

Dec. 24, 1940.

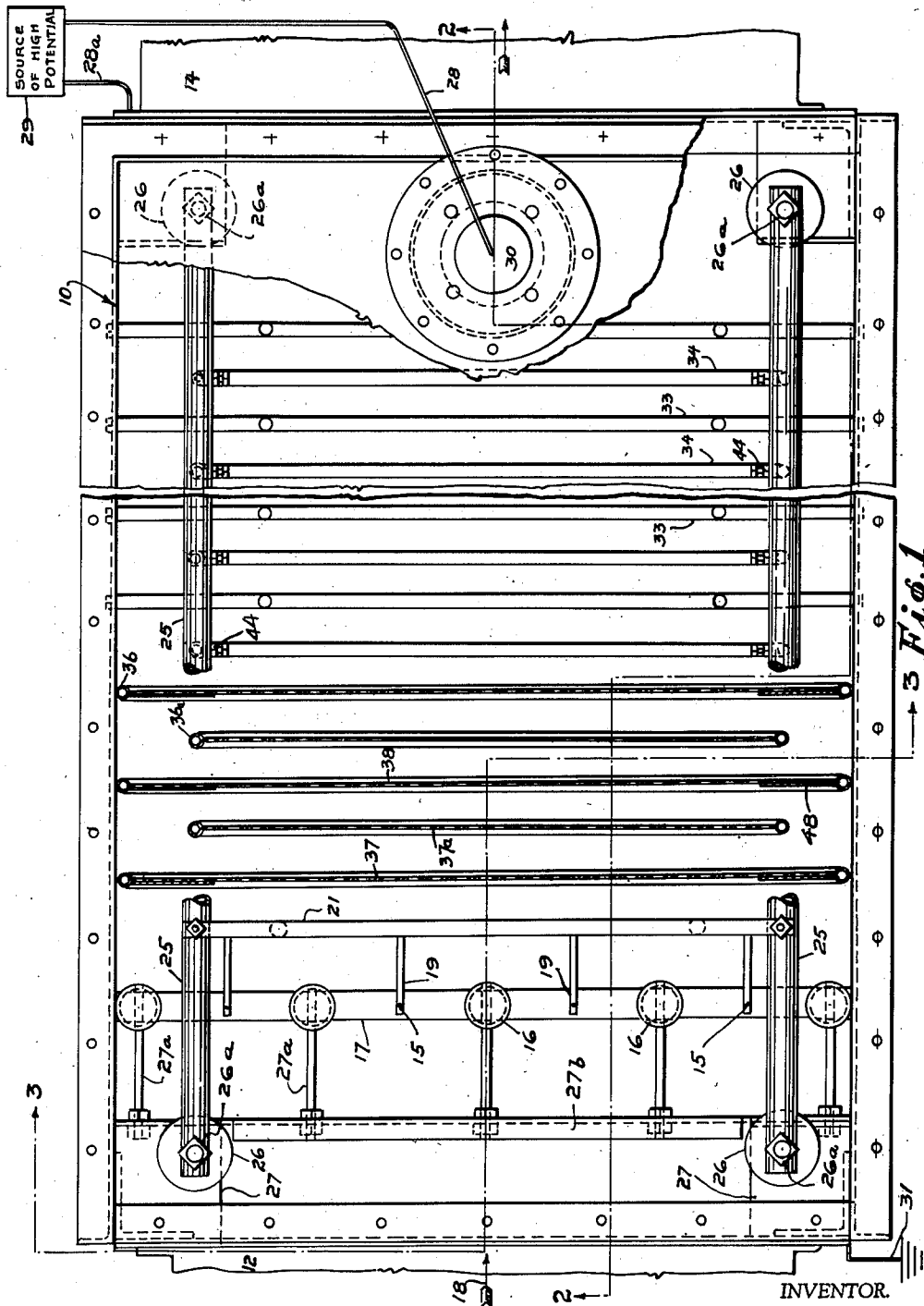
H. J. WHITE

2,225,677

METHOD AND APPARATUS FOR ELECTRICAL PRECIPITATION

Filed Dec. 29, 1938

5 Sheets-Sheet 1



INVENTOR.
Harry J. White
BY *Arthur P. White and*
Alfred W. White ATTORNEYS

Dec. 24, 1940.

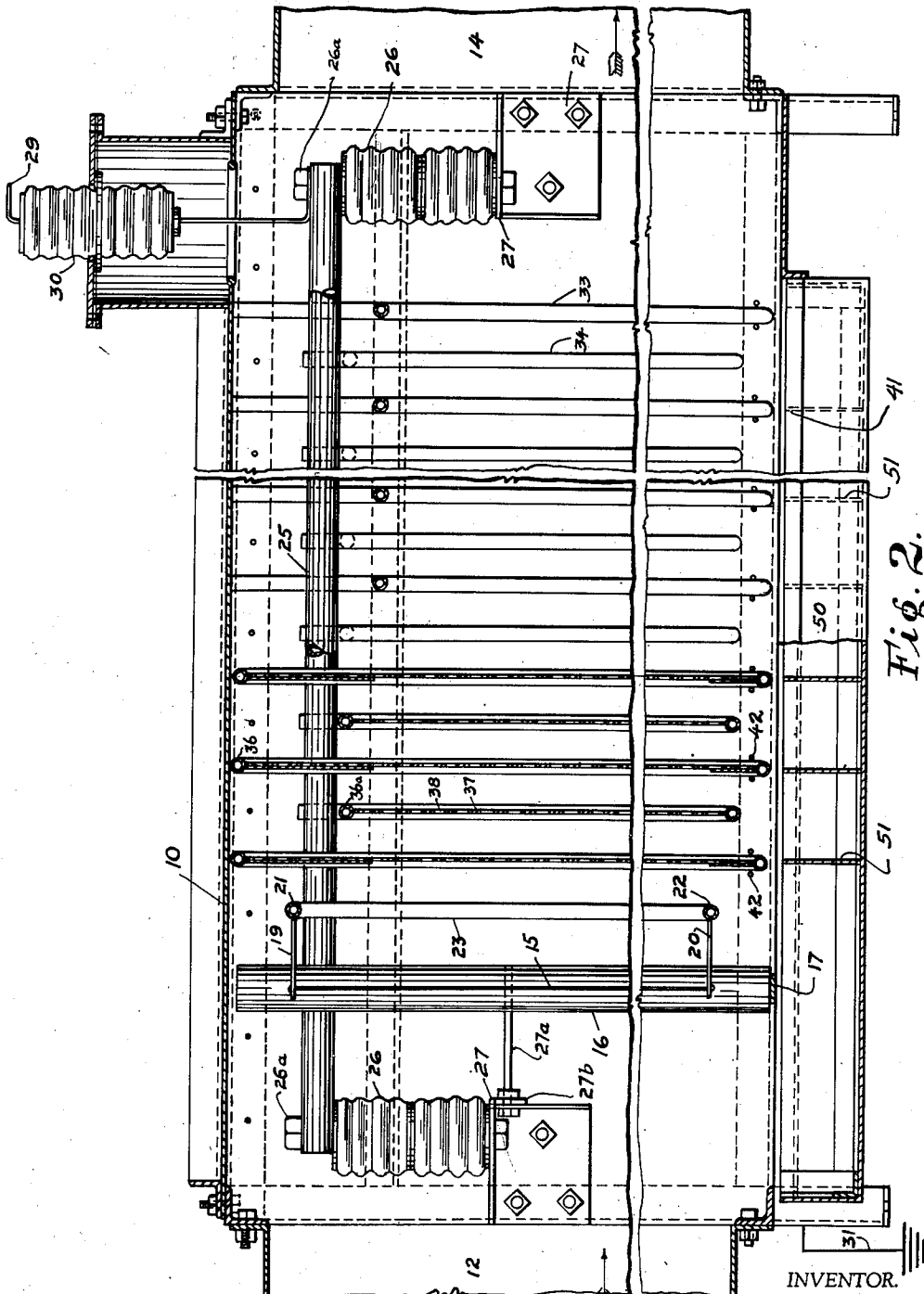
H. J. WHITE

2,225,677

METHOD AND APPARATUS FOR ELECTRICAL PRECIPITATION

Filed Dec. 29, 1938

5 Sheets-Sheet 2



INVENTOR.

