

May 7, 1940.

E. ANDERSON
ELECTRICAL PRECIPITATION

2,199,390

Filed Nov. 23, 1937

Fig. 1.

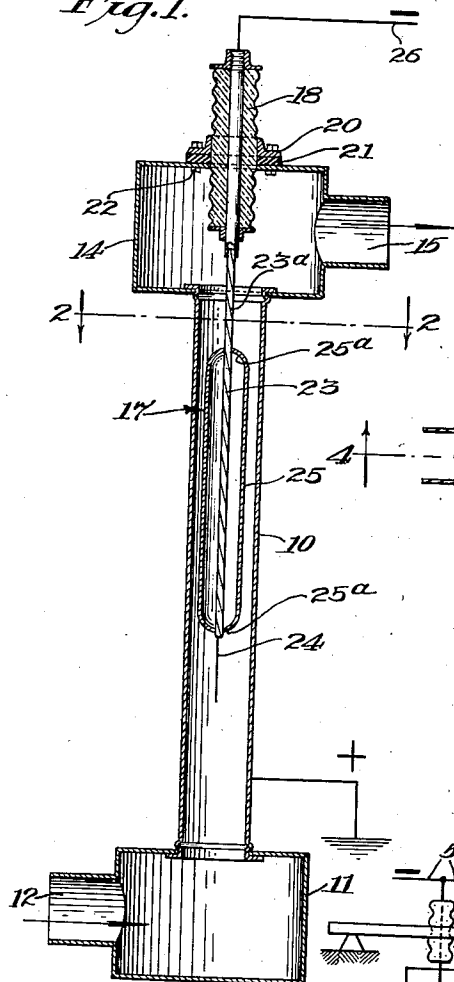


Fig. 2.

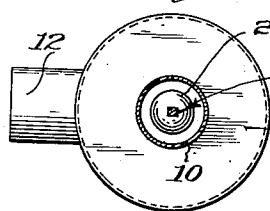


Fig. 3.

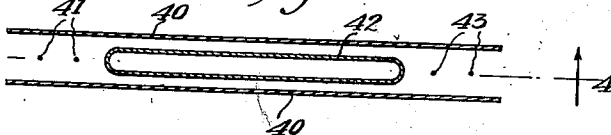
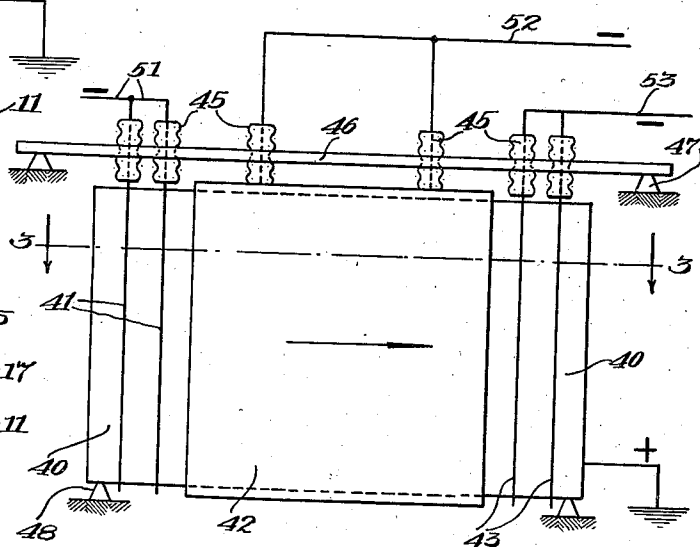


Fig. 4.



INVENTOR.
Evald Anderson,
BY *Arthur P. Husted* and *Alfred W. Husted*
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,199,390

ELECTRICAL PRECIPITATION

Evald Anderson, San Marino, Calif., assignor to
International Precipitation Company, Los
Angeles, Calif., a corporation of California

Application November 23, 1937, Serial No. 176,116

7 Claims. (Cl. 183—7)

The present invention is generally concerned with the art of electrically precipitating suspended particles from gases, and more particularly with improvements in the method and apparatus for electrical precipitation in a so-called "separated field" precipitator of the type disclosed in Patent 1,343,285 granted June 15, 1920, to W. A. Schmidt, though I am not limited thereto for the application of my present improvements.

