March 11, 1952 E. DEGIORGI 2,588,364

ELECTROSTATIC PRECIPITATOR

Filed May 16, 1947 8 Sheets-Sheet 1

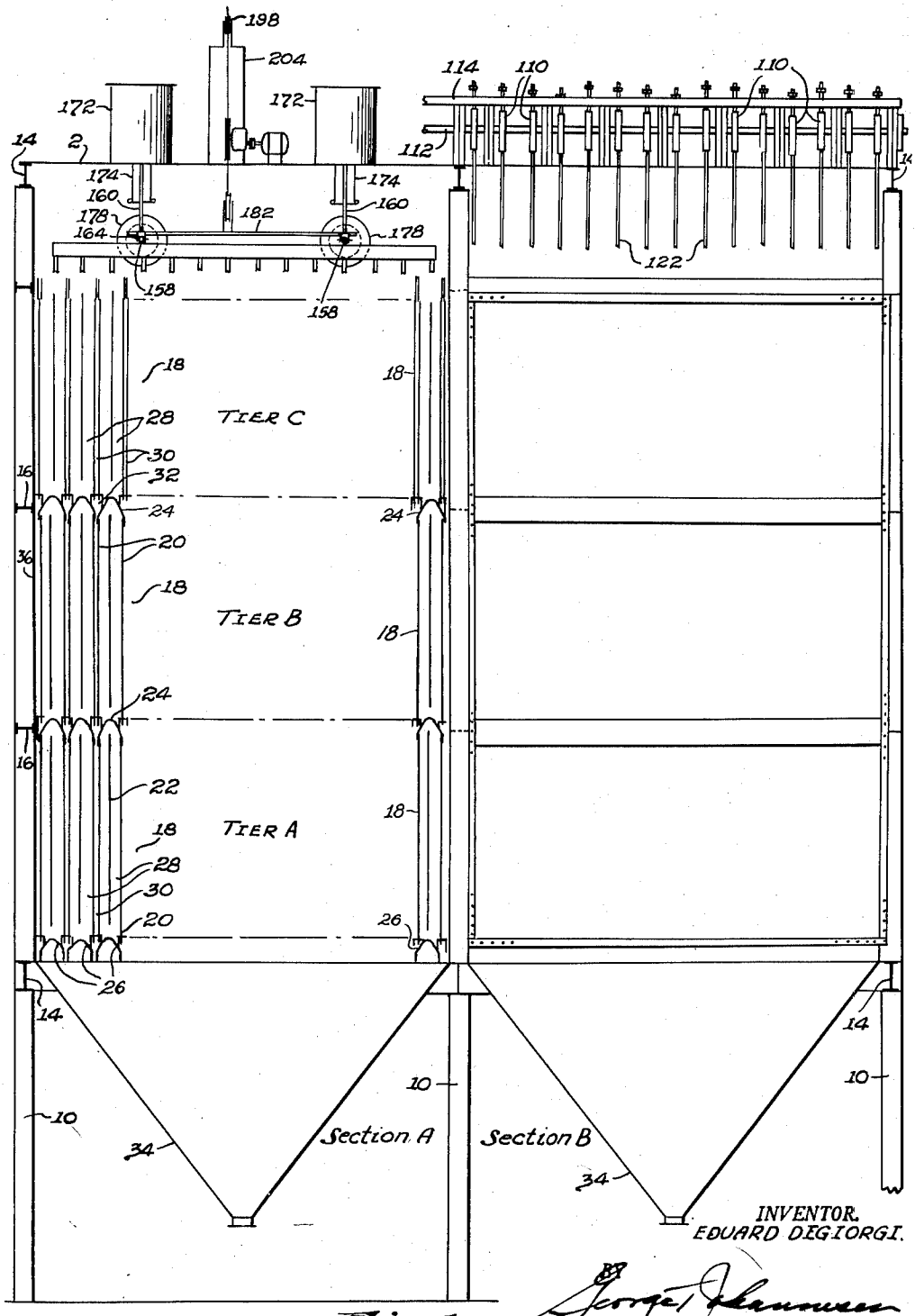


Fig. 1.

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March 11, 1952 E. DEGIORGI 2,588,364

ELECTROSTATIC PRECIPITATOR

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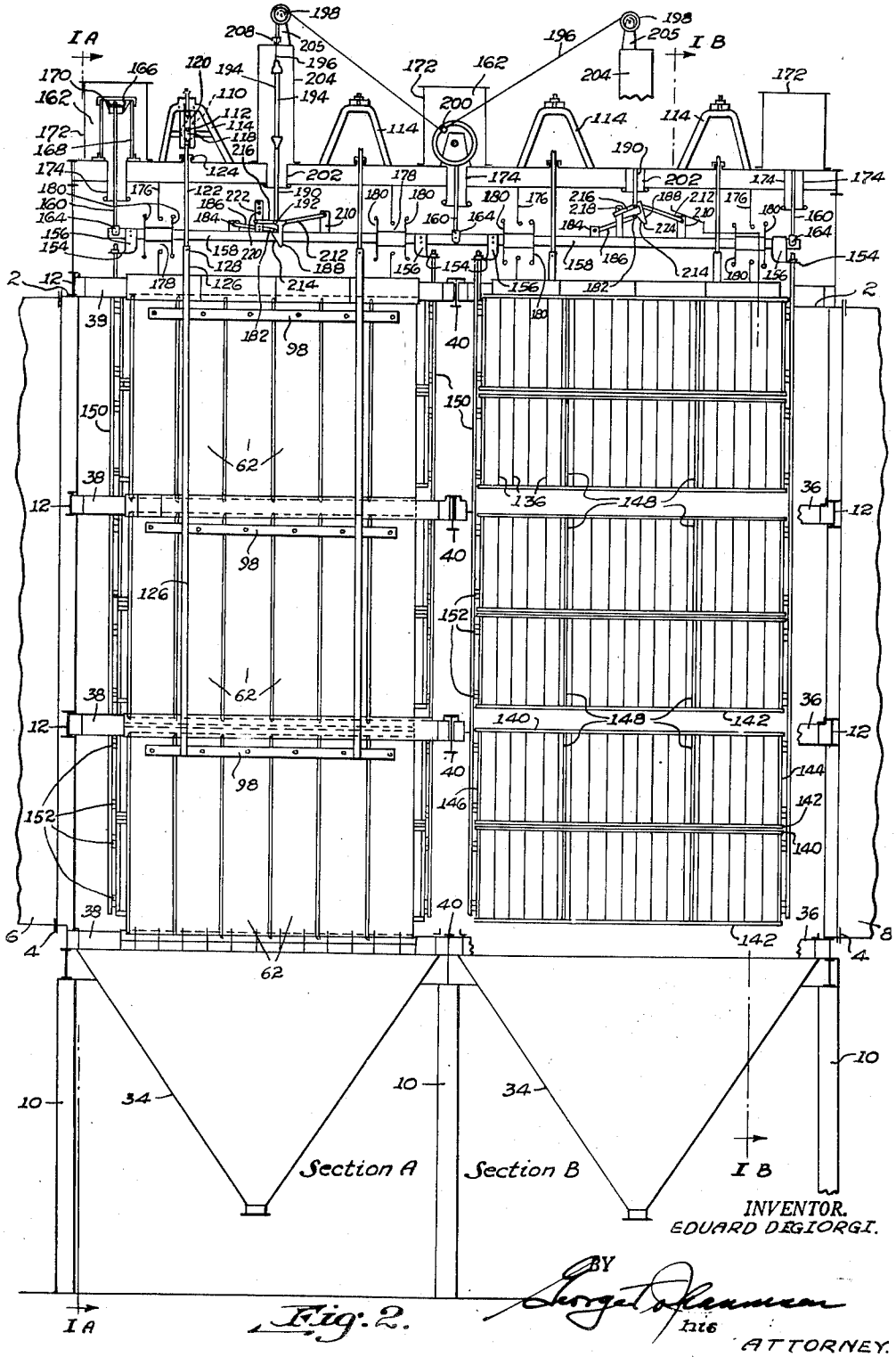


Fig. 2.

