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H. G. LUEDER
APPARATUS FOR THE PRODUCTION OF UNIPOLAR IONS
IN THE AIR OF A ROOM

3,417,302

Original Filed Feb. 5, 1963

5 Sheets-Sheet 1

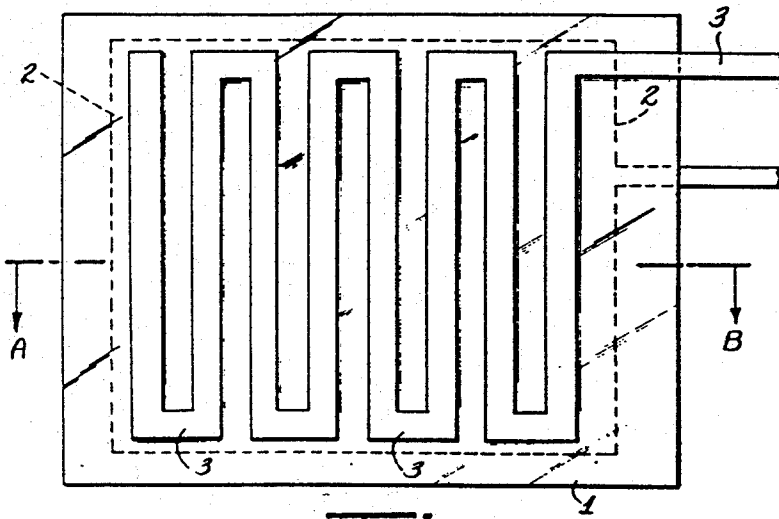


Fig. 1.

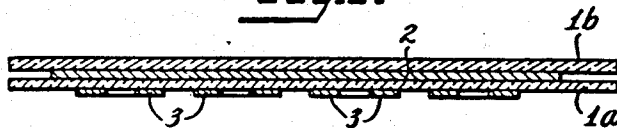


Fig. 1A.

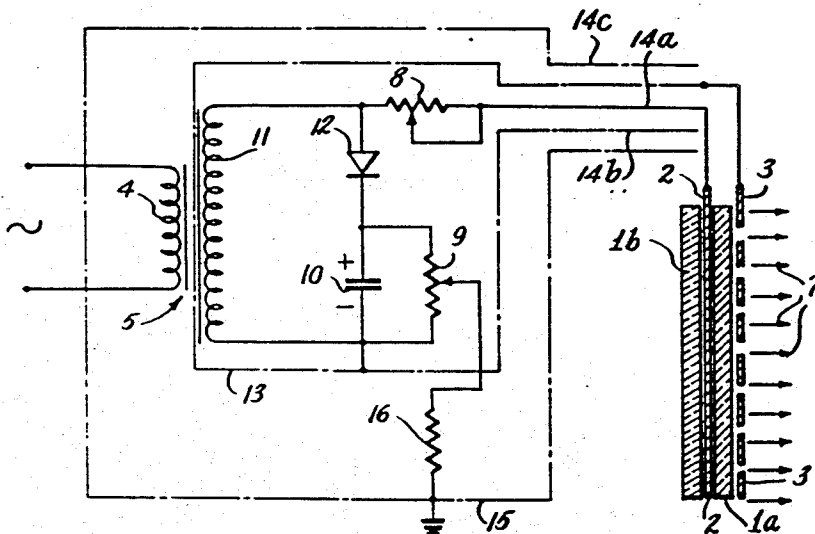


Fig. 2.

