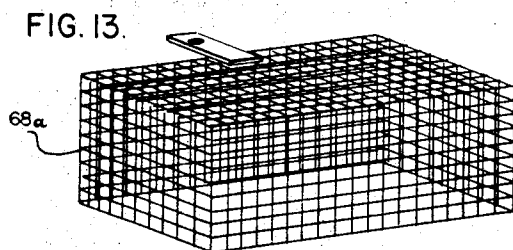
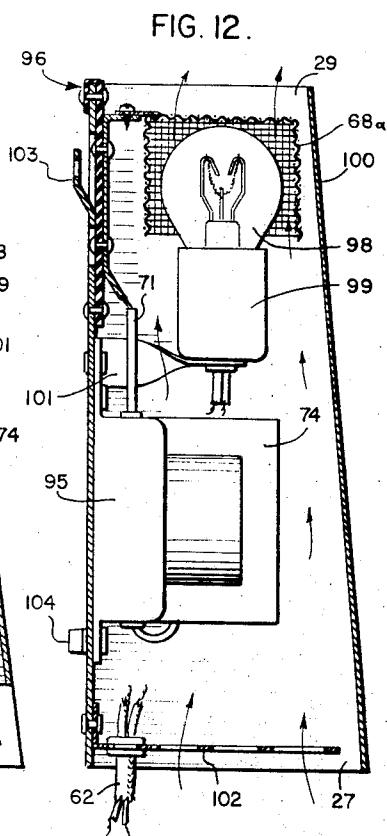
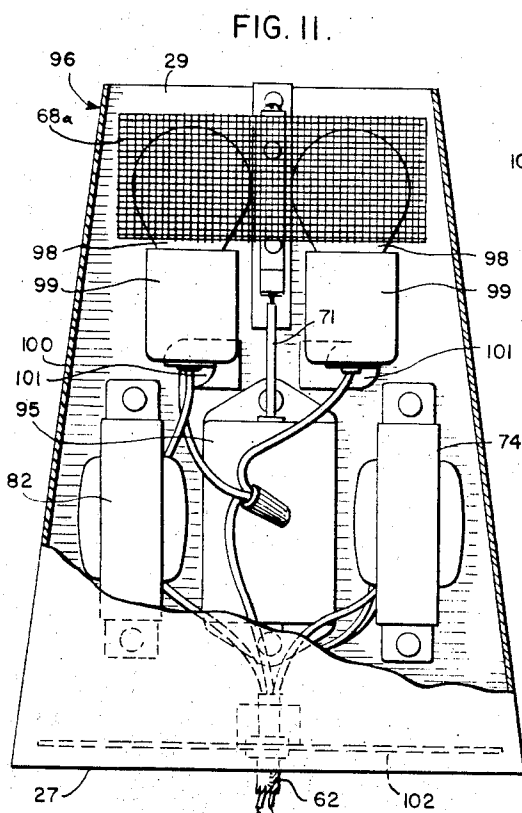
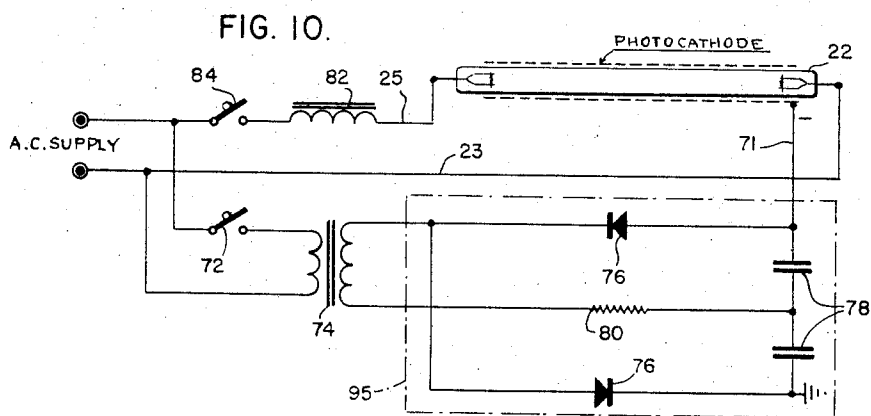
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4 Sheets-Sheet 3



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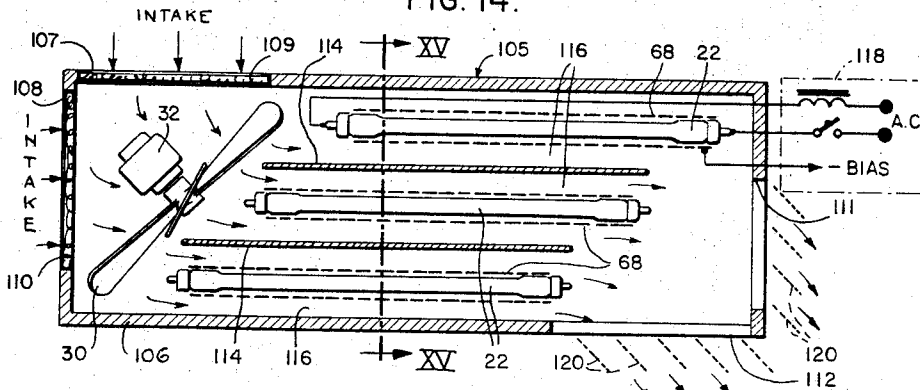
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FIG. 14.



DEODORIZED, DISINFECTED &
NEGATIVELY IONIZED AIR

FIG. 15.

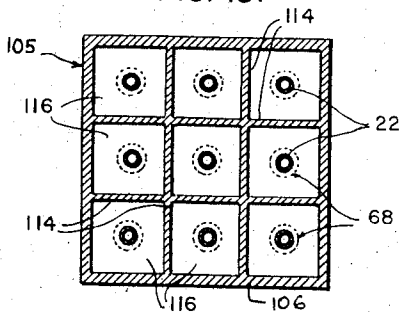


FIG. 16.

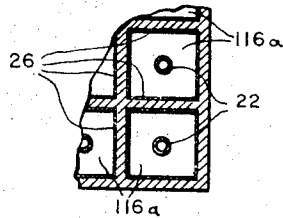
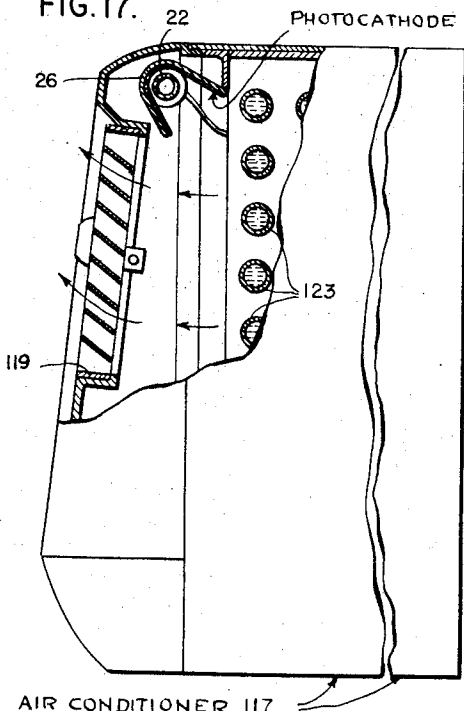
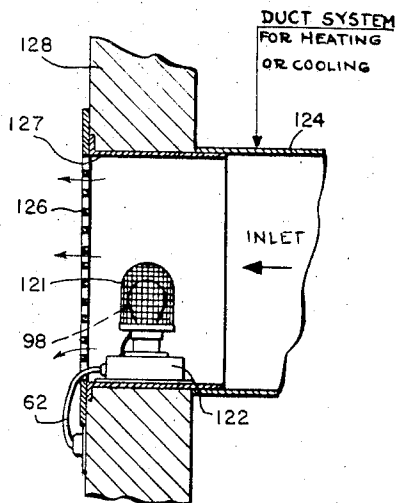


FIG. 17.



AIR CONDITIONER 117

FIG. 18.



