

March 5, 1935.

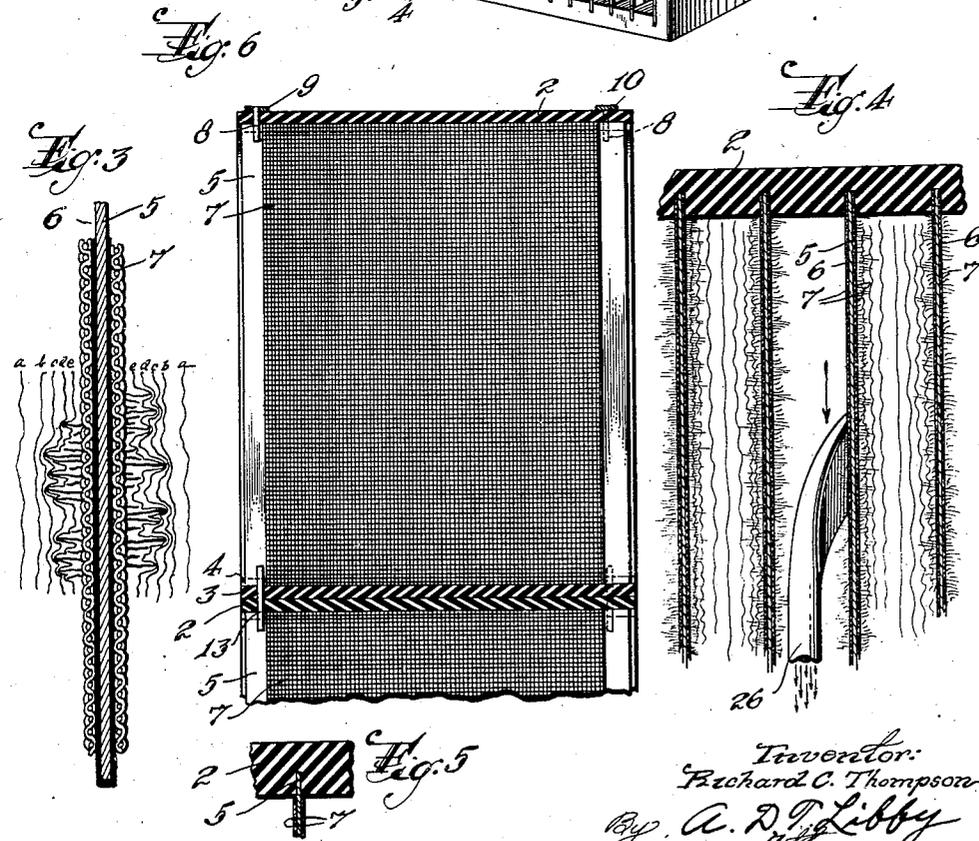
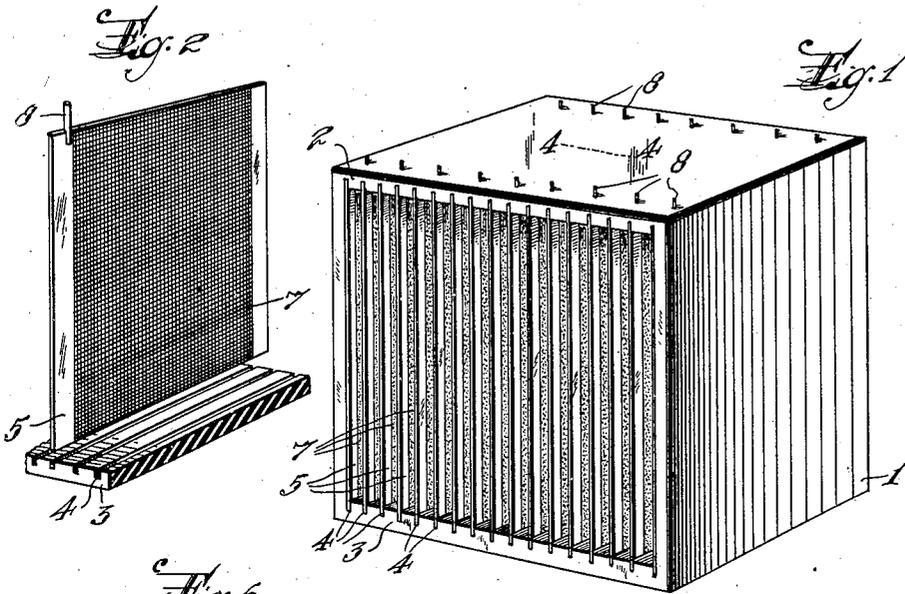
R. C. THOMPSON

