March 7, 1944. V. H. STEEL 2,343,338

METHOD AND MEANS FOR PURIFYING AIR

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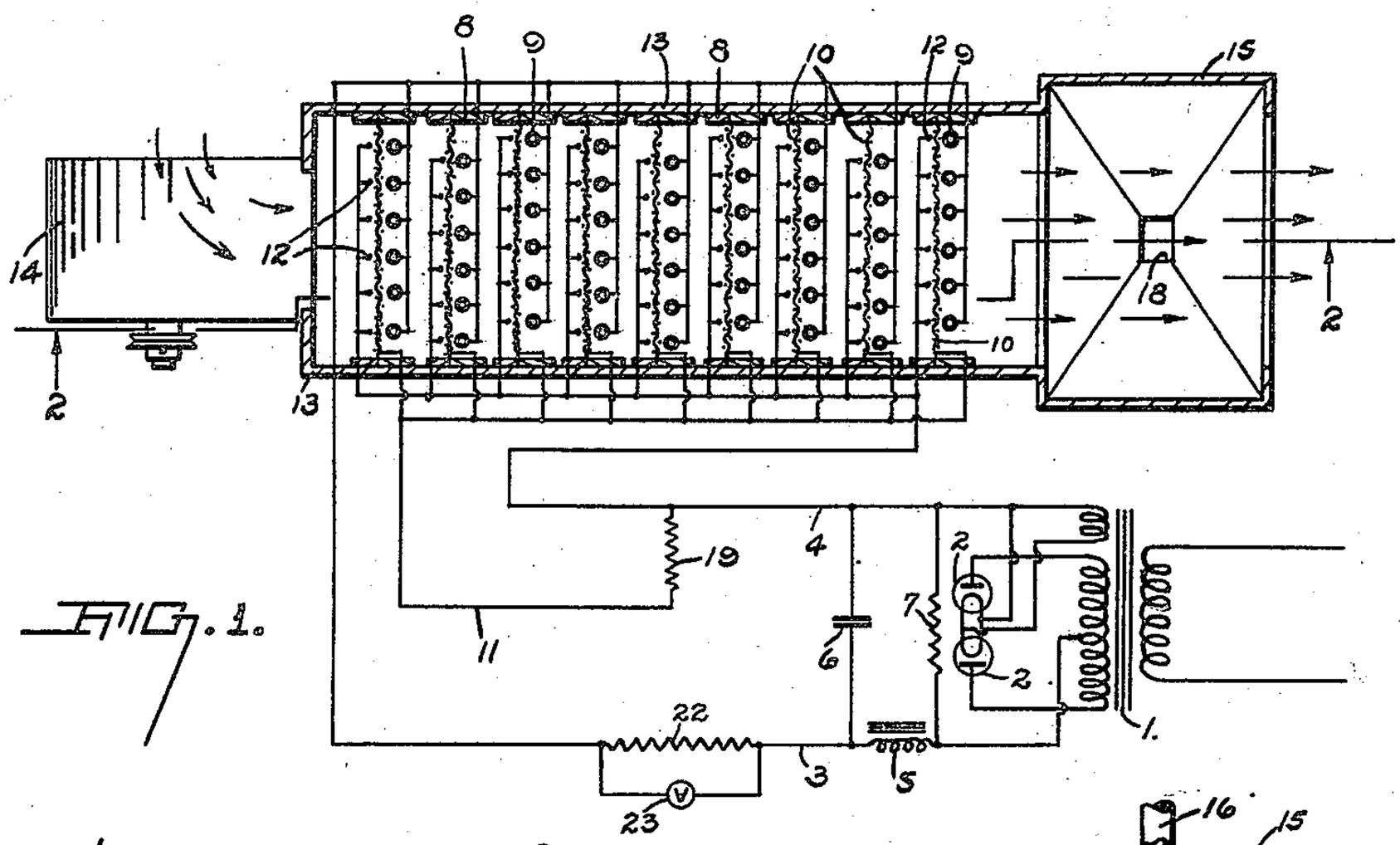

FIG. 1.