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3,403,252

AIR PROCESSING APPARATUS AND ION GENERATOR COMPRISING AN ELECTROMAGNETIC RADIATION SOURCE AND A STABLE ELECTRON EMITTING PHOTSENSITIVE MEMBER

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35 Claims. (Cl. 250—46)

ABSTRACT OF THE DISCLOSURE

An electric lamp, such as an ultraviolet-generating gaseous discharge lamp, and a photocathode that is stable in air and responsive to radiation produced by the lamp are arranged to inject free electrons into the surrounding air and generate negative ions therein when the lamp is energized. Various types of apparatus for filtering and then electronically treating air by utilizing an air-stable photosensitive component and different kinds of electric lamps are provided.

This invention relates to air processing apparatus and, more particularly, to apparatus for simply and inexpensively generating negative ions in air to control the ion concentration of the atmosphere within an enclosed space and, if desired, concurrently purifying, deodorizing and disinfecting the air while it is being supplied with negative ions.

Background of the invention

So-called electronic air purifying, disinfecting and deodorizing units are well known in the art as evidenced by U.S. Patent Nos. 2,702,862 and 2,855,641. Deodorization is achieved by means of an ozone-generating ultraviolet (UV) lamp whereas the removal of solid impurities from the air is accomplished by means of a filter or filters. Since ozone-generating UV lamps also emit bactericidal radiations in the 2537 Å. region of the spectrum, the air that is circulated through such units is also irradiated by the UV radiations emanating from the lamp and is thus disinfected.

Published reports indicate that an atmosphere rich in negative ions has a beneficial physiological and therapeutic effect. For example, it has been reported that persons suffering from respiratory ailments such as asthma, sinusitis, hay fever and the like obtain relief when the air has a high negative ion count and the healing of burns, wounds and similar injuries appear to be promoted when exposed to such an atmosphere. Positive ions, on the other hand, are believed to have a depressing and irritating effect. While the manner in which the negative ions react with the body to achieve such beneficial results is not known at the present time, research in this field is being conducted with promising results.

There are various ways to produce negative ions in air. For example, they can and have been produced thermionically by means of a heated coil or filament of suitable material such as thoriated tungsten wire, electrostatically by means of a highly charged wire or the like and, in accordance with a more recent development, by irradiating the air with particles from a radioactive source. However, since these methods of ionization inherently generate other forms of energy, such as heat, and in some cases positive ions, they have not proven entirely satisfactory from either a practical or design standpoint for use in negative-ion generating apparatus. In addition, the total number of negative ions that can be produced by such means under practical and safe operating conditions is rather limited. Because of these and other limitations the aforesaid modes of ionization have not been widely adopted commercially for use in negative-ion generating apparatus capable of

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controlling the polarity of the atmosphere by increasing its negative ion count.

Negative ions may also be produced in air by another means, namely, photoelectrically by irradiating a photosensitive member or so-called photocathode with radiations of the proper wavelength. In this case the impinging radiations cause electrons to be emitted from the photosensitive member into the air where they become attached to gas molecules or dust particles and convert them into negative ions. Up to the present there has not been developed an air processing unit capable of efficiently and consistently generating large numbers of negative ions in air by means of the photoelectric effect primarily because there has not heretofore been available a photocathode that has a low work function and is stable in air and thus capable of remaining sufficiently photosensitive over a long period of time. Since ozone is a strong oxidizing agent, this problem of stability of the photosensitive member assumes even greater proportions in devices which are also designed to deodorize the air being processed, such as the aforementioned prior art units which contain ozone-generating UV lamps for example.

It is accordingly the general object of this invention to provide apparatus for efficiently and inexpensively generating large numbers of negative ions in air for extended periods of time.

Another and more specific object is the provision of a negative ion generator of simple and inexpensive design that is compact and capable of efficiently and consistently producing large numbers of negative ions by means of the photoelectric effect and then introducing them into the atmosphere.

Still another object is the provision of specific air processing units which employ the aforesaid photosensitive material and mode of ion generation and are capable not only of generating large numbers of negative ions and introducing them into the atmosphere but also purifying, deodorizing and disinfecting the air, if desired, while it is being circulated through the units and negatively ionized.

Summary of the invention

The aforesaid objects, and others which will become apparent as the description proceeds, are achieved according to this invention by providing a composite photocathode that is stable in air and has a sufficiently low work function to enable it to emit large numbers of electrons when irradiated with electromagnetic radiation of a preselected wavelength, such as ultraviolet radiation for example. More specifically, the aforesaid photocathode is fabricated from photosensitive material that is stable in both air and ozone and said photocathode is preferably incorporated together with an ozone-generating UV lamp into apparatus for circulating air in such a manner that the air, in addition to being negatively ionized is also irradiated by the lamp and then discharged directly into the air before the generated negative ions are lost by recombination or otherwise neutralized within the unit. The UV lamp and photocathode can also be incorporated into existing air processing and circulating apparatus such as an air conditioner or a heating or cooling duct system for example, in which case the lamp and photocathode assembly is mounted inside the apparatus in such a position that the previously processed air is irradiated and supplied with negative ions just before it is discharged from the device.

Brief description of the drawing

A better understanding of the invention may be obtained by referring to the accompanying drawings wherein:

FIGURE 1 is a diagrammatic view of an air processing apparatus embodying the present invention;

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FIGS. 2 and 3 are fragmentary cross-sectional views on an enlarged scale of two types of photocathodes adapted for use in the air processing units shown in the other figures;

FIG. 4 is a side sectional view of an air processing unit which embodies the "axial-flow" principle and other design features illustrated in FIG. 1;

FIG. 5 is a cross-sectional view along the line V—V of FIG. 4, in the direction of the arrows;

FIG. 6 is a front elevational view of another type of air processing unit according to this invention;

FIG. 7 is a cross-sectional view along the line VII—VII of FIG. 6, in the direction of the arrows;

FIG. 8 is a fragmentary elevational view of the UV lamp and the photosensitive grid assembly employed in the devices shown in FIGS. 6, 7, 14 and 15;

FIGS. 8a and 8b are fragmentary views on a reduced scale of a modified form of lamp-and-photocathode assembly wherein the photosensitive member comprises a coating that covers all or half of the envelope of a tubular UV lamp, respectively, and thus constitutes an integral part thereof;

FIGS. 8c and 8d are fragmentary cross-sectional views on a greatly enlarged scale of the envelope of a UV lamp showing two types of composite photocathodes that have been coated directly onto the lamp envelope to provide lamps such as those shown in FIGS. 8a and 8b;

FIG. 9 is a cross-sectional view on a greatly enlarged scale of the photosensitive wire from which the grid photocathode enclosing the lamp in FIG. 8 is preferably fabricated;

FIG. 10 is a schematic representation of a combined UV lamp-ballasting and DC power supply circuit for operating the various ion generating units from an AC power source;

FIG. 11 is a front elevational view of still another form of air processing unit in accordance with the invention, part of the front wall being broken away to more clearly illustrate the interior of the unit;

FIG. 12 is a side sectional view of the unit shown in FIG. 11;

FIG. 13 is an enlarged perspective view of the foraminous grid of photosensitive wire employed in the unit shown in FIGS. 11 and 12;

FIG. 14 is a diagrammatic plan view of still another form of air processing unit according to the invention wherein a plurality of air processing cells or passageways are employed to enable a larger volume of air to be treated;

FIG. 15 is a cross-sectional view along the line XV—XV of FIG. 14, in the direction of the arrows;

FIG. 16 is a fragmentary cross-sectional view of another type of cell construction for the unit shown in FIG. 14;

FIG. 17 is a fragmentary side elevational view of an air conditioning unit, with a part of the housing being broken away to more clearly illustrate the disposition of the negative-ion generator and UV-irradiator assembly therein in accordance with the invention; and

FIG. 18 is a fragmentary side sectional view of the outlet and part of a heating or cooling duct with the UV lamp and photocathode assembly mounted therein in accordance with the invention.

While the photosensitive material of this invention may be combined with various kinds of radiant energy sources capable of emitting electromagnetic radiations of pre-selected wavelength, it will ordinarily be used with UV lamps and accordingly has been so illustrated and will be so described.