Harry J. White

BY *Arthur P. King and*
Reuben W. King ATTORNEYS

Dec. 24, 1940.

H. J. WHITE

2,225,677

METHOD AND APPARATUS FOR ELECTRICAL PRECIPITATION

Filed Dec. 29, 1938

5 Sheets-Sheet 3

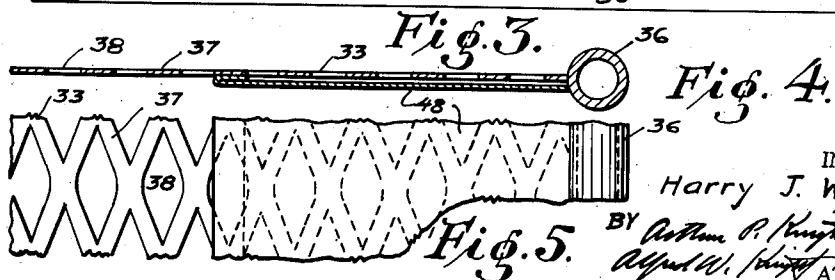
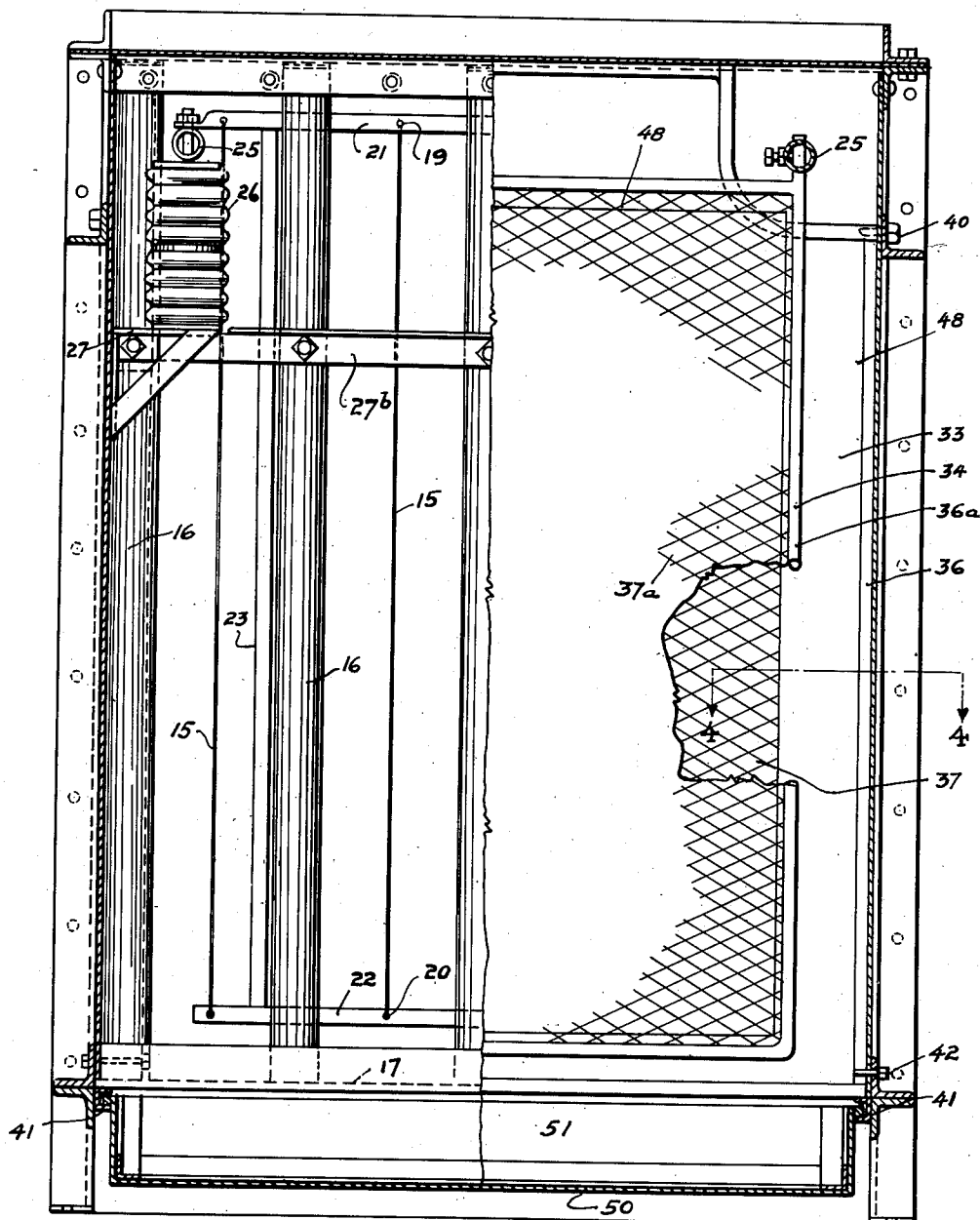


Fig. 3.

Fig. 4.

Fig. 5.

INVENTOR

Harry J. White

BY Arthur P. Knight and
Alfred W. Knight ATTORNEYS

Dec. 24, 1940.

H. J. WHITE

2,225,677

METHOD AND APPARATUS FOR ELECTRICAL PRECIPITATION

Filed Dec. 29, 1938

5 Sheets-Sheet 4

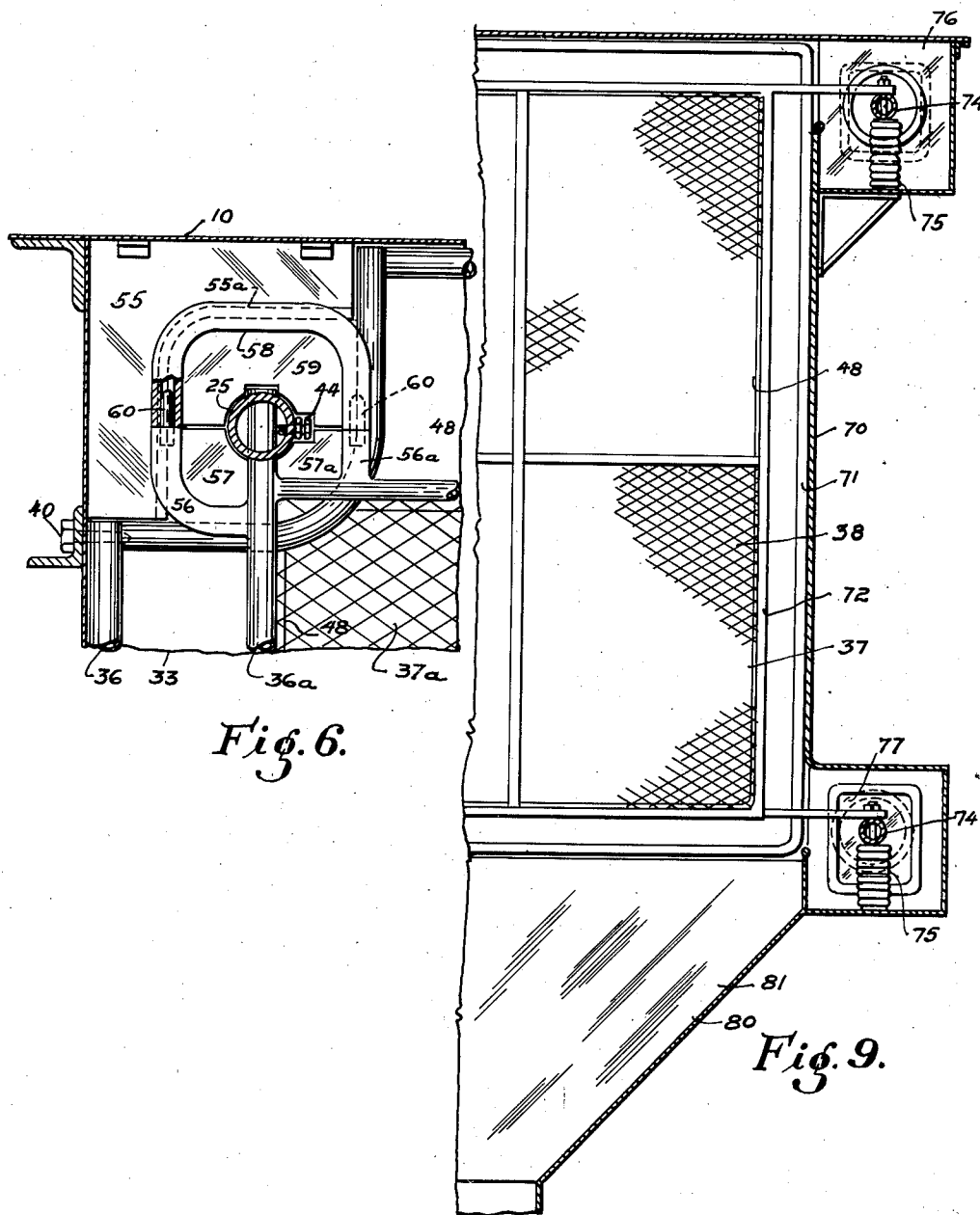


Fig. 6.