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ELECTROSTATIC PRECIPITATOR

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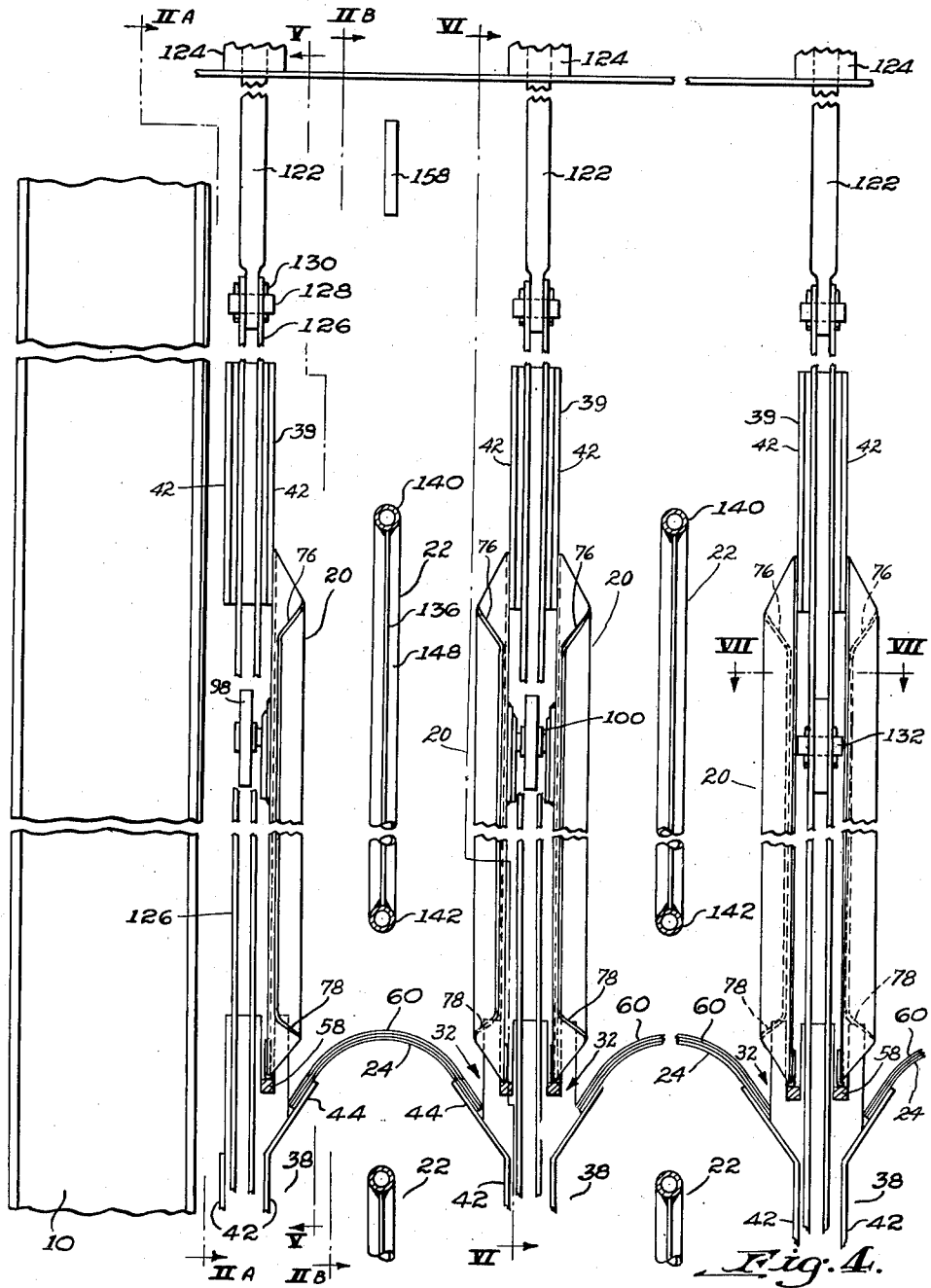


Fig. 3.

Fig. 4.

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ELECTROSTATIC PRECIPITATOR

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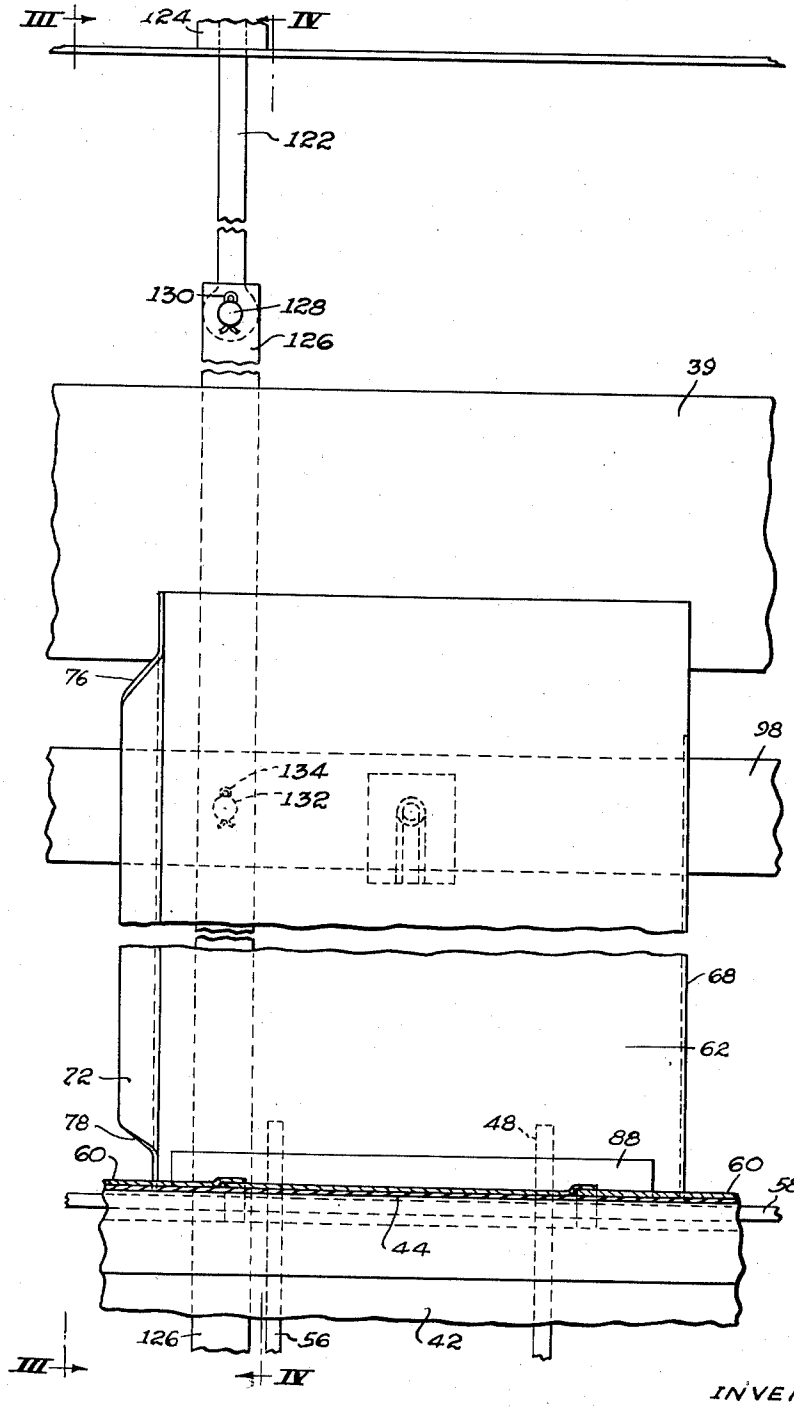


Fig. 5.