1,992,974

ELECTROSTATIC PRECIPITATOR

Filed March 18, 1931

3 Sheets-Sheet 1



Inventor:
Richard C. Thompson
By A. D. Libby
Attorney

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3 Sheets-Sheet 2

Fig. 7

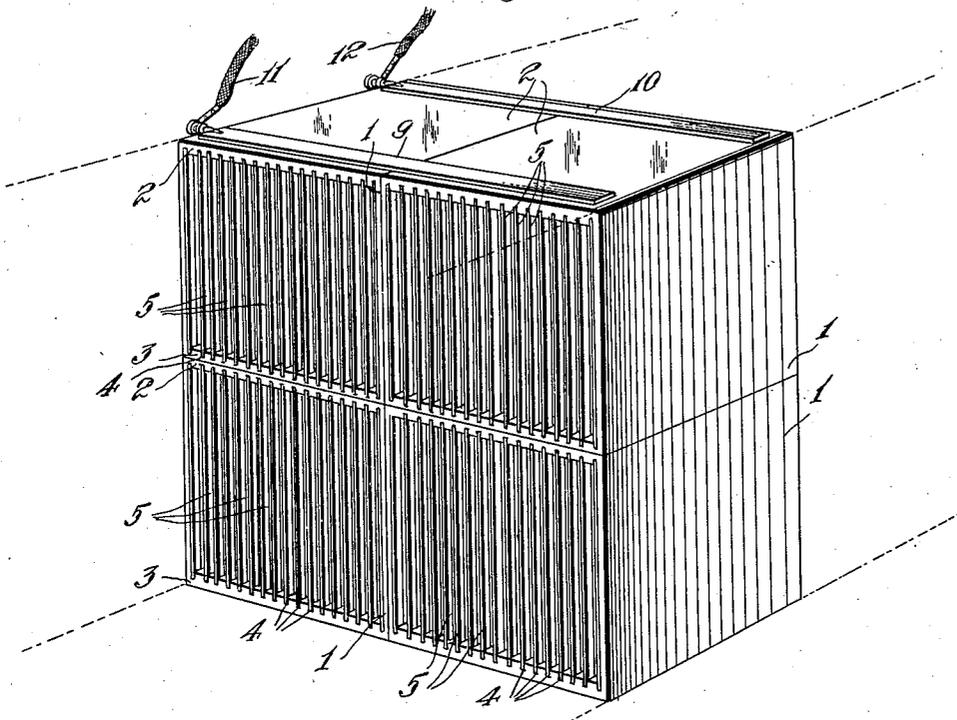
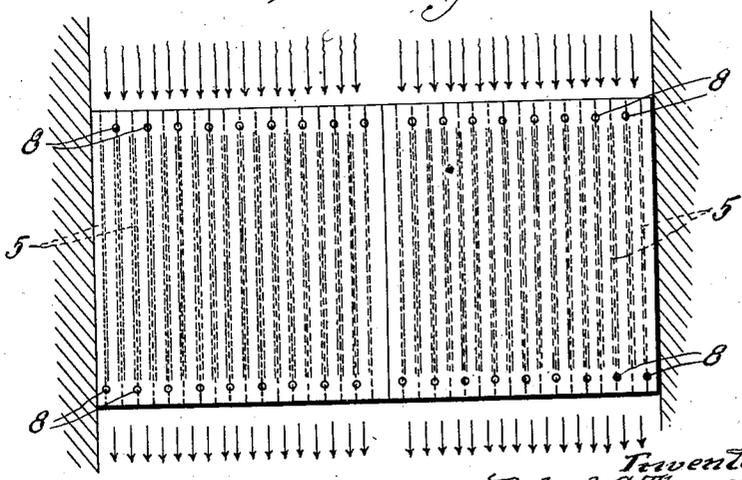


