April 3, 1934. O. U. LAWRENCE 1,953,082

ELECTRICAL PRECIPITATION

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Fig. 1.

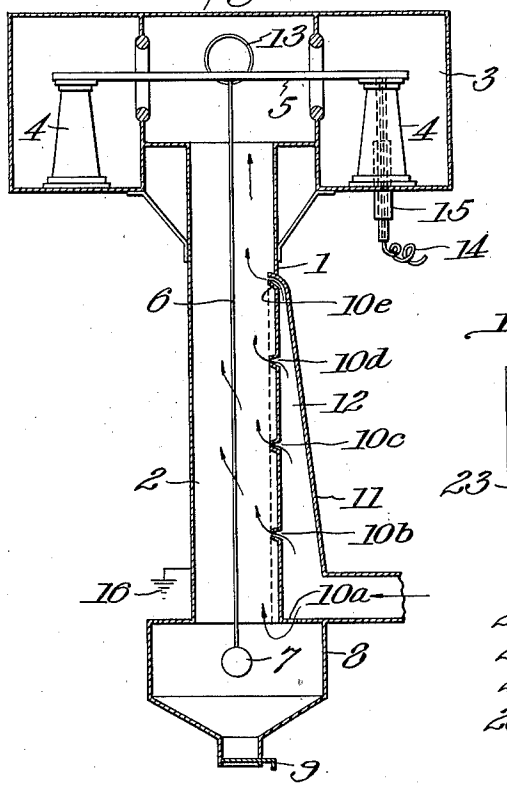


Fig. 2.

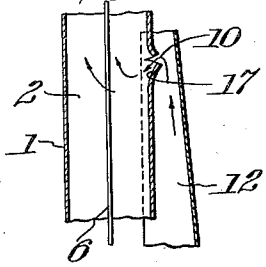


Fig. 3.

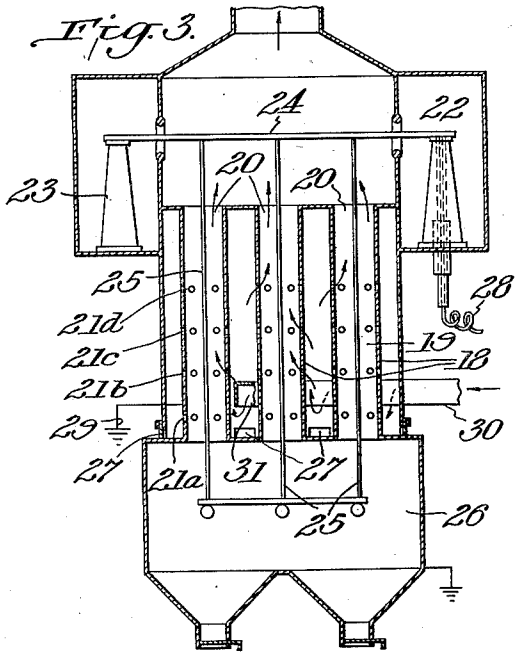


Fig. 4.

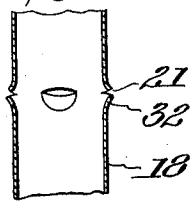


Fig. 6.

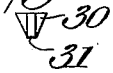
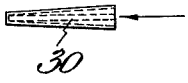


Fig. 5.



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Fig. 7.