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ELECTROSTATIC PRECIPITATOR

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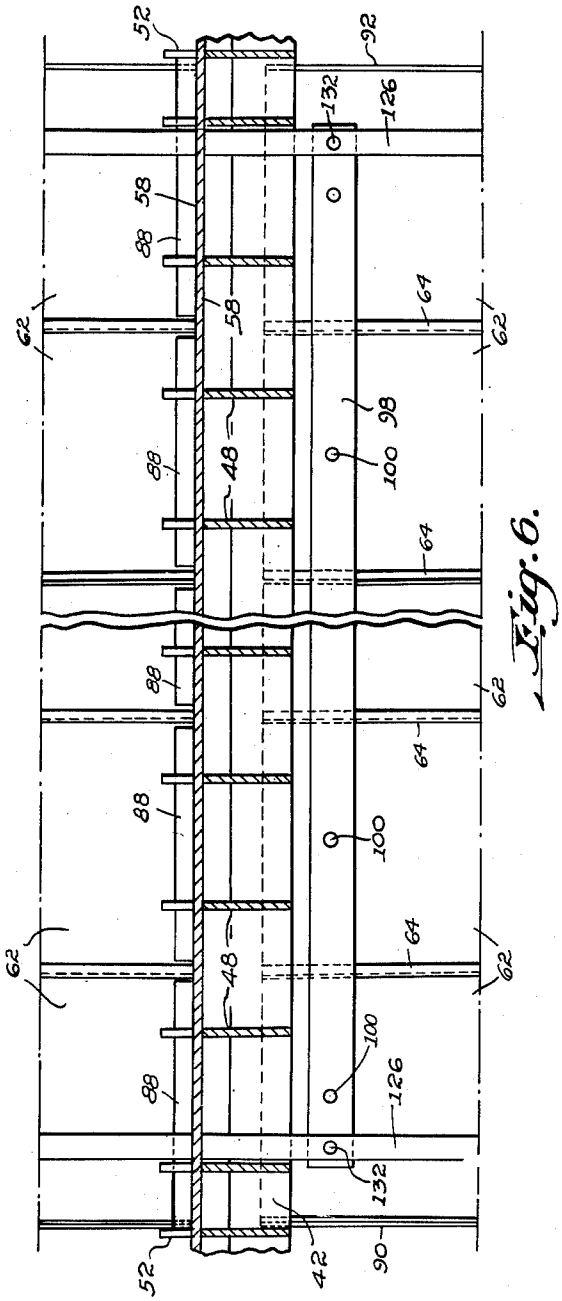


Fig. 6.

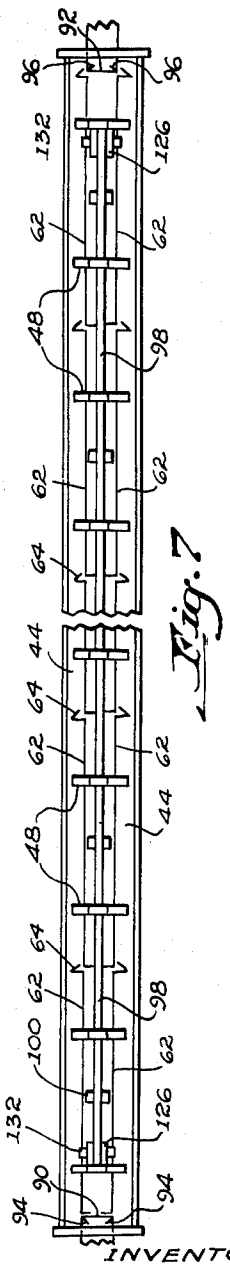


Fig. 7.

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ELECTROSTATIC PRECIPITATOR

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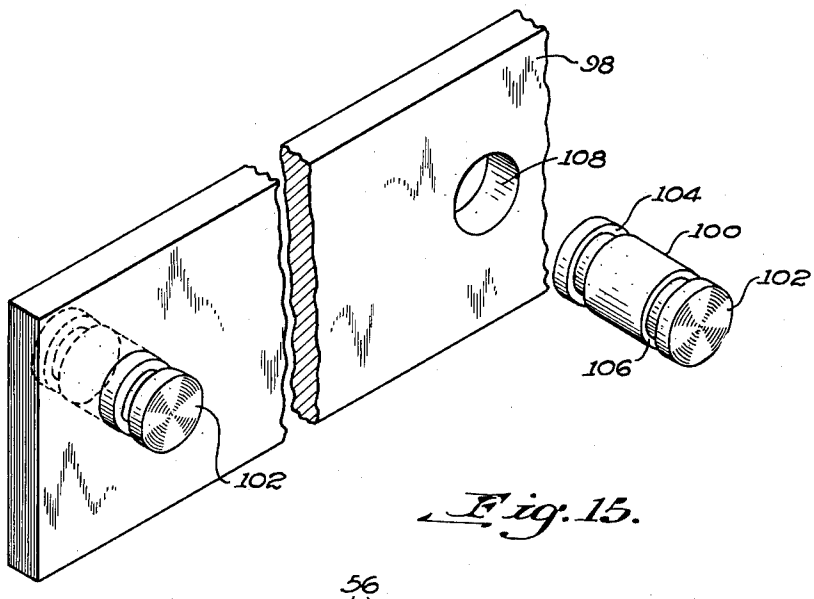


Fig. 15.

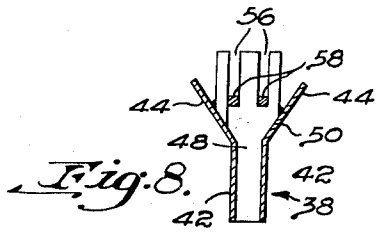


Fig. 8.

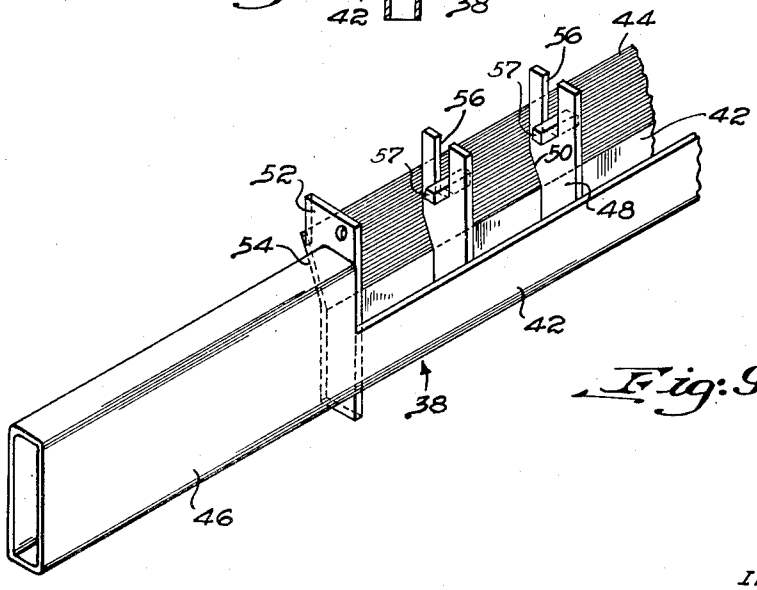


Fig. 9.