Briefly, the operation of electrical precipitation consists in passing gases, containing suspended fine particles of either solid or liquid, through an electric field in which the particles become electrically charged by attachment of electrons or ions and so are attracted to an electrically charged member upon which the charged particles are collected. It has been common practice to effect charging of the suspended particles by passing them between two opposed electrodes between which a high potential difference is maintained, one of the electrodes being of a type to facilitate therefrom silent or corona electrical discharge that causes suspended particles to become charged with the same electrical sign as the discharging electrode. This is termed charging or ionizing action. The charged particles migrate, under the influence of the electric field between electrodes, toward the other electrode which is a non-discharging electrode of extended surface, and collect or become precipitated upon the surface of the second electrode which is consequently termed the collecting electrode. A precipitator of this type using only two electrodes for the complete operation uses but a single electric field in which both charging and precipitation takes place, and is referred to as the "single-field" type for convenience, though it may have a series of duplicate fields.

In the following description and in the appended claims, the term "discharging electrode" will be understood to designate an electrode of which at least portions have a sharp surface curvature, and which usually takes the form of a member of small surface area such as a small diameter wire, or it may be a rod provided with sharp edges, whereby there may be created in the immediate vicinity thereof a sufficiently high electric field intensity to cause ionization and corona discharge; while the term "non-discharging electrode" will be understood to designate an electrode of extended surface area, substantially free from sharp corners or other parts of sharp surface curvature at all portions which are located within the electric field, so as to substan-

tially avoid or minimize ionization or corona discharge at that electrode.

It has been shown that distinct advantages result from forming two spatially-separate fields of different functions, the first field in the path of gas flow being primarily a charging or ionizing field and the second field being primarily a precipitating field. In this arrangement the gas is subjected successively to the two functionally distinct fields and it has been termed the "separated field" system. The first field is maintained between two electrodes of which one is a discharging electrode and the other is non-discharging, while the second field is maintained between two substantially non-discharging electrodes, of which one or both may be continuations of the electrodes of the first field.

There has been observed in electric precipitators a phenomenon termed "back corona" that greatly interferes with proper collection of particles and so reduces the collection efficiency. Without discussing the various theoretical aspects of back corona, it is sufficient to say that it appears when collecting solid particles that are relatively poor conductors. After a thin layer of these high resistance particles covers the collecting electrode, the layer usually punctures at some point, and at this point there first occurs a corona discharge from the collecting electrode and later, if the potential is sufficient, an arcing over to the ionizing electrode. The back corona or arc prevents proper precipitation of the particles which are allowed to pass on out of the precipitator. The subsequent reduction in collection efficiency is sometimes very great. Back corona phenomena are characteristic of the single-field precipitator and are not found usually in the precipitating field of the separated field type in which the collection electrode is opposed only by another non-discharging electrode; and under ordinary conditions there is much less tendency to form a corona or arc even at a puncture in the precipitated dust layer. Consequently, the latter type gives greatly improved performances under certain circumstances, as it does not permit the occurrence of inefficient operating conditions in the precipitating field. The separated field precipitator offers other marked advantages over the single-field precipitator because it can be more compactly built and uses less current, so that it is more economical to install and operate.

Another advantage of the separated field type of electrical precipitator results from the fact that, for a given spacing between two opposing

electrodes, a materially higher potential difference may be maintained, without causing disruptive discharge or arcing therebetween, when both electrodes are of the non-discharging type than when one of the electrodes is a discharging electrode. Consequently, by carrying out the precipitation between opposing non-discharging electrodes it is possible to maintain a higher potential gradient per unit distance in a direction from one electrode to the other, and therefore to cause more rapid movement of the charged particles in that direction, than in the single field type of precipitator. For this reason, the time required to effect precipitation of a given percentage of charged particles is materially reduced, resulting in an increased efficiency of collection or an increased capacity in terms of volume of gas treated per unit time, or both increased efficiency and increased capacity, in an apparatus of a given size. Additional advantages by way of more rapid precipitation are also made possible by the fact that the opposing non-discharging electrodes may be placed much closer together than has been found practical when one of the electrodes is a discharging electrode, thus decreasing the mean distance through which the charged particles must be moved by the electric field in order to reach a collecting surface.