Fig. 9.

INVENTOR.
Harry J. White
BY *Arthur P. King and*
Alfred W. King ATTORNEYS

Dec. 24, 1940.

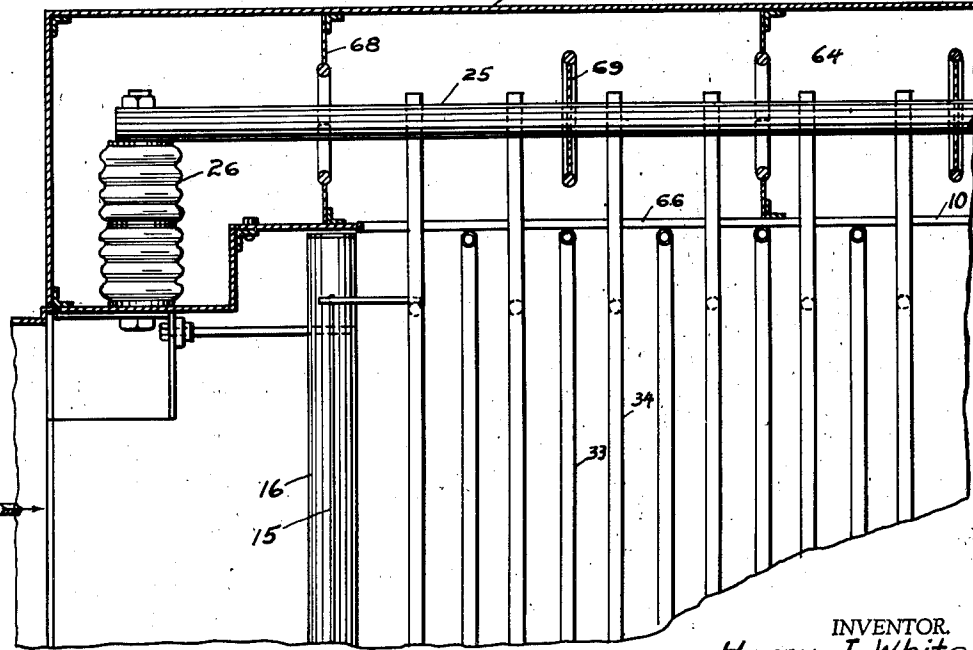
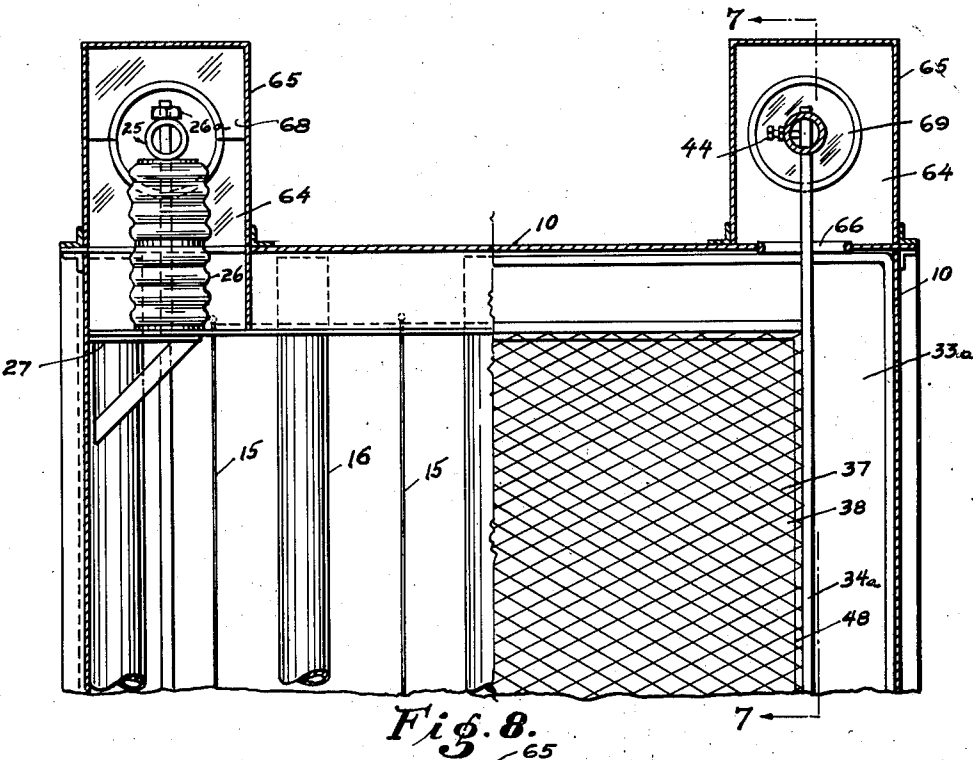
H. J. WHITE

2,225,677

METHOD AND APPARATUS FOR ELECTRICAL PRECIPITATION

Filed Dec. 29, 1938

5 Sheets-Sheet 5



INVENTOR
Harry J. White
BY *Arthur R. Knight*
Alfred W. Knight ATTORNEYS

UNITED STATES PATENT OFFICE

2,225,677

METHOD AND APPARATUS FOR ELECTRICAL PRECIPITATION

Harry J. White, Los Angeles, Calif., assignor to
Research Corporation, New York, N. Y., a corporation of New York

Application December 29, 1938, Serial No. 248,348

9 Claims. (Cl. 183—7)

The present invention is generally concerned with the art of electrically precipitating suspended particles from a stream of gas, and more particularly with improvements in methods and in apparatus of the type in which the particle laden gas is passed first through a charging field in which corona discharge is produced, to electrically charge the suspended particles, and is then passed through a spatially separate electrostatic precipitating field which is substantially free from corona discharge, to precipitate the charged particles. With this arrangement, the gas is subjected successively to 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 discharge electrode and the other is non-discharging, while the second field is maintained between two or more substantially non-discharging electrodes, it being preferred in the present invention to provide a plurality of pairs of substantially non-discharging electrodes between which there is established a plurality of precipitating fields.

In the following description and appended claims, the term "discharge electrode" will be understood to designate an electrode that facilitates corona discharge therefrom, because it has a configuration that establishes a sufficiently high potential gradient at or near its surface to create corona discharge before there is a disruptive discharge or sparkover. For this purpose, the discharge electrode usually takes the form of a member of small surface area, such as a small diameter wire or a rod provided with sharp edges or points, whereby there may be created in the immediate vicinity thereof a sufficiently high electric field intensity to cause ionization and corona discharge. The term "non-discharging electrode" will be understood to designate an electrode that minimizes or prevents corona discharge therefrom because it has a configuration that establishes a sufficiently low field concentration at or near the surface to suppress corona discharge at elevated potentials lower than the voltage required for disruptive discharge or sparkover. For this purpose, a non-discharging electrode usually is one 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 substantially avoid ionization or corona discharge at that electrode.