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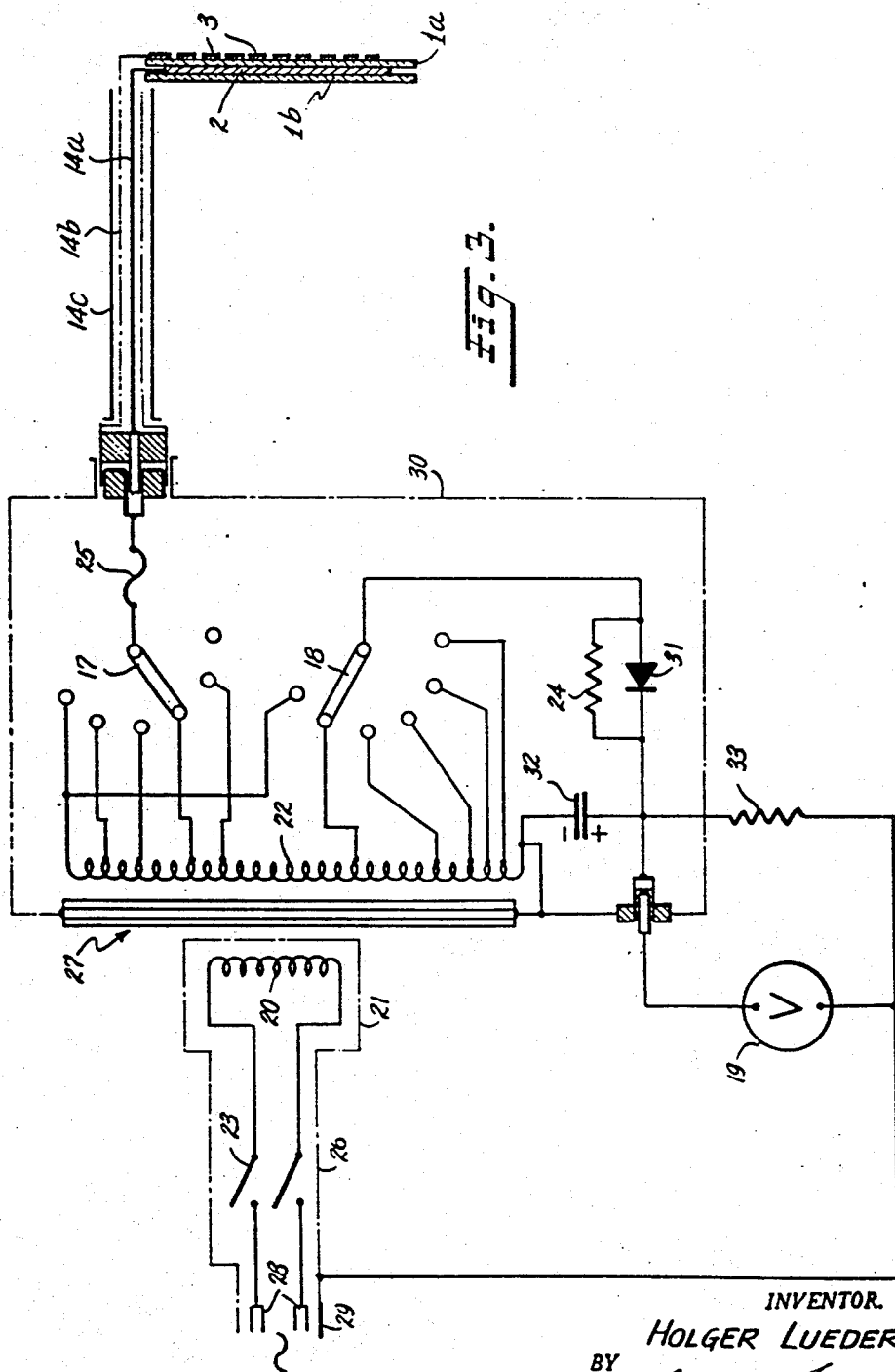
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THE PRODUCTION OF UNIFORMITY
IN THE AIR OF A ROOM

5 Sheets-Sheet 3



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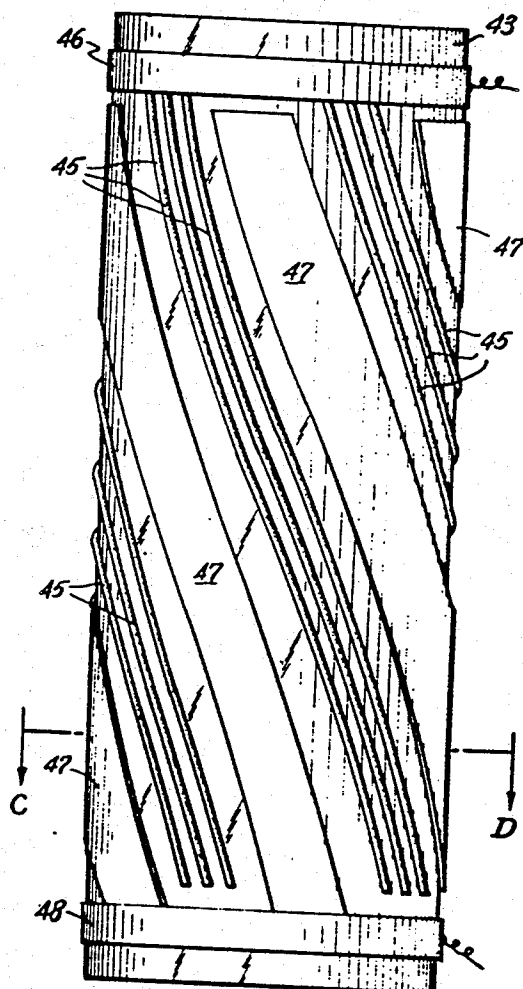


Fig. 5.

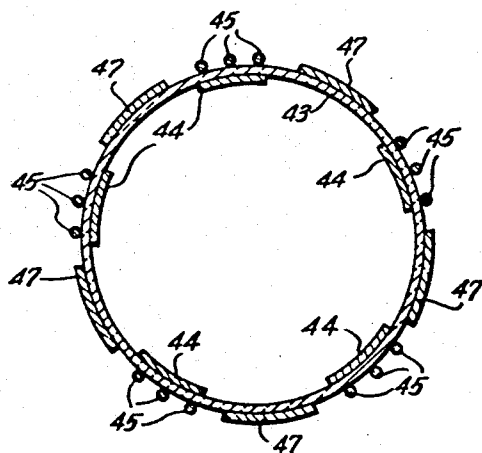


Fig. 5A.