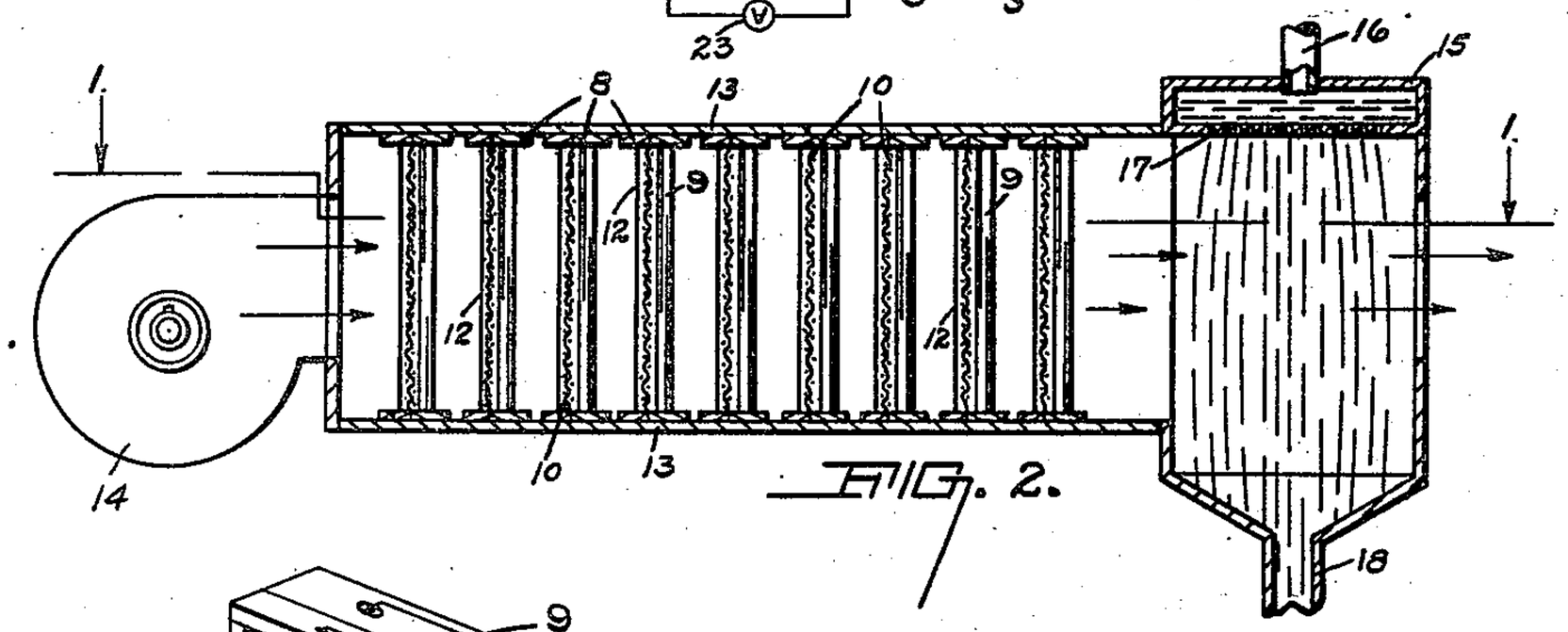

FIG. 2.