By comparison with a "single field" precipitator in which the suspended dust particles are

electrically charged and are precipitated in a single electric field, the separated field precipitator offers various advantages. Not only is the latter type often more economical to install and to operate, but it has certain inherent operating characteristics that render it more efficient with certain types of dust. For example, the precipitating section of the separated field precipitator is ordinarily substantially free from a phenomenon termed "back-corona" which is caused by the formation of a localized ionizing field on the collecting electrode and which interferes greatly with the effective collection of the suspended particles. Another advantage of the separated field type of precipitator is that, for a given spacing between two opposing electrodes, a materially higher potential difference may be maintained, without causing disruptive discharge or arc-over therebetween, when both electrodes are of the non-discharging type than when one of the electrodes is a discharge electrode. Consequently, it is possible to maintain a relatively higher potential gradient between two non-discharging precipitating electrodes than in a precipitator having the collecting electrode opposed by a discharge electrode. The higher potential gradient causes more rapid and effective collection of the particles.

However, certain precipitators of the separated field type have heretofore had the disadvantage of losing dust from the collecting surface of the precipitating electrodes when the gas stream exceeds a critical velocity, because the dust particles become either neutral or charged with the same polarity as the electrode and so are no longer attracted electrically to the collecting 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 on to the collecting electrode but have become so lightly held that after an agglomerated mass has formed, the gas stream is able to blow the agglomerate off the collecting surface and re-suspend it in the outgoing gas. The quantity of dust blown from the field at relatively low gas velocity is ordinarily negligible, as all the dust particles precipitated are securely held, but it becomes increasingly appreciable at higher velocities and operates to place a definite limit on the gas handling capacity of the treater, this limit being much lower than the capacity as measured by the ability of

the two fields to charge and precipitate the particles.

The action of the gas stream as it moves over the layer of the precipitated particles on the electrode, may be characterized as erosion of the dust layer. The critical gas velocity at which this erosion produces appreciable dust loss varies with several factors, one of the most important of which is the physical properties of the particles themselves. Dust loss above the critical velocity has the effect in practice of reducing the capacity of a unit of given size operating at a given efficiency, because of the limitation on dimensions required in order to keep the gas velocity below critical values. Expressed differently, the reduction of collection efficiency caused by erosion losses increases the size of plant equipment required to treat a given volume of gas without going below a minimum efficiency. Under such circumstances as these, it is possible to have either relatively high collection efficiency or relatively high gas capacity, but the combination of circumstances is such that maximum values of efficiency and capacity cannot be had simultaneously.

In the case of precipitators operating upon gas streams with relatively light dust loadings, as for example in modern air-conditioning equipment, it has become desirable to provide a treater with a large dust retention capacity in the sense that the precipitator should be able to retain a relatively large deposit of dust on the electrodes and still operate efficiently. With heavy dust loadings, it is necessary to clean the collecting electrodes of conventional precipitators at short intervals of the order of a few minutes, and for this purpose treaters have been equipped with heavy duty rapping mechanisms, often automatically operated, which jar the collecting electrodes at pre-determined intervals so as to shake loose the accumulated deposits of dust. Naturally, the lower the dust concentration in the gas stream, the longer may be the interval between successive cleanings. With a light dust loading, if the dust retention capacity of the treater be sufficiently high, the rapping mechanism can be eliminated entirely and hand cleaning resorted to because it may be sufficient to clean the electrodes once a day, or at intervals of greater magnitude. Under some circumstances this may be true, even though the dust loading is fairly heavy. Elimination of the rapping mechanism means not only a simpler, but also a lighter and more economical construction which better adapts the electrical precipitator to fill needs and conditions that are encountered with relatively low dust loadings.

Thus it becomes a general object of my invention to provide an improved separated field type of precipitator in which erosion losses are reduced and the precipitated particles are held in the treater against a tendency to re-suspend them in the gas stream, thus increasing the efficiency of the treater at the gas velocities above those now practical.

The general objects of my invention also include provision of a method of precipitating the charged particles in a precipitating section comprising the steps of passing the gas through a plurality of precipitating fields that act successively on the charged particles and are sufficient in number to collect substantially all particles even though the gas velocity is so high that the first field or few fields do not precipitate all particles, thus increasing capacity and efficiency.

It is also an object to provide a method of precipitation that involves passing the gas through successive precipitating fields to re-precipitate any re-suspended particles and to increase the gas capacity and collection efficiency by eliminating any agglomerates of particles from the gas leaving the precipitator.

It is also a principal object of my invention to provide an improved separated field type of precipitator in which the gas capacity of a treater of given size is increased by increasing the velocity of flow past the electrodes without requiring any increase in electrode size or the quantity of power used to effect the desired degree of precipitation.

Another object is to improve the collection efficiency and capacity of the separated field type of treater in such a way that the treater may be operated at maximum efficiency and maximum capacity without sacrifice of either.

A further object is to provide a precipitator of this character having a sufficiently high dust retention capacity to reduce the necessity of frequent rapping of the electrodes, and, under some circumstances, as when the precipitator is used with a gas stream of light dust loading, to make possible the entire elimination of mechanical rapping mechanism.

Another object of my invention is to provide an electrical precipitator of relatively large capacity which secures even distribution of the gas stream throughout the entire cross-section of the gas duct and which may easily be provided with baffles that divert the gas stream to the electrodes from that portion of the gas duct not occupied by electrodes.

Still another object of my invention is to provide a precipitator of the separated field type which is of simplified construction and may be manufactured easily and economically.

These objects are attained according to my invention by providing, in an electrical precipitation apparatus through which flows a stream of gas containing suspended particles to be removed, a pair of electrodes of which one is a discharge electrode, providing a charging field in which ionization is produced, and a plurality of sets of non-discharging electrodes, each set comprising a plurality of electrodes, disposed beyond said first pair of electrodes in the direction of stream flow and providing a plurality of precipitating fields substantially free of ionization or corona discharge. Each of these non-discharging electrodes is fluid-pervious and extends transversely to the direction of stream flow. These latter electrodes are preferably flat, plate-like members having openings through which the gas flows, and each electrode, taken as a whole, presents a substantially plane collecting surface disposed perpendicularly to the gas stream. Means are provided for applying a high potential difference between electrodes of the first pair in order to establish an ionizing or charging field around the discharge electrode, and for applying a high potential difference between members of each set of the non-discharging electrodes to establish a series of substantially non-discharging precipitating fields which effect precipitation of suspended dust particles, previously charged in the charging field, upon the fluid-pervious collecting electrodes. Certain of the precipitating fields in the series are oppositely directed to others of the precipitating fields.

The method of my invention includes passing the gas through an electric field producing corona

discharge in order to charge the suspended particles. The gas stream is then passed through a series of substantially non-discharging precipitating fields which are so maintained that successive fields are in opposite directions. As the gas passes through the plurality of precipitating fields, the electric forces exerted by successive fields are successively substantially coincident with and then opposed to the direction of gas flow. By subjecting the gas to a field forcing particles in the direction of gas flow and then one opposed to it the particles are precipitated on both faces of the fluid-pervious electrode bounding both fields. The steps of passing the gas stream through successive fields insures precipitation of dislodged agglomerates on succeeding electrodes of polarity opposite to the one from which the agglomerate was dislodged.

In a preferred form of my invention I provide a pair of electrode supports that are insulated from the precipitator housing and serve to support one or more discharge electrodes and alternate ones of the fluid-pervious collecting electrodes in a rigid unitary assembly that can be removed as a whole from the housing by movement parallel to the planes of the electrodes and transverse to the direction of gas flow. The remaining electrodes, which oppose the electrodes supported from these removable supports, are mechanically supported by the housing and electrically grounded through the housing.

The attainment of the above objects and advantages of my invention, as well as others not specifically mentioned, will be more clearly understood by reference to the following description and drawings, in which:

Fig. 1 is a plan view of a preferred form of separated field type precipitator with the top cover plate broken away;

Fig. 2 is a combined vertical section and elevation with the side cover plate broken away, the view being taken on line 2—2 of Fig. 1;

Fig. 3 is a combined transverse vertical section and end elevation, the section being taken on line 3—3 of Fig. 1;

Fig. 4 is an enlarged fragmentary horizontal section through the marginal portion of a fluid-pervious transverse electrode;

Fig. 5 is an enlarged fragmentary elevation of the portion of the electrode shown in Fig. 4;

Fig. 6 is an enlarged fragmentary vertical section of an upper corner of a precipitator showing an application of baffles to this portion of the treater;

Fig. 7 is a fragmentary longitudinal vertical section of a variational form of treater, the section being taken on line 7—7 of Fig. 8;

Fig. 8 is a fragmentary combined end elevation and transverse section of the treater illustrated in Fig. 7; and

Fig. 9 is a fragmentary vertical transverse section through another variational form of treater illustrating a four point suspension of the transverse collecting electrodes.

