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Shibuya et al.

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[45] **Apr. 16, 1974**

[54] **TWO-STAGE TYPE OF ELECTRIC DUST ARRESTER**

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[21] Appl. No.: **375,801**

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[52] **U.S. Cl.** **55/123**, 55/129, 55/130, 55/138, 55/139, 55/152, 55/154

[51] **Int. Cl.** **B01d 3/12**, B01d 3/45, B01d 3/41

[58] **Field of Search** 55/123, 129, 130, 138, 55/139, 152, 154, 156

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Attorney, Agent, or Firm—Price, Heneveld, Huizenga & Cooper

[57] **ABSTRACT**

A two-stage electric dust arrester having a charging stage and a collecting stage arranged in succession within a chamber defined by a casing. The charging stage includes a pair of charging electrodes spaced apart laterally of the path of flow of dust through the chamber. The collecting stage, located downstream includes a collecting electrode having a pocket extending along its length with an open face aligned with the space between the charging electrodes in the direction of movement of dust through the chamber. A high voltage DC source connected to the charging and collecting electrodes creates a field to accelerate dust particles as they move between the electrodes and for attracting the particles into the pocket.

14 Claims, 10 Drawing Figures

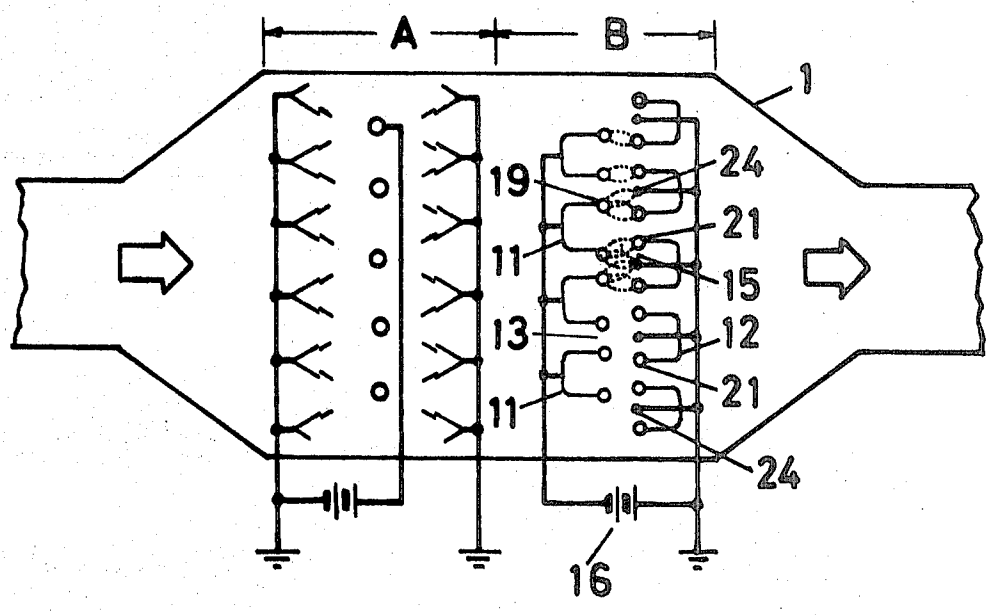


FIG.1

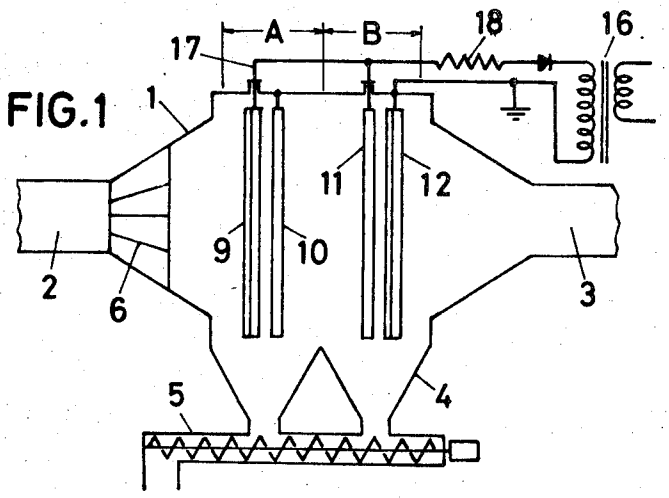


FIG.2

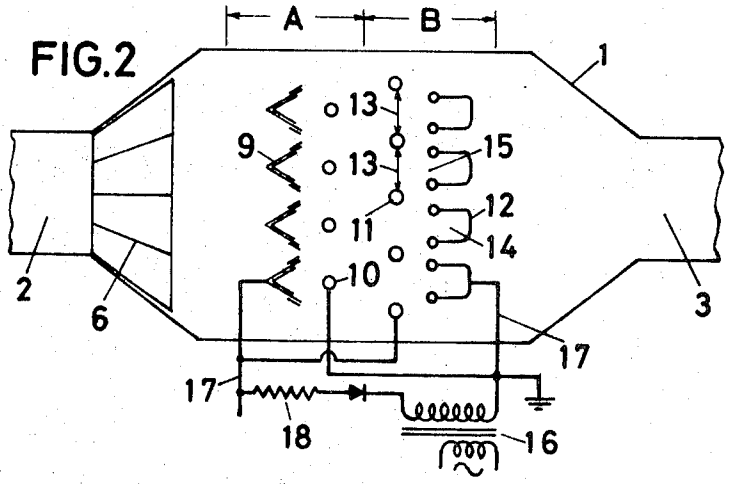


FIG.3

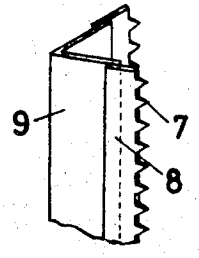


FIG.4

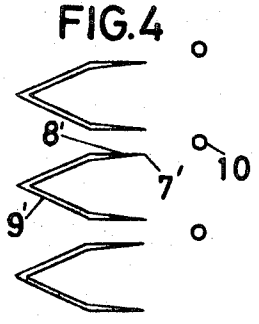


FIG. 5

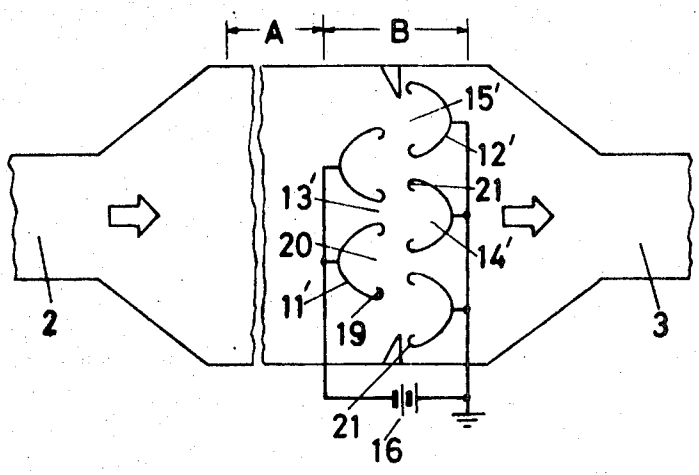


FIG. 6

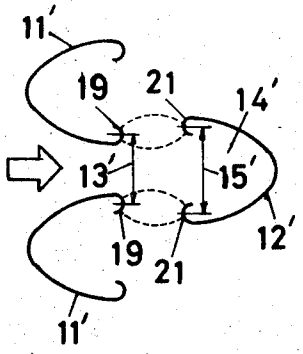


FIG. 7

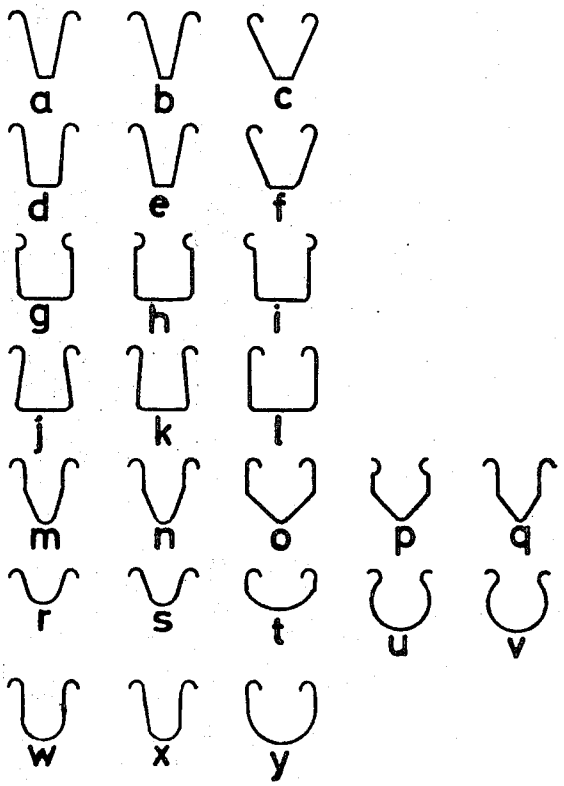


FIG. 8

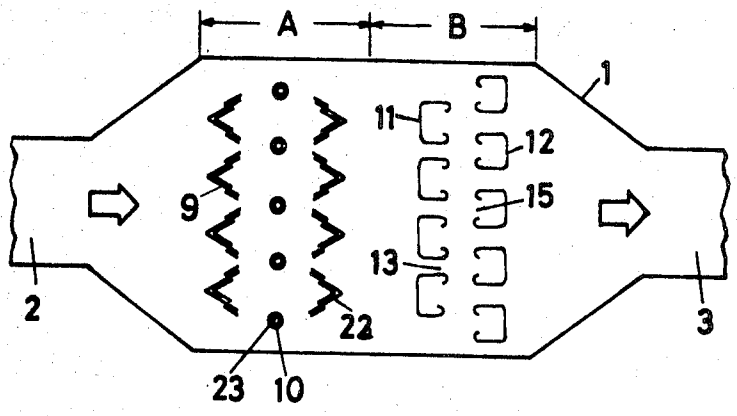


FIG. 9

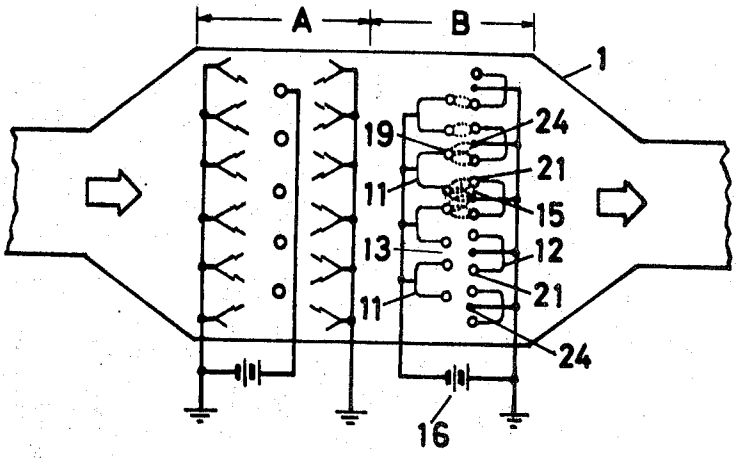
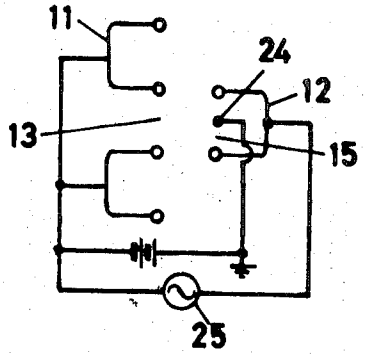


FIG. 10



TWO-STAGE TYPE OF ELECTRIC DUST ARRESTER

The present invention relates to an electric dust arrester for use in removal of dust contained in an exhaust gas discharged from a baking apparatus or kiln for limestone, cement and the like, a combustion apparatus for coal, petroleum and the like, or other exhaust gas sources.

More particularly, the present invention relates to improvements in a two-stage type of electric dust arrester consisting of a charging stage for charging the dust in the exhaust gas by making use of a corona discharge and a dust collecting stage disposed downstream of said charging stage for separating the charged dust from the exhaust gas.

The above-referenced two-stage type of electric dust arrester has an excellent feature over the so-called single-stage type of electric dust arrester comprising a corona discharge electrode and a dust collector electrode disposed opposite to the former in that even if the apparent resistivity of the dust is as high as $10^{11}\Omega\cdot$cm the dust collection can be achieved without being accompanied with anomalous phenomena such as, for example frequency of spark, inverse ionization, etc.