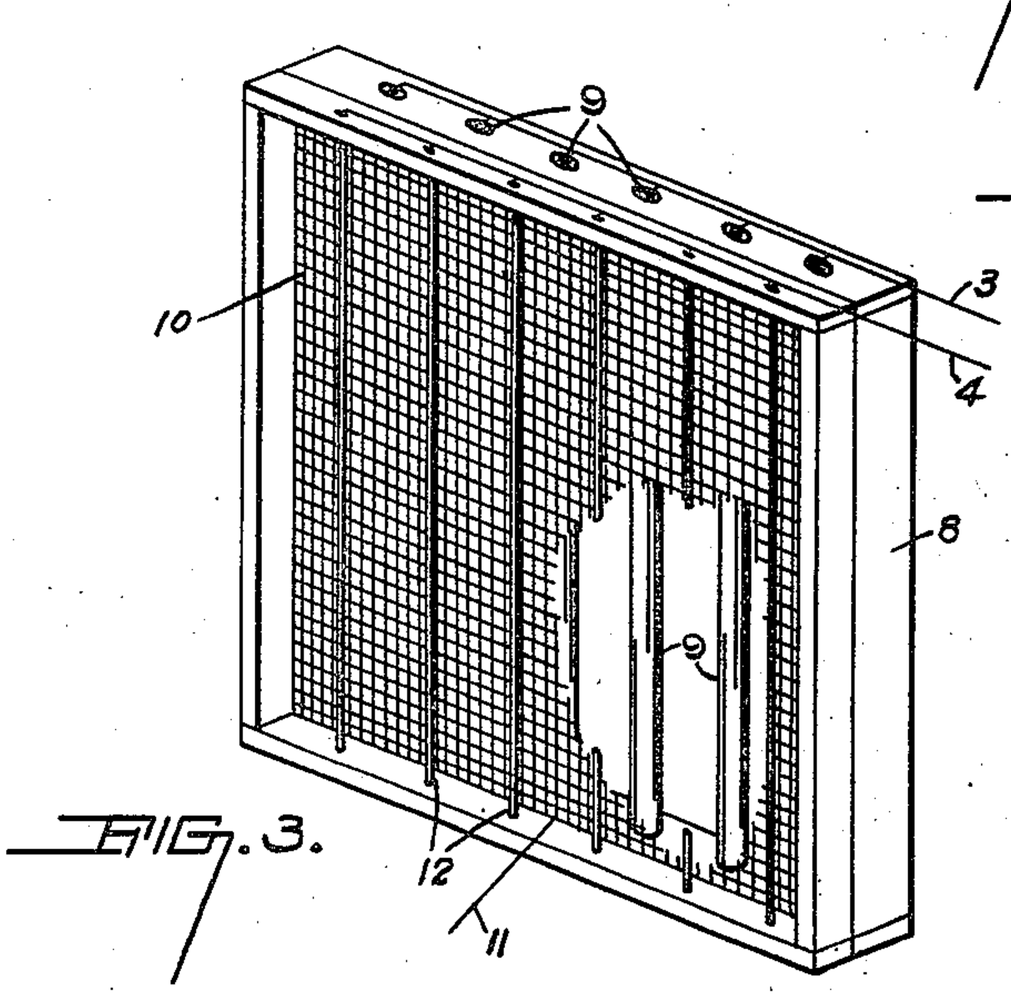

FIG. 3.

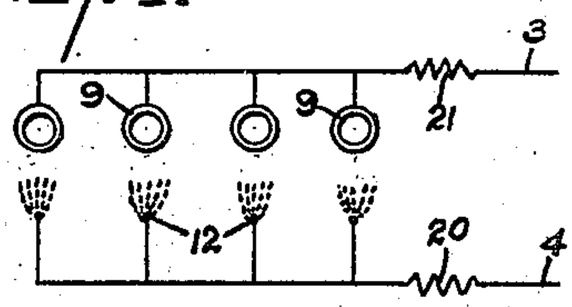

FIG. 4.

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2,343,338

METHOD AND MEANS FOR PURIFYING AIR

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19 Claims. (Cl. 21—54)

My invention relates to air conditioning, and it relates particularly to an improved method of air conditioning and apparatus therefor.

Means for controlling the temperature and humidity of air have heretofore been developed and are in common use. Where it is necessary to change either the temperature or humidity of air in a building with respect to the temperature or humidity outside, economy requires that the air within the building shall circulate in order that only a small amount of outside air need be admitted and treated. But this reduced ventilation results in an intolerable accumulation of odors within the building which limits the extent to which ventilation may be reduced. Thus, if odors can be controlled in a practicable manner, ventilation may be further reduced and a substantial saving over the present practice may be effected.

Attempts have heretofore been made to control odors within buildings by means of chemicals, ozone, and the like. While these expedients have probably been of some value in some cases, they have been objectionable in that the deodorant has itself possessed an objectionable odor, and, inasmuch as it has been difficult to control effectively the application of said deodorants, in many cases they have aggravated rather than improved the odor condition. Moreover, when used in excessive quantities some deodorants heretofore employed have been harmful to persons breathing them, rather than merely unpleasant, and it has been difficult to avoid always the use of excessive quantities.

The principal object of my invention is to provide a method and means whereby air-borne odors may be controlled conveniently and inexpensively without introducing new odors. I achieve this object largely by subjecting the air to an electric field of sufficient intensity to ionize and dissociate the oxygen thereof but of insufficient intensity to produce ozone or nitrogen compounds.

As mentioned, it is desirable to control odors within buildings in order that the amount of ventilation may be reduced thereby reducing the expense of heating or cooling, or of humidifying or dehumidifying outside air. Generally speaking, the amount of ventilation provided at present in buildings occupied by human beings may be considerably reduced without rendering the air in said buildings unhygienic. In other words, the odors which make ventilation necessary are unpleasant rather than harmful.