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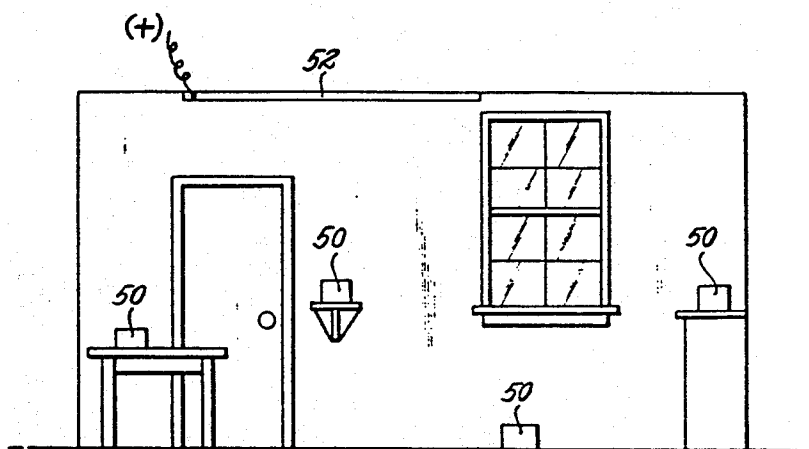


Fig. 8.

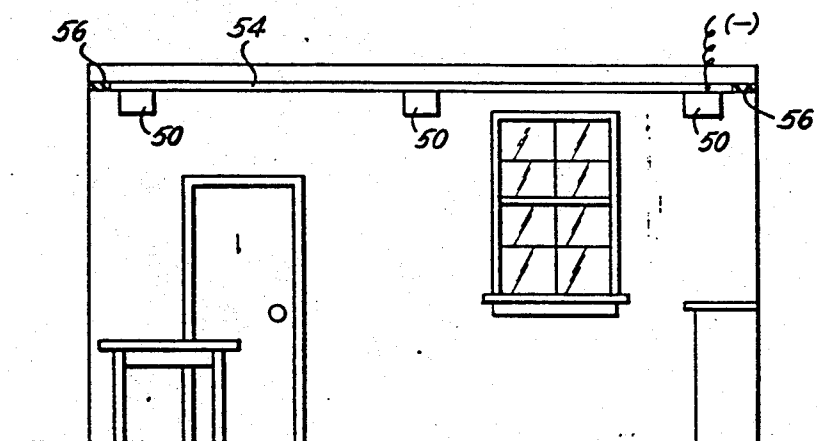


Fig. 7.

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3,417,302

APPARATUS FOR THE PRODUCTION OF UNIPOLAR IONS IN THE AIR OF A ROOM

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Original application Feb. 5, 1963, Ser. No. 256,413, now
Patent No. 3,337,784, dated Aug. 22, 1967. Divided
and this application June 27, 1967, Ser. No. 649,205
Claims priority, application Switzerland, Feb. 9, 1962,
1,641/62

12 Claims. (Cl. 317-262)

ABSTRACT OF THE DISCLOSURE

An ion generating arrangement in a room having an exposed electrode electrically connected to the ceiling and mounted on a thin dielectric plate with a counter electrode on the other side of the plate. A controlled corona discharge is produced while no more than $30 \cdot 10^{-12}$ grams of ozone per cubic cm. of air is produced.

Cross reference to related application

This application is a division of my copending application, Ser. No. 256,413, filed Feb. 5, 1963, now U.S. Patent No. 3,337,784.

The present invention relates to a method of and devices for the production of unipolar ions and for enriching the air of a room using oxygen ions and electrical fields while simultaneously deodorizing and removing from the air minute odor and suspension particles. It is known that man's well-being in closed rooms in agreeable temperature and humidity condition depends on both the freedom from dust and odors of the air and on the electrical conditions present in the room. The last mentioned conditions are substantially determined by the ionization of the air. Through oxygen ion osmosis in the lungs, good electric conditions exercise a healthy effect on the basic factors of life being capable, on the one hand, of enhancing resistance to pathogens, vital capacity and the performance of the nerves and, on the other, to produce more rapid recovery after excessive stress and work. Such conditions are found in nature largely in the places long since known as air resorts, but never in closed rooms. In the air of closed rooms, the positive carbon dioxide ions almost regularly exceed the negative oxygen ions because the positive ions, owing to their inferior mobility cannot deposit on the surfaces enclosing the room as rapidly as the negative oxygen ions.

Two fundamentally different principles have so far been employed in order to enrich the air of rooms with negative oxygen ions:

(a) An air stream is passed over an ion source, such as a radioactive material, a surface irradiated with light and emitting electrons or an electrical corona discharge, and the ions having the undesirable charge are retained by an electrical D.C. field. While the harmful ion source can be protected against tampering and, respectively, the persons present in the room completely protected against its radiation, there remains the disadvantage of its lack of efficacy caused by the fact that the electrical space charge entering the room together with the air stream will be largely deposited, owing to its self-consistent field, on the surfaces enclosing the room before it can be evenly distributed in the latter. For the same reason, it is hardly possible to distribute the oxygen ions in the rooms supplied along with an air stream unipolarly ionized in air conditioning equipment.