Description of the preferred embodiments

Turning now to the forms of the invention illustrated in the drawings, in FIG. 1 there is shown a diagrammatic representation of an axial-flow type of air processing unit 20 wherein an elongated tubular UV lamp 22 is centrally located within and extends axially of a cylindrically

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hollow air duct or casing 21. As indicated, the interior surface of the casing 21 is lined or coated with a suitable photoemissive material to provide a photocathode 26 thereat that is located in receptive proximity to the electromagnetic radiations emanating from the UV lamp 22 and is operable in response to the impinging UV radiations to emit electrons into the surrounding air and thereby convert gas molecules, dust particles, etc. therein into negatively charged ions. As is also indicated, the UV lamp 22 preferably but not necessarily produces both 1849 Å. and 2537 Å. radiations which, as is well known, generate ozone and kill bacteria, respectively, so that the air surrounding the lamp is not only supplied with large numbers of negative ions but is also deodorized and disinfected.

The photosensitive material from which the photocathode 26 is fabricated preferably has a work function that is low enough to enable it to respond to both of the aforesaid UV radiations. It is essential, however, that the photosensitive material be stable in air and, when an ozone-generating lamp is used, in ozone as well. Otherwise the composition and the work function of the surface layer of the photocathode 26 will change with time resulting in an undesirable fluctuation, and in most cases a decrease, in the number of negative ions produced. It has also been found necessary to ground and preferably connect the photocathode 26 to the negative terminal of a DC power supply as by a conductor 34 to prevent it from becoming positively charged through the loss of electrons and thus recapturing the electrons subsequently emitted and causing the negative ion production to gradually decrease with time.

The air duct or casing 21 has an intake opening 27 that is preferably, though not necessarily, covered by a filter 28 and is terminated at its opposite end by an outlet 29 that opens directly into the atmosphere. A suitable air circulating means such as fan 30 and motor 32 is provided at the intake opening 27 to enable contaminated air to be drawn into the unit 20, impelled through the casing 21 past the UV lamp 22 and photosensitive member 26, and out through the outlet 29, as shown by the arrows in FIG. 1. It should be noted that the filter 28 and the aforesaid fan and motor are located between the intake opening 27 and the lamp and photocathode assembly. This physical arrangement or sequence of components is an essential feature of the invention since experience has shown that if either the fan, motor, filter or any other obstruction having a large surface area is positioned rearwardly of the lamp 22 or photocathode 26 or over the outlet 29, the number of negative ions actually discharged into the atmosphere is drastically reduced indicating that most of them are being collected and neutralized by the filtering material or motor and fan assembly, etc. and thus lost. By arranging the aforesaid components in the above sequence contaminated air drawn into the air processing unit 20 is first purified by the filter 28, and then concurrently deodorized, disinfected and supplied with negative ions as it passes between the UV lamp 22 and photocathode 26, and the processed air finally discharged directly into the atmosphere, thereby not only refreshing the circulated air but controlling the concentration of negative ions therein.

In order for negative ion generating or air processing units of this character to be practical they must have a long useful life, be substantially maintenance-free, and be capable of reliably and efficiently generating large numbers of ions throughout their useful life. As will be appreciated, none of these requirements can be met if the photosensitive material and thus the photocathode 26 is unstable in air, and in ozone where an ozone-generating UV lamp is employed, or has too high a work function. While there are various metals such as aluminum and zinc that have work functions sufficiently low to enable them to emit large numbers of electrons under UV irradiation, they rapidly deteriorate in air and become coated with a layer of aluminum oxide and zinc oxide, respec-

tively, which compounds, unfortunately, are relatively poor photoelectric emitters. For example, it has been found that when aluminum foil is irradiated by UV in air the number of negative ions that are produced drops to about one-half the original value in the first 25 hours of operation and to about one-third of the initial output in the first 65 hours of operation. This indicates that the work function of aluminum oxide is much higher than for aluminum. Adsorbed oxygen or nitrogen also reduces the work function of a metal surface. In fact, it has been reported that any electronegative element on the surface of a photocathode will form an electrical dipole with the negative side at the surface thereby repelling electrons back into the metal and preventing their escape. Metals that are inert and thus exhibit the desired chemical stability, such as gold and platinum for example, have work functions that are much too high so that these metals by themselves are inherently unsuitable for use as the photo-sensitive material in an ion generator of this type.

It has been discovered that the combination of chemical stability and low work function essential for a practical UV-activated ion generator can be very conveniently and inexpensively obtained by combining two or more selected materials to form a composite photocathode. Briefly stated, such composite photocathodes comprise a clean base metal having a thin layer of photoemissive material thereover that is stable in air and is more electropositive than the base metal. By combining the photoemissive material with a base metal that is less electropositive, the work function of the photoemissive coating is decreased thereby making it more efficient when used as the photocathode in a negative ion generator. While the reason for this reduction in work function is not clearly understood, it is theorized that since the photoemissive material is more electropositive than the base metal and thus has a greater affinity for electrons, it tends to lose its valency electrons to the base metal thereby forming an electric dipole, the positive side of which is at the exposed surface of the photocathode. Thus there is established a positive potential equal to the strength of the dipole that tends to pull electrons from the photoemissive material, thereby reducing its work function. Stated differently, the layer of electropositive ions formed at the surface of the photocathode appears to function in much the same manner as the grid of a thermionic tube. It has been reported that the electric field which such positive ions can create at the metal surface is very great, and under certain conditions may be in the order of 2.5×10^6 volts/cm.

It has also been reported that an increased photoelectric effect can be obtained by using an electronegative intermediate layer in the aforesaid combination. That is, if an electropositive photoemitter is deposited on a highly electronegative element, such as oxygen, which in turn is carried by a substrate that is less electropositive than the photoemitter, then the photoemissivity of the latter will be greatly increased. A possible explanation for this phenomenon is that a stronger dipole is produced resulting in an even greater electric field and a propor-

tionately lower work function. Composite photocathodes of this type have been used in the phototube art, a typical example being Ag—O—Cs which has a very high photoemission in a vacuum. However, insofar as cesium is very unstable in air this particular combination of materials would obviously be unsuitable for use in an air processing unit. This principle can, nevertheless, be employed to provide composite stable photocathodes which are suitable. For example, there are many stable semiconductors that are photoemissive, such as SnO, SnO₂, CuO, Cu₂O, PbS, PbSe, Cu₂S and Sb. It has been reported that if the semiconductor is placed on a metal substrate that has a higher work function than the semiconductor, there will be an increase in the photoemissivity of the semiconductor. Thus, if a layer of the semiconductor about 200 to 500 Å. thick is evaporated onto any of the heavier metals, a dipole will be produced which has the effect of facilitating the escape of photoelectrons and thereby reducing the work function of the semiconductor.

Whatever the reason for the reduction in work function exhibited by the foregoing combinations of materials, the fact is that stable photoemissive materials which, by themselves, have work functions too high to permit them to efficiently generate the required large numbers of negative ions are rendered more photoemissive and thus suitable for use in air processing units. The photo-sensitive components employed in the units hereinafter described, accordingly, comprise composite photocathodes of the type illustrated either in FIG. 2 or FIG. 3. As shown in FIG. 2, if the photoemissive material 36 itself is stable in air (and ozone) it is simply coated onto a base metal 38a that is less electropositive thereby providing a two-element composite photocathode 26a. Alternatively, if the photoemissive material is not stable in air (or ozone), then a layer 40 thereof is first deposited onto the less-electropositive base metal 38b and then coated with a thin layer 42 of stable material, such as gold or the like, that is permeable to both UV radiation and electrons thereby providing a protective outer coating and a triple-element photocathode 26b as shown in FIG. 3. If the photoemissive layer 36 or 40 is a semiconductor then the photocathodes 26a and 26b will, in accordance with the foregoing discussion in connection with an intermediate layer of electronegative material, in reality be three and four-element photocathodes, respectively.

It will be obvious, of course, that the intermediate electronegative layer can also be oxygen associated with the surface of the base member in which case the oxygen can be present in the form of an oxide coating on the base member.

Following are some specific examples of various combinations of selected materials suited for use in fabricating the aforementioned composite photocathodes 26a and 26b, together with the numbers of negative ions typically generated thereby under UV irradiation from the type of lamps indicated under similar operating conditions, i.e., location of the lamp, velocity of the air, etc.