Fig. 8



Inventor
Richard C. Thompson
By A. D. Libby
Attorney

UNITED STATES PATENT OFFICE

1,992,974

ELECTROSTATIC PRECIPITATOR

Richard C. Thompson, Woodmont, Conn., assignor, by mesne assignments, to Thompson Engineering Company, Newark, N. J., a corporation of New Jersey

Application March 18, 1931, Serial No. 523,451

16 Claims. (Cl. 183-7)

This invention relates to means for removing particulate matter from a stream of gas, particularly air, where the material is suspended in the gas or air and consists of finely divided particles.

My invention is particularly useful in the cleaning of ordinary atmospheric air for use in the ventilation of buildings as distinguished from the methods used in cleaning the dust or fumes that arise in manufacturing plants, such as discharges from smoke stacks or the like.

Generally speaking, air cleaning for ventilation is of two general types:

One type, known as the viscous film cleaner, utilizes metal surfaces which are coated or wetted with some viscous fluid such as oil, and which are placed in the air stream so as to force the air to wipe over these oil-coated surfaces. The air, while passing through the device, is forced around sharp turns and the dust particles therein are thrown against the oil film and get stuck therein much the same as a fly is caught in the familiar "Tangle-foot". This method of air cleaning has many limitations as will be apparent to one skilled in this art without specifically reciting them.

The second type of air cleaner can be classified as a strainer in which the air stream is passed through porous material such as cloth or paper which is held in frames of various shapes and designs. These kinds of filters have numerous objections, one of which is the limited length of usefulness of the materials employed, as the pores or interstices rapidly fill up, finally stopping the flow of air. Where paper is used, the straining medium is thrown away, or where cloth is used, cleaning or washing operations must be performed at more or less frequent intervals. Other objections will be apparent without enumeration.

In the industrial field, in addition to the above methods, air cleaning has been performed in one of two other ways:

First, by means of the centrifugal dust arrester or "cyclone" with which the dust or dirt is removed somewhat on the principle of the cream separator.

Another method used in the industrial field, is known as the electrostatic precipitation method in which rather high potentials are used and the dust particles are driven to collecting electrodes by a bombardment of ions, which is evidenced by the corona discharge which is characteristic of an installation of this kind.

While my present invention may be classed with

the last-mentioned type of gas or air cleaner, it should be kept in mind, when reading the description which follows, that my apparatus functions altogether differently from the conventional electrostatic precipitator, in that it works purely on the principle of electrostatic attraction such as is evidenced by the process of picking up a piece of paper with a comb that has been rubbed over a woolen surface, as opposed to the dynamic driving of particles in a field of active discharge. As far as I am aware, this principle has never before been employed in dust arresters.

It is therefore one of the objects of my invention to provide a method of cleaning air for ventilation purposes by utilizing the principle or principles of electrostatic attraction in such a way that there is no corona discharge, thereby avoiding what is inevitable if a corona is formed; namely, the generation of ozone and various oxides of nitrogen which are objectionable, and in fact, absolutely intolerable in air that is to be breathed.

It is another object of my invention to provide an apparatus in which the potential employed is relatively low, thereby avoiding the inconvenience and danger of extremely high tension apparatus, and furthermore able to operate very economically as regards current consumption.

Another object of my invention is to provide an apparatus which is effective in its operation, especially as regards the very smallest particles; one that is simple and easy to manufacture and install, and furthermore easy to keep clean and maintain in order.

A further and general object of my invention is to provide an apparatus for the purpose described which overcomes all the objectionable features which at present are in the types of cleaners heretofore referred to.

Other objects will be apparent to one skilled in this art on reading the specification taken in connection with the annexed drawings, wherein:

Figure 1 is a perspective view of a cleaner unit which may be used individually or in combination with other units to build up a cleaner of any desired capacity.

Figure 2 is a perspective fragmentary view showing one of the plates positioned in a portion of the casing shown in Figure 1.