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ELECTROSTATIC PRECIPITATOR

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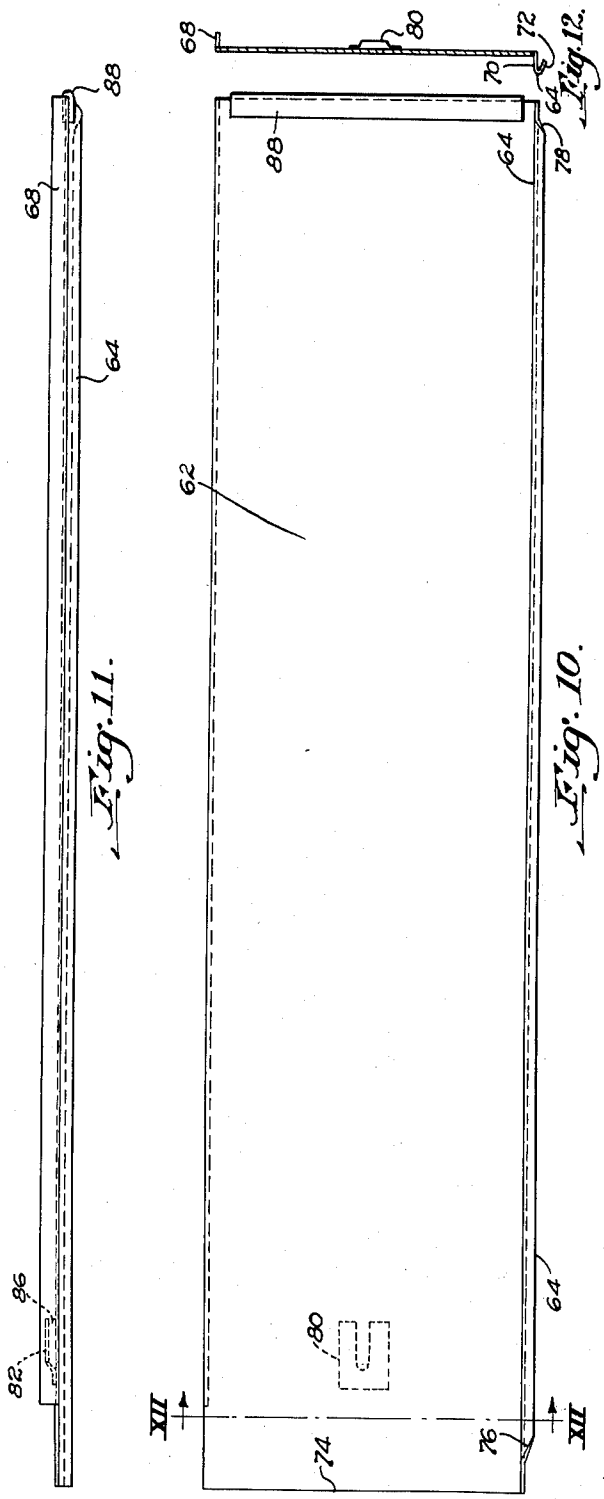


Fig. 11.

Fig. 10.

Fig. 12.

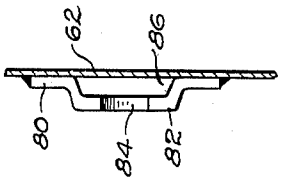


Fig. 14

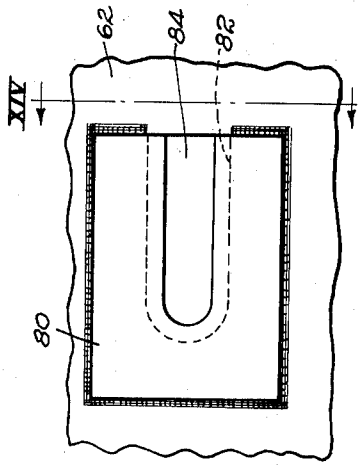


Fig. 13.

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ELECTROSTATIC PRECIPITATOR

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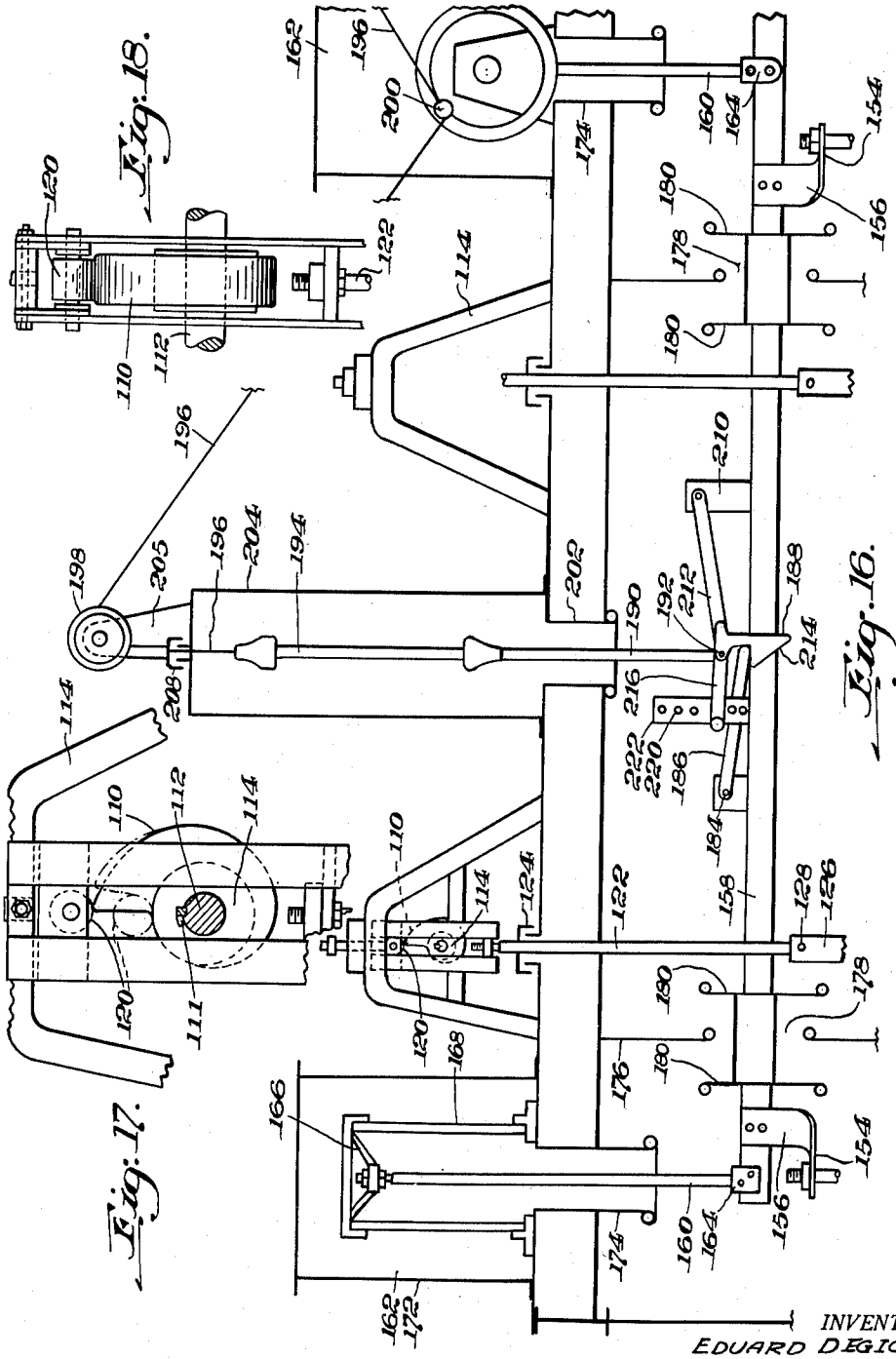


Fig. 16.

Fig. 17.

Fig. 18.

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Patented Mar. 11, 1952

2,588,364

UNITED STATES PATENT OFFICE

2,588,364

ELECTROSTATIC PRECIPITATOR

Eduard Degiorgi, Zurich, Switzerland, assignor to Koppers Company, Inc., Pittsburgh, Pa., a corporation of Delaware

Application May 16, 1947, Serial No. 748,482

19 Claims. (Cl. 183—7)

1

This invention relates to electrostatic precipitators and is particularly directed to apparatus for electrostatically precipitating solid particles, such as dust, fume, fly ash and like particles hereinafter collectively referred to as dust, from gases at high temperatures.

The invention has for its objects to provide improved means for electrostatically removing dust from gases at high temperatures; to provide improved collecting electrodes for electrostatic precipitators; to provide improved means for dislodging accumulated dust from collecting electrodes; to provide improved means for withdrawing dislodged dust from the gas stream; to minimize redispersion of dislodged dust; to minimize overall construction and maintenance cost; to avoid the disadvantages of the prior art and to obtain advantages as will be pointed out or as will become apparent as the description proceeds. Further objects will appear in the description of the invention.

A problem which has long confronted those skilled in the art of removing dust from high temperature gases by means of electrical precipitators and, heretofore, has not been satisfactorily solved, is that of removing the dust which accumulates on the collecting electrode. This problem is particularly acute where the dust is light and fluffy, such as, fly ash, which is carried in flue gas from boilers and the like. The present invention is primarily directed to the solution of this problem.