TABLE I

Base Member	Stable photoelectric material	Unstable photoelectric material	Stable protective coating	Thousands of negative ions produced/ml. (with photocathode grounded or negatively charged as indicated)				
				Grounded	130 v.	250 v.	420 v.	900 v.
Cu (screen).....		Ag.....	Au.....	¹ 52	¹ 285		¹ 285	¹ 182
CuO (screen).....		Ag.....	Au.....	¹ 0.26	¹ 52		¹ 210	¹ 156
Glass (plate).....	SnO ₂			¹ 13				
Cu (screen).....	CuO			¹ 52			¹ 78	
Ag (screen).....	AgS			² 21-53		² 100-130		
Pb (plate).....	PbS			² 65			² 104	
Cu (screen).....		Zn.....	Au.....		¹ 52			
		Al (plate).....	Au.....	¹ 1.8	¹ 32.5	¹ 41.6	¹ 41.6	

¹ One G10T 5½ H germicidal UV lamp marketed by the Westinghouse Elec. Corp.
² Two 794 H S11 ozone-generating lamps marketed by the Westinghouse Elec. Corp.

As can be seen from Table I, by properly combining selected materials it is possible to obtain photocathodes that will have a low threshold voltage and thus a high photoemissivity and yet be stable enough to remain photosensitive for long periods of time in air and thus able to reliably generate the desired number of negative ions. A Cu—Ag—Au photocathode has given excellent results on both counts and is accordingly preferred. In addition, and of equal importance, the composite photocathodes can be very conveniently and inexpensively fabricated. For example, the preferred Cu—Ag—Au photocathode can be fabricated by dipping a copper sheet or screen in dilute nitric acid and then water to remove any oxide. The cleansed metal is then immediately placed into a silver cyanide bath and electroplated using silver as the other electrode. When the copper color is no longer visible the silver-coated copper is then withdrawn and placed into a gold cyanide bath and electroplated until the silver color has just disappeared. It has been found that when this procedure is used the layer of silver that is deposited will be sufficiently photosensitive whereas the layer of gold will be sufficiently thin to permit the UV radiations to penetrate through to the silver layer and the photoelectrons to pass through to the atmosphere, but will still be thick enough to provide the desired protection from corrosive effects of the atmosphere. The permissible thickness of the protective layer will vary depending upon the particular material employed but preferably it should not be greater than about 100 atom layers thick since with greater thicknesses the absorption of UV becomes excessive.

In addition to those listed, zinc, aluminum, iron, lead and gold may also be used as the base metal. Aluminum foil would make an excellent photocathode if it weren't for the fact that it deteriorates rapidly in air and especially ozone. However, this problem can be solved by coating the aluminum with a protective coating such as a thin UV-and-electron-transmitting film of suitable inert material such as gold (as indicated in Table I above) or with silicon monoxide or titanium monoxide or the like.

It has also been found that the number of negative ions produced varies somewhat with the thickness of the layer of photoemissive material. However, this is not too critical and satisfactory results have been obtained by maintaining the thickness of the silver layer, in the case of the aforementioned Cu—Ag—Au photocathode for example, between 50 and 300 atom layers.

The number of negative ions actually introduced into the atmosphere depends also upon the wattage of the UV lamp 22, the ratio of 1849 Å. to 2537 Å. radiation it emits, the rate of flow of the air through the unit, the type of photocathode, the design and air flow characteristics of the unit, and the magnitude of the negative potential applied to the photocathode. A high rate of flow will blow most of the ions out of the unit before they are neutralized and will thus result in the largest number of "free" or usable ions. Care must be taken, however, not to create excessive air turbulence inside the unit and to avoid placing any large obstacle near or over the outlet, such as the fan or even a plastic grill having very small openings, since this will remove many of the ions from the air stream. A rate of air flow of from 40 to 100 c.f.m. and a negative potential within the range of about 150 to 500 volts have given very satisfactory results.

With specific reference now to FIGS. 4 and 5, there is shown an air processing unit 44 embodying the axial-flow principle illustrated in FIG. 1. The unit 44 consists of two annular cowlings 46 and 47 that are joined together by an outer cylinder 48 and an inner cylinder 50 thereby forming a double-walled casing that defines a cylindrical air passageway. The cowling 46 is provided with an annular sleeve 54 that defines the outlet 29 of the unit 44 and has three radially extending spokes 56

(shown more particularly in FIG. 5), which support a lamp socket 52 centrally within the air passageway. Similarly, the cowling 47 is provided with a sleeve 53 which defines the intake opening 27 and has radial spokes 59 that support a second lamp socket 53 as well as an air circulating means such as a motor 32 and a fan 30 centrally within the air passageway. The intake opening 27 is desirably covered by a suitable filter 28 adapted to remove solid impurities from the contaminated air drawn into the unit. An ozone-generating UV lamp 22 of elongated tubular configuration is mounted in the sockets 52 and 53 and extends coaxially of the inner cylinder 50, the inner surface whereof carries a stable composite photocathode 26 of the type discussed above.

Preferably, the inner cylinder 50 is fabricated from electrically-conductive material such as copper and constitutes the base metal for the photocathode 26 which thus forms part of the inner wall of the unit 44 that defines the air passageway. The cowlings 46 and 47 are preferably made of plastic and are provided with legs 63 to enable the unit 44 to be carried about and set down on a table or the like. Recessed within the space between the outer cylinder 48 and inner cylinder 50 is a compact lamp-ballasting and voltage-converting circuit 60 that is connected, as shown more particularly in FIG. 4, by conductors 23 and 25 to the lamp sockets 52 and 53, to the inner cylinder 50 by a conductor strap 61 and to the motor 32 by a conductor 33. The aforesaid circuit is adapted to be connected to an AC convenience outlet by means of a power cord 62 that passes through a grommated opening 64 in the bottom of the outer cylinder 48.

In FIGS. 6 and 7 there is shown another type of air processing unit 65 comprising an elongated housing 66 of generally rectangular cross-section that is preferably fabricated from plastic or the like. Located within and extending longitudinally of the upper section of the housing 66 is a tubular elongated UV lamp 22 that is mounted in a pair of sockets 52 and 53 secured to the sides of the housing. As shown more particularly in FIG. 8, the lamp 22 according to this embodiment is enclosed by a foraminous or grid type photocathode 68 of cylindrical configuration that is fabricated from photosensitive wire, such as copper wire that is coated with silver and then gold for example, as illustrated in FIG. 9. The grid photocathode 68 is held in spaced relationship with respect to the lamp 22 by ring holders 70 attached to each of the lamp bases. The grid photocathode 68 as shown in FIG. 6 is connected by means of the ring holders 70, a conductor 71 and an "ON-OFF" switch 72 mounted on the front of the housing 66 to a transformer 74 and a network of rectifiers 76, capacitors 78 and a resistor 80 connected to operate as voltage-rectifier and multiplier circuit as hereinafter described. The aforesaid circuit is, in turn, connected to an AC-outlet by a power cord 62 that passes through a grommated opening 64 in the side of the housing. The UV lamp 22 is connected to a ballast 82 by conductors 23 and 25 through a second "ON-OFF" switch 84 mounted on the front of the housing, the other end of said ballast being connected to one side of the supply line through the power cord 62.

As shown in FIGS. 6 and 7, the back of the housing 66 is provided with a circular intake opening 27 that is centrally located at the lower edge of the unit and is covered by a suitable filter 28. A fan 30 and motor 32 are mounted within the lower section of the housing 66 adjacent to and in alignment with the aforesaid intake opening and filter. Extending upwardly from the bottom of the housing 66 and the fan 30 is a first baffle 88 that is arcuate and extends up past and then curves back toward the lamp 22 terminating proximate the grid photocathode 68. As shown in FIG. 6, the baffle 88 is divergent upwardly and at its wide end is at least as long as the UV lamp 22. Thus, contaminated air drawn through the filtered intake opening 27 is funnelled by the baffle 88

upwardly to the front of the lamp-and-grid assembly and thence, by means of a second baffle 90, around the underside, back and top of the aforesaid assembly to a slot outlet 29 in the front of the housing 66, which outlet and baffle 90 extend the entire length of the lamp almost completely across the housing.