(b) A stream of negative oxygen ions has also been produced without circulating the air and supplied to the

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air breathed, but the ion source had to be placed in the room without a protective jacket. However, owing to the hazard of radiation and, respectively, high voltage inherent in radioactive and corona discharge ionizers, this is possible only where the rooms are continuously supervised by trained service personnel. This is one of the reasons why ionization of air in enclosed rooms has so far been effected only infrequently in private apartments and most frequently in special treatment units of hospitals and institutes. While the hazards of high voltage can be obviated in ultraviolet light ionizers by current limitation with a sufficiently high internal resistance, it is generally not easy to screen the persons present in a room against UV light, UV light and corona discharge ionizers moreover display the disadvantage that the generation of ions is accompanied by the development of ozone or even nitric oxides which are highly toxic in more powerful concentration.

It is an object of the invention to eliminate the combination of ion production with the generation of ozone and nitric oxides as well as the hazard of high voltage hitherto common in the art. The method according to this invention is based on the following process: the ions are produced at the edges of a thin electrode resting on a dielectric layer, by means of glow or corona discharges maintained by an alternating voltage source, the other surface of the said dielectric layer being covered by a laminar counterelectrode. If thickness of the dielectric layer and the alternating voltage applied to the two electrodes is kept within certain limits, the stabilized glow and corona discharges on the insulating layer are kept to a length of fractions of a millimeter and at limited intensity, in which case the generation of ozone and nitric oxides is negligible according to test results. But at the same time the negative oxygen ions are withdrawn from the discharge and admixed to the breath air in an amount corresponding a concentration up to 10^6 ions per cubic cm. by means of an electrostatic field produced in the surroundings of the discharge electrode. Owing to the limitation of the glow and corona discharge to a length of a fraction of a millimeter, the ion source is operated under conditions which allow mixing with the air, according to the electric field strength, up to 10^6 unipolar ions but not more than about $30 \cdot 10^{-12}$ grams of ozone per cubic cm. of the air, an amount of ozone which is substantially imperceptible and physiologically insignificant.

Owing to the limitation in respect of dimension and intensity of the glow and corona discharge it has for the first time become possible to obtain, by means of electrical discharges the negative oxygen ions independent of the ozone production rate, in a dosage determined by the intensity of the electrostatic field and to supply same to the persons present in the room. The electrostatic field may be generated by means of semiconducting electrodes such as formed by the furniture in and the normal delimiting surfaces of the room.

On the other hand, as desirable in rooms having an odor, the ozone generation may be intensified independently of the maintained ion concentration, to an amount which deodorizes the room air without exceeding the allowable concentration of $30 \cdot 10^{-12}$ grams ozone per cubic cm.; this is obtained by control of the alternating voltage at the counterelectrode.

To maintain the glow or corona discharges, alternating voltages between 1,000 and 4,000 volts are required; to generate the electrostatic field, direct voltages up to 4,000 volts. Danger to life normally involved in voltages of that magnitude is eliminated, according to the invention, by insulating the laminar counterelectrode on all sides, fusing it and enclosing its power supply and the entire A.C. source in a metallic jacket connected to the other

pole of the A.C. source. On the other hand, owing to the low intensity of the ion flow in the constant electrical field, the D.C. source may be provided with an internal resistance of at least 10^9 ohms without noticeable voltage loss so that, in the event that the conducting electrode is touched, the voltage is limited to a harmless or non-perceptible magnitude.

The unipolar ionization of the air, however, commonly involves the further hazard that the fine aerosol particles having a dimension in the magnitude of 1 micron, which are contained in the air, are highly charged and will largely be retained, owing to such charge, in the depths of the tracheo-bronchial tree. In industrial areas, respiration of unipolarly ionized air may cause toxic substances to deposit on the sensitive respiratory epithelium which, when not charged, are normally almost completely expelled or deposited in the upper portions of the respiratory tract. This may cause the osmosis of oxygen in the respiratory epithelium to be so severely affected that transitory losses of consciousness and symptoms of suffocation are experienced.

This hazard is present principally when the methods summarized under (a) above are employed unless the air passed over the ionizator is not almost completely cleared of suspended particles by means of a so-called absolute filter. With the methods described under (b) hereof it is eliminated if a large portion of the particles having a unipolar charge have with the passage of time, been removed from the air by the electrical space field and deposited on the surfaces delimiting the room and of all objects located in the room. The arrangement for the performance of the method will then, constitute an electrical precipitator device in the room itself, which cleans the air rather efficiently, despite an electrode distance ten to a hundred times larger than in a normal electric precipitator equipment because the air remains between the electrodes many hundred times longer.