Figure 3 is a somewhat diagrammatical view of one of the plates, showing the manner of insulating the fibrous material used on the plate and the manner of electrification thereof.

Figure 4 is a partial view through the casing

along the lines 4—4 of Figure 1, showing one manner of cleaning the plates; the plates that are shown, except a part of one, being in the condition just before cutting off the electrification.

Figure 5 is a fragmentary view showing a modified form of carrying the plate in the insulator at the top of the casing.

Figure 6 shows a section through the casing parallel to one of the plates, and illustrates how two casings may be placed one above the other.

Figure 7 is a perspective view of a combination of four of the units as illustrated in Figure 1.

Figure 8 is a diagrammatic view showing a part of the air stream through a pair of the units such as shown in Figure 7.

Figure 9 is a diagram of one method of obtaining the required potential and its application to the dust precipitator.

Figure 10 shows a modified form of obtaining the potential used in connection with the dust precipitator.

Figure 11 shows a modified form of arranging plates carrying the fibrous material, alternate plates being of insulating material.

Referring now to the details wherein like numbers refer to corresponding parts in the various views, 1 is a casing made up of any suitable insulating material preferably having non-hygroscopic properties. The top and bottom portions 2 and 3 are provided with preferably parallel slots 4 within which are positioned plates 5. The plates 5 are of metal and as shown in Figure 3, are preferably covered over the surface with an insulator 6. The plates 5 may be ribbed, if desired, to give stiffness. The insulator 6 may be varnished cambric or the like, or a baked enamel, or a suitable lacquer. This sort of insulation applied directly to the plate, I have found to be very effective in that it prevents excessive use of current when the gas to be cleaned has a high relative humidity. As far as the precipitation of dust is concerned, this insulator has little or no effect, but it does prevent the leakage of electricity over the surface of the dielectric material forming the supporting frame for the precipitator plates; hence the requirement of high resistance rather than high dielectric strength.

After the plates 5 have been insulated by the insulator 6, they are covered by a coating 7 of fibrous material. This coating may be fastened to the plates 5 in any of a number of ways, such as by stitching through holes in the plates, or cementing to the plates as shown in Figure 4, or preferably to the insulation 6. I have used paper-like material manufactured from bagasse, a cellulose acetate cloth having a texture similar to canton flannel, turkish toweling, and poorer grades of plush, but so far I have found the cheaper grades of burlap to be the most satisfactory.

After the plates have been prepared in the manner described, they are assembled with the casing to provide a complete unit as shown in Figure 1. In the assembly, all the plates 5 are alternately arranged so that there are two rows of terminals 8 on opposite sides of the unit whereby the one polarity of an exciting source of current may be attached to all the terminals in one row, and the opposite polarity of the source of current attached to the other row of terminals as indicated in Figures 9 and 10.

In Figure 4, the plate 5, with the insulation 6, is carried into the slots 4 in the casing member 2, whereas in Figure 6, only the edge of the plate 5 is carried into the casing member 2.

I have found that by arranging the plates 5 substantially one inch apart, in the manner shown in Figure 1, I get very satisfactory results by applying to the opposite sets of plates, a potential of approximately ten thousand volts, and passing the air being cleaned through at a velocity not exceeding 700 ft. per minute. The plates 5 may be of any desired area, but I prefer to make up these electrode plates to about fifteen inches square, so that the complete unit contains approximately fifteen of these plates, while the sides of the container may also be equipped with burlap. This construction provides a unit that is very light and therefore very easy to handle not only in the manufacture, but in the shipping and installation, and a number of these units may be put together in combination to give the desired amount of surface to handle the air required for any particular job. In the case of installations of any considerable size, the units may be arranged with various proportions in horizontal and vertical rows, thus giving great flexibility of shape to meet the exigencies of available space.