However, the separated field precipitator has heretofore had the disadvantage of losing dust from the collecting surface of the precipitating electrode when the gas stream exceeds a critical velocity, because the dust particles become neutral or charged the same as the electrode and so are no longer attracted electrically to the electrode. Examination of the dust blown out of the precipitator discloses that the loss is chiefly in the form of agglomerates of a number of the particles originally suspended in the gas, indicating that apparently the particles have been once precipitated onto the collecting electrode but have become so lightly held that, after an agglomerated mass has formed, the gas stream is able to blow the agglomerates off the collecting surface. The quantity of particles blown from the field at relatively low gas velocities is negligible as all the dust particles precipitated are securely held, but it becomes increasingly appreciable at higher gas velocities and operates to place a definite limit on the capacity of a treater, this limit being much lower than the capacity as measured by the ability of the two fields to charge and precipitate the particles. This loss of particles is apparently caused primarily by the absence of any corona in the precipitating field since it does not occur to an appreciable extent at comparable gas velocities in single-field precipitators where the corona continually bombards the particles with ions or electrons so that the particles are oppositely charged to the precipitating electrode and adhere more securely to the collecting surface.

Electric precipitators of all types have been used chiefly for industrial purposes, and in this field it has been immaterial whether or not any new compounds or gases have been formed by the action of the electric field. But with the present trend toward air conditioned offices and homes electrical precipitating units are being designed to clean air used for ventilation; and in this type of use it is of prime importance that the precipitator not produce any substances that are either annoying because of their odor or dangerous to health. Consequently production of ozone and oxides of nitrogen, formerly of little

significance in industrial installations, has now become a factor of importance in air conditioning units, since these gases are distinctly irritating to many people, and ozone, according to some medical authorities, is potentially harmful in excessive concentrations. What upper limit of ozone concentration is permissible is not definitely established though it is now set at various points approximately averaging one part per ten million parts of air, a concentration that is only a small fraction of that produced by most conventional precipitators.

Thus it becomes a general object of my invention to provide an improved separated field type of electric precipitator in which the precipitated particles are effectively trapped against blowing out of the treater.

Another object is to improve the separated field type of precipitator so that the gas capacity of a treater of a given size can be increased by increasing the velocity of flow past the electrodes without any increase in the electrode size or the electric power applied, and so that initial investments and operating costs can be kept to a minimum.

A further object is to provide a precipitator in which the conditions producing back corona phenomena are prevented from arising in the precipitating field thus keeping the precipitator always at a relatively high precipitation efficiency.

An additional object of my invention is to provide an electrical precipitator that does not introduce into the air physiologically objectionable products in quantities above established tolerance limits, so that the precipitator may be adapted to clean air for ventilating purposes.

These objects are attained according to my invention by passing a stream of gas containing suspended particles to be precipitated through successive electric fields, in one of which fields the particles are electrically charged and in another of which fields substantially all the electrically charged particles entering the field are subsequently precipitated, and finally passing the gas through an electric field in which suspended particles or agglomerates entering the field are again subjected to a charging action and reprecipitated in said final field.

In apparatus for carrying out my novel method of electrically precipitating suspended particles, I provide a series of successive spatially-separate electrode arrangements each of which is adapted to maintain an electric field, the first of these fields being an ionizing or charging field, another one being a substantially non-discharging precipitating field, and the last or final field being both an ionizing and a precipitating field.

How the above objects and advantages of my invention, as well as others not specifically mentioned, are attained, will be more clearly understood by referring to the following description and drawing in which:

Fig. 1 is a vertical section through a preferred form of electrical precipitator;

Fig. 2 is a horizontal section on line 2—2 of Fig. 1.

Fig. 3 is a horizontal section through a variational form of electric precipitator on line 3—3 of Fig. 4; and

Fig. 4 is a vertical section on line 4—4 of Fig. 3 showing the electrodes in elevation.

There is shown in Fig. 1 a tubular type of precipitator comprising a single tube 10 of substantially circular cross-section that is preferably

uniform, or nearly so, throughout its entire length. At the lower end of the tube is gas inlet means in the form of housing 11 which is connected at 12 to a conduit (not shown) connected to some source of gas containing dust or other suspended particles. At the upper end of tube 10 is gas outlet means in the form of housing 14 which may be connected at 15 to a suitable gas conduit (not shown) or may open to the atmosphere. A uniform diameter is preferred for tube 10 since it is much easier and less expensive to make a straight tube than one of varying diameter; and also because if a number of tubes are connected in parallel between headers 11 and 14, the space occupied is determined by the largest tube diameter and this diameter can be kept to a minimum with straight tubes.