However, certain mircroorganisms may be carried by the air in a virulent form for substantial distances thereby spreading disease from one person to another. Ordinarily these microorganisms leave the diseased person within minute droplets of liquid emitted upon coughing or sneezing, and further evaporation of the liquid of these droplets results in the formation of minute particles of the nature of Langevin ions, many of which acquire negative electrical charges.

A further object of my invention is to provide a method and means whereby air-borne, disease-producing microorganisms may be destroyed or rendered less virulent. I achieve said object by the method and means hereinafter described for deodorizing air.

In achieving the aforesaid objects, large numbers of positive molecular oxygen ions will be formed. Although these positive molecules probably are not harmful in the weak concentrations occurring in nature, I deem it undesirable that high concentrations of positive molecular ions be released in a room occupied by people. It is, therefore, desirable that the positive ions be neutralized when they have served their purpose of purifying the air of which they are a part and before they are released into the room.

Thus, a further object of my invention is to provide means whereby positive molecular ions may be neutralized, leaving a preponderance of negative molecules. I achieve said object by providing a water spray at the exit of an air passageway wherein ionization occurs. The numerous negatively charged water particles resulting from the well-known Lenard effect quickly neutralize the positive charges of the oxygen molecules.

On the other hand, it is desirable that other agencies that might destroy positive oxygen ions before they reach the aforesaid water spray shall be eliminated in order that said ions may have full opportunity to combine chemically with odoriferous or other foreign matter in the air. Positively charged oxygen molecules are more active chemically than are uncharged molecules. Seemingly it is necessary for electrons to migrate from the substance that is oxidized. Furthermore, it is desirable to prolong as much as possible the life of oxygen atoms formed by dissociation of oxygen molecules coincidental with the formation of positive molecular ions. These nascent oxygen atoms are valuable oxidizing agencies, being very active, but they tend to combine with each other, reverting to molecular oxygen, and should be utilized before so combining.

A further object of my invention is to prolong the lives of both atomic oxygen and molecular oxygen positive ions. I achieve said object by removing surplus electrons by means of an electron trap placed in the vicinity of the positive electrode hereinafter described. As to positive molecular ions, electrons are removed to prevent insofar as possible the formation of negative ions that might neutralize the positive ions. Electrons do not readily unite directly with positive oxygen molecules to neutralize them, nor do electrons unite with nitrogen molecules to form negative ions. But they do unite read-

ily with neutral oxygen molecules to form negative ions, and the latter then neutralize the positive oxygen molecular ions. If some electrons can be removed before they combine with neutral oxygen molecules, more positive oxygen molecules will remain charged until they unite chemically with some foreign material, which is the desired result.

As to the atomic oxygen, the ionization process hereinafter described will result in the formation of positive and negative oxygen atoms, possibly in about equal numbers unless precautions are taken. This would be an undesirable result in that the recombining of oxygen atoms would thereby be facilitated, opposite charges drawing positive and negative atoms together, whereas I desire these atoms to remain in the atomic form until they combine with foreign material. However, by removing surplus electrons the number of negative atoms may be minimized. It is apparent that if a preponderance of positive atoms exists, the re-combining of these atoms will be hindered since their charges repel each other.

I achieve the aforesaid object of prolonging the lives of oxygen atoms and positive molecules in another respect by utilizing in an ionizer a voltage high enough to ionize oxygen, but not high enough to ionize substantial numbers of nitrogen molecules. Inasmuch as there is much more nitrogen in the atmosphere than oxygen, the number of electrons produced is thus effectively minimized thereby achieving a desirable result inasmuch as an electron trap will not be perfectly effective to remove surplus electrons.

I achieve said object in still another respect by arranging the electrodes of an ionizer in such a way that the movement of the air therethru will carry the oxygen atoms and molecules away from the region of highest electron concentration. Electrons are highly mobile under the force of an electric field, achieving a velocity of the order of 10,000 centimeters per second in a voltage gradient of one volt per centimeter whereas molecular ions have velocities in the neighborhood of one or two centimeters per second due to the force of the same field. Electrons move rapidly against the air stream toward the positive electrode and are most concentrated there. I therefore place my positive electrode ahead of my negative electrode so that the air stream passes from positive to negative. The more sluggish atoms and molecules are thus moved away from the electrons, the force of the electric field increasing the movement of positively charged particles.

A further object of my invention is to provide an ionizer that will function substantially independently of minor variations in line voltage. I achieve said result by providing a suitable resistor in series with the electron trap hereinafter described.