In Figure 7, I have illustrated four or these units in combination. It will be seen that conductor strips 9 and 10 are used to connect the terminals 8 together whereby the opposite poles of the source of exciting potential may be connected to strips 9 and 10 by the conductors 11 and 12. The units may be attached together by various mechanical arrangements, but as shown in Figure 6, terminal pins 13 are used as dowels between the bottom strip 3 of one unit and the top strip 2 of another unit, at the same time serving to electrically connect those plates which are in the same vertical row. The connecting strips 9 and 10 fastened to the terminal pins 8, anchor the top parts of the units together. The pins 8 are therefore preferably identical with pins 13, and will serve just as pins 13 do, if another unit were on top of these two.

In order to provide the necessary current for use in connection with my air cleaning apparatus, I have provided an inexpensive way of obtaining this from the ordinary lighting circuit which, as shown in Figures 9 and 10, is 110 volt 60 cycle A. C. In Figure 9, the switch 14 controls the supply current to a pair of transformers 15 and 16 which furnish filament current to rectifier tubes 17 and 18 which may be of the well-known type on the market such as the De Forest 866. A control switch 19 supplies current to a potentiometer 20 from which a step-up transformer 21 is supplied with any voltage within the range of the potentiometer 20. The secondary of the transformer 21 delivers up to ten thousand volts, which current is rectified by the rectifiers 17 and 18, a current filter system being provided by a plurality of condensers 22 shunted by high resistances 23, a choke coil 24 and resistances 25 completing the filter. The leads 11 and 12 coming from this source of supply lead to the air cleaner.

In Figure 10, two 566 type rectifiers are used in series on each side of the circuit, and in this arrangement, from ten to twenty thousand volts may be obtained for the purpose to be hereinafter referred to. In this arrangement, twenty pairs of condensers are used, each shunted by high resistances of the order of five hundred thousand ohms.

Either arrangement shown in Figures 9 and 10 provides a simple and inexpensive manner of obtaining a source of current for exciting the plates of the precipitator which is marked P in these diagrams. Because of the principle on which 75

my precipitator operates, the amount of power required is very low and can be obtained in the manner described. Why this is true, is explained in detail below.

Coming now to the operation of my apparatus, it will be understood that the unit shown in Figure 1, or any combination of units such as shown in Figure 7, is positioned so as to receive the gas or air brought to it by a suitable duct through which the air is driven by the usual fan or pump.

With the potential applied to the precipitator from the source and in the manner described, the multitudinous number of fibers lying on the surface of the fibrous covering 7, are excited or caused to "stand out" under the electrification in a manner somewhat as shown in Figures 3 and 4. If the air is not moving, any particle of matter in suspension therein, would start in motion substantially at right angles to the plate, but since the air is in motion, the particle takes a path which is the resultant of the two forces working on it; i. e., the motion of the air in which it is floating, and the pull of the electrostatic field. The particle is thus drawn over on to the surface of the electrode 5. Were the fibrous covering 7 not on this electrode, and were the particle a sufficiently good conductor of electricity, the instant it touched the electrode, it would receive a charge from it and be repelled by the same forces that had just drawn it over. It would then cross to the opposite electrode, where it would receive an opposite charge, be repelled, and so on until the air stream carried it out of the machine.

This difficulty must be overcome by some treatment of the electrode surface so that once the particles have reached it, they either cannot get away or are not repelled. For example, we might use a sticky surface such as a film of viscous substance. This presents certain difficulties in cleaning, and I have found that a fibrous covering will accomplish the same purpose. My explanation of why this is so, follows:

From observation based on many experiments and tests, it appears that the field of electrification may be represented somewhat as illustrated in Figure 3, wherein the lines *a, b, c, d, e*, represent equi-potential lines, the potential being the lowest along the line *a*. The particle crosses the lines of equi-potential at an oblique angle, and since the points of the fibers are extremely small as compared with the area between the fibers, the particle will, by virtue of its own momentum, pass into the field below the line *e*, and finally end up on the side of one of the projecting fibers. Once here, it is in a sense shielded from electrostatic forces, for while they may tend to repel it from the particular fiber on which it lands, the charges on fibers adjacent exert an equal force to make it stay where it is; consequently, these forces cancel each other. The air stream, taking the path of least resistance, does not penetrate into the space between the fibers, and the particle therefore simply sticks where it stops by natural adhesion—just as it might stick to the side of a wall. It will be seen by the foregoing that the only electricity actually used is that required to charge the particles. This is in sharp contrast to the precipitators at present employed, which are so designed as to actually drive an electric current through the gas being cleaned.

