

March 5, 1946.

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2,395,927

ELECTRICAL PRECIPITATOR

Filed Dec. 10, 1943

4 Sheets-Sheet 1

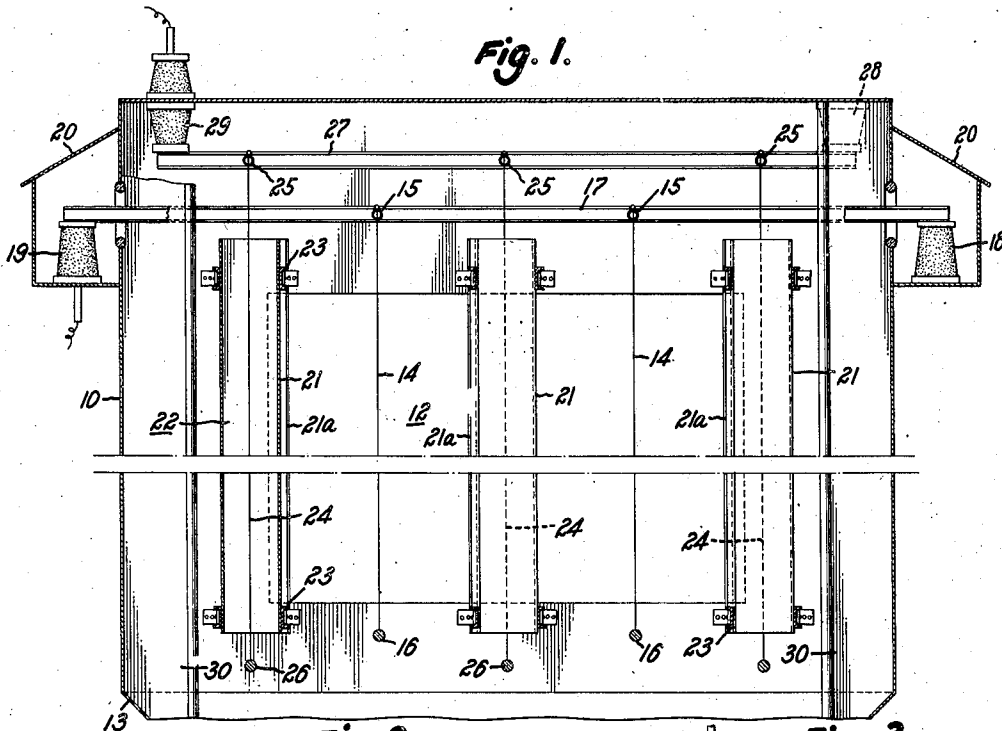


Fig. 2.

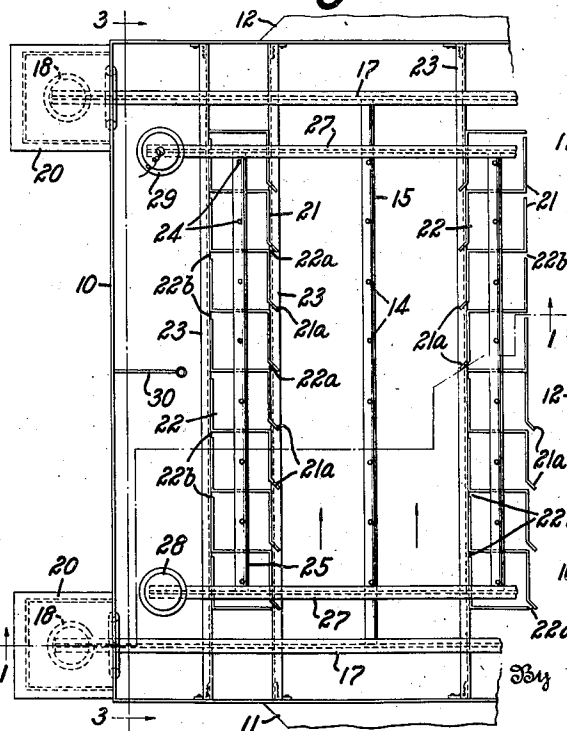
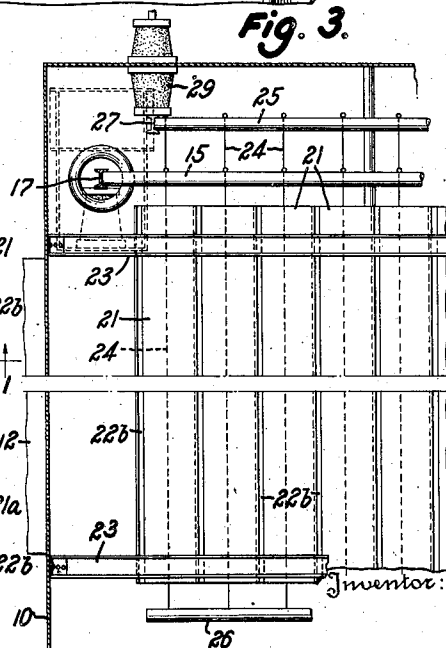