However, upon removal the dust accumulated on the dust collector electrode as by hammering, once the accumulated dust is dispersed again into the exhaust gas, in the case of the single-state type of electric dust arrester, the recharging of the dust particles is achieved immediately and is collected by the dust collector electrode. In the case of the two-stage type of electric dust arrester there is a disadvantage that the dust particles are admixed into the exhaust gas without being recharged and thus discharged to the exterior.

A principal object of the present invention is to make it possible to collect the dust particles without exposing the particles to the exhaust gas flow, even in the case of dust having an apparent resistivity equal to or higher than $10^{11}\Omega\cdot$cm, or even upon removal of the dust which has once accumulated on the electrode as by hammering.

A second object of the present invention is to intensely charge the dust particles in the exhaust gas by making said particles contact directly to the corona discharge electrode.

A third object of the present invention is to adjust the flow of the exhaust gas by means of the electrode and thereby eliminate the proper flow adjusting means.

A fourth object of the present invention is to provide double contact between the exhaust gas containing dust particles and the corona ions in parallel and antiparallel flows and thereby uniformly charge the dust particles in the exhaust gas.

A fifth object of the present invention is to lower the temperature at the opposite electrode and thereby prevent the inverse ionization phenomena.

A sixth object of the present invention is to cause all the charged dust particles to move towards the inlet of the pocket of the collector electrode.

A seventh object of the present invention is to capture the charged dust particles in a space in front of the collector electrode, separate them from the exhaust gas by making use of a gravity, and thereby make them drop away.

According to the present invention, a two-stage electric dust arrester includes a charging stage and a collecting stage arranged in succession within a chamber defined by a casing, from an inlet to an outlet thereof. The charging stage includes at least a pair of charging electrodes spaced apart laterally of the path of flow of dust through said chamber. The collecting stage includes collecting electrodes aligned with the space between the charging electrodes in the direction of movement of dust through said chamber from the inlet to the outlet. Pockets are formed in the collecting electrodes and extend lengthwise thereof, the pockets have an open face directed upstream toward the charging electrodes to receive dust particles. A high voltage DC source of electrical energy is connected to said charging and collecting electrodes for creating a field to accelerate dust particles as they move between said charging and collecting electrodes and for attracting the particles into the pockets of the collecting electrodes.

The present invention will be more fully understood from the following description of a number of embodiments of the two-stage type of electric dust arrester illustrated in the accompanying drawings, in which:

FIG. 1 is a schematic side view showing an outline of the two-stage type of electric dust arrester according to the present invention,

FIG. 2 is an enlarged plan view of the same,

FIG. 3 is an enlarged perspective view of a part of the apparatus in FIGS. 1 and 2,

FIG. 4 is a plan view showing a modification of the part shown in FIG. 3,

FIG. 5 is a schematic plan view showing another embodiment of the present invention,

FIG. 6 is an enlarged plan view of a part of the apparatus in FIG. 5,

FIG. 7*a* through 7*y*, respectively, show alternative embodiments of a part of the electrodes shown in FIG. 6,

FIGS. 8 and 9, respectively, are plan views illustrating further modified embodiments of the invention, and

FIG. 10 is a plan view showing a modification of a part of the apparatus in FIG. 9.

The two-stage type of dust arrester illustrated in FIGS. 1 and 2, comprises a charging stage A and a dust collecting stage B arranged within a casing 1 in succession from an inlet 2 of the casing towards an outlet 3. In addition, beneath the casing 1 are provided a hopper 4 for dust and a transfer conveyor 5, and further in the proximity of the inlet 2 are provided guide blades 6.

The charging stage A consists of angle-shaped corona discharge or charging electrodes 9 having a contactor 8 with sharp tips 7 fixedly secured thereto and rod-shaped opposite electrodes 10 disposed downstream of discharge electrodes 9. Corona discharge electrodes 9 and opposite electrodes 10 are arrayed in multiple at intervals along the respective planes transverse to the flow of exhaust gas.