After a time, of course, the fibers become coated with the particulate matter and must be cleaned.

In the cleaning operation, the gas or air current is stopped and the current cut off the precipitator.

The plates 5 may be removed from the casing and cleaned in any satisfactory manner, or a specially shaped nozzle 26 connected to any conventional vacuum cleaner may be utilized as indicated in Figure 4, where the movement of the nozzle 26 over the surface of the fibrous material 7 has drawn the dust from between the fibers and caused these to lie down more or less closely, but will not prevent their standing outwardly again when the potential is next applied. As shown in this figure, the plates are shown—except on the one plate above the nozzle—with the fibers in electrified position. However, I may use a full automatic cleaning arrangement, but this mechanism is not shown and described herein but forms the subject matter of another application.

While I have shown the plates arranged in a vertical manner, they may be placed horizontally. I may alternately arrange conducting and non-conducting plates both similarly coated with fibrous material. This arrangement is shown in Figure 11 wherein plates 5' are insulating material and therefore are non-conducting. The conducting plates are charged with opposite potentials, the non-conducting plates placed midway between the active ones acquiring surface charges by induction. With this combination, I have found a spacing between the active plates of 1½ inches and a potential of 17,500 volts to be very satisfactory. I have obtained excellent results by spacing the plates as herein set forth and using the voltage specified, but I do not wish it to be understood that the figures be strictly adhered to.

Hence, it will be apparent that the mechanical details for carrying my invention into practice may be varied over a considerable range, and I therefore do not want to be unduly limited in the interpretation of the appended claims.

Having thus described my invention, what I claim is:

1. An apparatus for the work described, including a plurality of metallic plates arranged in parallel relationship and directly covered with fibrous material, the fibers of which are sufficient in number and length to trap and hold the dust particles attracted thereto from the air stream as described, means for passing a stream of air to be cleaned between said plates, means for supplying a source of D. C. current of a voltage insufficient to cause generation of objectionable gases in any appreciable quantity in the air being cleaned and applying it to alternate plates, said plates being spaced apart so said potential difference will thoroughly electrify said fibrous material.

2. An apparatus for the work described, including a plurality of flat metallic plates arranged in parallel relationship, said plates being first covered with a relatively thin but high-resistance insulating material for the purpose described and then covered with fibrous material, the fibers of which are sufficient in number and length to trap and hold the dust particles attracted thereto from the air stream as described, means for applying a source of D. C. potential of the order of approximately 10,000 volts to alternate plates, said plates being spaced apart so said potential difference will thoroughly electrify said fibrous material without generating gases in any appreciable quantity objectionable to breathing.

3. A unit for an apparatus for the work described, including; a casing with two open ends, a plurality of metallic plates arranged in parallel relationship within the casing and extending be-

tween said open ends, said plates being directly covered with a fibrous material, the fibers of which are sufficient in number and length to trap and hold the dust particles attracted thereto from the air stream as described, and means for applying the opposite poles of a suitable source of direct current to alternate plates, said plates being spaced so that in combination with the potential of the source of current, no gases in any appreciable quantity objectionable for breathing purposes will be formed in the air passing between the plates.

4. A unit for an apparatus for the work described, including; a casing with two open ends, a plurality of metallic plates arranged in parallel relationship within the casing and extending between said open ends, said plates being first covered with a relatively thin but high-resistance insulator and then with a material having a multitude of fibers capable of "standing out" and attracting particles thereto when electrified, and means for applying the opposite poles of a suitable source of direct current to alternate plates for electrifying said fibers for the purpose described, said plates being spaced so that in combination with the potential of the source of current, no gases in any appreciable quantity objectionable for breathing purposes will be formed in the air passing between the plates.