A further object of my invention is to produce oxygen atoms and ions uniformly throughout air being treated. I achieve said object by passing said air thru a plurality of electrodes arranged in staggered relation.

Other objects and details of my invention will be described with reference to the accompanying drawing, in which:

Fig. 1 is a horizontal section, taken on the line 1—1 in Fig. 2; of apparatus embodying my invention, the electrical portions thereof being shown schematically;

Fig. 2 is a vertical section taken on the line 2—2 in Fig. 1;

Fig. 3 is a perspective view of a portion of the structure shown in Fig. 1, a portion thereof being shown broken away; and

Fig. 4 is a partly schematic, partly diagrammatic fragmentary view of a modification of my invention illustrating the mode of operation thereof.

Transformer 1, which may be supplied with electrical power from any suitable source, supplies a voltage in the neighborhood of 10,000 volts to each of half-wave rectifier tubes 2 so that about 10,000 volts D. C. is produced between wires 3 and 4, this voltage being maintained substantially constant by choke 5 and condenser 6. I prefer to provide resistor 7 of a suitable type to by-pass a small current to improve the regulation of the foregoing power supply. It will be understood that any other suitable source of direct current may be used, and that the voltage required will vary widely with different arrangements of electrodes, hereinafter described.

Frames 8 are provided with three sets of electrodes. First, metal tubes 9 are all connected together and to tubes 9 of all of the other frames 8 and to wire 3, which I prefer to be the negative wire of the D. C. power supply. Second, a wire screen 10 is mounted in each of frames 8, and all of the screens 10 are connected together and to wire 11. I prefer to make frames 8 of some suitable insulating material and to insulate tubes 9 from screens 10. Third, wires 12 are all connected together and to wire 4. Wires 12 are insulated from both tubes 9 and screens 10. Housing 13 defining a chamber in which frames 8 are arranged may be made of wood, if desired, and blower 14 driven by any suitable source of power, not shown, serves to force air therethru. Frames 8 are all alike except that tubes 9 and wires 12 therein are spaced differently in different frames, as shown by way of example in Fig. 1. The uniform distribution of ions and atoms in the air to be purified is a matter of great importance. Deodorants heretofore used have been introduced into the air in a concentrated form and then diffused mechanically. However, a uniform distribution has not been achieved in this way, and diffusion is even more difficult where atomic oxygen having a short life is utilized. On the other hand, by passing the air thru a plurality of staggered electrodes, oxygen atoms and ions will be present in the immediate vicinity of particles of foreign material to be oxidized.

Although I prefer to stagger tubes 9 and wires 12 in the way shown in Fig. 1, it is not necessary that they be staggered in any particular way. The essential thing is that successive pairs of electrodes shall be out of longitudinal alinement with respect to the air stream in order that ionization and dissociation may occur uniformly throughout the volume of air being treated.

Water box 15 supplied with water from any suitable source thru pipe 16 has a perforated bottom 17 adapted to spray water across the end of housing 13, said water draining away thru pipe 18. I prefer said water box to embody a large number of small perforations in order that a fine spray may be produced. However, if a course spray be allowed to splash as it falls, a similar result will be achieved. Seemingly it is the breaking up of water particles that results in the smaller particles acquiring negative charges. These smaller particles floating in the air constitute a negative space charge, while the corresponding positive charges are carried away by the larger droplets.

As mentioned, screens 10 are all connected to

wire 11. In order that these screens may serve to trap electrons, they should have applied to them a voltage approximating that applied to wires 12, and I prefer to arrange them close to wires 12. It may happen that, due to mechanical imperfections that are unavoidable in inexpensively constructed equipment, one of wires 12 may come in contact with a screen 10. I prefer to supply voltage to screens 10 from the same source that supplies wires 12, that is, from wire 4, but to supply said screens thru resistor 19 which may be of the order of several megohms. Thus, if one of wires 12 comes in contact with a screen, no serious damage will result since resistor 19 will merely be shorted.

However, this arrangement for supplying voltage to screens 10 has other more important functions. Electrons formed in the electric field between the cathode (negative electrodes 9) and positive wires 12 will be attracted to screens 10 and, flowing thru resistor 19, will cause a voltage drop between positive wires 12 and screens 10. In other words, screens 10 will assume a voltage intermediate that of wires 12 and cathode 9, and this intermediate voltage will approximate the natural potential that would be assumed by said screens due to their position in the field intermediate wires 12 and cathode 9. Thus, screens 10 will assume a voltage that ordinarily will disturb the electric field between wires 12 and cathode 9 very little. Nevertheless, a substantial number of electrons will move to said screens, and they will thus serve as electron traps.