Located centrally and co-axially of tube 10 is the rigid central electrode generally indicated at 17. Electrode 17 is mounted at its upper end in insulator bushing 18 which passes through an opening in the top wall of housing 14, the opening being somewhat larger in diameter than the bushing. The bushing and electrode assembly are supported on the top wall of the housing by a flanged ring 20 which rests upon gasket 21 of rubber or similar compressible material placed between the ring and the top of housing 14. This construction permits electrode 17 to be accurately aligned with the axis of tube 10 since the electrode assembly can be moved bodily in a direction radial of the tube to the extent of the clearance between bushing 18 and the housing wall; and the electrode can be moved angularly with respect to the tube axis by tightening bolts 22 at one side of the bushing more than at the opposite side so as to compress gasket 21 unequally. Any suitable number of bolts 22 may be provided at angularly spaced positions around the bushing, said bolts serving to hold the bushing and electrode assembly carried thereby in adjusted position and to compress the gasket 21 between flange 20 and the top wall of housing 14, which extends transversely across the upper end of tube 10.

The central electrode may have any one of a number of different forms but preferably comprises a length of twisted square rod 23 at the lower end of which is attached a short length of smooth steel wire 24 of a smaller diameter. The lower portion of the twisted rod, commencing just above the point of attachment of wire section 24, is surrounded by a smooth-walled cylindrical jacket or shield 25 of larger diameter than the twisted rod, said shield being secured to or supported on the rod 23 in any suitable manner, as by welding, and forming in effect, an integral part of the electrode. The shield 25 is preferably formed as a hollow tube, for the sake of lightness in weight, and is closed at both ends, preferably by rounded end portions 25a. The shield extends upward to a position somewhat below the upper end of the tube 10, so that the upper portion 23a of rod 23 within said tube is exposed. As will be well understood by persons skilled in the art, electrode sections having exposed surfaces of relatively small radius, such as is provided in this case by the smooth wire section 24 and by the sharp corners of the exposed twisted rod section 23a, bring about silent or corona discharge when a high potential is applied to the central electrode. However, shielded section 25 has no such outer surfaces of small radius and consequently there is substantially no discharge from this portion of the electrode. A twisted rod is preferred

for the central electrode since it not only has the necessary physical characteristics required to produce corona discharge, but it is also sufficiently rigid that it does not vibrate under operative conditions and holds the section 25 accurately centered in the tube. With flexible electrodes, such as wire, it has been necessary to attach them at their lower ends to weights or fixed members in order to keep them taut and centered in the tube. However, the wire section 24 of the electrode assembly herein described is sufficiently short and rigid to prevent undue flexing thereof.

In operation, a high potential current is applied to the central electrode by conductor 26 connected usually to the negative terminal of a suitable source of unidirectional current, such as a transformer and mechanical rectifier or like equipment known to persons skilled in the art, adapted to create a high potential between the electrodes sufficient to cause corona discharge from the discharging electrode sections but not sufficient to cause arcing or disruptive discharge between the electrodes. Tube 10 forms the non-discharging electrode opposing the central discharging electrode, and is grounded or attached to the positive terminal of the power source so that in either case it is positive with respect to electrode 17. Electrode section 24 and the surrounding section of opposed electrode 10 form one electrode arrangement or grouping which maintains a charging or ionizing field between the two electrodes. The shielded electrode section 25 forms with the surrounding section of opposed electrode 10 another electrode arrangement or grouping that maintains for the length of shield 25 a substantially non-discharging precipitating field between the electrodes. Likewise there is a third electrode arrangement, comprising section 23a of electrode 17 above the shield and the upper end of the surrounding electrode 10, that maintains between the two electrode sections an electric field having ionizing characteristics.

The gas enters through housing 11 and flows upwardly within electrode 10. The gas stream first passes through the lower ionizing field in which the particles become electrically charged with the same polarity as the discharge electrode. Ionization takes place very quickly so that wire section 24 may be relatively very short, as the field need be only of sufficient length in the direction of gas flow to charge substantially all the suspended particles without precipitating any material amount of them on the tube walls. However it is often found in practice to be preferred to use an ionizing field of longer than minimum length so that an appreciable amount of particles is precipitated in the initial field. The gas next passes through the precipitating field around electrode section 25, and this field is of sufficient length in the direction of gas flow to effect precipitation of substantially all the originally charged particles entering the field. All precipitated particles collect on the walls of tube 10.