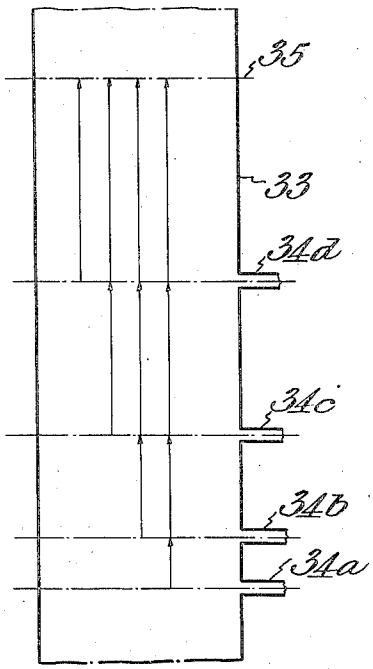
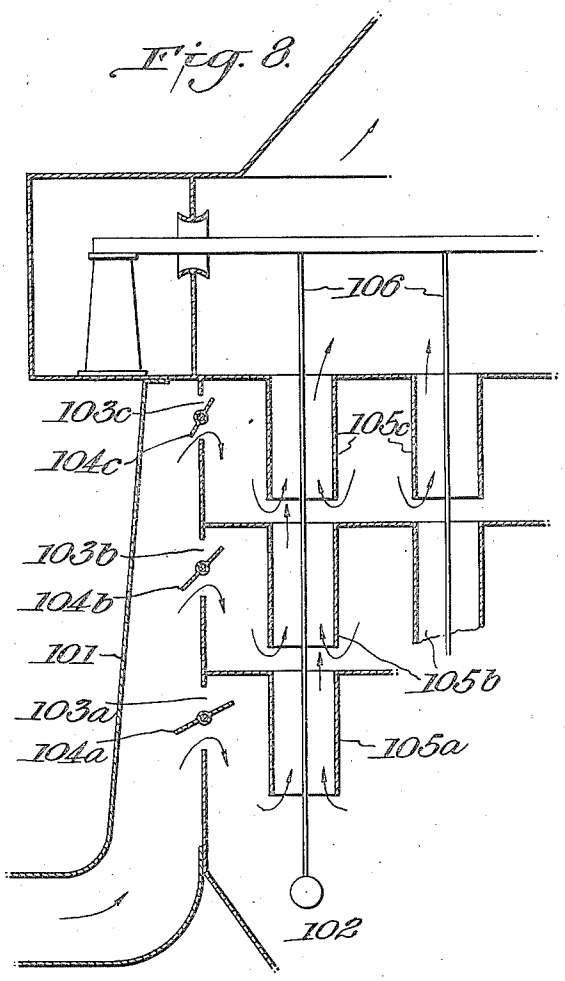


Fig. 8.



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UNITED STATES PATENT OFFICE

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ELECTRICAL PRECIPITATION

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Application August 31, 1932, Serial No. 631,257

12 Claims. (Cl. 183—7)

This invention relates to a method of and apparatus for electrically precipitating suspended particles from a gas. More particularly the invention relates to a method and apparatus wherein portions of the gas to be treated are introduced into the separation chamber at different points along the path of flow of the gas through the chamber.

In electrical precipitation processes wherein suspended matter is removed from a gas by passing the gas through an electric field, it has been found that the electrical characteristics of the gas are very materially affected by the presence of minute solid particles and/or minute droplets of liquid. The conductivity of the gas has been found to vary considerably with variations in the character and concentration of the suspended matter and this variation has been very troublesome to designers and operators of electrical precipitation apparatus.

In the processes as now carried out, all of the gas is admitted at one end of a separation chamber and carries with it into the chamber all of the suspended matter which must be removed. The greater part of the suspended matter is removed during the passage of the gas through the first portion of the separation chamber and hence the concentration of the suspended matter is much less in the last portion of the chamber than in the first portion; thus with certain types of suspended materials and/or relatively high concentration of suspended material, the electrical conductivity of the gas varies considerably throughout the chamber.

This condition is undesirable as the concentration of suspended matter in the first portion of the separation chamber is often so high that a sufficiently high voltage to precipitate the suspended matter cannot be maintained between the electrodes in this portion of the chamber and considerable suspended matter passes into the last portion of the chamber. As it is necessary, from practical considerations, to maintain a uniform voltage drop between electrodes in all portions of the chamber, and the voltage in the second portion of the chamber is thus limited by the voltage in the first portion of the chamber, the voltage in the second portion of the chamber may well be insufficient to precipitate all of the suspended matter and thus much of the suspended matter is not recovered.

A theoretically ideal precipitator would be one wherein the concentration of suspended matter would be uniform through the entire length of the ionizing field and would become zero at a point in the chamber just beyond the limit of the field. It is obvious that such a condition would be very difficult, if not impossible to attain; in view of practical difficulties, however, in the method of present invention, such a condition is approached. In the present invention the gas to be treated is introduced into the separation chamber at a plurality of points along the path of the gas flow, whereby the concentration of suspended material is more uniform and there is a lower maximum concentration of suspended matter than in the prior art methods. In the present method, with a given quantity of gas to be treated in a given time, and consequently a given quantity of suspended matter to be removed, the concentration of suspended matter in passing any cross-section of the separation chamber is lower than in the methods of the prior art. In the prior art methods, all of the suspended matter must pass through the lower portion of the chamber is a given time. In the present method, only a fraction of the suspended matter must pass the same point in the given period of time, since the remainder of the suspended matter is introduced into the chamber at points above the given point. Thus it is seen that the maximum concentration of suspended matter is less in the present method than in the prior methods, and hence the range between maximum and minimum concentrations is correspondingly less.