Now suppose that, due to normal fluctuations, the voltage supplied to transformer 1 should increase somewhat. Electrons would then be produced in greater numbers because of the increase in voltage between wires 12 and cathode 9, and more electrons would flow to screens 10 and thru resistor 19. The increased voltage drop across resistor 19 would thus decrease the voltage between cathode 9 and screens 10, thus reduce the voltage gradient throughout the whole ionizer and substantially modify the effect of the increased voltage applied to transformer 1. Conversely, if the voltage applied to transformer 1 should decrease, screens 10 would serve to increase the voltage gradient and maintain substantially constant operation of the ionizer.

I will now describe the operation of my invention. The apparatus hereinbefore described may be placed in a room, the air within the room being circulated thru the ionizer. Or, if desired, the apparatus hereinbefore described may be used in conjunction with heating or cooling equipment or the like, air being passed preferably first thru the ionizer and then thru the other equipment. In any case, housing 13 should be of substantial size is order that the air may remain in it for sufficient time to permit oxidation of foreign material.

If a voltage is applied to cathode 9 and the anodes (wires 12), and said voltage is gradually increased, at a gradient of about 10,000 volts per centimeter a few of the electrons that are constantly being freed by cosmic rays and by other agencies will be accelerated by said voltage to a sufficient velocity so that, when they happen to collide with an oxygen molecule, they will have enough energy to remove an electron from said molecule, leaving a positive oxygen molecular ion. More kinetic energy is required for an electron to remove an electron from a nitrogen molecule, and the electrons will not attain enough velocity to ionize nitrogen until a voltage gradient of about 12,500 volts per centimeter is reached, and even with somewhat higher voltages very little nitrogen will be ionized.

The aforesaid electron after being removed from an oxygen molecule by collision with a fast moving electron will itself be accelerated by the voltage and it may collide with other oxygen molecules and thus release other electrons. Thus, as the initiating electron moves toward the anode under the force of the electric field it causes many other electrons to be released, and all of these electrons move substantially together toward the anode in what is commonly called an avalanche. All of the electrons due to one initiating electron will quickly be swept out of the electric field unless they first unite with some other object.

My invention thus functions in a manner somewhat similar to that of the well-known Geiger counter wherein electron avalanches are observed in order to count the initiating electrons thereby counting the cosmic ray bursts or other ionizing agencies. It functions differently, however, in that I desire to ionize by collision as many as possible oxygen molecules without employing a voltage sufficiently high to ionize nitrogen and I therefore encourage the production of initiating electrons at or near the cathode in addition to the initiating electrons produced by natural sources, whereas Geiger counters require that the electron avalanches be distinct in order that they may be counted and therefore the production of electron avalanches by initiating electrons other than those to be counted is prevented insofar as possible. In a Geiger counter, electron avalanches should not overlap, whereas with my invention many electron avalanches may advantageously be produced simultaneously.

In order to encourage the formation of initiating electrons at the cathode, I prefer to make cathodes 9 of substantial size for two reasons. First, in the ionization process hereinbefore described, an electron of some nitrogen atoms will be moved from its normal orbit to an outer orbit comprising a higher energy level where it remains in a more or less stable condition, and is known as a metastable atom. This electron will be readily released if the metastable collides with a metal surface. I therefore make my cathodes large in order that metastables carried along by the air stream may strike said cathodes in large numbers. It will be understood that metastables striking the positive electrode, or anode, would serve no useful purpose inasmuch as the electrons released would merely be drawn to the anode instead of initiating electron avalanches.

Second, I make my cathodes large in order that certain radiant energy may strike them readily, thereby releasing electrons from the metal surface. This radiant energy may be produced by the ionization process, that is, molecules colliding with an electron having insufficient velocity to remove another electron therefrom may have an electron removed to an outer orbit, thereby absorbing energy. When said electron returns to its inner orbit, it gives up this energy in the form of radiation.

Furthermore, electrons may be released at the cathode from points of concentrated field intensity such as exist around dust particles thereon. It should not be thought that my purpose of favoring the release of free electrons at or near the cathode is in any way inconsistent with my purpose of removing surplus electrons in the vicinity of the positive electrodes. It is desirable

that as many as possible electrons be released in order that the remaining molecule of oxygen may be charged positively, and in order that the free electrons may dissociate oxygen molecules within the electric field. After the free electrons have served these purposes, it is desirable that they be removed to prolong the life of the oxygen atoms and positive molecular ions as hereinbefore described.