By virtue of the curved retroverted configuration of the first baffle 88 and the helical configuration of the second baffle 90, the inner ends whereof overlies but are spaced from each other, the contaminated air is conveyed from the intake opening 27 along a tortuous path past the lamp 22 and grid photocathode 68 in a direction transverse to the longitudinal axis of the lamp, and thence directly to the atmosphere through the outlet 29. The housing 66 can be provided with legs 63 to permit the unit 65 to be set down at a convenient location or, as shown by the dotted lines in FIG. 7, can be permanently affixed to a wall 73 or the like by means of a bracket 69 and a spacer 67. If desired, the flow of processed air from the unit may be controlled by widely spaced louvers 86 over the outlet 29, which louvers are shown in dotted outline in FIG. 7.

As shown in FIGS. 8a and 8b, instead of the photocathode 68 comprising a cylindrical screen grid that is mounted over the lamp 22, the photocathode can comprise a composite coating 92 that is deposited directly on the lamp envelope 21 and covers all or only half of its surface, respectively. In this case, the photocathode would comprise an integral part of the lamp 22. It will be obvious, of course, that unless the coating 92 is sufficiently thin to be UV-transmissive, a lamp 22 such as that shown in FIG. 8a, will only operate as a negative ion generator and will not deodorize or disinfect the air since the entire lamp envelope is coated and the required UV radiations would not be able to pass therethrough.

As shown in FIG. 8c, the coating 92 comprises a base layer 93 that is UV-transmissive and a layer 94 of stable photoemissive material that is more electropositive than the base layer and sufficiently thin to be permeable to electrons. Thus, the UV radiations generated within the lamp 22 will pass through the envelope 21 and base layer 93 and excite the photoelectric outer layer 94 causing electrons to be emitted into the atmosphere.

If a layer 91 of unstable photoemissive material is used then a protective coating 95 of gold or the like is applied thereover, as shown in FIG. 8d, which coating is sufficiently thin to permit the passage of electrons.

While the negative potential required to prevent polarization of the photocathode may be obtained from batteries or the like, a voltage-converter and multiplier circuit that is combined with the lamp-ballasting circuit in the manner shown in FIG. 10, is preferred. As described previously in connection with the air processing unit 65 illustrated in FIGS. 6 and 7, one end of the lamp 22 is connected directly to one side of the AC supply and the other end of the lamp connected to the other side of the line through the ballast 82 and the previously mentioned "ON-OFF" switch 84. The photocathode is charged to a predetermined negative potential in the order of about 250 volts by connecting it through the conductor 71 to the negative side of a voltage-rectifier and multiplier circuit which comprises the aforesaid pair of rectifiers 76, the pair of condensers 78 and the resistor 80 connected in voltage rectifying and doubling relationship with the secondary winding of the transformer 74, the primary of which is connected across the AC supply line by means of the other "ON-OFF" switch 72 and suitable conductors. Since the DC supply circuit is used merely to maintain the photocathode at a negative potential, the current drawn by such circuit and the power consumption thereof will be so small as to be virtually nonexistent for all practical purposes.

As shown in FIGS. 11 and 12, a combined air deodorizing, disinfecting and negative-ion generating unit 96 wherein the air is thermally circulated through the

unit can be readily provided in accordance with this invention by mounting a pair of single-ended ozone-generating UV lamps 98 within a metal housing 100 that is open top and bottom to provide an outlet 29 and an intake opening 27, respectively. As shown, the lamps 98 are supported within and at the upper end of the housing by sockets 99 and brackets 101 secured to the back of the housing. The UV lamps are adapted to be operated from an AC outlet through a power cord 62 and a ballast 82 (FIG. 11). The desired negative potential on the photocathode 68a is derived from a transformer 74 and the aforementioned voltage-rectifying and multiplying circuit the components whereof are placed within a case 95 which, together with the aforementioned ballast and transformer are also secured to the back of the housing 100. The photocathode 68a in this case comprises a rectangular screen grid that is open at the bottom, as shown in FIG. 13, and held in enclosing relationship with the UV lamps 98 by means of a bracket insulatively anchored to the back of the housing 100. As before, the grid photocathode 68a is connected by means of a conductor 71 to the negative output terminal of the voltage-rectifier and multiplier circuit within the case 95. A grating 102 is desirably attached to the bottom of the housing 100 to cover the intake opening 27 and thus prevent anyone from accidentally contacting the power supply through the bottom of the unit, and also to provide means for anchoring the power cord 62. As shown in FIG. 12, an apertured tongue 103 and spacers 104 are provided at the back of the housing 100 to enable the unit to be mounted on a wall or the like.

In FIG. 14 there is shown a diagrammatic representation of another air processing unit 105 according to the invention which comprises, in general, an elongated housing 106 of rectangular cross-section having intake openings 107 and 108 at one end covered by filters 109 and 110, respectively, and a pair of outlets 111 and 112 at its opposite end. At least the central portion of the housing 106 is sub-divided by means of a plurality of baffles 114 into a plurality of air-processing cells or air passageways 116 that are square in cross-section, as shown in FIG. 15, and extend longitudinally within the housing parallel to the axis thereof. More or less centrally located within each of the air passageways 116 is mounted an elongated tubular UV lamp 22 and an enclosing grid photocathode 68 connected to a suitable ballast and DC supply circuit, respectively, such as that described above in connection with the units shown in FIGS. 6-7 and 11-12, which ballast and supply circuit are diagrammatically represented in FIG. 14 as being integrated with an enclosure 118.

As shown more particularly in FIG. 14, the UV lamps 22 and baffles 114 are of substantially the same length but are shorter than the housing 106 and arranged in diagonal formation therewithin to provide a generally triangular-shaped free space proximate the intake openings 107 and 108 for a fan 30 and a motor 32. The fan and motor unit are also diagonally oriented but in the opposite sense with respect to the corner of the enclosure 106 in which it is mounted so that the fan lies in a plane that is generally parallel to the plane tangent to the ends of the baffles 114. The fan 30 also is of sufficient diameter to span all of the air passageways 116 so that contaminated air drawn into the housing 106 through the intake openings 107 and 108 is forced through the passageways 116 in a direction parallel to the longitudinal axes of the lamps 22 and then discharged directly into the atmosphere through the outlets 111 and 112, as indicated by the arrows. If desired widely-spaced louvers 120 (shown in dotted lines) may be employed over the outlets to control the direction in which the air is discharged from the processing unit 105.

Insofar as a plurality of air-processing cells are provided in accordance with this embodiment of the invention, it will be appreciated that proportionately larger

volumes of contaminated air can be treated than in the case of the units hereinbefore described. Hence, such plural-cell units are especially suited for use in larger rooms such as operating rooms or school rooms, etc. In this connection, it is appropriate to point out that in the event that the presence of ozone cannot be tolerated, as for example in the case of an operating room, any of the UV lamps in any of the units can be rendered ozone-free by employing envelopes of Corning VYCOR glass No. 9710 or Corning soft glass No. 9823 which, as is well-known in the art, filter out all of the 1849 Å. radiation and transmit only the bactericidal 2537 Å. radiation.

In FIG. 16 there is shown an alternative type of air-processing cell 116a for a plural-cell unit such as that shown in FIG. 14. Instead of employing a foraminous or grid photocathode 68 that encloses each of the UV lamps 22 as in the embodiment shown in FIG. 14, the cells 116a in this instance are lined with a stable composite photosensitive member 26 which may be a screen or a solid base member coated with selected materials as hereinbefore described, or a plurality of coatings applied directly to the surfaces of the cells which thus serve as the supporting substrate.

In FIG. 17 there is shown another form of the invention wherein a UV lamp 22 and photocathode 26 are mounted in predetermined spaced relationship within an air conditioning unit 117 proximate the louvered outlet 119 thereof. The lamp and photocathode are mounted in such a location in the air conditioner that the circulated air sweeps past the aforesaid lamp and photocathode just before it is discharged into the atmosphere. As shown, this can be very readily accomplished by attaching the lamp-and-photocathode assembly to the air conditioner housing so that it is disposed in the intervening space separating the outlet 119 from the heat-exchanging unit 123. Thus, the air that traverses the aforesaid intervening space is further processed by the radiations from the UV lamp and thus deodorized and disinfected as well as being supplied with negative ions just before it is discharged into the atmosphere. As before, a suitable ballast and DC supply circuit (not shown) is provided and connected to the lamp 22 and photocathode 26, said ballast and circuit being so located as to constitute integral parts of the air conditioner.