Referring now particularly to Figs. 1—3, the electric precipitator shown therein comprises a housing 10 which is preferably rectangular in shape. The gas stream flows longitudinally through housing 10, entering from inlet header 12 and being exhausted through outlet header 14. Near the head or inlet end of housing 10, which forms a conduit for confining the gas during its flow through the treater, there is provided one or more pairs of electrodes between the members of which an ionizing field is estab-

lished in order to charge the particles suspended in the gas stream. Each of these pairs of electrodes comprises a discharge electrode 15 and a non-discharging electrode 16.

Non-discharging electrodes 16 are shown as vertically extending cylindrical members, preferably hollow tubes, of sufficient diameter to reduce or eliminate any corona discharge therefrom, and extend for the full height of housing 10, being supported on a transverse member 17. The upper end of each electrode is braced against lateral movement by a tie rod 27a which connects the electrode to a transverse member 27b extending between brackets 27. Electrodes 16 are aligned in a single plane extending transversely of housing 10 and preferably perpendicular to the line of gas flow indicated by arrow 18. It will be understood that other types of non-discharging electrodes, such as plates, may be used instead of the cylindrical members shown. Midway of the interval between each two non-discharging electrodes 16, there is located a discharge electrode 15 which preferably takes the form of a wire of relatively small diameter that facilitates the formation of corona discharge around the wire. Electrodes 15 extend vertically parallel to electrodes 16 and are located in the common transverse plane of the non-discharging electrodes, which plane extends transverse to the direction of gas flow. Each electrode wire 15 is stretched between a pair of vertically spaced arms 19 and 20 at the top and bottom respectively of the electrode. As shown in Figs. 1 and 3, arms 19 are attached to cross-bar 21 and arms 20 are attached to another cross-bar 22, the two cross-bars being joined by vertical members 23 to form a rectangular frame that supports all of the discharge electrode wires in place.

This rectangular frame is supported from cross-member 21, the ends of which rest upon longitudinally extending electrode supporting members or bus-bars 25. The ends of bus-bars 25 are in turn supported each upon an insulator 26 resting upon a bracket 27 attached to the walls of housing 10. High potential electric current is applied to electrodes 15 by electrical conductor 28 which is connected to one or both of the bus-bars and enters housing 10 through the lead-in insulator bushing 30. Conductor 28 is connected to some suitable source of high potential indicated diagrammatically at 29 as these devices are well known in the precipitation art. In general, it is preferable to provide at this source means for supplying unidirectional current although alternating current may be used; and conductor 28 is connected there to one side of this source, the housing 10 being connected through conductor 28a to the other side of the source. Housing 10 is provided with a suitable ground connection as shown at 31. Electrodes 16 are mechanically connected to housing 10 through support 17 and braces 27a, and the electrodes are thus electrically grounded through their connections with the housing. The high potential difference supplied to discharge electrodes 15 through conductor 28 and bus-bars 25 establishes a charging field between each discharge electrode and the opposing non-discharging electrode or electrodes 16. This charging field extends transverse to the direction of gas flow, and by having a sufficient number of pairs of these electrodes arranged in a single transverse plane, the charging fields extend entirely across housing 10 and all of the incoming gas

from header inlet 12 is passed through an ionizing field to charge the suspended particles.

At points removed in the direction of gas flow from the electrode structure previously described, there is located a plurality of sets, preferably two, of non-discharging collecting electrodes 33 and 34. Electrodes 33 of one set and electrodes 34 are all placed in parallel planes extending transversely of housing 10 and the stream of gas flowing through the housing, the electrodes preferably being substantially perpendicular to the gas flow.

Electrodes 33 are larger than electrodes 34 and, as shown in Fig. 3, substantially fill the entire cross-section of housing 10, except at the upper corners. The construction of an electrode 33 is shown in some detail in Figs. 3 to 5. It will be seen that each electrode comprises a frame member 36 around its periphery, and it is preferred to use for this purpose a hollow pipe or tube as it provides a member with desirably large external diameter and the requisite structural strength, without being unnecessarily heavy. The frame formed by pipe 36 bounds the entire periphery of electrode 33, and across this frame is placed a foraminous metal sheet 37 having numerous gas openings 38. It is preferred that metal sheet 37 present a substantially plane surface to the oncoming gas stream, for reasons which will be discussed later, and it has been found that the desired type of surface can be conveniently supplied by using expanded metal which has been rolled flat, or by punching the necessary gas openings 38 in a flat metal sheet. As shown in Fig. 3, electrodes 33 are each sufficiently large that they are substantially in engagement at their edges with the walls of housing 10, in order to prevent the gas stream from by-passing the electrodes, except at the upper corners of the electrodes which are cut away, as illustrated, by an amount determined by the minimum electrical clearance, to allow bus-bars 25 to pass longitudinally of the housing. Since electrodes 33 are in contact with housing 10 and grounded therethrough, it is necessary that there be at least sufficient spacing between any part of these electrodes and a bus-bar 25 to prevent an arc-over between these members.

Although any other suitable means of mounting electrodes 33 in place may be used, it has been found convenient to insert a pin 40 through the housing wall and into the electrode frame at each side of the housing. A convenient location is the open end of the hollow frame member where it extends horizontally near the upper end of the electrode, as illustrated in Fig. 3. Pins 40 are screw threaded or otherwise attached to the housing walls. The weight of the electrode may be carried on these two pins 40 if desired, or the electrode may rest at its lower end upon longitudinally extending channel members 41. The lower end of each electrode 33 is held against movement parallel to the gas stream by pins 42, there being a pair of spaced pins 42 at each side of the electrodes engaging opposite faces of the electrode. With this construction the electrode is held firmly against any horizontal movement, but can be withdrawn from between pins 42 by vertical movement.

Except for its smaller size and somewhat different shape, each electrode 34 is constructed substantially the same as an electrode 33. Each of these smaller electrodes is provided with a frame member 36a extending around its periphery, this member being preferably the same as the hollow pipe 36. Across the frame so formed is

placed a foraminous metal plate 37a having the fluid-pervious characteristics in general of the plate 37 just described.

Although any suitable means of supporting each electrode 34 may be employed, it has been found convenient to extend the side members of the frame 36a upwardly above the top horizontal member and pass these extensions of the electrode through bus-bars 25, as shown in Fig. 3. Set screws 44 in the electrode supports 25 hold the electrode against vertical movement; and the extensions of the frame members fit snugly in openings in the supports in order to afford sufficient resistance to swinging movement of the electrode to hold it in a vertical position.

High potential current is applied to the set of electrodes 34 through their connection to bus-bars 25, and consequently these transverse electrodes are spoken of as high tension electrodes. It is necessary that the high tension electrodes be spaced from the other set of electrodes 33 and all parts of housing 10, which are grounded, by sufficient distance to prevent any sparkover or short-circuiting. This minimum spacing of the high tension electrodes from the low tension parts of the precipitator is termed the electrical clearance, and the spacing between the edges of the electrode and the housing walls is at least equal to the required electrical clearance, though it may be greater. The amount of electrical clearance required varies with the nature of the opposing surfaces in accord with the general principles involved in facilitating or suppressing corona discharge. Since electrical clearance may be less where the opposed parts have relatively large radii of curvature, it is preferred to use a member having this characteristic around the periphery of electrodes 34, and also that the edges of the metal around the openings 38 in the foraminous metal sheets be rounded somewhat to eliminate very sharp edges which would necessitate increased spacing between successive electrodes 33 and 34. It will be noticed that the construction and design of all of the transverse electrodes is such as to render them substantially non-discharging at the electric potential supplied.