By virtue of the method according to the invention, the air of a room is freed from suspended and aerosol particles with particular efficiency if, according to a further object of the invention, several glow or corona discharge devices designed as ion sources are suspended from the ceiling or placed on tables at various points in order to fill the room more uniformly with oxygen ions. They are charged by a D.C. source with adjustable voltage via an internal resistance of at least 10^9 ohms. It is furthermore advantageous to distribute a plurality of glow or corona discharge devices serving as ion sources over the room underneath an intermediate ceiling insulated from the main ceiling and serving as an additional electrode; the negative oxygen ions produced by the said sources are drawn out therefrom into the room by an electrostatic field produced by a negative charge on the intermediate ceiling.

In the said two variants of the method according to this invention, the negative oxygen ions pass directly into the air. However, it must be admitted that the human body is passed by an electrical current directed not downwards as in the positive atmospheric electrical fine-weather field, but upwards. As it is known from the treatment of the human body with galvanic low currents, no favorable physiological effects are obtained with this current direction, it is in many cases advisable to modify the method according to the invention in such a manner that the body is subjected to a vertically downwardly directed field while the negative oxygen ions flow upwards. In this case the glow or corona discharge device serving as the ion sources must be distributed on the floor, or in theaters and lecture halls, in the back-rests of the front seats, or charged by D.C. sources of which the voltage can be adjusted, placed freely on the floor or on low tables below the level of heads. The oxygen ions supplied by the ion sources are drawn, according to a further object of the invention, into the air by means of a positive electrical field generated by means of a

ceiling electrode whereby the intensity of this field may continuously fluctuate between a great value and a low value in a rhythm determined by the distribution of the oxygen ions. The amplitude and cycle of this positive space field must be so adjusted to one another that the negative oxygen ions are drawn out from the ion sources during the interval of low electric field strength are lifted vertically upwards to the head level in the interval of great electrical field strength and, in the subsequent interval of low field strength distributed mainly in the horizontal direction so as to pass into the air in the desired concentration despite a positive residual space charge at head level, by the action of air convection and by diffusion.

A further condition to be met is that the maximum rate of the change in the field intensity of the positive space field in the body does not generate displacement currents larger than those generated in a constant electrical field of 3,000 volts /m. by physical action.

As in the first two variants of the method according to this invention, the oxygen ion concentration in the air is adjusted by the negative operating voltage of the glow or corona discharge devices to the level desired, which is done largely independently of the ozone generation of the discharges. The latter may again be adjusted, independent of the flow of oxygen ions, by means of an adjustable current limiting resistance or a voltage source with adjustable voltage in the A.C. circuit of the discharge electrodes to a value which just suffices to neutralize the odor particles but does not exceed an amount of about $30 \cdot 10^{-12}$ grams of ozone per cubic cm. of air.

In the second and third variants of the method according to this invention it is possible to support the transport of oxygen ions from the individual ion sources by means of a filtered fresh-air or supply air stream. In the third variant, application is dependent thereon if the individual ion source is located behind a protective grid connected with ground.

In the second and third variants, the method enables a comparatively uniform homogeneous supply of oxygen ions to be passed into the entire room, in particular if the ceiling field is rendered homogeneous also in the vicinity of the walls. Homogenization of the ceiling field may, according to the invention, be obtained by a double-layer wall and ceiling covering of which the layer adjacent the wall and ceiling is electrically highly insulating and the layer above it semiconductive.

In order to set up the vertical electrical field by means of an adjustable D.C. source, the semi-conductive layer is provided with two metallically conductive current-supply electrode strips of which the one establishes electrical contact everywhere at the skirting and the other everywhere along the lagging. In order to avoid inhomogeneities of the field at windows and walls, window and wall curtains have their upper and lower means provided with current supply lines of superior semi-conductivity or metallic conductivity which are electrically connected at their level to the semi-conductive wall covering and, respectively, to the said metallically conductive supply electrode strips.

As the particles suspended in the air will gradually be deposited on the ceiling, it is recommended that the semi-conductive ceiling covering be provided with a washable coating which does not noticeably obstruct the ion stream owing to its thinness.

Further objects of the invention appear from the devices described hereinafter for the performance of the method and from the embodiments illustrated in the drawings, in which:

FIG. 1 is a plan view of a form of electrode for practicing the present invention.

FIG. 1-A is a sectional view of the device of FIG. 1 taken along the line A-B of FIG. 1.

FIG. 2 is a diagrammatic circuit of an embodiment according to the invention;

FIGS. 3 and 4 are further embodiments according to the invention;

FIG. 5 is a front view of an electrical electrode arrangement;

FIG. 5-A is a sectional view taken along the line C-D of FIG. 5; and

FIGS. 6 and 7 are schematic representations of rooms in a building showing preferred arrangements of the present invention therein.

The method according to the invention for the production of unipolar ions while preventing the generation of undesired high amounts of ozone is based on a new knowledge concerning the rate of ozone generation as a function of the spatial extension of the glow and corona discharge on an electrode. In an electrode arrangement according to FIG. 1, the glow and corona electrode 3 is designed as a flat and very thin metal film carried by a dielectric insulation sheet 1a. The back surface of the sheet 1a is covered by a metallic counter electrode 2 which is protected by a second insulation sheet 1b. In an embodiment of the electrode arrangement of FIG. 1, the sheets 1a and 1b being of glass having a thickness of about 1 mm. and carrying as electrode 3 a 0.1 mm. thick metal foil affixed to the glass surface in the form shown in FIG. 1. Preferably the foil is made from a metal not easily vaporized, for example, from alloyed steel of the well known trade type V4A. The counterelectrode 2 is made from the same metal and has a thickness of about 0.5 mm. The two glass sheets 1a and 1b are both affixed to the counter electrode 2.