Fig. 3.



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Fig. 4.

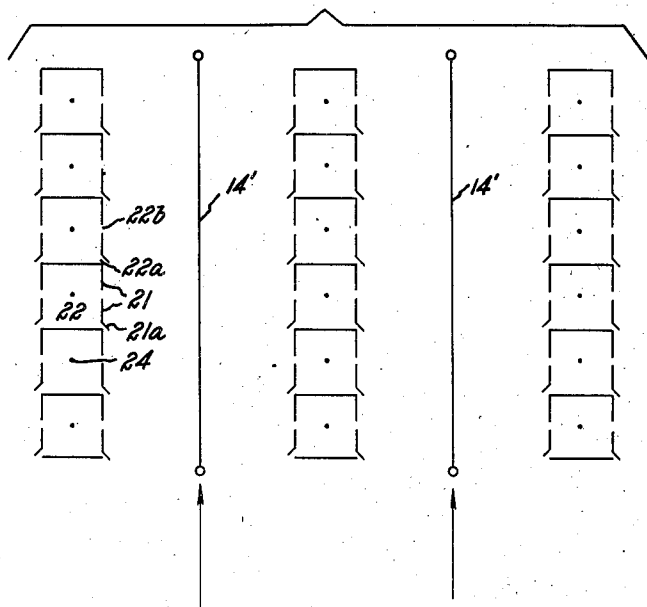
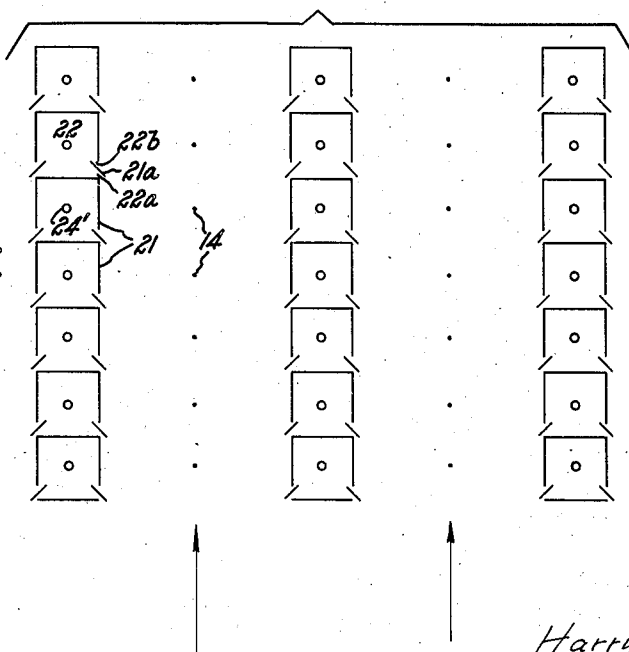


Fig. 5.