5. A unit for an apparatus for the work described, including; a casing with two open ends, a plurality of metallic plates arranged in parallel relationship within the casing and extending between said open ends, said plates being covered with at least a fibrous material having a multitude of fibers of various lengths projecting therefrom, the length being sufficient to trap and hold particles attached thereto and means for applying the opposite poles of a source of direct current to alternate plates, the potential of said source being high enough at the spacing of the plates to produce electrification of said fibers sufficient to remove particulated matter from the gas to be cleaned, but low enough to prevent the formation of gases in any appreciable quantity objectionable to breathing, such as ozone.

6. An apparatus for the work described comprising a plurality of units as set forth in claim 5.

7. An apparatus for the work described as set forth in claim 5, further characterized in that the plates are so carried by the casing that the fibrous surfaces may be cleaned.

8. The process of cleaning air for breathing purposes by the electro-static method which consists in passing streamlets of the particle-laden air between a series of parallel plates covered by a fibrous material having the characteristic of "standing out" sufficiently to attract and hold particles in the passing air, and electrifying the fibrous material to a uni-directional potential which will attract the particulated matter in the air without generating gas, such as ozone, in any substantial quantities objectionable to breathing.

9. The process of cleaning air for breathing purposes by the electro-static method which consists in passing streamlets of particle laden air between a series of parallel plates covered by a relatively thin but high-resistance insulator, and a material having a multitudinous number of movable fibers, and electrifying the fibrous material to a uni-directional potential which will attract the particulated matter in the air without generating gas, such as ozone, in any substantial quantities objectionable to breathing.

10. An apparatus for the work described composed of a plurality of units as set forth in claim 5, further characterized in that means are provided whereby the placing of the units together in group relationship automatically makes the proper electrical inter-connections between the plates comprising the electrodes of the several units.

11. An electrostatic precipitator for cleaning air to be breathed including a plurality of electrodes positioned so as to have a stream of air to be cleaned passed by them, means for applying electric charges to said electrodes whereby particles in the air will be energized and drawn toward the electrodes without generation of an objectionable amount of noxious gases in any appreciable quantity objectionable to breathing, the surfaces of said electrodes being such as to hold the particles, when they reach the electrodes, against opposing electrostatic action.

12. An electrostatic precipitator for the purpose described including; a plurality of spaced alternately conducting and non-conducting plates both similarly coated directly on opposite sides with fibrous material, the alternate conducting plates being connected to be charged with opposite potentials, said non-conducting plates acquiring surface charges by induction from said conducting plates, and means for charging said conducting plates from a source of direct current.

13. An electrostatic precipitator for cleaning air for breathing purposes including; a plurality of metal plates positioned to have a stream of air pass between them, sheets of dielectric fibrous material of the character described directly fastened to opposing sides of said plates, said plates being adapted to distribute a static charge to said fibrous material to attract and hold particles from the air stream thereto, and means for charging said plates from a suitable source of direct current, said plates being spaced so that in combination with the potential of the charging means, gases in any appreciable quantity objectionable for breathing purposes will not be formed in the air between the plates.

14. An element for an electrostatic precipitator for cleaning air for breathing purposes including; a metal plate directly covered on opposing sides with material having a multitude of relatively long fibers adapted to "stand out" and attract and hold particles from the air thereto, on application to the plates of a suitable potential which will not produce gases in any appreciable quantity objectionable to breathing.

15. An element for an electrostatic precipitator for cleaning air for breathing purposes including; a metal plate insulated by a relatively thin but high-resistance insulator and provided with an outer covering of material having a multitude of relatively long fibers adapted to "stand out" and attract and hold particles from the air thereto, on application to the plate of a suitable potential which will not produce gases in any appreciable quantity objectionable to breathing.

16. An electrostatic precipitator as set forth in claim 13, further characterized in that the plates are so mounted and positioned, that the fibrous material associated with them may be cleaned by causing a relative movement between the plates and a vacuum cleaning nozzle.

RICHARD C. THOMPSON.

CERTIFICATE OF CORRECTION.

Patent No. 1,992,974.

March 5, 1935.

RICHARD C. THOMPSON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 24, for "or" read of; page 4, first column, line 38, claim 5, for "attached" read attracted; and second column, line 46, claim 13, after "air" insert the word passing; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 9th day of April, A. D. 1935.

Leslie Frazer

Acting Commissioner of Patents.

(Seal)