The invention may also be advantageously applied to further process air that has been previously cooled or heated and is being conveyed by means of a duct system to an outlet. This form of the invention is shown in FIG. 18 and as there illustrated consists of a single-ended ozone-generating UV lamp 98 and an enclosing grid photocathode 121 mounted in spaced apart relation on a suitable base 122 so as to provide a unitary structure that is placed within the duct 124 of the air conveying system proximate one of its outlets 127 mounted in a wall 128 or the like. The base 122 also houses the lamp-ballasting and voltage-converting circuit, which circuit is connected to an AC outlet by a power cord 62 that passes through the screen or register 126 covering the outlet 127. Thus, pretreated air passing through the duct 124 is exposed to the UV radiations from the UV lamp 98 and picks up negative ions produced by the photocathode 121 just before it is discharged into the room, thereby additionally treating the air by disinfecting and deodorizing it and supplying it with negative ions.

It will be recognized from the foregoing that the objects of the invention have been achieved by providing an ion-generating unit and component that are capable, by virtue of the stability and low work function of the photosensitive member, of inexpensively and reliably generating large numbers of negative ions and introducing them into an enclosed atmosphere before they are lost by neutralization, recombination, etc. In addition, there have been provided herein several preferred designs of ion-generating and air-processing units which are especially adapted by virtue of the configuration and or-

ganization of the UV lamp and photosensitive member to process large quantities of contaminated air, or air that has previously been treated and is being circulated through a separate air processing unit such as an air conditioner or through a duct system.

While several embodiments of the present invention have been illustrated and described in detail, it is to be understood that various modifications in the construction and organization of the parts thereof can be made without departing from the spirit and scope of the invention.

I claim:

1. The combination of an electric lamp that generates electromagnetic radiation of a preselected wavelength when energized and includes an envelope that transmits said radiation, and a photosensitive component disposed adjacent to said lamp in receptive proximity to such transmitted radiation, said photosensitive components comprising (a) a photoemissive material that is unstable in air and emits electrons in response to impinging electromagnetic radiation from said lamp, and (b) a protective layer of an air-stable material that is permeable to electrons and thus transmits said emitted electrons into the surrounding air with attendant production of negative ions therein.

2. The combination of an electric lamp that generates ultraviolet radiation when operated and includes an ultraviolet-transmitting envelope, and a member covering at least a portion of said envelope and including a composite photosensitive coating that is disposed in receptive proximity to ultraviolet radiation transmitted by said envelope; said photosensitive coating comprising (a) a layer of photoemissive material that is unstable in air and emits electrons in response to impinging ultraviolet radiation, and (b) an overlying protective layer of a material that is stable in air and permeable to both ultraviolet radiations and electrons and thus transmits said emitted electrons into the surrounding air with attendant production of negative ions therein.

3. The combination of an electric lamp that generates electromagnetic radiation of a preselected wavelength when operated and includes an envelope that transmits said radiation, and a coating on and covering at least a portion of said envelope, said coating comprising (a) a layer of photoemissive material that is unstable in air and emits electrons in response to impinging electromagnetic radiation transmitted by said envelope, and (b) an overlying protective layer of an air-stable material that is permeable to electrons and thus transmits said emitted electrons into the surrounding air with attendant production of negative ions therein.

4. The combination of an electric lamp that generates ultraviolet radiation when energized and includes an ultraviolet-transmitting envelope, and a composite photosensitive coating on and covering at least a portion of said envelope; said photosensitive coating comprising (a) an ultraviolet-transmitting base layer of electrically-conductive material on said envelope, (b) a layer of photoemissive material over said base layer, said photoemissive material being unstable in air and responsive to impinging ultraviolet radiations transmitted by said envelope and base layer, and (c) a protective layer of an air-stable material over said layer of photoemissive material that is permeable to electrons and thus transmits electrons emitted by said photoemissive material into the surrounding air with attendant production of negative ions therein.

5. The combination of an ozone-generating ultraviolet lamp having an envelope that is ultraviolet-transmissive, and a member adjacent to said envelope in receptive proximity to the radiation from said lamp, said member comprising (a) a photoemissive material that is unstable in air and emits electrons in response to impinging ultraviolet radiation from said lamp, and (b) a thin protective coating of a material that is stable in air and ozone and permeable to both ultraviolet radiation and electrons and

thus transmits said emitted electrons into the surrounding air with attendant production of negative ions therein.

6. Apparatus for generating negative ions in air and introducing them into the atmosphere comprising; an electric lamp that generates electromagnetic radiation of preselected wavelength, a composite photosensitive member located in receptive proximity to electromagnetic radiations produced by said lamp, said photosensitive member comprising (a) a photoemissive material that is unstable in air and responsive to impinging electromagnetic radiations from said lamp, and (b) a protective layer of an air-stable material that is permeable to electrons and thus transmits electrons emitted by said photoemissive material into the surrounding air with attendant production of negative ions therein, and means for circulating air past said photosensitive member and introducing the negative ions generated thereby directly into the atmosphere before they are neutralized.

7. Negative-ion generating apparatus as set forth in claim 6 wherein said lamp and photosensitive member are surrounded by an enclosure having an intake opening and an outlet, and the generated negative ions are carried by the air stream produced by said air circulating means through said outlet and introduced directly into the atmosphere.

8. Apparatus for purifying and controlling the negative ion concentration of the air in an enclosed atmosphere comprising a source of radiations of preselected wavelength, an electrically-conductive photosensitive member located in receptive proximity to the radiations emanating from said source, said photosensitive member being stable in air and including a photoemissive material that is operable in response to impinging radiations from said source to cause electrons to be emitted from said photosensitive member into the surrounding air with the attendant production of negative ions therein, an enclosure surrounding said photosensitive member and radiation source having an intake opening and an outlet, means for circulating air through said enclosure past said photosensitive member and introducing the negative ions generated thereat directly into the atmosphere through said outlet before they are neutralized, a filter covering said intake opening adapted to remove solid impurities from the air before it is circulated through said enclosure, and means for applying a negative potential to said photosensitive member.

9. Air processing apparatus comprising a source of ultraviolet radiation including ozone-generating radiations below 2000 Å., an electrically-conductive photosensitive member located in receptive proximity to the radiations emanating from the said ultraviolet source, said photosensitive member being stable in air and ozone and including a photoemissive material that is operable in response to impinging radiations from said ultraviolet source to cause electrons to be emitted from said photosensitive member into the surrounding air with the attendant production of negative ions therein, an enclosure surrounding said photosensitive member and ultraviolet source and having an intake opening and an outlet, means for applying a negative potential to said photosensitive member, and means for circulating air through said enclosure past said ultraviolet source and said photosensitive member and introducing the negative ions generated thereby directly into the atmosphere through said outlet before they are neutralized, whereby the air circulated through said enclosure is deodorized and supplied with negative ions.

10. Air processing apparatus as set forth in claim 9 wherein said ultraviolet source also emits bactericidal radiations below 3000 Å., whereby the air circulated through said enclosure is disinfected in addition to being deodorized and supplied with negative ions.

11. Air processing apparatus as set forth in claim 10 wherein said source of ultraviolet radiations comprises an ozone-bactericidal ultraviolet lamp, and the intake open-

ing of said enclosure is covered by a filter, whereby air circulated through said enclosure is first purified and then deodorized, disinfected and supplied with negative ions.