It has been customary in the past to provide means for rapping the collecting electrodes to dislodge the dust particles which have accumulated on them. It was difficult, however, to prevent redispersion of the dust in the gas stream. It was necessary, therefore, that the precipitators be undesirably small or that the flow of gas be interrupted during the rapping operation.

In order to overcome these difficulties it has been proposed, as set forth in U. S. Patents 1,882,949 and 2,061,045, to provide means at different elevations along the surface of the collecting electrodes to receive the dislodged dust and to withdraw it from the gas stream. In such apparatus, however, the upward flow of the gas coupled with the lateral impact of the rapping device tended to defeat the present objective of preventing redispersion of the dislodged dust into the gas stream and it was necessary, therefore, in order for the patentees to achieve this object, to locate the receiving means very close together thereby increasing the cost of construction and maintenance or to make the unit undesirably

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high in order to reduce the dust content of the gas stream to the desired low level. In these and other respects such apparatus failed to achieve the desired objectives.

The present invention comprises a novel and advantageous construction and arrangement, particularly with reference to the collecting electrodes, whereby the above mentioned objectives may be accomplished and the disadvantages of the prior art avoided. The invention may be best understood by reference to the accompanying drawing in which:

Figure 1 is a view looking in the direction of gas flow taken partly as a transverse section, section A being taken along line IA—IA, Figure 2 and section B being taken along IB—IB, Figure 2;

Figure 2 is a longitudinal section on planes parallel to the gas flow, section A being taken along IIA—IIA, Figure 3, and section B being taken along IIB—IIB, Figure 3;

Figure 3 is a detailed view of part of Figure 1 taken in section along line III—III of Figure 5;

Figure 4 is a detailed view of a like part of Figure 1 taken in section along line IV—IV, Figure 5;

Figure 5 is a detailed view taken along V—V, Figure 3;

Figure 6 is a detailed view of a cross beam of Figure 2 taken along line VI—VI, Figure 3;

Figure 7 is a section taken along line VII—VII, Figure 4;

Figure 8 is a cross-section of the horizontal beam shown in Figure 7;

Figure 9 is an isometric view of a similar beam;

Figure 10 is a side elevation view of a collecting electrode plate;

Figure 11 is an end elevation of Figure 10;

Figure 12 is a cross section view of Figure 10;

Figure 13 is a detail of a holding plate seen in Figure 10;

Figure 14 is a section taken along line XIV—XIV, Figure 13;

Figure 15 is a detail of the lifting bar showing one of the pins displaced;

Figure 16 is a detailed view of the upper left hand portion of Figure 2, and

Figures 17 and 18 are detailed views of the cam lifting mechanism.

Referring now to the drawing and more particularly to the Figures 1 and 2, the precipitator is shown in transverse and longitudinal sections. The precipitator elements, which will be more particularly described, are enclosed in a horizontally extending housing 2 of generally rectangular transverse and longitudinal sections. This

casing constitutes a part of a flue or conduit for conducting dust-laden gases to and from the precipitator elements. The open ends of the housing 2 are united by means of suitable joint 4 with the inlet and outlet flues or conduits 6 and 8. The housing 2 and precipitator elements therein are supported by a framework of steel beams comprising upright steel beams 10, transverse beams 12 and longitudinal beams 14 and longitudinal cross-beams 16. This framework is suitably lined with steel plates or sheets as required to form the desired closure (housing 2). Details of the construction of the framework and housing are not shown because it is within the skill of the art to provide a suitable supporting structure and housing for the precipitator elements of the invention.

The precipitator elements are arranged in two or more tiers. Three such tiers, designated as A, B and C are shown in the drawing as more particularly seen in Figure 1. In each tier there is provided a plurality of parallel precipitating units 18 each of which comprises spaced parallel collecting electrodes 20 extending longitudinally of the housing 2 with intermediate discharge electrode assemblies 22 operatively associated therewith. Each pair of such collecting electrodes, with the exception of those in the top tier is provided with a cover member 24 which is convex in cross-section; i. e. shaped like an inverted U, V or semicircle. A like member 26 is located at the bottom of the precipitating units 18 of the bottom tier A. These members act as tops and bottoms to the precipitating units making them into parallelly disposed longitudinal channels 28 through which the incoming dust laden gas passes in travelling from the inlet flue 6 to the outlet flue 8.

As best seen in Figure 1 it will be observed that each of the precipitator units is shaped like an inverted U, or shall we say, like a hair-pin, and are disposed side by side, but spaced sufficiently to provide a narrow channel 30 between adjacent collecting electrodes. The collecting electrodes 20 extend downwardly into the V formed by each pair of units 18 and are spaced sufficiently from the top members 24 to provide horizontal slot-like passageways 32 leading from the channels 28 of the precipitating units 18 into the narrow passages 30 between them. As dust is dislodged from the collecting electrodes 20 it tends to fall down along the surface of said electrodes to the bottom of each tier where it is deflected through the slot like passages 32 by the sloping sides of the convex cover members 24 into the narrow channels 30 through which it falls into one or more hoppers 34 at the bottom of the structure.

In order to simplify construction and operation of large capacity precipitators two or more units such as described above may be included in a single housing as illustrated by section A and B of Figure 1. It will be observed that in these figures the detail of the precipitator unit 18 have not been completed throughout since it is purely repetitious. It should be noted, however, that adjacent the outside walls 36 of the housing 2 the passageways are defined by the outside walls 36 and the collecting electrode 20 of the adjacent precipitating unit 18. Between the sections the channel may be much larger, depending upon the spacing of the adjacent units of the adjacent sections, or separate partitions or walls (not shown) limiting the width of the channel may be provided.

The collecting electrodes 20 of each tier are supported on horizontal supporting beams 38 and 39 parallelly disposed with reference one to the other and extending longitudinally of the housing 2. The ends of these beams are supported by the transverse beams 12. In order to simplify construction and operation of large size precipitators the precipitating units may be divided longitudinally into two or more sections as illustrated by sections A and B of Figure 2. In such case the inner ends of the supporting beams 38 are supported by cross-beams 40 located between said sections. These supporting beams are constructed so as to provide rigid immobile supports for the collecting electrodes.

The particular construction of the supporting beams 38 is best seen in Figures 8 and 9. Each such beam comprises parallel side plates 42, each provided at the top with a unitary outwardly flaring plate 44. It will be understood, of course, that where the supporting beam is adjacent the side wall of the housing 2 only one such outwardly flaring plate 44 will be provided as best shown in Figure 9. At each end there is provided a tubular section 46 which is formed as a unitary structure with the side plates 42. These tubular supporting sections extend from the collecting electrode 20 to the transverse beams 12 and cross-beams 40.

At spaced intervals along the length of the supporting beams are provided vertical cross-plates 48. These plates extend into said supporting beams between side plates 42 and have outwardly flaring shoulders 50 resting on the outwardly flaring plates 44 and conforming to the slope thereof as best seen in Figure 8. These plates are welded or otherwise united with contiguous portions of supporting beam to form a unitary structure. At the inner end of the tubular portion 46 of these beams there is provided an end plate 52 which has a shape similar to that of the cross-plates 48 but preferably has longer shoulders 54, preferably substantially of the same length as the outwardly flaring side 44. These plates are welded or otherwise united to the contiguous parts of the supporting beam to form a unitary rigid structure.

The cross-plates 48 are each provided with a vertical slot 56 aligned with each side plate 42. These vertical slots are adapted to receive the collecting electrodes as will be more particularly described. In the bottom of each slot 56 there is welded or otherwise secured an anvil or striking bar which may be a separate member 57 for each cross-plate as shown in Figure 9 or a continuous bar 58 as shown in Figures 5 and 6.

The supporting beams 38 are required to give lateral support only and do not need the supporting cross-plates and striking bars required for beams 38. Likewise, they do not need the outwardly flaring plates 44. It is sufficient, therefore, for them to be constructed simply of the parallel plates 42.

The arrangement of the above described supporting beams and the disposition of the various elements of the precipitating units 18 with respect thereto are best illustrated in Figures 3 and 4, the details of which may be best understood after the collecting electrodes 20 have been described in further detail. It is sufficient to note here that the outwardly flaring side plates 44 of the supporting beams 38 together with the cover plates 60 constitute the convex cover member 24 previously described.