Operating an electrode arrangement according to FIG. 1 by an adjustable high voltage A.C. source, a glow and corona discharge of the so-called stabilized type occurs at sufficiently high voltages, mainly along the edges of the discharge electrode 3. It has been discovered that an electrode arrangement of this design when operated with reduced spatial extension of the discharge to a fraction of one millimeter is suitable for use as an ion source of sufficient yield yet which generate only a negligible amount of ozone. Hence, such an electrode arrangement can be used as an ion source for producing up to 10^6 ions per cubic cm. to the surrounding air by means of an electric field without causing a concentration of ozone exceeding a value of $30 \cdot 10^{-12}$ grams per cubic cm. of air.

An embodiment of the equipment according to the invention suitable for operating an electrode arrangement as described above in connection with FIG. 1 is shown in FIG. 2, comprising a high voltage A.C. source to maintain a glow and corona discharge at the electrode arrangement and a high voltage D.C. source to generate an electric field to withdraw unipolar ions from the discharge to the room surrounding this ion source. The high voltage A.C. source is provided with a high voltage power transformer 5 designed to have a breakdown voltage of at least 5000 volt and an insulation of the windings against the core of at least 10^{11} ohms. The primary winding 4 is supplied by 50 c.p.s. A.C. current from the normal power line, for example at a voltage of 220 volts. The secondary winding 11 is connected at one end to the screen 13 and at its other end through an adjustable resistor 8 to the inner conductor 14a of a coaxial high voltage supply cable for the electrode arrangement. The outer conductor 14b of this cable is connected to the screen 13 which also surrounds the secondary winding 11 of the transformer 5.

The electrode equipment shown in FIG. 2 corresponds to the arrangement of FIG. 1 and is provided with two insulation sheets 1a and 1b enclosing the protected high voltage carrying electrode 2 connected to the inner conductor 14a of the high voltage supply cable, and the glow and corona electrode 3 affixed to the outside surface of the insulation sheet 1a and connected to the outer conductor 14b of the supply cable. The high voltage supply cable is enclosed in a metallic screening or wrapper

14c which is connected to the grounded metallic case 15 of the high voltage equipment.

The high voltage D.C. source comprises a rectifier 12 and a condenser 10 bridged by a potentiometer 9 and is supplied by the secondary winding 11 of the transformer 5. The tap of the potentiometer 9 is connected through a resistor 16 of at least 10^9 ohms to the grounded metal case 15. Depending upon the adjustment of the potentiometer 9, the screen 13, the outer conductor 14b and the discharge electrode 3 carry a lower or higher negative D.C. voltage relative to the case 15 and also relative to the ground. Hence, the adjustable high voltage D.C. source generates an electric field 7 effecting the withdrawing of negative oxygen ions from the ion source (electrode 3) in the direction of the arrows.

To free the outer unprotected discharge electrode 3 from an appreciable A.C. voltage, it is necessary to reduce the capacitance to ground of the electrode 3 and the whole circuit enclosed in the screen 13. It is therefore advantageous to connect the poor earth capacity end of the secondary winding 11 to the screen 13. The screen 13, the enclosed circuitry therein, the outer conductor 14a of the high voltage supply cable and the electrode 3 should have altogether an insulation resistance against the ground of at least 10^{11} ohms.

The embodiment of the invention according to FIG. 2 described above permits control of the enrichment of negative oxygen ions in the air of a room by adjusting the potentiometer 9 and control of the rate of ozone generation and concentration in the air by adjusting the resistor 8.

Another embodiment of the invention is shown in FIG. 3 using the electrode arrangement according to FIG. 1 which is supplied by a high voltage cable 14a, 14b and 14c of the same type as described above in connection with the equipment of FIG. 2. The grounded metal case enclosing the whole equipment and being connected to the metal wrapper 14c of the high voltage cable is not shown in FIG. 3. The high voltage power transformer 27 has a screened primary winding 20 which is connected through a main switch 23 to the input terminals 28. The screen of the primary winding 20 is a part of a screening metal case 21 surrounding the switch 23 and the terminals 28. The screening case 21 is connected to the input plug 29 intended for connection to a grounded neutral line conductor.

The secondary winding 22 is connected at one end to a metal screen 30 enclosing the high voltage A.C. and D.C. sources. This screen 30 is in contact with the outer conductor 14b which is also connected to the discharge electrode 3. The voltage carrying protected counter electrode 2 is connected through the inner conductor 14a and a safety fuse 25 to a step switch 17 for selecting one of different taps of the secondary winding 22 of the transformer 27.