The final one in the series of spatially-separated fields arranged successively in the direction of gas flow is the combined ionizing and precipitating field around electrode section 23a. As the gas passes through this field, the most important function of the field is to recharge and reprecipitate agglomerates of particles that have been once precipitated in the field 25, but which have been so lightly held on the walls of tube 10 as to be carried on by the gas stream. Although the exact nature of the action inside the precipi-

tator is not known, it appears from observations that almost all the material blown out of the precipitating field is in the form of agglomerates. In an ionizing field the flow of ions to the collecting electrode keeps all precipitated particles charged and attracted to the electrode; but in a substantially non-discharging field the precipitated particles lose their original charge and apparently become so lightly held in place that the gas stream carries away agglomerated masses of particles. In the final ionizing field, the agglomerated particles are again charged and reprecipitated. The precipitation of agglomerates takes place much more rapidly than precipitation of individual particles, apparently because of the observed fact that the larger agglomerated masses take on such a large number of charges in an ionizing field that they travel toward the collecting electrode many times faster than the original small particles. The ionizing nature of the final field causes the agglomerates to adhere securely to the outer electrode. The net cross-sectional area of the gas passage is less in the precipitating field and the gas velocity proportionally higher, than in the other fields, because of the enlarged diameter of electrode section 25. However, any tendency toward a lower over all collection efficiency as a result of the increase in velocity in the precipitation field is completely counteracted by the final ionizing field and the reduced velocity in the final field facilitates reprecipitation of the material.

Without going into detail, it will be clear from the foregoing disclosures that the series of fields may include more than one of the ionizing and precipitating fields as at 24 and 25, but that, whatever number or arrangement of such separate fields is used, the last field in the series is an ionizing field as at 23a that traps or reprecipitates any particles escaping the precipitating field next preceding. The method of precipitation is the same for any number of fields and consists in passing the gas stream through successive fields in which the gas is subjected to successive ionizing and precipitating actions, and finally to an ionizing action adapted to also precipitate particles. It will also be understood that I am not limited to the illustrated construction in which the electrode arrangements forming each field are sections of continuous electrodes, for I may replace either or both of electrodes 10 and 17 with a plurality of individual electrodes of which each one is limited in extent to its individual field, and the successive fields may be either contiguous or separated by intervening spaces.

The advantages of this type of precipitator are several. The space required for a precipitator handling a given volume of air is determined mainly by the necessary extent of the precipitating field. By separating the fields so that each performs a single function, each field is designed according to its individual characteristics and operates at higher efficiency so that the size of a precipitator can be reduced to a minimum in a separated field type. Another result is that the length of discharging electrodes is materially reduced over that required in the single-field type; and since the power consumed is roughly proportional to the current flowing from the discharge electrode, and the current at a given voltage, in turn, is approximately proportional to the length of the discharge electrode, the total power consumed in the separated field precipitator is greatly reduced from that used

in other types. This economy feature is enhanced rather than lessened by using a final ionizing and reprecipitating field, since the current consumption in the final field is relatively low and permits the initial ionizing field to be of minimum dimensions since the final field acts as a trap to catch any particles missed by the initial field. Actual comparisons have shown that a given volume of gas can usually be treated with the precipitator described above with as little as 25% or less of the current required in a single-field precipitator.

The separated field precipitator has a high dust collection efficiency, except at higher air velocities as mentioned above. By adding a final ionizing section to a standard two-field treater, the velocity through the same test precipitator has been increased by 25% and more without any loss in efficiency, while the loss at the increased velocity is only about 15% of the loss without the final ionizing field. The novel step of trapping agglomerates in a final ionizing field allows operation of the precipitator at gas velocities sufficiently high to remove agglomerates from the precipitating surfaces since these particles are later reprecipitated and retained in the treater.

These various characteristics have important unsuspected influences on the production of ozone and nitric oxide, as the precipitator operates now with only negligible formation of these undesirable products. Formation of ozone and nitric oxide occurs in fields having corona discharge and the rate of formation of each gas is roughly proportional to both the current consumed and the length of discharging electrode. Since a decrease in electrode length decreases the current, it also decreases the quantity of ozone and nitric oxide formed in proportion to the second power of the change in length. Ozone is formed at a relatively constant rate independently of the gas velocity past the electrodes within the range of velocities used in practice, but of course the concentration varies inversely as the velocity so that the increased velocity at which this novel precipitator can operate further reduces the unit concentration of ozone or nitric oxide. Tests have shown that conventional single-field precipitators as now constructed and operated are usually unsatisfactory in ventilating units since they produce ozone considerably in excess of the upper limit of tolerance now adopted which is about .1 p. p. m. By comparison, the treater above described has been found to produce only .02 to .1 p. p. m. of ozone with about .04 p. p. m. regularly obtainable under favorable conditions. Thus the ozone concentration is materially less than that produced by a single-field precipitator of equal capacity and the production of nitric oxide shows a similar decrease.