As best seen in Figures 2, 6 and 7, the collect-

ing electrodes 20 of each tier are made up of a plurality of vertical section plates 62 arranged in a common vertical plane with their vertical edges in juxtaposition. Each of plates 62 have upstanding ribs 64 along their vertical edges which function to reinforce the section plate and to impede the flow of gas along the surface of the collecting electrodes as will be described in greater detail later. They also provide an overlapping joint which permits each section plate to move vertically independently of the others. Thus, there is provided an articulated collecting electrode of which the section plates 62 constitute the articles and the ribs 64 the joints.

The construction of the section plates 62 is best shown in Figures 10 through 14. Each is made of an elongated flat plate provided along one edge with an inwardly turned rib 68 and along the other edge with the outwardly turned reinforcing rib 64 comprising an outwardly turned portion 70 and an inwardly turned portion 72. It is noted that the inwardly turned portion 72 terminates substantially at the plane of the outer surface of the plate 62. The two reinforcing ribs 64 and 68 extend substantially the full length of the plate 62 and impart rigidity thereto. The inturned rib 68 preferably terminates short of the upper edge 74 of the plate 62 to facilitate insertion and removal of the plate as it will be presently described. The outstanding rib 64 similarly may be cut away both at the top and the bottom as best shown at 76 and 78 in Figures 10 and 5 to provide clearance with respect to adjacent parts and to facilitate insertion and removal.

To the back of plate 62 near the top 74 there is welded on or otherwise fastened a small plate 80 which is embossed at 82 and slotted at 84 so as to form a slot with undercut channels 86 between the embossed portion 82 and the plate 62, as best shown in Figure 14. The undercut slot 84 is open at the bottom and closed at the upper end (Figure 13) for purposes which will presently be described. At the bottom of plate 62 a sheet of steel 88 bent on itself and about plate 62 is welded thereto to provide a reinforced striking surface. This reinforcing plate extends substantially the width of plate 62 and in assembled position rests on the anvils or striking bar 58 as best seen in Figures 3 and 4.

The above described section plates are assembled in the precipitator with bottom edges resting in the slots 56 of cross-plates 48 of supporting beams 38 as best seen in Figures 3 and 4 and with top edges resting against the side plates 42 of the next higher supporting beam. The section plates are thus arranged side by side in a common plane as illustrated in Figure 7 with the upstanding joint or rib 64 overlapping the juxtaposed edge or side of the adjacent plate. Suitable means, a suitable modification of which will be described presently, is provided to hold the plates in contact with the side plates 42 of the supporting beams 38. Thus supported, the section plates are adapted for a limited vertical movement and, by means of a suitable mechanism as will presently be described, the section plates may be raised off of the anvils or striking bars 58 and dropped thereon at suitable intervals and in suitable order to dislodge the dust which accumulates on the collecting electrodes 20 in operation of the precipitator. Vertical closure strips 90 and 92 are provided at the ends of each assembly to seal off the channels 30 from the gas stream. These strips are provided with

inturned edges 94 and 96 to impart rigidity thereto.

We may pause now to note the operation and effect of the above described construction and arrangement of the collecting electrodes. It should be remembered that in the particular type of precipitator involved the flow of gas is horizontal; i. e., the gas flows longitudinally through the housing 2, and that any dust particles dislodged from the surface of the collecting electrodes and redispersed into the gas stream tend to be carried along with the gas stream to a point farther along the particular channel through which the gas is passing. Now, by raising the section plates 62 and dropping them on the striking bars 58 a shock is imparted to the collecting electrodes which has substantially no normal component. This means that the dust particles are removed or dislodged from the surface of the collecting electrodes by a shearing action, the impetus of which tends to project the dust particles on their downward path. If a rapping means were used which imparted a shock laterally to the collecting electrodes, the normal component would be relatively large and the plate would be caused to vibrate intensely thus projecting the particles of dust away from the collecting electrode and into the stream of gas. In an upwardly flowing gas stream such action is not particularly disadvantageous, although it does result in the multiple precipitation of the same particles of dust. However, in a precipitator of the type involved here where the gas flow is horizontal and the dislodged particles tend to be carried with the gas stream to a point farther along in the channel 28, it is vitally important.

Now, if a plate is dropped on its edge on an anvil, the shock imparted thereto is dissipated in several ways among which are the bounce or rebound of the plate and the lateral vibrations set up therein. In order to minimize the latter, which as has been fully explained, are undesirable in the particular apparatus here involved, I have provided the vertical reinforcing ribs 64 and 68, previously described, which impart a degree of rigidity to the section plate which tends to increase the rebound, and hence the shearing action and to dampen lateral vibration which tends to impel the dust particles into the gas stream. Furthermore, the outstanding ribs 64 tend to impede the flow of gas along the surface of the collecting electrodes so that any redispersed dust has less tendency to migrate longitudinally in the precipitator. The net effect of the various features above described is this: when the section plates 62 are raised and dropped on the striking bars 58, the dust particles are sheared from the surface of the collecting electrodes 20 and given an impetus downwardly along the surface thereof. These particles therefore tend to drop straight down along the surface of the collecting electrodes without being redispersed into the gas stream. When they reach the bottom they fall onto the outwardly flared plates 44 of the supporting beams 38 and are deflected through the slot-like passages 32 into the narrow channels 30 whence they are conducted to the hoppers 34.

The mechanism for raising and lowering the section plate 62 comprises a cam actuated lifting bar 98 pivotally connected to each section plate 62 by means of the pins 100 projecting from the lifting bar 98 into the slot 84 of the plate 80 which is welded or otherwise fixed to the inner surface of the section plate 62 near the top thereof. The

pins 100 are provided with heads 102. The undercut slot 84 slips over the head 102 so that the head engages the embossed portions of the plate 82. This arrangement constitutes the means above referred to for holding the section plate 62 in position with the top edges against the side plates 42 of the supporting beam 38.

The head 102 of the pin suitably may be formed by machining an annular channel 104 on the pin. In such case the diameter of the pin will be substantially the width between the undercut channels 86 and the diameter of the neck 106 of the annular channel 104 will be substantially that of the slot 84. The pins 100 are journaled in holes 108 in the lifting bar as best illustrated in Figure 15. The pins may be welded in place if desired to form a unitary structure, but ordinarily where each end of the pin supports a section plate welding is not necessary. In fact, it is advantageous not to do so in view of the greater ease of replacing worn pins.

The section plates 62 are removable by raising them until the undercut slot 84 is free of the head 102 of the pin. It is for this purpose that the rib 68 is terminated short of the top edge 74 of the section plate. This distance should equal the distance the section plate overlaps the side plate of the supporting beam plus the length of the slot 84. This facilitates the insertion and the removal of the section plate. It is desirable for this purpose also to have the slot 56 equal in length to or longer than the slots 84. This facilitates inserting the section plate since it is easier in such case to effect engagement of the undercut slot 84 with head 102 of the pin.

The lifting bar 98 is raised and dropped by means of the cam 110 which is driven by shaft 112 journaled in framework 114. The cam is embraced by a stirrup 116 slotted at 118 to permit it to reciprocate with respect to the shaft 112. A cam rider 120 is adjustably mounted in the top of the stirrup. The bottom of the stirrup is fastened to a connecting rod 122 which passes into the housing tube through gland 124. The bottom of connecting rod 122 is pivotally connected to strap hangers 126 by means of the pins 128 and cotters 130. These strap hangers extend down through the narrow channels 30 and each lifting bar (there is one for each tier) is pivotally connected to the strap hangers by pins 132 and cotters 134.

In the form of the invention shown as seen in Figure 2 each end of the supporting bars 98 are supported by the strap hangers 126. There is thus provided a pair of cam actuated strap hangers for each set of lifting bars. The two cams of each pair may be operated alternately or in unison; preferably, they are operated so that first one end of the lifting bar 98 and then the other is lifted and dropped at uniformly spaced periods. The cam 110 is spiral shaped in order to effect gradual lifting and an abrupt drop. The cam may be mounted on the shaft 112 with a lost motion connection 111 whereby the abruptness of the drop is accentuated.