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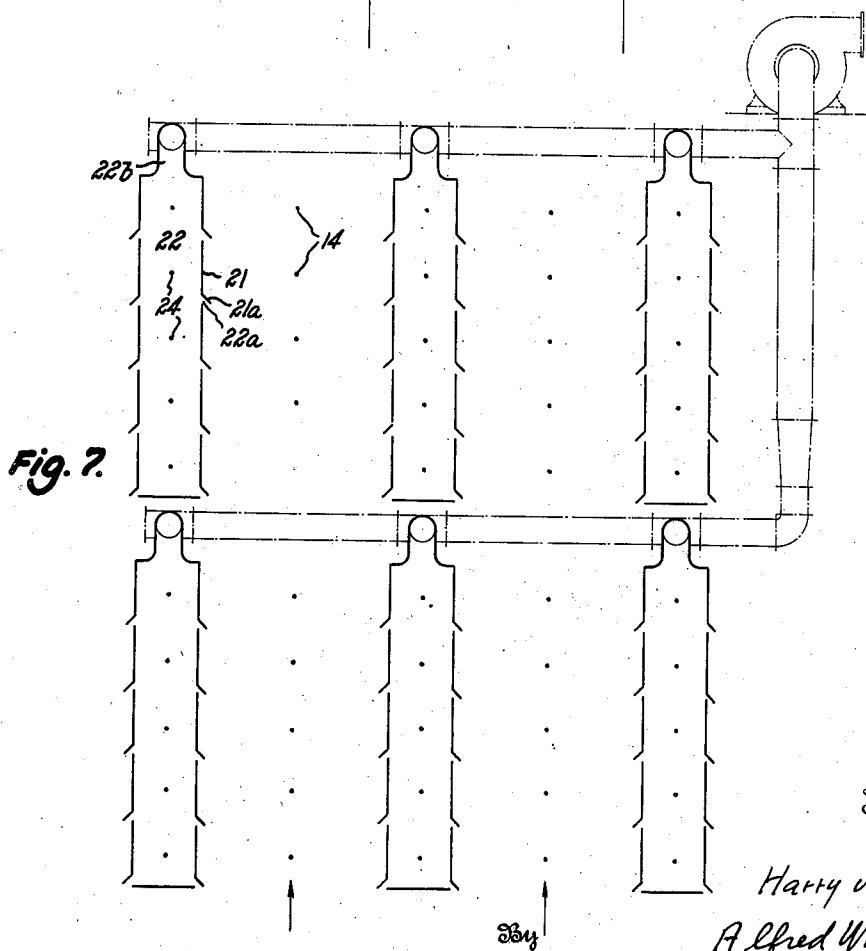
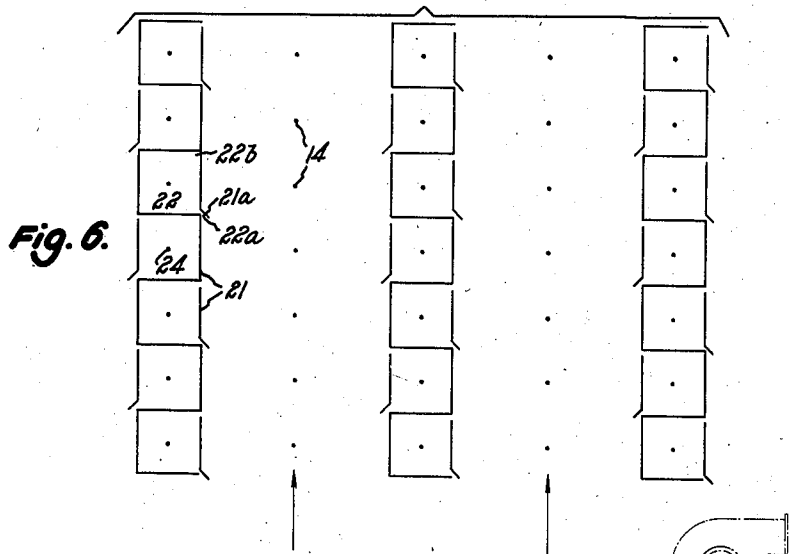
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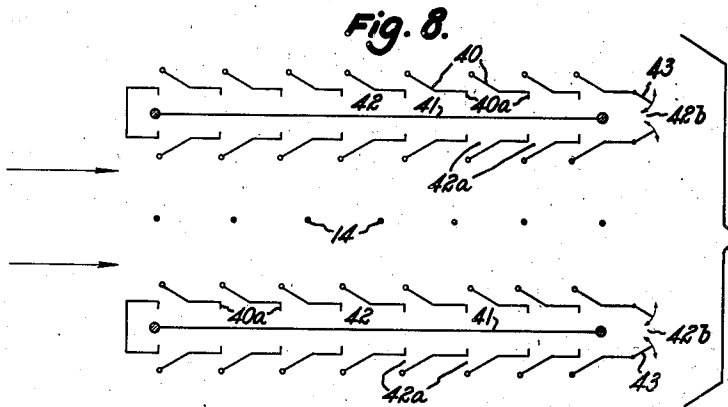
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,395,927