Another step switch 18 with taps on the secondary winding 22 is provided for the high voltage D.C. source comprising a rectifier 31, bridged by a resistor 24, and a condenser 32. The D.C. voltage across the condenser 32 is connected to the screen 30 and to the neutral plug 29, respectively, through the resistor 33 of at least 10^9 ohm. Hence, the discharge electrode 3 carries a negative voltage from this D.C. source, relative to ground.

The step switch 17 is provided with an idle position in which the A.C. current circuit to the counter electrode 2 is interrupted. This position is used for checking the insulation resistance of the electrode arrangement, the high voltage supply cable and the whole circuit enclosed in the screen 30 against ground by means of an electrostatic voltmeter 19 indicating the voltage across the resistor 33. The insulation resistance has a sufficiently high value only when the voltage across the resistor 33, during checking, is low compared with the voltage across the condenser 32.

Furthermore, the voltage across the resistor 33 is a quantitative measure of the number of ions flowing per second from the ion source into the room. If the ion source is freely suspended or mounted in a room, then within a distance of 100 cm. from the ion source a current of 10^5 to 10^6 high mobile negative ions is flowing through an area of 1 square cm. when the voltage across the resistor 33 of about 10^{10} ohms has a value of 20 to 200 volts. It is appropriate to arrange the taps on the secondary winding 22 connected to the step switch 18 in such a manner that the D.C. voltage and the said ion flow is reduced by amounts when switching from the higher to the lower positions, for example, reduced to $\frac{1}{3}$ with each step.

The resistor 24 in the high voltage D.C. source has a high value but being chosen such that the D.C. voltage at the condenser 32 follows fast enough during changing the position of the step switch 18.

The rate of delivered ions may be indicated, in lieu of the electrostatic voltmeter 19, by an electronic counter circuit shown in the embodiment of the invention according to FIG. 4. The high voltage A.C. and D.C. sources enclosed in the screen 30 are identical to the corresponding circuits of the equipment according to FIG. 3. The counter circuit, enclosed in a screen 21a which is a part of the screen 21 surrounding the primary power supply circuit, comprises a cold cathode glow discharge tube 36 having a control electrode connected through a resistor 34 to the resistor 33. The value of the resistor 34 is at least three times larger than the value of the resistor 33. The anode circuit of the tube 36 is supplied by a separate D.C. source comprising the winding 37 of the transformer 27, the rectifier 38 and the condenser 39. The tube 36 is ignited when the condenser 35 is charged to a voltage exceeding the ignition voltage of the tube 36, but is immediately extinguished after an ignition owing to the discharge of the condenser 35 which is slowly charged through the very high resistance of the resistor 34. Each ignition of the tube 36 is visible and gives an indication that, since the preceding ignition, an amount of negative ions has been delivered corresponding to the time constant of the condenser 35 and the resistor 34.

To prevent the flow of an A.C. current through the resistor 33 which could effect a premature ignition of the tube 36 the metallic screen 21a enclosing the winding 37 of the transformer 27 and the whole electronic counter circuit is grounded through the neutral plug 29. Furthermore, the use of control knobs for steps switches 17 and 18 having shafts made of insulation material and grounded metal parts may minimize any influence therethrough.

Designing the circuits according to FIGS. 2, 3 and 4, it is important to minimize the ground capacitance of the metal screen casings 13 and 30, respectively, and to prevent the occurrence of a pricking spark when touching the unprotected discharge electrodes of the ion source during operation. Hence, the metal screen casings 13 and 30 should be surrounded by an insulating plastic case and the grounded metal screens 21 and 21a should be as small as possible in dimensions.

The equipments according to FIGS. 3 and 4 are provided with a safety fuse 25 in the connection to the inner conductor 14a of the high voltage supply cable to the electrode arrangement which is designed to be fused if the glass parts of the electrode arrangement are destroyed, and to interrupt the connection to the high voltage winding of the power transformer. It is pointed out that the electrode arrangement may be surrounded by a strong metal grid connected electrically to the outer metal wrapper 14c of the high voltage supply cable on the premises that the grid is provided with meshes wide enough to allow a sufficient influence from the electrostatic field outside the grid to the discharge electrode inside the grid.

The embodiment of the invention according to FIG. 4 shows an electrode arrangement in form of a glass bulb

or tube 40 being provided on its inside with a conductive layer 41 connected to the inner conductor 14a of the high voltage supply cable and forming the protected voltage carrying electrode. The discharge electrode 42 connected to the outer conductor 14b of the high voltage supply cable being arranged as a winding of thin metal wires or metal strips affixed to the outer surface of the bulb. For example, the glass bulb 40 may have a wall thickness of 0.8 mm. and the winding 42 may be made from a wire 0.1 mm. thick with a distance between adjacent windings of about 4 mm.