It has also been found that where certain kinds of gases are to be treated and/or certain kinds of suspended materials are present in the gas to be treated, the gas is more readily ionized than in the case of other gases and/or other suspended materials. The degree to which such a gas will be ionized will vary, increasing as the gas passes through the electrical field which causes the ionization. As the gas approaches the locality where it leaves the electrical field, it may be so highly ionized and consequently such a good conductor that arcs will pass if an attempt is made to maintain the voltage across the gas in this condition at a value suitable for the less ionized gas which has just entered the field. The introduction into the chamber, at several points along the path of flow, of gas which is not ionized, lowers the concentration of highly ionized gas and renders the electrical conditions in the separation chamber more stable.

Where the suspended matter is composed of particles of different materials having different electrical characteristics, the particles which are more readily precipitated are removed from the gas in the earlier stages of the operation, and the less easily precipitated particles are removed in the latter stages. Consequently the deposit on one portion of the collecting electrode has certain electrical characteristics and the deposit on another portion of the collecting electrode may have entirely different electrical characteristics, which condition may have a detrimental effect on the operation of the electric field. The present inven-

tion substantially eliminates this condition, as particles of each of the different materials are introduced into the separation chamber at several points and are deposited in the several portions of the separation chamber, whereby the deposit on the walls of the collecting electrode has substantially uniform electrical characteristics in all portions of the separation chamber.

Through agglomerative action easily precipitable particles of suspended matter act as nuclei for less easily precipitable particles, which action still further tends to cause non-uniformity in the precipitation of the particles throughout the separation chamber. The present invention reduces this undesirable effect by distributing the easily precipitable particles throughout the chamber whereby a more uniform agglomerative action is secured.

Heretofore in the construction of precipitators for certain types of gases and/or certain types of suspended materials, it has been necessary to provide in the separation chamber two or more electric fields, separately energized and having different electrical characteristics, because the electrical characteristics of the gas at the inlet were so different from the characteristics of the gas after it had been partially treated. With the present invention a more uniform character of gas throughout the separation chamber is attained and it is not necessary to provide more than a single electrical field. Inasmuch as the initial cost and the maintenance cost of the electrical equipment for a precipitator amounts to a considerable proportion of the total cost, the provision of a precipitator having but a single field, and consequently considerably less electrical equipment than a precipitator requiring several fields, is accompanied by a substantial decrease in the cost of construction and operation of the precipitator.

An object of the invention is to provide a precipitator wherein the difference between the maximum and minimum concentration of suspended matter in the separation chamber is materially less than in any other precipitator.

Another object of the invention is the provision of a precipitator wherein there is obtained a more uniform and a more complete removal of suspended matter than in any precipitator of the prior art.

Another object of the invention is the provision of a method of precipitating suspended matter from a gas wherein the gas to be treated is introduced into the separation chamber at different points along the path of flow of the gas through the chamber.

Still another object of the invention is the provision of a method of electrical precipitation wherein the gas is admitted to the separation chamber in such a manner that the gas is subjected to the ionizing effect of the electric field uniformly in all portions of the separation chamber.

Other objects will appear from the following description taken in connection with the accompanying drawings, wherein:

Fig. 1 is a vertical sectional view showing a precipitation system constructed according to the invention;

Fig. 2 is a view showing a detail of construction which may be employed with the apparatus of Fig. 1;

Fig. 3 is a view similar to Fig. 1, showing another embodiment of the invention;

Figs. 4 to 6 are fragmentary sectional views showing details of construction of the devices of Fig. 3; and

Fig. 7 is a diagrammatic view showing a separation chamber provided with a plurality of inlets disposed at successively greater distances in the direction of travel of the gas.

Fig. 8 is a fragmentary sectional elevation of another embodiment of the invention.

In Fig. 1 is shown an electrical precipitation system embodying the invention, wherein an elongated, vertically disposed cylinder 1 serves both to enclose a separation chamber 2 and as a collecting electrode. The chamber 2 opens at its upper end into a chamber 3 in which is disposed a pair of hollow pedestal insulators 4 supporting a cross member 5 from which is suspended a discharge electrode 6 in the form of a wire disposed coincidently with the axis of the cylindrical collecting electrode 1 and tensioned by a weight 7 secured to its lower end.