ELECTRICAL PRECIPITATOR

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Application December 10, 1943, Serial No. 513,765

3 Claims. (Cl. 183—7)

This invention relates to the electrical precipitation of suspended particles from gases and is particularly directed to improved collecting electrode structures for electrical precipitators and to electrical precipitators including the new collecting electrode structures.

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 are then 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 two electrodes being a discharge electrode at which there is silent or corona electrical discharge that ionizes the gas and causes the suspended particles to become charged with the same electrical sign as the discharge electrode. This is termed charging action.

In the "single stage" type of precipitator, the charged particles migrate under the influence of the electric field between the electrodes toward the other electrode which is a non-discharge electrode of extended surface, and collect or become precipitated upon the surface of that electrode which is consequently termed the collecting electrode. In the "two-stage" or "separated field" type of precipitators, the gas containing all or a substantial proportion of the charged particles passes into a second or precipitating field, typically maintained between opposed non-discharged electrodes, and, under the influence of the precipitating field, the charged particles migrate to one of the electrodes between which the field is maintained and are deposited thereon. The latter electrode is likewise termed a collecting electrode. The novel collecting electrode structures of the present invention may be advantageously utilized as collecting electrodes in either single-stage or two-stage precipitators.

In the following description and in the 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 spark-over. 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 they may be created in the immediate vicinity thereof a sufficiently high electric field intensity to cause ionization and corona discharge. The term "non-discharge 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 spark-over. For this purpose, a non-discharge 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.

Dust particles in the gas stream become electrically charged in the ionizing field and there migrate to the collecting electrode under the influence of the electrical forces exerted on them, and when the particles reach and are precipitated on the electrode the electric charges are neutralized or lost. The layer of dust particles on the electrode is exposed ordinarily to the gas stream which tends to blow off loose individual particles or agglomerations of particles, the erosion being a result of the gas velocity. The particles are held on the electrode more or less securely against erosion either by electrical forces or by the physical properties of the particles themselves. When the collecting electrode is within the range of the charging field, as in the single field type of precipitator, the field recharges and reprecipitates most of the particles that may be blown off the electrode, but even then some particles are blown along the electrode surface and off the outlet end of the electrode when the dust has such physical properties that the particles offer little resistance to gas erosion. In the two-stage type of precipitator in which there is typically no corona discharge in the second or precipitating field, most of the material removed from the collecting electrode by erosion is not recharged and is carried out of the precipitator by the gases.

There are some dusts that are particularly hard to collect for this reason, one typical example being "fly ash" which is composed of particles that have a generally spherical shape and have very little inherent tendency to adhere to the electrode or to each other. Characteristics such as these facilitate erosion of the precipitated dust layer by the gas stream, the particles that are picked up being carried away by the outgoing

cleaned gases. Very little erosion takes place at low gas velocities and may be neglected, though the rate increases slowly with increasing velocity up to some velocity termed the "critical velocity" above which erosion loss increases rapidly with an increase in velocity and becomes quite appreciable. It is probably true of most dusts, if not all, that there is a critical velocity above which losses are appreciable. The present interest centers particularly around dusts for which the critical velocity is relatively low, since the amount of these dusts carried into the outgoing gas stream is considerable and makes it difficult to obtain high overall collection efficiencies at economic velocities. Obviously, the critical velocity for a given dust limits the capacity of a given treater if good collection efficiency is to be obtained.