Each of the shafts 112 are provided with a plurality of these cams as best seen in Figure 1. One such cam is provided for each pair of collecting electrodes defining the narrow passages 36. As illustrated in Figure 1, section B, the cams are mounted in staggered relation one to the other. In this manner the several electrodes are raised and dropped at different times. It is particularly important that the raising and dropping of the pair of electrodes forming a single precipitating unit should be alternated one with the other so that the general efficiency of the precipitator may be maintained at a high level. Similarly, and for the same purpose, the cams operating section B of Figure 2 should alternate with those operating section A of that figure.

The heaviest load of dust deposited on the collecting electrodes will be on those section plates nearest the inlet. The cams of section B, Figure 2, therefore may be rotated more slowly than those of section A in order to provide a longer interval between rappings. Similarly and for the same purpose, the second row of cams of each section may be operated more slowly, if desired, than the first row.

The discharged electrodes proper consist of a plurality of vertically disposed parallel rods 136 generally angular (square for example) in cross-section to provide edges to promote discharge. The rods 136 are mounted in a tubular frame structure 138 consisting of top and bottom tubes 140 and 142, end tubes 144 and 146, and intermediate cross-tubes 148. The frames are suspended midway between the collecting electrodes by hanger rods 150 to which they are removably fastened by suitable fastening means 152. Two such frames are provided for each tier.

The rods 136 are so spaced as to provide a plurality of precipitating electrodes for each section plate 62 (3 are shown) and they should be spaced closely enough together to obtain substantially uniform deposition of dust over the surface of the section plate with which they are associated in accordance with principles well known in this art. It will be observed that the spacing between each group of three, as seen in Figure 2, is slightly larger than the spacing between the individual rods of each group. This wider spacing is provided to accommodate the outstanding ribs 64. Thus, the end rod of each group of three is spaced further from the outstanding rib 64 than it is from the section plate proper, a distance sufficient to prevent arcing over.

The hanger rods 150 are suspended from transverse angles 154, fastened as shown at 156 to longitudinal supporting bars 158. These longitudinal supporting bars are in turn supported by the hanger rods 160 which are supported from the insulators 162. The bar 158 is fastened to the hanger rod 160 by a clevis 164. The other end of the hanger rod 160 is fastened to a spider 166 which rests on the top of a pipe 168 of ceramic or other rigid insulating material which, in turn, rests on the top of housing 2. A cover 170 is provided for pipe 168 and the whole insulator assembly is enclosed in a housing 172. The hanger rod 160 extends through the top of housing 2 through a pipe 174 of sufficient diameter to prevent arcing. The bottom edge of said pipe is beaded also to prevent arcing.

The space between the uppermost tier of collecting electrodes and the top of the housing 2 is provided with a plurality of transverse partitions 176 extending entirely across the precipitator to prevent the dust laden gas from bypassing the precipitator unit. Each such partition is provided with apertures 178 through which the longitudinal supporting bars 158 project. The edges of these apertures are beaded and spaced sufficiently from said bars to prevent arcing over. Each of the bars 158 is provided with baffle plates 180 of somewhat larger diameter than the apertures 178 and disposed on each side of the partitions 176 a distance sufficient to prevent arcing over. These baffle plates are beaded

at their edges for this purpose too. The apertures 178 coupled with the baffle plates 180 constitute a path of high resistance to gas flow so that very little, if any, gas is by-passed to the precipitator unit.

The discharge electrode rods 136 are electrically connected through their supporting structure, above described, to the positive pole of a suitable rectifier, not shown.

As best shown in Figures 1 and 2, rapping means is provided for dislodging dust from the discharge electrodes. This means comprises a striker rod 182 of sufficient length to span the space between the two longitudinal supporting bars 158 and to rest freely thereon. The striker 182 is linked to fixed pivots 184 by links 186 so that the striker rod 182 conveniently may be lifted off of the longitudinal supporting bars 158 and dropped thereon. Sufficient shock is thereby imparted to the discharge electrodes to dislodge what little dust accumulates on them.

Striker rod 182 is lifted by hook 188 which is pivotally connected to hanger rod 190 at 192, which in turn is supported through the insulator 194 by a cable 196 running over sheave 198 to a crank 200. The hanger rod 190 passes through the top of housing 2 through a beaded pipe 202 of sufficient size to prevent arcing and is enclosed by housing 204 upon which is mounted the sheave support 205 and the gland 208 through which cable 196 passes through the housing.

The hook 188 is pivotally connected to fixed pivots 210 by links 212 pivotally connected to the hook and is provided with a projection 214 adapted to engage the striker rod 182 when in the position shown in Figure 2, section A. It is also provided with a rigid member 216 projecting in the same direction as the projection 214. Above the rigid member 216 and in the path of its vertical movement is located a tripping pin 218 adapted to the position in one of several holes 220 arranged in vertical alignment in a suitable support 222. When the crank 200 is rotated the hook 188 is lifted, lifting with it the striker rod 182. When it reaches the elevation shown in Figure 2, section B, the rigid member 216 will have engaged the pin 218 and caused the hook 188 to pivot sufficiently to release the striker rod 182, and permit it to fall back on the horizontal bars 158. The bottom edge of the projection 214 is bevelled as shown at 224 so that when the hook is again lowered it will automatically reengage the striker rod.

While I have described my invention with reference to a particular embodiment thereof, it will be understood that variation may be made therefrom without departing from the spirit and scope of the invention as described in the specification and set forth in the appended claims.

I claim:

1. In an electrostatic precipitator the combination which comprises a substantially rectangular horizontally disposed conduit through which a stream of dust laden gas may be passed horizontally, a plurality of longitudinally parallel vertically disposed partitions extending from the top to the bottom of said conduit dividing said conduit into a plurality of narrow longitudinal passages, said partitions including at the opposed faces thereof tiers of collecting electrodes, electrostatic discharge means operatively associated with said collecting electrodes and adapted to precipitate dust thereon, said partition being hollow from at least the bottom of the uppermost of said tiers of collecting electrodes to the bottom of said

conduit with the bottom open to the exterior of said conduit, means for closing at least the front end of said hollow partition thereby forming a vertical passage through which dust may drop to the exterior of said conduit without being disturbed by the gas stream flowing therein, rapping means for imparting shock to said collecting electrodes to dislodge dust therefrom and deflecting means located between said tiers of collecting electrodes for deflecting dislodged dust into said hollow partition.

2. In an electrostatic precipitator the combination which comprises parallel vertically disposed flat collecting electrodes, electrostatic discharge means between said collecting electrode and operatively associated therewith to precipitate dust thereon, conduit means for directing a horizontal flow of gas between said electrode means, said collecting electrodes including a plurality of flat plates arranged substantially in a common plane with their edges in juxtaposition with the juxtaposed edges turned out in opposite directions to provide reinforced ribs and one of the turned out edges being turned back in and terminating on the surface of the juxtaposed plate to provide a reinforced lap joint, said rib and joint being disposed in the vertical position, rapping means for applying impact in the vertical plane thereof whereby the shock imparted thereto has no substantial normal component and the dust is dislodged from the plates by a shearing action and tends to drop along the surface of said plates between said joints, and receiving means for receiving the dislodged dust.

3. In an electrostatic precipitator the combination which comprises parallel vertically disposed flat collecting electrodes, electrostatic discharge means between said collecting electrode and operatively associated therewith to precipitate dust thereon, conduit means for directing a horizontal flow of gas between said electrode means, said collecting electrodes including a plurality of flat plates arranged substantially in a common plane with their edges in juxtaposition with the juxtaposed edges turned out in opposite directions to provide reinforced ribs and one of the turned out edges being turned back in and terminating on the surface of the juxtaposed plate to provide a reinforced lap joint, said rib and joint being disposed in the vertical position, said plates resting on and being movable vertically with respect to a fixed base, a lifting bar, means for supporting said lifting bar in a horizontal position parallel to and adjacent to the outside of each of said collecting electrodes, means pivotally connecting said lifting bar to each of said plates adjacent thereto and means for lifting and dropping at least one end of said lifting bar.