Because of the required spacing between the edges of the high tension electrodes and the housing walls, there is left around these electrodes an opening through which an appreciable portion of the gas stream can by-pass the electrode without going through the openings in the electrode itself. This tendency of the gas stream to by-pass the electrodes can in a large measure be eliminated by providing the grounded electrodes with imperforate marginal portions that act as baffles to prevent the gas from moving in a straight path in the region adjacent the housing walls. Although these imperforate marginal portions may take other forms, it is convenient simply to apply baffle plates 48 to one face of the electrodes, as by welding. This construction is illustrated in Figs. 3, 4 and 5 in which it will be seen that the baffle plates 48 are applied to the top, bottom, and side edges of electrodes 33, and that the baffles extend inwardly from the outer periphery of the electrode a distance sufficient that the inner baffle edges are approximately in line with the periphery of the smaller electrodes. It is preferred that the inner edges of baffles 48 be slightly inside of the frame members 36a, as shown in Fig. 3, as this construction renders the baffling effect more effective without materially reducing the minimum cross-section available to the gas stream. The effect of providing the al-

ternate grounded electrodes with marginal baffles is to reduce the fluid-pervious portions of all the transverse electrodes to approximately the same size and shape, and to align these fluid-pervious portions in the direction of gas flow so that the gas tends to flow only in the desired direction and location since it follows the path of least resistance.

One of the particular advantages of the electrode construction and arrangement thus far described is the ease with which the precipitator may be assembled or dis-assembled for inspection, repair, or cleaning of the electrodes. By removing the top cover plate of housing 10 and unscrewing the four bolts 26a or other means that attach longitudinal electrode supports 25 to insulators 26, the entire high tension electrode assembly, including both discharge electrodes 15 and transverse electrodes 34, can be removed from the precipitator by lifting the assembly vertically to move the electrodes parallel to the plane of the transverse electrodes. Not only are the electrodes thus removed as a unit made easily accessible, but the electrodes remaining in the precipitator housing may be reached easily for cleaning in place or removal individually.

Housing 10 is open on its underside throughout at least that portion of the length extending under the transverse electrodes. This opening in the housing is immediately above a removable dust collecting receptacle into which the dust precipitated on the electrodes falls. Although it will be realized that this collecting receptacle may take other forms than that illustrated herein, it is preferred that this receptacle be in the nature of a drawer 50 which slides longitudinally of the housing and is supported by guides which slide within horizontally extending channels 41 at either side of the housing, as seen in Fig. 3. Drawer 50, if unobstructed throughout its entire length, would provide space through which the gas stream could by-pass the electrodes; and in order to prevent this a plurality of vertical baffles 51 are placed in the drawer. From electrical considerations it is preferable to align each of the baffles vertically with a grounded electrode 33, as then the baffle can be extended upwardly to the electrode, or at least sufficiently close thereto to prevent gas flow around the electrode. The number of baffles 51 used is immaterial and depends upon the amount of baffling desired; but I have shown one baffle 51 beneath each of the grounded electrodes as this secures the maximum effectiveness of these baffles.

When the precipitator is in operation, the particles suspended in the incoming gas stream pass through the ionizing field maintained across the width of the housing between electrodes 15 and 16. Assuming that standard practice is followed by supplying unidirectional current to the electrodes, the discharge electrodes 15 are of negative polarity and consequently the particles suspended in the gas stream become charged negatively. These particles are then carried by the gas stream toward the first transverse electrode which may be a high tension electrode 34, but is here shown as a grounded electrode 33 and consequently of positive polarity or oppositely charged to the suspended particles. Some of the negatively charged particles are attracted to the positively charged electrode and are precipitated on the front or upstream side thereof, the particles becoming neutralized or even positively charged.

The remaining negative particles pass through openings 38 and enter the first precipitating field

maintained between the first two collecting electrodes. This field is in a direction to force the charged particles toward the grounded electrode against the gas stream, and consequently a large part of the remaining particles are precipitated on the rear or downstream face of the first electrode 33. The deposition is also facilitated by eddying of the gas stream as it passes through the electrode, since the eddies tend to carry dust particles toward the back face. Negatively charged particles as yet unprecipitated pass through the first high tension electrode 34 and enter the second precipitating field, oppositely directed to the first, that tends to precipitate particles on the front face of the second grounded electrode 33. This action is repeated at each electrode 33, and the negative particles are subjected to a series of successively oppositely directed fields that effect substantially complete initial precipitation on the first few grounded electrodes.

If for any reason there are positively charged particles in the gas stream, these particles tend to go through the first electrode and precipitate upon the first high tension electrode 34, since the high tension electrode is negatively charged and opposite in sign to these positively charged particles.

With respect to the positively charged particles, the initial precipitating field is in a direction that coincides with the gas flow and that forces the particles toward the face of the first high tension electrode. The next field, being oppositely directed, tends to precipitate positive particles on the back side of the electrode. This precipitating action is the same as described for negative particles, the particles in both instances being subjected to successive fields of opposite direction.

In the event that any agglomerates are dislodged by the gas stream from a collecting electrode, these agglomerates are usually charged with the same polarity as the electrode from which they are removed and consequently become precipitated again upon the next electrode of opposite polarity. Consequently, regardless of the charge carried by an agglomerate, it will encounter a number of electrodes of opposite polarity upon which it will be precipitated in the same way as the original charged particles; and in the event that it is again eroded off an electrode, it will still encounter one or more electrodes of opposite sign upon which it can become re-precipitated, unless of course it is blown off the last electrode.

The transverse electrodes are preferably alternately high tension and grounded, as there is then maintained a substantially non-discharging electric field between each two successive electrodes. Considering the first and second electrodes encountered by the gas stream, as shown in Fig. 1, the electrostatic precipitating field maintained between this pair of electrodes is in a direction to oppose movement of the negatively charged particles in the direction of gas flow, since these particles are attracted toward the grounded electrode and repelled from the high tension electrode. If the second and third electrodes are considered as a pair, the non-discharging precipitating field between them is maintained in a direction that assists the movement of negatively charged particles in the direction of gas flow, and it is opposite in direction to the first field. This arrangement of transverse electrodes is preferred because there is maintained between each two successive electrodes a substan-

tially non-discharging precipitating field, and successive fields are in opposite directions, that is, the fields at the two sides of each electrode are oppositely directed. The inter-electrode spacing is preferably uniform; but it may be desirable

- 5 under some conditions to make the spacing between successive pairs of electrodes greater than the spacing between members of the pair instead of substantially equal to it.
- 10 The effectiveness of the collecting electrode arrangement in bringing about a highly efficient dust collection and preventing agglomerate loss is the result largely of two factors. The first of these factors is the arrangement of a series of
- 15 transverse electrodes through which the gas stream passes. Regardless of the charge carried by any suspended particles, and whether these particles have been charged in the ionizing field or have been charged on a transverse screen and
- 20 then blown off, these particles encounter one or more electrodes of opposite sign upon which they will become precipitated, except when the particles are blown off the last electrode. The plurality of electrodes form an effective trap which
- 25 catches substantially all the particles, even though the gas velocity is so high that the initial pair of electrodes alone would be ineffective to hold all of the precipitated dust. Because the heaviest collection is on the initial screens and
- 30 agglomerates are first blown from these screens, it is clear that there is little chance of agglomerates escaping until the last few screens become heavily coated with precipitated particles; and likewise, very little material can escape
- 35 from the precipitator as long as the final few screens remain fairly clean.

- The second of these factors is the shape of the transverse electrodes themselves. Each of these electrodes presents a substantially plane collecting surface to the gas stream. Since this surface is preferably at right angles to the gas stream, there is much less tendency for the particles to be eroded and re-suspended than when the collecting electrode extends in the direction of gas flow.
- 45 Furthermore, the dust holding capacity of each transverse screen is relatively high, since the flat portions of the electrode between the gas openings collect and hold a relatively large amount of precipitated dust, these collecting surfaces being so disposed as not to be subject to the high erosion effect of the gas as it passes through the openings. The collected dust forms a relatively thick layer on the front and back sides of the transverse electrodes until it is no longer able
- 55 to adhere to the metal surface and drops off from its own weight. The collected dust drops off the screen electrodes more readily than from plate electrodes since on the latter the dust layer is continuous and has greater ability to sustain its own weight. Experience indicates that this collected dust falls from the electrode mostly in
- 60 pieces too large to be re-suspended in the gas stream and that these large falling pieces drop directly into dust collection drawer 50. With
- 65 some dusts no rapping or shaking of the electrodes, manually or mechanically, is necessary to clean them, and with other dusts hand cleaning at relatively long intervals is satisfactory. Although there may be some agglomerates which
- 70 are small enough to be re-suspended, these particles become re-precipitated upon succeeding electrodes. The deposit on the electrode is naturally the same pattern as the metal portion of the screen, and it is preferable that the collecting
- 75 surface between successive gas openings be not

too large in order to facilitate breaking away of the precipitated layer. On the other hand, these portions between the gas openings should not be too small since then the gas stream has a more highly erosive effect.