This collection difficulty is inherent in the nature of the dust being collected and has the effect of reducing the capacity of a unit of a given size operating at a given normal efficiency, because of the limitation on dimensions required in order to keep the gas velocity below critical values. Expressed differently, the reduction in collection efficiency caused by erosion losses increases the size of the plant and equipment required to treat a given volume of gas without falling below a minimum efficiency.

A principal object of the invention is to provide an improved electric precipitator in which loss of collected material by erosion or redispersion in the gas stream is substantially reduced or eliminated.

A further object of the invention is the provision of an improved form of collecting electrode construction for electrical precipitators.

Another object of the invention is the provision of an improved method for the removal of suspended particles from gases by electrical precipitation.

These and other objects and advantages which will be clearly apparent from the following description of the invention are attained by the provision of a collecting electrode structure including primary material collecting surfaces at least partially exposed to the stream of gas being treated, secondary collecting surfaces fully shielded from the stream of gas, precipitating electrode means positioned to precipitate material on said secondary collecting surfaces, and means for directing a flow of gas including material eroded from the primary collecting surfaces into the space between the discharge electrode means and the secondary collecting surfaces.

A typical electrical precipitator embodying the invention includes a precipitating electrode structure and a collecting electrode structure spaced therefrom to define a gas passage therebetween and comprising extended surface members defining one or more vertically-extending passageways and providing primary material collecting surfaces and a plurality of openings, preferably vertically-extending slots, establishing communication between the gas passage and the vertically-extending passageways, means, such as vane elements or suitably positioned fans, for directing gas flow from said gas passage into said vertically-extending passageways, means providing secondary material collecting surfaces within the vertically-extending passageways, and precipitating electrode members within the vertically-extending passageways spaced and insulated from the secondary material collecting surfaces.

The secondary material collecting surfaces may

be provided at least in part by the extended surface members which provide the primary material collecting surfaces, utilizing, for example, opposite faces of said members to provide the two collecting surfaces. When the secondary material collecting surfaces are provided by different members from those providing the primary material collecting surfaces, the latter members may also provide or support the precipitating electrode members which cooperate with the secondary collecting surfaces to effect the precipitation of material thereon.

If the collecting electrode structure of the invention is embodied in a single stage precipitator, the complementary precipitating electrode structure will include discharge elements, while if the collecting electrode structure is embodied in the precipitating stage of a two-stage precipitator, the complementary precipitating electrode structure will typically be of the non-discharge type.

In general, the average field strength between the precipitating electrode members within the vertical passageways and the secondary collecting surfaces therein may be of the same order as the average field strength between the collecting electrode structure and the precipitating electrode members complementary thereto.

The invention will be more particularly described for the purpose of illustration with reference to the accompanying drawings in which:

Fig. 1 is a sectional elevation of an electrical precipitator embodying the principles of the invention;

Fig. 2 is a partial plan view of the precipitator of Fig. 1 with the top cover plate removed;

Fig. 3 is a partial sectional elevation on line 3-3 of Fig. 2, and

Figs. 4 to 8 are diagrammatic representations of illustrative embodiments of the invention.

In Figs. 1-3, 10 is a precipitator casing provided with gas inlet 11, gas outlet 12 and a collecting hopper 13 for precipitated material.

Within the casing 10 are complementary precipitating and collecting electrode structures spaced apart to define longitudinal gas passages through the casing.

The precipitating electrode structure comprise discharge electrodes 14, consisting of wires suspended from horizontal tubes 15 and maintained taut and in proper spaced relationship by rods 16. Tubes 15 are carried on I-members 17 which are supported on insulators 18 and insulator bushing 19 contained in insulator housings 20. The precipitating electrode structure is energized through the insulator bushing 19.