A variational form of separated field precipitator having a final ionizing field but using plate type electrodes is illustrated in Figs. 3 and 4. With this construction, there are provided a pair of spaced parallel plates 40 that serve as collecting electrodes. Midway in the space between electrodes 40 are placed in succession one or more ionizing electrodes 41, a non-discharging plate type electrode 42, and finally one or more ionizing electrodes 43. Electrodes 41 and 43 are in the form of fine wires or similar shapes which produce a corona discharge from these electrodes when a high potential current is applied, while electrode 42 is preferably of the plate type hav-

ing an extended surface and rounded corners so that there is substantially no discharge from this electrode. Although electrode 42 may be a solid member, it is preferred that it be a hollow member because of the decrease in weight.

In the drawing, the construction is shown diagrammatically, and electrodes 41, 42 and 43 are suspended by insulating bushings 45 from a common support 46 which may be mounted on supports 47. Collecting electrodes 40 may be suitably supported in any desired manner, as at 48.

As in the form first described, there is maintained in this precipitator a series of successive spatially-separate electric fields through which the gas is passed. The initial ionizing field is maintained between ionizing electrodes 41 and the opposed sections of electrodes 40, the subsequent precipitating field is maintained between electrode 42 and the opposed sections of electrodes 40, while the final ionizing and reprecipitating field is maintained between electrode 43 and the opposed sections of electrodes 40. Central electrodes 41, 42 and 43 are shown as being each provided with an individual conductor 51, 52, and 53, respectively, by means of which high potential currents at the same or different voltages are applied to these electrodes from any suitable source of power. It is also within the scope of my invention to connect all of these electrodes to a single conductor in which event all electrodes will be maintained at the same potential.

The method of operation of this form of precipitator is in general the same as already disclosed. The precipitator is enclosed within a suitable housing, not shown, so that the gas stream is passed horizontally between electrodes 40 in the direction shown by the arrows, and the gas is subjected in succession to the charging action of the field around electrode 41, to the precipitating action of the field at electrode 42, and finally to the charging and reprecipitating action of the field at electrode 43. In the first of these fields, substantially all of the suspended particles become electrically charged and are then precipitated in the first or second field. By the time the gas has passed electrode 40 precipitation of the suspended particles is substantially complete. Any remaining suspended particles or agglomerates of particles blown off the collecting electrode are trapped by the final field in which these particles or agglomerates are recharged and reprecipitated.

The dimensions of the electrodes and the extent of the several fields in the direction of gas movement may be determined according to the type of material being handled in the precipitator. Electrode 42 is relatively thicker than electrode 41 or 43 so that the cross-sectional area of the passage for the gas stream is reduced and the velocity of the gas past electrode 42 is correspondingly increased. The gas stream then moves through the final electric field at the original lower velocity which facilitates complete precipitation of particles reaching this field.

The construction in Figs. 3 and 4 differs somewhat from that shown in Figs. 1 and 2 in that the centrally disposed electrodes of each field are individual members rather than sections of a single member. This permits successive fields to be maintained at different potentials, if desired, by connecting the electrode to separate conductors as shown in the drawing. If it is desired to maintain the different sections of electrode 40 in the successive fields at different poten-

tials, this can easily be done by electrically insulating these sections of plates 40 from each other so that each of the collecting electrodes then forms three electrically separate collecting electrodes although physically they are only different sections of a single member. If desired, this modification can also be made in the precipitator illustrated in Figs. 1 and 2.

Having described the method of carrying out my invention and various forms of apparatus adapted to performance of that method, it will be understood that the foregoing disclosure is to be considered as descriptive of rather than limitative upon the appended claims, for changes may be made in the method of operation and the construction without departing from the spirit and scope of my invention.