The arrangement shown is preferred because two sets of transverse electrodes provide a collecting electrode system that is simple, compact, and efficient. It provides a plurality of spaced precipitating fields having a common direction, 10 with a field of opposite direction between two of the first mentioned fields. The structure may be modified by adding one or more sets of non-discharging electrodes to the collecting electrode system without changing the fundamental mode 15 of operation. The number of electrodes in each of the two sets will vary with several factors, such as gas velocity, character of the dust, and voltages used. But under ordinary circumstances about eight to ten electrodes in each set have 20 been found sufficient to secure the advantages of the invention. A higher number of electrodes gives still higher efficiency and so may be desired in some designs; but in most instances the increase in efficiency per each electrode added 25 decreases after the first eight or ten electrodes in each set. Again, a lesser number may be adequate on some occasions.

Fig. 6 illustrates an optional baffling arrangement which may be employed with the precipitator described when the spacing between the periphery of a high tension electrode and the housing walls exceeds the minimum electrical clearance, the proportions shown illustrating how, 30 when the spacing is increased to two or more times the electrical clearance, baffling can be used that prevents any straight line flow of gas through the entire length of the precipitator along the upper corners where the bus-bars pass. A typical example of this type of baffling is illustrated in Fig. 6, and comprises an L-shaped plate 40 55 attached to the cover plate of housing 10 in the plane of a grounded electrode 33. Little or no clearance between the edge of the plate and the electrode is required, except to insure fitting of the several parts. The generally rectangular shaped opening left at plate 55 around bus-bar 25 is covered by a baffle-plate of approximately similar shape attached to the high tension electrode 50 in the plane of the latter. Two short pieces of pipe 56 and 56a, of the same size as the electrode frame, are welded to the electrode frame in the positions shown, and a pair of small plates 57 and 57a are welded in place to fill the gaps between pipes 56, frame member 36a, and pipe 56a. In order to permit assembly of the electrodes in the manner previously described, the upper portion of this baffle is made removable and comprises a U-shaped pipe member 58 and a plate 59 extending across the arms of the U-shaped pipe. The upper ends of pipes 56 and 56a are provided with pins 60 which may be inserted into the ends of pipe 58 in order to hold the upper half of the baffle in place. Plates 57, 57a, and 59 are notched as shown to fit around bus-bar 25 and set screw 65 44. Sharp edges around the periphery of each baffle are eliminated by rolling the edges, as at 55a, or by using pipes 56, 56a, and 58, to reduce the minimum electrical clearance at these points.

The two baffles illustrated are each attached to an electrode in the plane of that electrode, and provided with rounded edges to eliminate corona discharge from the baffles. When the spacing between the high tension electrode and the housing walls is in excess of twice the electrical clear- 75

ance, the baffles may overlap by the amount of the excess as they must at all times be spaced from oppositely charged members by at least the minimum electrical clearance. The use and design of baffles depends of course on how completely by-passing of the gas is to be eliminated.

There is illustrated in Figs. 7 and 8 a variation of my invention which illustrates a modified baffle arrangement designed to more completely counteract any tendency of the gas stream to by-pass the electrodes. On top of housing 10 which confines the gas stream, are two auxiliary compartments 64 formed by housings 65, which extend for the full length of main housing 10 and enclose the insulators and longitudinal members supporting the high tension electrodes. The construction and arrangement of these parts is substantially the same as already described, except that the top wall of housing 10 passes underneath insulators 26 so that they are no longer in the gas stream. The vertical side members of the high tension electrode frames are extended upwardly a sufficient distance to be received in bus-bars 25 in the manner previously described. An elongated slot 66 is formed at each side in the top wall of housing 10 to permit these electrodes to extend through the housing wall into the auxiliary compartments 64, the slots 66 being of sufficient size to afford the necessary electrical clearance between the high tension electrodes and the grounded housing.

As may be seen from Fig. 8, the size and shape of the transverse electrodes is somewhat modified since the grounded electrodes 33a conform exactly to the cross-section of housing 10 and now completely fill the cross-section of the housing, since the necessity of electrical clearance from the bus-bars no longer exists. High tension transverse electrodes 34a are the same as previously described, except that the top frame member is closer to the top of housing 10, and the side members extended upwardly a greater distance. As before, baffle plates 48 are applied to the grounded electrodes to provide them with imperforate marginal portions that reduce the gas pervious portions of all electrodes to substantially the same dimensions and align these gas pervious portions in the direction of gas flow.

If desired, additional baffle members 68 and 69 may be supplied, to still further reduce the tendency of gas to by-pass the electrodes by flowing through compartments 64. Baffles 68 are in the form of rectangular plates filling the cross-section of housing 65 and provided with circular central openings concentric with bus-bars 25. These baffles are preferably made in two parts, the upper portions being attached to the walls of housing 65, and the lower portion being attached to the top wall of housing 10. This split construction facilitates assembly and disassembly of the precipitator. Baffles 69 are discs attached concentrically to bus-bars 25 and preferably have a diameter at least equal to the diameter of the openings in baffles 68. When baffles of this type are used, the clearance between bus-bars 25 and the walls of the enclosing housing is preferably at least twice the required electrical clearance. Baffles 68 and 69 are preferably arranged alternately in compartment 64 and the baffles may be placed along the compartment at any desired intervals and in any desired number, subject to requirements of electrical clearance.

This construction preserves all the advantageous features of the construction previously de-

scribed, and operates in the same manner. When it is desired to remove the high tension electrode assembly, the first operation is to remove housings 65, taking with them the upper portions of baffles 68. The nuts 26a fastening bus-bars 25 to insulators 26 are unscrewed, following which operation the cover plate of housing 10 is loosened. The electrode assembly can then be removed by lifting it vertically in a direction parallel to the transverse planes of the electrodes, the cover plate of housing 10 being lifted upwardly with the assembly after the electrodes have been raised sufficiently to bring the top horizontal frame members of the high tension electrodes into engagement with the underside of the cover plate. It is contemplated that all features of construction not specifically shown or described in connection with Figs. 7 and 8 are the same as previously described in connection with Figs. 1 to 6.

There is shown in Fig. 9 another variational form of construction which is particularly adapted to large units requiring a heavier construction than previously shown. In this form, the gas is confined by housing 70 across which extends a number of transverse grounded screens 71 supported on the housing walls. Placed between transverse screens 71 are a number of high tension transverse electrodes 72 which are supported at both their upper and lower ends on longitudinally extending electrode supports or bus-bars 74, the bus-bars being insulated from the housing by supporting insulators 75. The transverse electrodes 71 and 72 are of fluid-pervious construction arranged in series in the same manner previously described.

Bus-bars 74 and insulator 75 are preferably enclosed in auxiliary compartments at the sides of the housing 70, this construction corresponding in general to that shown in Figs. 7 and 8. These auxiliary compartments may also be provided, if desired, with grounded baffles 76 attached to the walls of the compartment and provided with a central circular opening through which the bus-bars pass, and rectangular baffles 77 mounted on the bus-bars. These baffles are arranged to prevent the gas stream from by-passing electrodes by flowing along the auxiliary compartment, in the manner described in connection with Figs. 7 and 8.

The dust falling from the collecting electrodes is collected in hopper 80 provided at the bottom of housing 70 in place of drawer 50, the lower end of the hopper being in communication with a suitable dust valve or conveying means, which may be of any conventional type suitable for the purpose. Hopper 80 is provided with a number of baffles 81 that extend vertically and are preferably in alignment with grounded electrodes 71. These baffles in the hopper prevent by-passing of the gas and direct the stream flow through the fluid pervious portions of the transverse electrodes.