4. In an electrostatic precipitator the combination which comprises an inverted U-shaped collecting electrode the sides of which are operatively associated with at least one discharge electrode, a like assembly disposed adjacent thereto with the adjacent sides parallel and spaced sufficiently to form a narrow vertical passage, means adjacent the other sides of said assemblies forming like passages, collecting electrode means supported above and in vertical alignment with each of said passages with the bottom edge thereof spaced sufficiently from the bight of the inverted U-shaped electrode to permit passage of dust into said passages, discharge electrode means operatively associated with said collecting electrode means in vertical alinement with said discharge

electrode, and means for dislodging particles collected on said collecting electrodes.

5. In an electrostatic precipitator the combination which comprises a series of collecting electrode assemblies including an immobile base, a vertical collecting portion resting on said base and movable vertically with respect thereto, and electrostatic discharge means operatively associated with said vertical collecting portion; each of said vertical collecting portions being provided with lifting means having disengaging means operative when said vertical collecting portion is lifted a predetermined amount to allow said vertical collecting portion to drop back onto said immobile base and said disengaging means being operatively staggered in said series whereby to avoid dropping of said vertical collecting portions in unison; and dust receiving means located at the bottom of and in line with each of said vertical collecting portion whereby dust dislodged therefrom falls into said receiving means.

6. In an electrostatic precipitator the combination which comprises a series of collecting electrode assemblies including an immobile base and a plurality of collecting portions resting on and movable vertically with respect thereto, electrostatic discharge means operatively associated with said vertical collecting portions, means associated with each of said assemblies for lifting said collecting portions, said means being operative in each assembly to drop said collecting portions in each assembly in succession on said immobile base and being operatively staggered in said series whereby to avoid dropping of said vertical collecting portions of said assemblies in unison, and dust receiving means located in line with said vertical collecting portions whereby dust dislodged therefrom falls into said receiving means.

7. In an electrostatic precipitator, a collecting electrode comprising an articulated plate including a plurality of vertical plates arranged substantially in a common plane with their edges in juxtaposition with the juxtaposed edges turned out in opposite directions to provide reinforcing ribs and one of the turned out edges being turned back in and terminating on the surface of the juxtaposed plate to provide a reinforced lap joint.

8. In an electrostatic precipitator, the combination which comprises an electrostatic discharge means and a collecting electrode assembly associated therewith, said assembly including an immobile base, an articulated collecting plate, the articles of which are separately, vertically movable with respect to said base, means on said base for holding said articulated plate, said means permitting vertical movement of said articles, means for lifting said articles and dropping them in succession onto said base and dust receiving means in alignment with said articles whereby dust dislodged from said articles falls into said dust receiving means.

9. In an electrostatic precipitator, a collecting electrode assembly which comprises a horizontally disposed beam, a second horizontally disposed beam above and in vertical alignment therewith, electrode supporting means adjacent one side of the first named beam, electrode supporting means adjacent the other side of the first named beam, collecting electrode units supported in said electrode supporting means with their upper edges resting freely against the sides of said second beam and means for holding said electrodes in contact with the sides of said second beam, said electrode supporting means and said holding means being so constructed as to permit vertical movement of said collecting electrode units, and means for lifting and dropping said collecting electrode units.

10. Apparatus according to claim 8 in which the lifting means comprises a lifting bar horizontally disposed between and spanning a plurality of said articles, means for supporting said lifting bar in a horizontal position, means connecting said lifting bar to said spanned collecting electrode units, at least during upward movement of said bar, means for lifting and dropping one end of said bar whereby to cause the articles spanned by said bar to be elevated to progressively different elevations from which they progressively drop onto said base.

11. Apparatus according to claim 8 in which the lift means comprises a lifting bar horizontally disposed between and spanning a plurality of said articles, means for supporting said lifting bar in a horizontal position, means connecting said lifting bar to said spanned collecting electrode units, at least during upward movement of said bar, means for lifting and dropping one end of said bar whereby to cause the articles spanned by said bar to be elevated to progressively different elevations from which they progressively drop onto said base, and means for lifting the other end of said bar whereby to cause said articles to be elevated to progressively different elevations in the other direction from which they drop progressively onto said base.

12. In an electrostatic precipitator, an electrode assembly which comprises a discharge electrode frame mounted in vertical position, a plurality of discharge electrodes arranged vertically in said frame, a platelike collecting electrode arranged on each side of said frame and parallel thereto and having vertical reinforcing ribs projecting inwardly toward said frame and to each other thereby providing a plurality of vertical panels on said platelike electrodes, said discharge electrodes being arranged to provide a group of uniformly spaced electrodes for each of said panels the end electrodes of which are uniformly spaced with respect to said vertical ribs and spaced farther from the end electrode of the adjacent group than the distance between the group electrodes.

13. In an electrostatic precipitator, an element of collecting electrode which comprises a flat plate having parallel edges, unitary reinforcing ribs along each edge so arranged that the rib of one edge projects substantially in the opposite direction to the rib of the other edge, one of said ribs being turned backwardly toward said plate away from the edge of said plate, said turned back portion extending substantially to the plane of said plate.

14. In an electrostatic precipitator the combination which comprises conduit means for conducting dust laden gases, a horizontally disposed housing forming part of said conduit means and having open ends communicating with said conduit means and forming inlet and outlet means to said housing, a plurality of longitudinal beams arranged within said housing in a plurality of uniformly spaced horizontal and uniformly spaced vertical rows and provided with vertical sides, the beams of at least all but the top of said horizontal rows being open at the top and bottom over at least a portion of their length, cross-plates extending into the open tops of said beams and forming a unitary structure therewith and having an enlarged upper portion, alined vertical

slots in said enlarged upper portion of said cross-plates substantially in alinement with the innermost side of the outside beams and each side of the intermediate beams, a plurality of flat plate-like collecting electrodes having their bottom edges disposed within the said slots and their upper edges resting against the sides of the corresponding longitudinal beam in the next higher row, electrostatic discharge means operatively associated with the collecting electrodes, cover means spanning the open topped longitudinal beams adjacent in the same horizontal row, said cover means extending from the top of one side of one beam to the top of the other side of the other beam and sloping downwardly to each of said sides, the vertical slots in said cross-pieces being so located with respect to said covers as to provide a passage leading into the vertical channel formed by the sides of the beam and means for raising and dropping said electrodes to dislodge any dust accumulated thereon.

15. The apparatus of claim 14 in which said collecting electrodes comprise a plurality of separate plates arranged substantially in a common plane with their edges in juxtaposition, and adapted for vertical movement with respect to each other and in which said electrode raising and dropping means comprises a plurality of horizontal lifting bars located in vertical alinement with said longitudinal beams and spanning a plurality of said plates, means for supporting each end of said lifting bar and means for lifting and dropping at least one end of said lifting bar and engaging means on said lifting bar for engaging the spanned plates at least during vertical movement of said lifting bar.

16. The apparatus of claim 15 in which said engaging means comprises a headed pin projecting laterally from said lifting bar and an undercut lot on the innerface of said plate, closed at the top and open at the bottom, and adapted to engage over the head of said pin.

17. The apparatus of claim 14 in which said juxtaposed plates have one of the juxtaposed edges turned inwardly to provide a reinforced rib and the other turned outwardly toward said electrostatic discharge means, and then inwardly and terminating on the surface of the juxtaposed plate to provide a reinforced lap joint.

18. In an electrostatic precipitator the combination which comprises a plurality of elongated inverted U-shaped collecting electrode units, arranged in spaced vertical and spaced horizontal rows, with the bottom edges of each unit in each horizontal row in the same horizontal plane, and the center line of each unit in each vertical row in the same vertical plane, the spaced between the vertical rows being such as to provide a long narrow opening between the bottom edges of the unit in one row and the bights of the units of the next lower row.

19. In an electrostatic precipitator the combination which comprises vertically disposed collecting means having dust receiving means at the bottom and intermediate the height thereof dividing said collecting means into separate electrode units each of which consists of a plurality of vertical panels, electrostatic means associated with each unit and having at least one vertical electrode associated with each of said panels, and means for dislodging dust from said collecting means.

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