The collecting electrode structure comprises a plurality of sheet metal members 21, shaped and arranged to provide a plurality of vertically-extending passageways 22 having vertical inlet slots 22a and outlet slots 22b. Adjacent the inlet slots 22a the members 21 are provided with lip member 21a, extending outwardly into the gas passages to direct a portion of the gas stream flowing immediately adjacent the outer surfaces of members 21 into the vertical passages 22. The members 21 are supported from the end walls of casing 10 by beam members 23 extending horizontally adjacent the upper and lower ends of the members 21.

Within each of the vertical passageways 22 provided by members 21, is positioned a discharge electrode 24 suspended from horizontal tubes 25 and maintained taut and in proper position by rods 26. Tubes 25 are carried on I-members 27 which are supported from insulators 28 and in-

ulating bushing 29 through which the discharge electrodes 24 are energized.

Baffles 30 aid in confining the gas flow within the interelectrode spaces.

In operation, suspended material contained in a gas stream passed horizontally through the apparatus is collected initially on the surfaces of the sheet metal members 21 facing the precipitating electrodes 14. The gas velocity in the main gas passages between the collecting and precipitating electrode structures is maintained above the velocity at which erosion occurs and preferably at such a velocity that all or a substantial part of the primarily deposited material is removed by erosion. Thus the whole or a major part of the deposited material is carried along the primary collecting surface in the direction of gas flow in the main gas passages. The lips 21a projecting from the collecting surfaces adjacent the inlet slots 22a cause a small portion of the gas stream adjacent the collecting surfaces to flow into each of the passageways 22, a corresponding amount of gas flowing out of the passageways through outlets 22b. The amount of flow through the passageways 22 is adjusted by suitably altering the area of opening of the inlet or outlet slots or by altering the angle of the lips 21a or by any combination of these means, and is preferably adjusted to a velocity which will permit a high efficiency of precipitation within the passageways.

Thus the material deposited in the primary precipitating field is transferred by erosion and gas flow into a secondary precipitating field where it is collected under conditions of relatively low gas velocity upon the shielded inner surfaces of members 21. Very high gas velocities of 25 to 50 feet per second or even higher may be used in the main gas passages.

The collecting electrode structures may be rapped during operation to cause the collected material to drop into a hopper or other suitable receiver in the bottom of the apparatus.

Alternative arrangements and constructions of the inlet and outlet openings and the lip members are shown diagrammatically in Figs. 4, 5 and 6 in which corresponding elements are given the same number as in Figs. 1-3.

In the construction of Fig. 4, the primary precipitating electrodes 14' are shown as non-discharge electrode members, while in the construction of Fig. 5 the secondary precipitating electrodes 24' are shown as non-discharge electrode members. Similar replacement of the discharge type primary and secondary precipitating electrodes shown in the constructions of Figs. 1 to 7 may also be made. The use of non-discharge type primary precipitating electrodes, as shown in Fig. 4, together with either discharge or non-discharge type secondary precipitating electrode members, is particularly advantageous when using the construction as the second or precipitating stage of two-stage electrical precipitators.

In general, it is preferable to maintain a potential difference between the primary precipitating electrodes and the collecting electrode structure at about 30 to 50 kv. with a spacing of 4 inches, for example, if the primary precipitating electrode is of the discharge type, and somewhat higher, say 40 to 60 kv. for the same spacing, if the precipitating electrode is of the non-discharge type. Average field strengths of the same order of magnitude are preferably maintained between the secondary precipitating electrodes and the secondary collecting surfaces.

It is generally advantageous to maintain the

primary collecting electrode surfaces at ground potential with the primary precipitating electrodes being of negative polarity with respect to ground potential, and the secondary precipitating electrodes also being of negative polarity with respect to ground potential in the forms of the invention shown in Figs. 1, 2, 3, 4, 6 and 7, and being of positive polarity with respect to ground in the form of the invention shown in Fig. 5. In the form shown in Fig. 8 the primary precipitating electrodes 14 may be negative and the secondary collecting electrodes 41 may be positive with respect to the primary collecting electrode structure. However, other arrangements are feasible as long as the general potential difference relations suggested above are maintained.