I claim:

1. The method of electrically precipitating from a stream of gas particles of foreign matter suspended in the gas stream, that includes passing the gas stream through an electric ionizing field in which the particles are electrically charged, next passing the gas stream through an electrostatic precipitating field which is substantially free from electric discharge and in which charged particles are precipitated from the gas stream, and finally passing the gas stream through another electric ionizing field in which any suspended particles are both charged and precipitated, the several fields being spatially-separate from each other.

2. The method of electrically precipitating from a stream of gas particles of foreign matter suspended in the gas stream, that includes passing the gas stream through an electric ionizing field in which the particles are electrically charged, next passing the gas stream through an electrostatic precipitating field which is substantially free from electric discharge and in which the charged particles are precipitated from the gas stream, the gas stream velocity through the precipitating field being maintained sufficiently high that agglomerated precipitated particles are removed from the precipitating surfaces and carried by the gas stream, and finally passing the gas stream through a separate electric ionizing field in which said agglomerated particles are recharged and re-precipitated.

3. The method of electrically precipitating from a stream of gas particles of foreign matter suspended in the gas stream, that includes passing the gas stream through an electric ionizing field in which the particles are electrically charged, next passing the gas stream through an electrostatic precipitating field which is substantially free from electric discharge and in which the charged particles are precipitated from the gas stream, the gas stream velocity through the precipitating field being maintained sufficiently high that agglomerated precipitated particles are removed from the precipitating surfaces and carried by the gas stream, and finally passing the gas stream through a separate electric ionizing field in which said agglomerated particles are recharged and precipitated, the gas velocity in the final field being lower than in the precipitating field.

4. In electric precipitation apparatus through which flows a stream of gas carrying suspended particles to be precipitated, the combination of a first pair of electrodes of which one is a discharging electrode and which are adapted to maintain an electric field of an ionizing character that charges the suspended particles as they

move through the field; a second pair of non-discharging electrodes positioned beyond the first in the direction of gas flow, the electrodes of the second pair being adapted to maintain a substantially non-discharging precipitating field that precipitates on one of the electrodes charged particles as the gas stream passes through the precipitating field; a third pair of electrodes similar to the first pair but positioned beyond the second pair in the direction of gas flow and adapted to maintain an ionizing field that charges suspended particles entering the field and precipitates them on one electrode of the third pair, said three pairs of electrodes being arranged successively in the direction of gas flow with the last mentioned field the final field entered by the gas stream while flowing through the precipitation apparatus; and means for moving the gas stream past the second pair of electrodes at a velocity sufficient to redisperse in the gas stream particles once precipitated on said one of the second pair of electrodes.

5. In electric precipitation apparatus through which flows a stream of gas carrying suspended particles to be precipitated, the combination of a first electrode arrangement adapted to maintain an electric ionizing field, a second electrode arrangement adapted to maintain a substantially non-discharging electrostatic precipitating field, and a third electrode arrangement adapted to maintain an electric ionizing field, said three fields being arranged successively in the direction of gas flow to treat the gas successively with the last mentioned field the final field entered by the gas stream, the first field being of such length as to charge substantially all the particles in the gas stream, the second field being of such length as to precipitate substantially all the particles entering the field, and the final field being of sufficient length to charge and precipitate

substantially all agglomerates leaving the second field.

6. An electric precipitator through which flows a stream of gas carrying suspended particles to be precipitated, comprising a tubular electrode forming a substantially circular gas passage of substantially uniform diameter throughout its entire length, gas inlet and outlet means at opposite ends of the tubular electrode, a central electrode disposed longitudinally of the tubular electrode and of a character to bring about corona discharge from it, and a hollow shield surrounding a section of the central electrode intermediate its ends to eliminate corona discharge from the shielded section intermediate the discharging sections near the ends of the electrode, said shield being of sufficient diameter to increase the gas velocity past the shield to a value at which some agglomerates of precipitated particles are removed from the surface of the tubular electrode and carried into the field of the final discharging section of the central electrode adjoining the gas outlet.

7. In a method of precipitating suspended particles from a stream of gas by passing the gas stream through a charging field in which corona discharge is produced, to electrically charge the suspended particles, and subsequently passing the gas stream at a relatively high velocity through an electrostatic precipitating field which is substantially free from electric discharge, to precipitate charged particles, the velocity through the precipitating field being sufficiently high to redisperse in the gas stream particles once precipitated by the precipitating field the step which comprises passing the gas stream finally through another electric field in which corona discharge is produced to re-precipitate agglomerated particles carried out of the electrostatic precipitating field by the gas stream.

EVALD ANDERSON.