It will be understood that the precipitator of Fig. 9 will be supplied with one or more pairs of electrodes 15 and 16 constructed and arranged as shown in Figs. 1 to 3 in order to charge the particles suspended in the incoming gas, and that these electrodes will be arranged in housing 71 at the inlet end thereof ahead of the transverse collecting electrodes. The method of operation of this form of my invention is substantially the same as that already described in connection

with the previously described forms, consequently the same advantages are obtained.

Having illustrated and described various forms of my invention, it will be understood that changes in the arrangement and construction of parts may be made without departing from the spirit and scope of my invention; and consequently it is desired that the foregoing description be construed as illustrative of rather than restrictive upon the appended claims.

I claim:

1. In an electrical precipitation apparatus through which flows a stream of gas containing suspended particles to be removed, the combination of a pair of electrodes of which one is a discharge electrode; means for applying a high potential difference between said electrodes to establish a charging field; and a plurality of non-discharging collecting electrodes disposed beyond said first pair of electrodes in the direction of stream flow, each of said non-discharging electrodes being fluid-pervious and extending transversely to the direction of stream flow; said non-discharging collecting electrodes being arranged in two or more sets with all the members of each set being electrically similar; electrode supports insulated from the housing and extending longitudinally thereof and supporting all the members of one set of transverse non-discharging electrodes in an assembly that is removable as a unit from the housing by movement parallel to the planes of the electrodes; and means for applying potential difference between sets of non-discharging electrodes to establish a plurality of precipitating fields of which certain fields are in one direction and others of said fields are in the opposite direction, the fields in said opposite direction being interposed between fields in said one direction.

2. In an electrical precipitation apparatus through which flows a stream of gas containing suspended particles to be removed, the combination of a pair of electrodes of which one is a discharge electrode; means for applying a high potential difference between said electrodes to establish a charging field; and at least sixteen non-discharging collecting electrodes disposed beyond said first pair of electrodes in the direction of stream flow, each of said non-discharging electrodes being fluid-pervious and extending transversely to the direction of stream flow; and means for applying a potential difference between successive ones of the non-discharging electrodes to establish a plurality of successive precipitating fields that in direction alternately coincide with and oppose the gas flow through the non-discharging electrodes.

3. In an electrical precipitation apparatus through which flows a stream of gas containing suspended particles to be removed, the combination of a pair of electrodes of which one is a discharge electrode; means for applying a high potential difference between said electrodes to establish a charging field; and at least sixteen fluid-pervious, substantially non-discharging collecting electrodes disposed transversely of the stream flow at points beyond the first mentioned pair of electrodes in the direction of stream flow, said non-discharging electrodes being arranged in pairs with the spacing between pairs substantially equal to the spacing between the members of a pair; and means for maintaining the electrodes of each pair at opposite polarity, with a high potential difference between them to establish a series of substantially non-discharging precipitat-

ing fields of which the fields between pairs are opposite in direction to the fields between the members of a pair.

4. In an electric precipitation apparatus through which flows a stream of gas containing suspended particles to be removed, the combination of a housing confining the gas stream; a plurality of discharge electrodes arranged in a plane transverse of said gas stream; a plurality of non-discharging electrodes arranged in said transverse plane opposing and spaced from said discharge electrodes; means for maintaining a charging field between said discharge and non-discharging electrodes; a plurality of fluid pervious, substantially non-discharging collecting electrodes extending transversely of the gas stream in parallel planes and each filling substantially the entire cross-section of the housing except for electrical clearance, the transverse electrodes being arranged in series spaced from each other in the direction of gas flow; a pair of electrode supports insulated from the housing extending in the direction of gas flow and supporting the discharge electrodes and alternate ones of the fluid pervious transverse electrodes in a rigid assembly that is removable as a unit from the housing by transverse movement parallel to the planes of the electrodes; and means for maintaining a series of substantially non-discharging precipitating fields between successive pairs of transverse fluid pervious electrodes.

5. In an electric precipitation apparatus through which flows a stream of gas containing suspended particles to be removed, the combination of an electrically grounded housing of generally rectangular cross-section confining the gas stream; a plurality of discharge electrodes arranged in a plane transverse of said gas stream; a plurality of non-discharging electrodes arranged in said transverse plane opposing and spaced from said discharge electrodes; means grounding said non-discharging electrodes through the housing; means for maintaining a charging field between said discharge and non-discharging electrodes; a plurality of fluid-pervious, substantially non-discharging collecting electrodes extending transversely of the gas stream in parallel planes and each filling substantially the entire cross-section of the housing except for electrical clearance, the transverse electrodes being arranged in series spaced from each other in the direction of gas flow; a pair of electrode supports insulated from the housing extending in the direction of gas flow and supporting the discharge electrodes and alternate ones of the fluid pervious transverse electrodes in a rigid assembly that is removable as a unit from the housing by transverse movement parallel to the planes of the electrodes; means grounding the remaining transverse electrodes through the housing; and means for maintaining a series of substantially non-discharging precipitating fields between successive pairs of transverse fluid pervious electrodes.

6. In an electric precipitation apparatus through which flows a stream of gas containing suspended particles to be removed, the combination of a housing having an opening in its underside and confining the gas stream; a pair of electrodes of which one is a discharge electrode; means for maintaining a charging field between said pair of electrodes; a plurality of fluid-pervious, substantially non-discharging collecting electrodes extending transversely of the gas stream in parallel planes and each filling substantially the entire cross-section of the housing

except for electrical clearance, the transverse electrodes being arranged in series spaced from each other in the direction of gas flow; electrode supports insulating from the housing alternate ones of the fluid pervious transverse electrodes; mounting means for the remaining transverse electrodes electrically connecting said remaining electrodes to the housing; a precipitated dust collecting receptacle under the housing and closing the opening therein; a plurality of vertical baffles in the collecting receptacle, each of said baffles being vertically aligned with one of said remaining transverse electrodes and sufficiently closely spaced therefrom substantially to prevent gas flow around the transverse electrodes and through the receptacle; and means for maintaining a series of substantially non-discharging precipitating fields between pairs of transverse fluid-pervious electrodes.

7. In an electrical precipitation apparatus through which flows a stream of gas containing suspended particles to be removed, the combination of a housing confining the gas stream; a pair of electrodes of which one is a discharge electrode; means for applying a high potential difference between said electrodes to establish a charging field; and a plurality of fluid-pervious, substantially non-discharging collecting electrodes disposed transversely of the stream flow at points beyond the first mentioned electrodes in the direction of stream flow, alternate ones of said transverse electrodes being spaced around their peripheries from the housing by at least the required electrical clearance, the others of the transverse electrodes being of sufficient size to engage the housing walls and each having marginal imperforate portions of sufficient width that the fluid-pervious portions of all transverse electrodes are of approximately the same size and aligned in the direction of gas flow; and means for applying a high potential difference between

successive transverse electrodes to establish a plurality of precipitating fields.

8. The method of precipitating suspended particles from a gas stream that includes the steps of subjecting the gas stream containing suspended particles to the action of an electric field producing corona discharge in order to electrically charge the particles; and then subjecting the gas stream containing charged suspended particles to the action of a series of substantially non-discharging precipitating fields maintained successively in opposite directions that successively exert forces on the charged particles in directions substantially coincident with and opposed to the direction of gas flow in order to precipitate the particles.

9. The method of precipitating suspended particles from a gas stream that includes the steps of maintaining an electric field producing corona discharge; subjecting the gas stream containing suspended particles to the action of said electric field to electrically charge the particles; maintaining a series of substantially non-discharging precipitating fields in successively opposite directions between a series of electrodes of which successive ones are of opposite polarity; subjecting the gas stream containing charged suspended particles to the action of the series of fields that exert forces on the charged particles in directions successively substantially coincident with and opposed to the direction of gas flow to precipitate the particles; and subjecting precipitated particles that are dislodged from an electrode and resuspended in the gas stream to the action of at least a portion of said series of non-discharging fields to reprecipitate the resuspended particles on an electrode of a polarity opposite to that of the electrode from which the particles were dislodged.

HARRY J. WHITE 40