In the arrangement shown in Fig. 7, the gas passageways 22 have a plurality of inlets 22a and a single outlet 22b which may be led directly into the gas stream or may be connected to a suitable system of ducts leading to an exhaust fan, as indicated in the drawings, to provide a more positive control of the gas velocity through the secondary collecting spaces 22. Instead of the duct system, adjustable dampers, such as are shown in Fig. 8, may be provided at the outlets 22b.

In the form of the invention shown in Figs. 8 and 9, the discharge electrode elements 40a providing the secondary precipitating corona discharge are carried by extended surface members 40, which provide the primary material collecting surfaces, and the secondary material collecting surfaces are provided by extended surface members 41, which are insulated from the members 40.

The members 40 define gas passageways 42 with inlet openings 42a and outlets 42b. The outlets 42b may be provided with adjustable dampers 43, as shown, or may be connected to a suitable flue and fan system as indicated in Fig. 7.

The discharge precipitating electrodes 14 of Fig. 8 may be replaced by non-discharge type precipitating electrodes as shown in Fig. 4 and the discharge elements 40a may be eliminated from extended surface members 40, so that the latter act as non-discharge precipitating electrodes with respect to secondary collecting electrode members 41.

I claim:

1. An electrical precipitator comprising: a primary precipitating electrode structure; a collecting electrode structure spaced therefrom to provide a gas passage therebetween and comprising wall means defining a vertically extending space within said collecting electrode structure and shielded from the flow of gas in said passage, said wall means providing primary material collecting surface portions of extended area facing toward said gas passage, secondary material collecting surface portions of extended area facing toward said shielded space, and a plurality of slots establishing communication between said gas passage and said shielded space, said slots being spaced apart in the direction of gas flow in said passage and extending transversely with respect to said gas flow, and said collecting electrode structure being provided with gas deflecting members disposed adjacent said slots in position to direct gas from said gas passage into said shielded space and with at least one opening for outflow of gas from said shielded space at a position removed from said slots; and secondary precipitating electrode members within said shielded space and spaced from said secondary material collecting surface portions.

2. An electrical precipitator comprising: a primary precipitating electrode structure; a collecting electrode structure spaced therefrom to provide a gas passage therebetween and comprising wall means defining a vertically extending space within said collecting electrode structure and shielded from the flow of gas in said passage, said wall means providing primary material collecting surface portions of extended area facing toward said gas passage, secondary material collecting surface portions of extended area facing toward said shielded space, a plurality of slots establishing communication between said gas passage and said shielded space, said slots being spaced apart in the direction of gas flow in said passage and extending transversely with respect to said gas flow, and said collecting electrode structure being provided with gas deflecting members disposed adjacent said slots in position to direct gas from said gas passage into said shielded space and with a plurality of openings between said shielded space and said gas passage for outflow of gas from said shielded space at positions removed from said slots; and secondary precipitating electrode members within said shielded space and spaced from said secondary material collecting surface portions.

3. An electrical precipitator comprising: a primary precipitating electrode structure; a collecting electrode structure spaced therefrom to provide a horizontally extending gas passage therebetween and comprising wall means defining a plurality of vertically extending passageways within said collecting electrode structure and shielded from the flow of gas in said passage, said wall means providing primary material collecting surface portions of extended area facing toward said gas passage, secondary material collecting surface portions of extended area facing toward the respective shielded passageways, and a plurality of horizontally spaced vertical slots establishing communication between said gas passage and the respective shielded passageways, and said collecting electrode structure being provided with gas deflecting members disposed adjacent said slots in position to direct gas from said gas passage into said shielded passageways and with openings for outflow of gas from the respective shielded passageways at positions removed from said slots; and secondary precipitating electrode members within the respective shielded passageways and spaced from said secondary material collecting surface portions.

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