12. Apparatus for generating negative ions in air and introducing them into an enclosed atmosphere to control the negative ion content thereof comprising, a cylindrically hollow casing having an intake opening at one end and an outlet at its opposite end, an elongated tubular ultraviolet lamp mounted within and extending axially of said casing, an electrically-conductive photosensitive member within said casing spaced from said ultraviolet lamp and shaped and arranged to permit the free flow of air through said casing, said photosensitive member being stable in air and operable in response to impinging radiation from said ultraviolet lamp to emit electrons into the surrounding air with attendant production of negative ions therein, a fan and motor unit within said casing located between said intake opening and said photosensitive member, and circuit means carried by said casing for connecting said ultraviolet lamp and said fan and motor unit to and operating them from an AC voltage source and applying a negative potential to said photosensitive member, whereby air axially circulated through said casing between said ultraviolet lamp and photosensitive member is supplied with negative ions and expelled from said outlet directly into the atmosphere before the generated negative ions are neutralized.

13. Air processing apparatus comprising a cylindrically hollow casing having an inner and an outer wall and an intake opening at one end and an outlet at its opposite end, an elongated tubular ultraviolet lamp mounted within and extending coaxially of said casing and adapted when energized to emit ozone-generating and bactericidal radiations, a hollow cylinder of electrically-conductive material within and insulated from said casing and constituting a part of the inner wall thereof that surrounds said ultraviolet lamp, the surface of said cylinder facing said ultraviolet lamp being photosensitive and stable in air and ozone and operable in response to radiations from said lamp to emit electrons into the surrounding air with attendant production of negative ions therein, a fan and motor unit within said casing located between said ultraviolet lamp and said intake opening, a filter covering said intake opening, circuit means recessed between the inner and outer walls of said casing for operating said ultraviolet lamp from an AC voltage source and for converting AC voltage to DC voltage and applying a negative potential of predetermined magnitude to said cylinder, and conductor means carried by said casing for connecting said circuit means and fan and motor unit to an AC power supply, whereby air axially circulated through said casing between said ultraviolet lamp and the photosensitive surface of said cylinder is first purified and then deodorized, disinfected and supplied with negative ions.

14. Air processing apparatus comprising an elongated housing having a front and a back, an elongated tubular ultraviolet lamp mounted within said housing, said ultraviolet lamp extending longitudinally of said housing and being adapted when energized to emit ozone-generating and bactericidal radiations, a foraminous electrically-conductive photosensitive member disposed in encircling relationship with at least a part of said ultraviolet lamp in receptive proximity to the radiations emanating therefrom, said photosensitive member being stable in air and ozone and operable in response to impinging radiations from said ultraviolet lamp to emit electrons into the surrounding air with attendant production of negative ions therein, an intake opening in the back of said housing remote from said ultraviolet lamp, a fan and motor unit within said housing closer to said intake opening than said ultraviolet lamp and photosensitive member, baffle means for funnelling the air stream produced by said fan and motor unit past said photosensitive member and ultraviolet lamp in a direction transverse to the longitudinal axis of said lamp and thence directly to an outlet

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provided in the front of said housing, circuit means carried by said housing for operating said ultraviolet lamp from an AC voltage source, means within said housing for applying a negative potential of predetermined magnitude to said photosensitive member, and conductor means for connecting said circuit means and said fan and motor unit to an AC power supply, whereby air circulated through said housing is directed past said photosensitive member and ultraviolet lamp transversely of the longitudinal axis of the lamp and thus deodorized, disinfected and supplied with negative ions and then expelled directly into the atmosphere through said outlet.

15. Air processing apparatus comprising an elongated generally rectangular housing having a front and a back, an elongated tubular ultraviolet lamp within said housing extending horizontally within the upper section thereof and adapted when energized to emit ozone-generating and bactericidal radiations, a foraminous electrically-conductive photosensitive member mounted in encircling relationship with at least a part of said ultraviolet lamp, said photosensitive member being stable in air and ozone and operable in response to impinging radiations from said ultraviolet lamp to emit electrons into the surrounding air with attendant production of negative ions therein, a circular intake opening in the back of said housing centrally located at the lower edge thereof and thus remote from said ultraviolet lamp, a filter covering said intake opening, a fan and a motor unit mounted adjacent said intake opening and arranged to draw air into said housing, a first baffle extending from said fan to said ultraviolet lamp and defining an upwardly divergent and arcuate retroverted passageway for the air stream generated by said fan to the front and underside of said lamp, a second baffle extending from the underside of said ultraviolet lamp and the uppermost end of said first baffle to a slot outlet in the upper part of the front of said housing that extends approximately the full length of said lamp, said second baffle defining a generally helical passageway that communicates with the passageway defined by the said first baffle at the underside of said ultraviolet lamp and extends therefrom around the back and top of said lamp directly to said slot outlet, circuit means within said housing for operating said ultraviolet lamp from an AC voltage source and for converting AC voltage to DC voltage and applying a negative potential to said photosensitive member, conductor means for connecting said circuit means and fan and motor unit to an AC power supply, and switch means mounted on said housing for selectively energizing said ultraviolet lamp and voltage converter, whereby air drawn into said housing is first purified and then circulated past said ultraviolet lamp and photosensitive member at substantially right angles to the longitudinal axis of the lamp and thus deodorized, disinfected and supplied with negative ions when said lamp and voltage converter are energized.

16. Air processing apparatus comprising a housing open top and bottom to permit the thermal circulation of air and adapted to be mounted on an upstanding supporting member, an ozone-generating bactericidal ultraviolet lamp mounted within said housing, a foraminous photosensitive and electrically-conductive member mounted in encircling relationship with at least a part of said ultraviolet lamp, said photosensitive member being stable in air and ozone and operable in response to impinging radiations from said ultraviolet lamp to emit electrons into the surrounding air with attendant production of negative ions therein, circuit means carried by said housing for operating said ultraviolet lamp from an AC voltage source, conductor means for connecting said circuit means to an AC power supply, and means mounted on said housing for applying a negative potential to said foraminous photosensitive member, whereby air thermally circulated through said housing and foraminous member is deodorized, disinfected and supplied with negative ions.

17. Air processing apparatus comprising an elongated

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housing having an intake opening at one end and an outlet at its opposite end, a plurality of baffles extending longitudinally of said housing and arranged to partition at least the medial interior portion thereof into a plurality of separate elongated air-passageways that are open at both ends and communicate with said intake opening and said outlet, a fan and a motor within said housing located between said intake opening and the adjacent ends of said air-passageways and arranged to draw air into said housing and impel it through said air-passageways, an elongated tubular ultraviolet lamp mounted within and extending longitudinally of each of said air-passageways, a photosensitive and electrically-conductive member disposed adjacent each of said ultraviolet lamps in receptive proximity to radiations emanating therefrom and arranged to permit the free passage of air through the respective air-passageways, said photosensitive member being stable in air and operable in response to impinging ultraviolet radiations to emit electrons into the surrounding air with attendant production of negative ions therein, circuit means carried by said housing for operating said ultraviolet lamps from an AC power supply, means carried by said housing for applying a negative potential to said photosensitive member, and conductor means for connecting said circuit means to an AC power source, whereby air drawn into said housing and circulated through said air-passageways is supplied with negative ions and expelled directly into the atmosphere through said outlet.

18. Air processing apparatus comprising an elongated housing having an intake opening at one end and an outlet at its opposite end, a filter covering said intake opening, a plurality of interconnected baffles within said housing arranged to partition the interior thereof into a plurality of separate and elongated air-passageways that are open at each end and extend parallel to each other and the longitudinal axis of said housing, said air-passageways being of approximately equal length and terminating short of said intake opening to provide a free space thereat and having their opposite ends in direct communication with said outlet, a fan and a motor mounted in the free space between said intake opening and passageways, said fan being oriented to draw air into said intake opening and impel it through said air-passageways, an elongated tubular ultraviolet lamp mounted centrally within and extending longitudinally of each of said air-passageways, said ultraviolet lamp when energized being adapted to emit ozone-generating and bactericidal radiations, a photosensitive and electrically-conductive member in each of said air-passageways encircling at least part of the ultraviolet lamp therein and located in receptive proximity to radiations emanating from said ultraviolet lamp and arranged to permit the free passage of air through said air-passageways, said photosensitive member being stable in air and ozone and operable in response to impinging ultraviolet radiations to emit electrons into the surrounding air with attendant production of negative ions therein, circuit means within said housing for operating said ultraviolet lamps from an AC voltage source and for converting AC voltage to DC voltage and applying a negative potential of predetermined magnitude to said photosensitive member, and conductor means for connecting said circuit means and motor to an AC power supply, whereby air drawn into said housing and circulated through said air-passageways is first purified, then deodorized, disinfected and supplied with negative ions, and finally discharged directly into the atmosphere through said outlet.