I prefer screen 10 to be of rather open mesh in order that it may not unduly distort the electric field, providing, however, a substantial surface to serve as an electron trap. If screen 10 is not utilized, it may be desirable to make wires 12 of larger area than the fine wires which I prefer, although a higher voltage will then be required. If screen 10 should not be used, I prefer to provide resistor 20 or 21 (Fig. 4) in series with the electrodes to provide the regulatory function hereinbefore described with reference to resistor 19.

In the ordinary operation of my invention, a minute electrical current will flow in wire 3 due to the electrons attracted to wires 12 and screens 10, it requiring about 6.35×10^{18} electrons to form one ampere. It is desirable to measure this current in order to determine the extent of the ionization and dissociation produced. I prefer to interpose resistor 22 in wire 3 and to measure the voltage developed across said resistor by means of voltmeter 23, which may be of a vacuum tube type, thereby measuring the current in wire 3.

I am aware that resistors have heretofore been interposed in series with the electrodes of Geiger counters for the purpose of measuring the current therein. Superficially, it would seem that these resistors would serve the regulatory purpose for which I provide resistors 20 or 21. However, they would not in fact serve this purpose to any substantial extent inasmuch as said resistors heretofore used have developed a voltage drop of only a small fraction of a volt whereas the voltage applied to the electrodes has been several thousand volts. I provide resistors 20 or 21 of sufficiently high resistance to produce a substantial reduction in the voltage applied to my electrodes when the number of electrons released increases substantially.

In Fig. 4 I have indicated approximately by dots the concentration of electrons due to an electron avalanche. I deem the multiplication of free electrons in these avalanches of great importance, and I prefer to utilize a voltage just high enough to form avalanches of electrons released from oxygen atoms and molecules. At much lower voltages, free electrons will dissociate oxygen molecules into nascent atoms, which are extremely valuable. But at lower voltages there are not enough free electrons produced by natural sources, such as by cosmic rays, to dissociate enough oxygen molecules. However, when these few free electrons produced by cosmic rays are multiplied in avalanches by a voltage high enough to cause ionization by collision, abundant electrons for dissociating oxygen molecules are produced and the oxygen molecules from which these electrons have been removed constitute positive molecular oxygen ions which are themselves valuable oxidizing agents.

I claim:

1. The method of purifying air comprising directing a stream of air thru an electric field, lying between closely spaced positive and negative electrodes, such field being of such intensity as to ionize the oxygen molecules therein but of insufficient intensity to ionize substantial amounts of nitrogen therein.

2. The method of purifying air comprising directing a stream of air thru an electric field, lying between closely spaced positive and negative electrodes, such field being of such intensity as to ionize the oxygen molecules therein but of insufficient intensity to ionize substantial amounts of nitrogen therein, and arranging in said air stream another positively charged electrode spaced from the first mentioned positive electrode, thereby to attract electrons to said second mentioned positive electrode and thereby to remove said electrons from said air stream.

3. The method of purifying air comprising directing a stream of air thru an electric field, lying between closely spaced positive and negative electrodes, such field being of such intensity as to ionize the oxygen molecules therein but of insufficient intensity to ionize substantial amounts of nitrogen therein, and thereafter introducing into and intermixing with said stream of ionized air, finely divided, negatively charged water particles to neutralize positive ions therein.

4. The method of purifying air comprising directing a stream of air thru an electric field, lying between closely spaced positive and negative electrodes, such field being of such intensity as to ionize the oxygen molecules therein but of insufficient intensity to ionize substantial amounts of nitrogen therein, arranging in said air stream another positively charged electrode spaced from the first mentioned positive electrode, thereby to attract electrons to said second mentioned positive electrode and thereby to remove said electrons from said air stream, and thereafter introducing into and intermixing with said stream of ionized air, finely divided, negatively charged water particles to neutralize positive ions therein.

5. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having closely spaced related pairs of positive and negative electrodes lying in said air stream, and means for maintaining a potential difference between said electrodes of such magnitude as to ionize oxygen molecules in said stream of air but of insufficient magnitude to ionize substantial quantities of nitrogen molecules therein.

6. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having closely spaced related pairs of positive and negative electrodes lying in said air stream, and means for maintaining a potential difference between said electrodes, said electrodes, positive and negative, being arranged in spaced but related pairs, the negative electrode of a pair being positioned down stream with respect to its positive electrode.

7. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, and means for directing a stream of air thru said ionizer, said ionizer having closely spaced related pairs of positive and negative electrodes lying in said air stream and being spaced longitudinally and laterally of said stream of air, said electrodes in said stream being arranged out of longitudinal alinement.

8. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having closely spaced related pairs of positive and negative electrodes lying in

said air stream arranged in rows extending across said stream of air, the electrodes in adjacent rows being staggered to produce a maze thru which said stream of air passes.

9. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having positive and negative electrodes, means for maintaining a potential difference between said electrodes, said electrodes, positive and negative, being arranged in spaced but related pairs lying in said air stream, said pairs having a third electrode maintained at a potential intermediate that of said positive and negative electrodes constituting said pair, said third electrode being positively charged.

10. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having positive and negative electrodes, means for maintaining a potential difference between said electrodes, said electrodes, positive and negative, being arranged in spaced but related pairs lying in said air stream, said pairs having a third electrode physically intermediate the positive and negative electrodes and maintained at a potential intermediate that of said positive and negative electrodes constituting said pair, said third electrode being positively charged.

11. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having positive and negative electrodes lying in said air stream, means for maintaining a potential difference between said electrodes, said electrodes, positive and negative, being arranged in spaced but related pairs, said pairs having a third electrode maintained at a potential intermediate that of said positive and negative electrodes constituting said pair, said third electrode being positively charged, being electrically connected thru a resistance element.

12. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having positive and negative electrodes lying in said air stream, means for maintaining a potential difference between said electrodes, said electrodes, positive and negative, being arranged in spaced but related pairs, said pairs having a third electrode maintained at a potential intermediate that of said positive and negative electrodes constituting said pair, said third electrode being positively charged, being electrically connected to said positive electrode thru a resistance element.

13. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having positive and negative electrodes arranged in rows extending across said stream of air, said electrodes, positive and negative, being arranged in spaced but related pairs, the electrodes, positive and negative, constituting rows of related pairs of electrodes being mounted in a common insulated frame with said third electrode lying intermediate said rows and extending the full width thereof.

14. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having positive and negative electrodes arranged in rows extending across said stream of air, said electrodes, positive and negative, being arranged in spaced but related pairs, the electrodes, positive and negative, constituting rows of related pairs of electrodes being connected in each row by a common conductor and being mounted in a common insulated frame with said third electrode lying intermediate said rows and extending the full width thereof.

15. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having positive and negative electrodes arranged in rows extending across said stream of air, said electrodes, positive and negative, being arranged in spaced but related pairs, the electrodes, positive and negative, constituting rows of related pairs of electrodes being mounted in a common insulated frame with said third electrode lying intermediate said rows and extending the full width thereof, the electrodes thus mounted in said frames being fixed at optimum distances with respect to each other in the frame, the electrodes thus mounted being removable as a unit with said frame from said air chamber.

16. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having closely spaced related pairs of positive and negative electrodes lying in said air stream, means for maintaining a potential difference between said electrodes, and a resistance element arranged in series with said positive and negative electrodes interposing sufficient impedance to maintain voltage drop across said resistance element to prevent the production of excess electrons.

17. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having closely spaced related pairs of positive and negative electrodes lying in said air stream, means for maintaining a potential difference between said electrodes, and a spray head adapted to produce finely divided water particles in said air stream to neutralize the positive molecular ions in said air stream.

18. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having closely spaced related pairs of positive and negative electrodes lying in said air stream, means for maintaining a potential difference between said electrodes, and a spray head adapted to produce finely divided water particles in said air stream to neutralize the positive molecular ions in said air stream, said spray head being arranged in said chamber down stream from said ionizer.

19. An air purification apparatus defining a chamber, an ionizer arranged in said chamber, means for directing a stream of air thru said ionizer, said ionizer having closely spaced related pairs of positive and negative electrodes lying in said air stream, means for maintaining a potential difference between said electrodes of such magnitude as to ionize oxygen molecules in said stream of air but of insufficient magnitude to ionize substantial quantities of nitrogen molecules therein, and a spray head adapted to produce finely divided water particles in said air stream to neutralize the positive molecular ions in said air stream, said spray head being arranged in said chamber down stream from said ionizer.

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