It is known that glow and corona discharges when used to produce ions cause a so-called "ion wind" in the direction of the ion flow and hence a return air stream. In order to prevent the return air stream from depositing uncharged dust on the insulating layer or body in the vicinity of the discharge, according to the invention the outer surface of the electrode arrangement is equipped not only with the metallic discharge electrode but the space between adjacent parts of the discharge electrode is covered by a further plane auxiliary electrode which carries a lower voltage relative to ground than the discharge electrode. The auxiliary electrode is designed merely as a depositing electrode for the particles contained in the return air stream. FIG. 5 shows an embodiment of such an electrode arrangement comprising a glass tube 43 having its inside surface provided with a conductive layer 44 as a counter electrode and its outside surface with thin wires 45 of a diameter of about 0.1 mm. to form the discharge electrode. All wires 45 are connected to a conductive ring 46 and extend spirally on the outside surface of the tube 43. The strips 47 of metal foil, which may be cemented to the glass tube 43, being the depositing electrodes for the dust contained in the return air stream and are connected to a second conductive ring 48. The two rings 46 and 48 being the terminals and are supplied with the above mentioned higher and lower voltage, respectively, relative to ground.

FIG. 6 schematically illustrates a room having the features heretofore referred to and wherein a plurality of ion generators 50 are positioned throughout the room at elevations somewhat below the normal head height of a person occupying the room. The ion generators 50, schematically shown, are of the type and construction already described in detail. Numeral 52 indicates a ceiling electrode connected to a source of positive direct current whereby to cause upward migration of the ions generated. While no control means are shown for the potential applied to the electrode 52, it is to be understood that the field strength created thereby is intended to be cyclic for the reasons and with the results already mentioned herein.

FIG. 7 schematically illustrates a second arrangement within a room wherein a false ceiling 54 is provided spaced from the natural ceiling of the room and insulated therefrom by such insulating means as indicated at 56. The intermediate ceiling 54 is preferably at least semi-conductive and is connected to a source of negative potential as indicated. The ion generators 50 are suspended from the intermediate or false ceiling 54 and their glow and corona electrodes are electrically connected to the intermediate ceiling 54.

I claim:

1. Apparatus for enriching the air in a room with negative oxygen ions, comprising: an ion generator having a glow and corona electrode exposed to the air of said room and mounted on one face of a dielectric sheet having a thickness of about 1 mm. and a counter electrode mounted on the other face of said sheet; means for applying an A.C. voltage of the order of 1000 to 4000 volts to said electrodes; means for controlling the amplitude of said A.C. voltage; means for imposing a D.C. electric field through the air space around said generator in said room and comprising a source of D.C. having its positive terminal connected to ground means and its

negative terminal connected to said glow and corona electrode through a resistor of at least 10^9 ohms; and means for changing the amplitude of said D.C. field.

2. Apparatus as defined in claim 1 wherein said air space is defined by means comprising a room having a ceiling; an intermediate ceiling in said room of at least semi-conductive material; said ion generator being carried by said intermediate ceiling, said intermediate ceiling and said glow and corona electrode being electrically connected together.

3. Apparatus as defined in claim 1 wherein said room has a floor and a ceiling; there being a plurality of said generators distributed throughout said room and each being spaced upwardly from said floor a distance less than the normal height of a person's head; said positive terminal of said D.C. source being connected to said ceiling, which constitutes said ground means.

4. Apparatus as defined in claim 1 wherein said glow and corona electrode is a conductive coating of a thickness not over .1 mm. on said one face and arranged thereon to define a predetermined pattern; said counter electrode being a conductive coating on said other face and being covered by an outer layer of insulating material.

5. Apparatus as defined in claim 1 including a further layer of insulating material covering said counter electrode.

6. Apparatus as defined in claim 1 wherein said dielectric sheet is of cup-like shape; said glow and corona electrode being on the outer surface thereof, said counter electrode being on the inner surface thereof.

7. Apparatus as defined in claim 1 wherein said dielectric sheet is in the form of a hollow cylinder; said glow and corona electrode being on the outer surface thereof and having spaced portions; an auxiliary electrode on said outer surface and extending between said spaced portions and being spaced therefrom.

8. Apparatus as defined in claim 1 wherein said D.C. voltage source and a source of A.C. voltage includes a transformer in a grounded metallic case; the ends of the secondary winding of said transformer being connected, respectively to said electrodes; said D.C. source having its negative terminal connected to that end of said secondary winding which is connected to said glow and corona electrode and its positive terminal connected to said case through a resistor of at least 10^9 ohms.

9. Apparatus as defined in claim 8 wherein said sec-

ondary winding is connected to said ion generator through a coaxial cable having its inner conductor connected to said counter electrode and its outer conductor connected to said glow and corona electrode; a conductive shield enclosing said coaxial cable and being connected to said grounded case; a conductive screening case within said grounded case and insulated therefrom, said screening case enclosing said A.C. source, including said secondary winding and being connected to the outer conductor of said coaxial cable.

10. Apparatus as defined in claim 8 wherein said secondary winding includes a plurality of taps; a stepping switch arranged to selectively connect any one of said taps to said counter electrode, said stepping switch further having an open-switch position.

11. Apparatus as defined in claim 8 including an electrostatic voltmeter connected in parallel with that resistor between the positive terminal of said D.C. source and ground.

12. Apparatus as defined in claim 8 including an electronic counter device connected between the positive terminal of said D.C. source and ground.

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