19. The combination of an air conditioner having a heat exchanger and an outlet that is spaced from the point at which air is discharged from said heat exchanger, and apparatus for generating negative ions in and irradiating the air discharged from said heat exchanger and thus further processing it just before it is introduced into the atmosphere through said outlet, said apparatus comprising an ultraviolet lamp located within said air conditioner

proximate said outlet and adapted when energized to emit radiations below 3000 Å. into the intervening space between said heat exchanger and outlet, a photosensitive member in receptive proximity to radiations emanating from said ultraviolet lamp and operable in response thereto to emit electrons into the aforesaid intervening space with attendant production of negative ions in the air traversing said space, and circuit means integral with said air conditioner for operating said ultraviolet lamp from an AC power source and preventing said photosensitive member from becoming polarized through the loss of electrons.

20. The combination of an air conditioner and an ultraviolet-irradiating and negative-ion generating apparatus as set forth in claim 19 wherein said photosensitive member is electrically conductive and said circuit means includes a voltage-converting circuit that is connected to said photosensitive member and operable when energized to apply a negative potential of predetermined magnitude thereto.

21. The combination of a duct for conveying air from an air-processing unit and discharging it into an enclosed atmosphere through an outlet, and apparatus for generating negative ions in and irradiating the treated air just before it is expelled from said outlet, said apparatus comprising an ultraviolet lamp in said duct located proximate said outlet, said ultraviolet lamp being adapted when energized to emit radiations below 3000 Å., a photosensitive member disposed in receptive proximity to radiations emanating from said ultraviolet lamp, said photosensitive member being stable in air and ozone and operable in response to impinging ultraviolet radiations to emit electrons into the surrounding air with attendant production of negative ions therein, and circuit means connected to said ultraviolet lamp and photosensitive member for operating said lamp from an AC power source and preventing the polarization of said photosensitive member through the loss of electrons.

22. The combination of an air duct and ultraviolet-irradiating and negative-ion generating apparatus as set forth in claim 21 wherein said photosensitive member is electrically conductive, said ultraviolet lamp and photosensitive member are held in operative relationship with one another by support means, and said circuit means is carried by said support means and includes a voltage-converting circuit that is connected to said photosensitive member and operable when energized to apply a negative potential of predetermined magnitude thereto.

23. An ion generator comprising: an ultraviolet lamp for irradiating photons, a plate located adjacent to said ultraviolet lamp whereby the photons irradiated from said lamp may cause electrons to be emitted from said plate, said lamp and said plate being arranged to form an air gap separating the plate from the lamp, means for introducing molecules which are capable of being ionized into said air gap so that the molecules may pick up the electrons emitted by said plate and form negative ions, means for impressing a negative voltage on said plate to repel the negative charges from said plate, and means for causing said negative ions to flow out of said air gap.

24. The combination of an electric lamp that generates ultraviolet radiations when energized and includes an ultraviolet-transmitting envelope, and a composite photosensitive coating on and covering at least a portion of said envelope; said photosensitive coating comprising an ultraviolet-transmitting base layer of electrically-conductive material on said envelope, a layer of photoemissive material over said base layer that is unstable in air and more electropositive than the material comprising said base layer and is operable in response to impinging ultraviolet radiations transmitted by said envelope and base layer to emit electrons into the surrounding air with attendant production of negative ions therein, and a third layer of another material that overlies said layer of photoemissive material and is stable in air and permeable to electrons.

25. An air purifier comprising a housing having formed in the walls thereof an air inlet and an air outlet, an air-moving device positioned within said housing to draw air along a path from said air inlet to said air outlet, an air filter connected to said housing and positioned along said path, an ionizing source of radiation mounted within said housing in position to irradiate air proceeding along said path, and a grounded photoelectron emitter mounted within said housing in close proximity to said ionizing source in a position to intercept some of the radiation proceeding from said ionizing source and having a work function less than the quantum level of said radiation whereby upon receipt of said radiation said emitter emits electrons which enter said path.

26. An air purifier as described in claim 25, said emitter being positioned within said housing to intercept radiation from said ionizing source which, if not so intercepted, would proceed through said air outlet.

27. An air purifier as described in claim 25, said air filter being positioned across said air inlet.

28. An air purifier as described in claim 25, said ionizing source being a mercury lamp emitting ultraviolet radiation in the wave lengths 1849 and 2537 Angstroms, and said emitter having a work surface whose work function is less than 6.6 volts.

29. An air purifier comprising a housing having formed in the walls thereof an air inlet and an air outlet, an air-moving device positioned within said housing to draw air along a path from said air inlet to said air outlet, an air filter connected to said housing across said path, an ultraviolet radiation generator in the form of a mercury lamp mounted within said housing and positioned to irradiate air proceeding along said path, a grounded photoelectron emitter mounted within said housing in close proximity to said mercury lamp and positioned to intercept some of the radiation proceeding from said ionizing source, the work function of surface of said emitter being less than 6.6 volts.

30. An air purifier as described in claim 29, said emitter being in the form of a sheet of material interposed between said lamp and said air outlet.

31. An ion generator comprising: a lamp source of irradiation for irradiating photons, an object located adjacent to said lamp whereby the photons irradiated from said lamp may cause electrons to be emitted from said object, said lamp and said object being arranged to form an air gap separating the object from said lamp, means for introducing molecules which are capable of being ionized into said air gap so that the molecules may pick up the electrons emitted by said object and form negative ions, means for impressing a negative voltage on said objects to repel the negative charges from said object and means for causing said negative ions to flow out of said air gap.

32. An ion generator comprising a source of irradiation for irradiating photons, a plate located adjacent to said source of irradiation whereby the photons irradiated from said source may cause electrons to be emitted from said plate, said source of irradiation and said plate being arranged to form an air gap separating the plate from said source, means for introducing molecules which are capable of being ionized into said air gap so that the molecules may pick up the electrons emitted by said plate and form negative ions, means for impressing a negative voltage on said plate to repel said negative ions from said plate and means causing air stream to flow in said air gap for discharging said ions from said air gap, the velocity of said air stream the magnitude of said negative voltage and the dimensions of said air gap being such that the ions which are formed in said air gap are discharged from said air gap before they become neutralized by being repelled back to the source or to some other positively charged body.

32. An ion generator comprising: a substantially cylindrical source of irradiation for irradiating photons, an

elongated plate partially surrounding said source of irradiation and spaced from said source of irradiation to provide an air gap, the dimensions of said air gap being such that the photons irradiated from said source may cause electrons to be emitted from said plate, means for introducing molecules which are capable of being ionized into said air gap so that the molecules may pick up the electrons emitted by said plate and form negative ions, means for impressing a negative voltage on said plate to repel said negative ions from said plate, and means for causing an air stream to flow through said air gap in a direction generally parallel to the longitudinal axis of said source from one part of said air gap to the end of said air gap; the velocity of said air stream, the magnitude of said negative voltage and the dimensions of said air gap being such that the ions which are formed in said air gap are discharged from said air gap before they become neutralized by being repelled back to the lamp or to some other positively charged body.

34. In combination, an electric lamp that generates electromagnetic radiations when energized, and a composite photosensitive member that (a) is disposed in radiation-receptive proximity to said lamp, (b) is stable in air, (c) reflects impinging radiation emanating from said lamp, and (d) also emits electrons in response to impinging radiation produced by said lamp, said photosensitive member comprising a photoemissive material that is unstable in air and an overlying layer of a material that is stable in

air and permeable to electrons to protect said photoemissive material from the atmosphere and to transmit electrons from said photoemissive material into the surrounding air with attendant production of negative ions therein.

35. The combination set forth in claim 34 wherein; said lamp generates ultraviolet radiation, and said radiation-reflective photosensitive member comprises an aluminum plate having a gold coating that is permeable to both electrons and ultraviolet radiation.

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