A collecting chamber 8 is disposed below the separation chamber 2 and trap door 9 permits the removal of the deposited material from the collecting chamber 2.

A longitudinally extending row of perforations 10*a*, 10*b*, 10*c*, 10*d*, and 10*e* are provided in the wall 1 of the separation chamber 2 and a tapered member 11 cooperates with the perforated portion of the wall to form a distributing chamber 12 from which the gases to be cleaned pass through the perforations 10 into the separation chamber 2. An outlet 13 is provided in the wall of the upper chamber 3 for the discharge of the gases.

The cross member 5 is connected by means of a conductor 14, which passes through one of the insulators 4 and through an insulating bushing 15, to a source (not shown) of high tension electric current. The cylinder 1 constituting the collecting electrode is connected to ground, as indicated at 16. Thus when a conducting gas is present in the separating chamber 2, there is completed a series circuit which includes the two electrodes 1 and 6.

In operation, the gas from which suspended matter is to be precipitated, is admitted through the distributing chamber 12 and passes through the several perforations 10 into the separating chamber 2. It will be seen that the suspended matter in the gas which passes into the separation chamber 2 through the lower openings 10*a*, 10*b*, is precipitated out and collects on the chamber wall 1 in the lower portion of the chamber 2 so that the gas passing into the upper portion of the chamber carries considerably less suspended matter; hence the major portion of suspended matter entering the upper portion of the chamber is that which is carried into the chamber by the gas which enters through the upper openings 10*d* and 10*e*. The openings 10 are of such size and so arranged that the concentration of suspended matter is substantially uniform throughout the entire chamber as described above. Numerous variations in the size and arrangement of openings are possible; for example, the openings may be made of progressively differing size, or they may be spaced at progressively differing distances, or both.

In order that the gas passing into the separation chamber 2 of the device shown in Fig. 1 will not strike against the discharge electrode 6 and cause it to sway, the gas is introduced into the separation chamber 2 in a direction opposite to the direction of flow of the gas through the chamber. This is effected as shown in Fig. 2 by pro-

viding an outwardly projecting lip 17 on the lower edge of each perforation 10.

Another form of the invention is shown in Fig. 3 wherein a plurality of vertically disposed cylinders 18 are arranged in parallel relation within a distributing chamber 19 and serve both as separating chambers 20 and collecting electrodes. Each of the collecting electrodes 18 is formed with a plurality of sets of circumferentially disposed perforations 21*a*, 21*b*, 21*c* and 21*d*, providing communication between the distributing chamber 19 and the separating chamber 20.

The separating chambers 20 open into an upper chamber 22 in which is disposed a pair of insulators 23 supporting a cross member 24 from which depends a set of discharge electrodes 25, one for each collecting electrode. Below the separating chambers 20 is a collection chamber 26 for collecting the precipitated material. The distributing chamber 19 has a plurality of clean-out doors 27 in its lower portion, whereby any material which has been removed from the gas by gravity, may be removed from the chamber 19.

Figs. 5 and 6 show a plan view and an end view of the portion of an inlet conduit 30 which extends into the distributing chamber. The end of the conduit is tapered and is provided with an open bottom 31 whereby the gas is introduced into the chamber 19 with substantially eddyless flow.

The electrical circuit is substantially similar to that in Fig. 1, except that all of the discharge electrodes 25 are connected in parallel to a conductor 28, and the collecting electrodes 18 are similarly connected in parallel to ground (indicated at 29) whereby all electrodes of similar kind are at the same electric potential.

The operation of this form of the invention is similar to the operation of the first form. The conductor 28 is connected to a source (not shown) of high tension electric current and electric fields are thus set up in the separating chambers 20. The gas to be treated is introduced through the inlet conduit 30 into the distributing chamber 19 and passes through the perforations 21 in the electrodes, into the chambers 20. Certain portions of the gas pass into the chambers 20 through the lower sets of openings 20*a*, 20*b* and the other portions pass upwardly in the distributing chamber 19 and enter the chambers 20 through the upper sets of openings 20*c*, 20*d*, whereby a substantially uniform distribution of suspended matter in the chambers 20 is possible.