The dust collecting stage B consists of elongated rod-shaped driving electrodes 11 extending in the vertical direction and rod-shaped collector electrodes 12 disposed downstream of the driving electrodes. The driving electrodes 11 are arrayed in multiple at intervals providing gap spaces 13 along a plane perpendicular to the direction of the exhaust gas flow. The collector electrodes 12 are also arrayed in multiple at an interval along a plane transverse to the exhaust gas flow. An elongated pocket 14 is formed within collector elec-

trode 12 extending in the lengthwise direction. An inlet 15 of pocket 14 is disposed downstream of the gap space 13 formed between adjacent driving electrodes 11 and is directed towards gap space 13.

A high voltage DC source 16 is connected across the corona discharge electrodes 9 and opposite electrodes 10 and also across the driving electrodes 11 and the collector electrodes 12 via conductors 17 and a limiting resistor 18 as shown in the figures.

In operation, the exhaust gas discharged from an exhaust gas source (not shown) flows from gas inlet 2 through guide blades 6, charging stage A and dust collecting stage B to gas outlet 3. The dust particles floating in the exhaust gas are charged by the negative ion flow directed from corona discharge electrodes 9 to opposite electrodes 10.

Since the corona discharge electrodes 9 illustrated in FIGS. 1 and 2 are formed in an angle-shape cross-section and their corner edges are directed upstream, the exhaust gas flow is temporarily choked upon passing through the gap spaces between the corona discharge electrodes 9. The dust particles in the exhaust gas are caused to contact the electrodes so that they are intensely charged in a short period of time.

The charged dust particles directed into the dust collecting stage B are driven from driving electrodes 11 toward collector electrodes 12. In particular, since a high voltage DC source is connected across driving electrodes 11 and collector electrodes 12, the charged dust particles are conveyed to within the pockets 14 of the collector electrodes 12. Because of the DC electric field established between electrodes 11 and 12, dust collects on collector electrodes 12. The collector electrodes 12 are applied with mechanical shocks as by hammering, and the dust then torn off the electrodes 12 falls through the space in the pockets 14, reaches the conveyor 5 via the hopper 4, and then is discharged to the exterior. Therefore, the exhaust gas passing through the dust collecting stage B is converted to a clean gas containing no dust, and then led to the outlet 3.

While the corona discharge electrodes 9 were formed, in the above-described embodiment, in an angle-shape having a contactor 8 with sharp tips 7 fixedly secured thereto, the same function and effect can be expected as shown in FIG. 4 by employing corona discharge electrodes 9' of angle-shape having a contactor 8' and a plurality of needle-like protrusions 7' mounted at a predetermined interval in the lengthwise direction along the rear edges on both sides of the angle-shaped body.

In the two-stage type of electric dust arrester illustrated in FIGS. 5 and 6, the component parts designated by the same references bearing the prime (') designation as those in FIGS. 1 and 2 achieve the same functions. Reference numeral 19 designates an arcuated field forming surface provided on each side of the rod-shaped driving electrode 11' having an arcuated transverse cross-section, the open end 20 of said driving electrode 11' being directed downstream. Driving electrodes 11' shown in FIGS. 5 and 6 are distinguished from those shown in FIGS. 1 and 2 in that the configurations of the transverse cross-section are different from each other and in that on each side of open end 20 is formed a DC electric field forming surface 19 of arcuated shape.

Gap spaces 13' formed between DC electric field forming surfaces 21 of arcuated shape of the adjacent driving electrodes 11' are disposed so as to oppose the inlet openings 15' of the collector electrodes 12' defined by field forming surfaces 21 formed on the respective sides of collector electrodes 12' which are provided downstream of driving electrodes 11'. The width of the inlet openings 15' is broader than that of gap spaces 13'.

The negatively charged dust particles conveyed to the narrow regions between respective adjacent driving electrodes 11' in dust collecting stage B are, due to the negative polarity of the potential on driving electrodes 11', repulsed by driving electrodes 11', concentrated by the electric field between the driving electrodes 11' and collector electrodes 12' toward collector electrodes 12' which are maintained at a positive potential and collected in pockets 14' of electrodes 12.

Since the DC electric field is established toward the inner side of the collector electrode 12' as shown by dotted lines in FIG. 6, almost all of the dust particles in the exhaust gas which are moving along the lines of electric force, are conveyed toward the inner side of pocket 14' in the collector electrode 12'.

FIGS. 7*a* through 7*y* illustrate examples of modified cross-section configurations of driving electrodes 11' and collector electrodes 12' in the two-stage type of electric dust arrester shown in FIG. 5.