In Fig. 4 is shown a collecting electrode wherein the edges 32 of the perforations 21 are bent outwardly whereby the distance between the edges and the discharge electrode 25 is greater than if the edges were in line with the electrode wall. In this manner the possibility of objectionable arcing between the discharge electrode 25 and the edges 32 of the perforations 21 is decreased.

In Fig. 7 is shown diagrammatically one way in which a precipitator 33 constructed according to the invention is designed to provide a substantially uniform concentration of suspended matter.

The openings 34*a*, 34*b*, 34*c* and 34*d* are all of the same area and are spaced at distances from the bottom opening of one, two, three and four units. Assuming an equal ionizing effect in all portions of the chamber and a negligible pressure drop due to conduit resistance, the operation is as follows: One unit quantity of gas enters the first opening 34*a* and is acted upon by the electric field during the time that it takes the gas to pass to the portion of the chamber opposite the second opening 34*b*, or one unit of time.

At the second opening 34*b*, a second unit of quantity of gas is introduced. Since the chamber is of uniform diameter, and since two unit quantities of gas are now in the chamber opposite the second opening 34*b*, the gas will have twice the velocity in its flow between the second opening 34*b* and the third opening 34*c*, as between the first opening 34*a* and the second opening 34*b*. Assuming that all of the matter which was suspended in the gas introduced through the first opening 34*a* has been precipitated by the time this portion of the gas reaches the second opening 34*b*, the only suspended matter carried in the gas flowing between the second opening 34*b* and the third opening 34*c* is that introduced through the second opening 34*b*, or one unit quantity. Since the gas flows twice as fast from the second opening 34*b* to the third opening 34*c*, it is necessary, in order that the forces acting to remove the particles may have an equal length of time to bring about the removal, that the distance of flow be twice as great as in the first case.

This principle is carried out for as many openings as are necessary; thus the fourth opening 34*d* is three units of distances from the third opening 34*c*, and the fifth is four units from the fourth, etc. The fourth opening 34*d* is four units of distance from the end of the electron field (indicated at 35); hence the four units of gas which are in the precipitator above the fourth opening 34*d* travel through a field four units in length.

It is possible to attain a similar result in other manners, such as by varying the sizes of the openings or the number of openings at each level. It is also often necessary to vary the design to allow for other factors such as drop in pressure due to conduit resistance, non-linear variation in ionizing effect due to different speeds of flow and other variant conditions.

The openings may be provided with slides, dampers or similar devices to enable them to be wholly or partially closed, and these devices can be manually or automatically adjusted. It is also advantageous for certain problems where the conditions are not well known to provide means for varying the distances between the openings or sets of openings.

Figure 8 is a fragmentary view in cross sectional elevation of an electrical precipitator showing one embodiment of the invention. The gas to be cleaned flows to the precipitator through flue 101. The gas enters the chamber 102 surrounding the electrodes through a plurality of openings 103*a*, 103*b*, 103*c*, the effective sizes of which are controlled by dampers 104*a*, 104*b*, 104*c*, respectively. The collecting electrodes 105, which guide the gases past discharge electrodes 106 and furnish surfaces upon which the suspended matter is precipitated, are divided into a plurality of sections 105*a*, 105*b*, 105*c*, which construction permits the gas to be treated to enter the electric fields surrounding the discharge electrodes at several points and makes possible the advantages provided by the invention. If the sections 105*a*, 105*b* and 105*c* are of equal length and cross section, and additional gas is added at the bottom of each section, the gas velocity through each successive section will be in excess of the one preceding it and the particles will be subjected to the electrical forces for less time in the subsequent sections. This makes it advisable to add less and less gas, and contained suspended matter, through the successive open-

ings. This desired regulation is secured with the dampers 104*a*, 104*b*, 104*c*. The shafts on which they are mounted extend beyond the wall of flue 101 making it possible to turn the dampers and so regulate conditions while gas is passing.

It should be apparent that numerous modifications of the invention are possible and that it is not limited to those shown and described herein. Although in the forms above described the cylinder serves both as confining means for the gas and as a collecting electrode, this is not necessary and the collecting electrode may take the form of a separate member or members disposed inside of the cylinder, which type of apparatus is common in the art.

It should be noted that where the term "gas" is employed in the foregoing description and in the following claims, it is to be interpreted as meaning a single gas or a mixture of several gases, this being the accepted meaning of the term by persons skilled in the art of electrical precipitation.

This application is a continuation-in-part of my application Serial No. 498,442, filed Nov. 26, 1930.

I claim:

1. In a system for the electrical precipitation of suspended matter from gases, the combination with a discharge electrode, of a chamber surrounding said electrode and having a plurality of gas inlets arranged longitudinally of said chamber, means for conducting gas to be treated to the exterior of said chamber, and means for causing all of the gas to pass into said chamber.

2. In a system for the electrical precipitation of suspended matter from gases, the combination with a discharge electrode, of a chamber surrounding said electrode and having a plurality of gas inlets arranged longitudinally of said chamber, baffles provided at said inlets to direct the gases into said chamber in a direction substantially opposite to the flow of gas through said chamber, means for conducting gas to be treated to the exterior of said chamber and means for causing all of the gas to pass into said chamber.

3. In a system for the electrical precipitation of suspended matter from gases, the combination with a discharge electrode, of a chamber surrounding said electrode and having a plurality of gas inlets arranged longitudinally of said chamber, said inlets being progressively smaller in the direction of flow of the gases, means for conducting gas to be treated to the exterior of said chamber and means for causing all of the gas to pass into said chamber.

4. In a system for the electrical precipitation of suspended matter from gases, the combination with a discharge electrode, of a chamber surrounding said electrode and having a plurality of gas inlets arranged longitudinally of said chamber, said inlets being spaced at progressively greater distances in the direction of flow of the gases, means for conducting gas to be treated to the exterior of said chamber and means for causing all of the gas to pass into said chamber.

5. In a system for the electrical precipitation of suspended matter from gases, the combination with a discharge electrode, of a chamber surrounding said electrode and having a plurality of gas inlets arranged longitudinally of said chamber, adjustable means for varying the size of said inlets, means for conducting gas to be treated to the exterior of said chamber and means for causing all of the gas to pass into said chamber.

6. Apparatus for the electrical precipitation of suspended matter from gases comprising a discharge electrode, a collecting electrode surrounding said discharge electrode to form a collecting chamber and having a plurality of openings therein spaced longitudinally of said collecting electrode, means for conducting gas to be treated to the exterior of said chamber and a casing member surrounding said collecting electrode and adapted to cause all of the gases to pass into said collecting chamber through said openings.

7. Apparatus for the electrical precipitation of suspended material from gases comprising a discharge electrode, a collecting chamber surrounding said discharge electrode, means for conducting gas to be treated to the exterior of said chamber, means for causing all the gas to pass into said chamber, including means for admitting the gas into said chamber at different points along the path of flow of the gas and in such quantities that the concentration of suspended matter is substantially uniform.

8. Apparatus for the electrical precipitation of suspended material from gases comprising a discharge electrode, a collecting chamber surrounding said discharge electrode, means for conducting gas to be treated to the exterior of said chamber, means for causing all the gas to pass into said chamber, including adjustable means for admitting the gas into said chamber at different points along the path of flow of the gas and in such quantities that the concentration of suspended matter is substantially uniform.

9. In an electrical precipitator for the removal of suspended particles from gases, the combination with discharge electrodes, of means for conducting gas to be treated to the precipitator collecting electrode surfaces positioned to direct all the gas supplied to the precipitator past the discharge electrodes, gas inlets in said surfaces spaced longitudinally along the path of the gases, said inlets being arranged as to size and spacing so that, for a definite rate of gas flow, a uniform concentration of suspended matter is distributed along the gas path for removal by the electrical forces.

10. In combination, a collecting electrode for an electrical precipitator constituting a passageway for gases, and a discharge electrode within said passageway for cooperating with said collecting electrode to form an electric field across said passageway, and inlet openings spaced longitudinally along said passageway and so proportioned that the successive increments of gas entering through said inlets will keep the concentration of suspended particles within the electric field approximately constant.

11. In the process of electrically precipitating suspended mattter from a gas by passing the gas through an electric field, the method which comprises introducing portions of said gas into the electric field at different points and in such quantities respectively that the concentration of suspended matter is substantially uniform throughout the electric field.

12. In the process of electrically precipitating suspended matter from a gas by passing the gas through an electric field, the method which comprises introducing portions of said gas at different points along the path of flow of said gas and in quantities corresponding to the velocity of gas at each of said points.

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