The corona discharge electrodes 9 in the two-stage type of electric dust arrester shown in FIG. 8 are similar to those shown in FIG. 2, but another set of corona discharge electrodes 22 are disposed downstream of opposite electrodes 10 in such manner that the apex edges of the angle-shaped bodies may be directed in the opposite direction to that of corona discharge electrodes 9. In addition, extending through the opposite electrodes 10 are formed passageways 23 for liquid coolant such as, for example, cooling water. Water feed and discharge pipes (not shown) are connected to passageways 23. The other component parts in FIG. 8 designated by the same reference numerals as those shown in FIG. 2, also achieve the same functions.

In operation, the dust particles in the exhaust gas flowing through the casing 1 are at first charged as moving along with the ionic wind caused by the corona discharge and emitted from the corona discharge electrodes 9 towards the opposite electrodes 10, subsequently they are charged as moving inversely in the direction of the ionic wind flowing from the other set of corona discharge electrodes 22 towards the opposite electrodes 10, and thereby the dust particles can be charged uniformly. In addition, the liquid coolant such as water flowing through the passageways 23 within the opposite electrodes 10 serves to lower the temperature of the dust layer adhered to the electrode surface and thereby greatly reduce the electric resistivity of the same, so that the inverse ionization phenomena caused by the dust adhered to the electrode surface may be eliminated.

In the two-stage type of electric dust arrester illustrated in FIG. 9, sorption electrodes 24 are provided at the center of the pocket 15 in the collector electrodes 12 and applied with a potential of the same polarity as the rod-shaped collector electrodes 12. The radius of curvature in the cross-section of the sorption electrodes 24 is smaller than that of the field forming surface 21 on each side of the collector electrodes 12.

Sorption electrode 24 is disposed substantially on the center line of gap space 13 formed between adjacent driving electrodes 11, in such manner that the extreme edge of the field forming surface of sorption electrode 24 is tangent to the plane including the extreme edges of the electric field forming surfaces on the respective sides of the collector electrodes 12. The other component parts designated by the same references as those described with reference to the preceding embodiments, achieve the same functions.

In this embodiment, a first uneven DC electric field as shown by dotted lines is established between the electric field forming surfaces 19 of driving electrodes 11 and electric field forming surfaces 21 of collector electrodes 12. Simultaneously a similar intense DC electric field is established between electric field forming surfaces 19 and sorption electrodes 24. Dust particles passing through gap spaces 13 between adjacent driving electrodes 11 are driven toward collector electrodes 12 by the first DC electric field and the intense DC electric field to be concentrated at and adhered to sorption electrodes 24 and also to be adhered to the inner surface of collector electrodes 12.

The dust adhered to the sorption electrode 24 grows gradually to form a dust layer, which peels off by applying mechanical shocks or vibrations as by intermittent hammering, and falls into the hopper 4 to be collected therein. Then the partly dispersed dust particles adhere to the collector electrodes 12. The dust particles dispersed upon hammering the sorption electrodes 24 start to disperse substantially from the center of the inlet opening 15 of the collector electrode 12, and are entirely transferred to the inner surface of the collector electrode 12 and thereby completely collected.

FIG. 10 shows schematically a part of a modification of the two-stage type of electric dust arrester illustrated in FIG. 9, in which an AC voltage source 25 is connected across driving electrodes 11 and collector electrodes 12. In this case, because the AC electric field established between driving electrodes 11 and collector electrodes 12, a part of the charged dust particles are captured in the space between these electrodes to be prevented from moving further, and under the captured condition the charged dust particles fall down to be collected.

It is intended that the scope of the present invention should not be limited to the preferred embodiments described above and illustrated in the accompanying drawings. All modifications employing the principles of the invention are therefore considered as included in the appended claims unless these claims by their language expressly state otherwise.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A two-stage type of electric dust arrester comprising a charging stage and a dust collecting stage arranged in succession within a casing from an inlet of said casing towards an outlet thereof, characterized by the provision of:

a. a collector electrode disposed downstream of a gap space formed between adjacent driving electrodes in said collecting stage, said collector electrode having a pocket formed therein extending in the lengthwise direction, the inlet opening of said pocket being directed towards said gap space, and

b. a high voltage DC source for establishing an electric field such that charged dust particles are driven in said electric field from said driving electrode toward said inlet opening of said pocket in said collector electrode.

2. A dust arrester as defined in claim 1, further characterized by corona discharge means in said charging stage, said corona discharge means including a plurality of spaced apart rod-shaped electrodes each having a body of angle-shaped transverse cross-section, the apex edges of said angle-shaped body being directed toward said inlet of said casing, the rear edges of said angle-shaped bodies being formed with sharp tips; and a plurality of opposite electrodes disposed downstream of said corona discharge electrodes.

3. A dust arrester as defined in claim 2, further characterized in said opposite electrodes having passageway means formed adapted for connection to a coolant source.

4. A dust arrester as defined in claim 1, further characterized in corona discharge electrodes disposed in front and rear stages in said charging stage along the flow path of dust containing gas through said casing and opposite electrodes positioned between said front and rear stages of said corona discharge electrodes.

5. A dust arrester as defined in claim 1, further characterized in that said driving electrodes and said collector electrodes are formed with pockets extending in their lengthwise direction; the side edges of said pockets providing electric field forming surfaces of circular cross-sectional configuration, said pockets in said driving electrodes having inlet openings therein directed toward said collector electrodes, and said pockets in said collector electrodes having inlet openings disposed downstream of said gap space formed between said adjacent driving electrodes.

6. A two-stage type of electric dust arrester comprising a charging stage and a dust collecting stage arranged in succession within a casing from an inlet of said casing towards an outlet thereof, characterized by the provision of:

a. a plurality of rod-shaped collector electrodes disposed downstream of a plurality of rod-shaped driving electrodes said driving electrodes being spaced apart having gap spaces formed therebetween, said collector electrodes having pockets formed therein extending in the lengthwise direction; said pockets having inlet openings directed toward said gap spaces,

b. rod-shaped sorption electrodes positioned at said inlets to said pockets of said collector electrodes; and

c. a high voltage DC source having a negative terminal connected to said driving electrodes and a positive terminal connected to said collector electrodes.

7. A dust arrester as defined in claim 6, further characterized in that said driving electrodes are formed with pockets extending in their lengthwise direction, said pockets having inlet openings therein, the side edges of said pockets in said collector electrode having electric field forming surfaces of arcuated cross-section configuration, said pockets in said driving electrodes and said pockets in said collector electrodes being opposed to each other, said inlet openings of said pockets in said collector electrodes disposed downstream of said gap spaces formed between adjacent driving elec-

trodes; said sorption electrodes being rod-shaped having a radius of curvature in the transverse cross-section smaller than that of said field forming surfaces of said collector electrodes and disposed downstream of the centers of said gap spaces.

8. A two-stage type of electric dust arrester as defined in claim **6**, further characterized in that the sorption electrodes are disposed in the proximity of a plane tangential to said electric field forming surfaces of arcuated cross-section configuration provided along the side edges of said pockets in said collector electrodes.

9. A two-stage type of electric dust arrester as defined in claim **6**, further characterized in that the polarity of the electric potential at said collector electrodes is the same as the polarity of the electric potential at said sorption electrodes.

10. A dust arrester as defined in claim **6**, further characterized by a high voltage AC source connected across said driving electrodes and said collector electrodes.

11. An electric dust arrester having a charging stage and a collecting stage arranged in succession within a chamber defined by a casing, said arrester characterized by said charging stage having a pair of charging electrodes spaced apart laterally of the path of flow of dust through said chamber; said collecting stage having a collecting electrode aligned with the space between said charging electrodes in the direction of movement of dust through said chamber; said collecting electrode having a pocket extending lengthwise thereof, said pocket having an open face directed toward said charging electrodes; and a high voltage DC source of electrical energy connected to said charging and collecting electrodes for creating a field to accelerate dust particles as they move between said charging and collecting electrodes and for attracting the particles into said pocket of said collecting electrode.

12. An electric dust arrester having a charging stage and a collecting stage arranged in succession within a chamber defined by a casing, said arrester characterized by said charging stage having a plurality of charging electrodes spaced apart laterally of the path of flow of dust through said chamber; a plurality of opposite electrodes positioned downstream of said charging electrodes; said collecting stage having a plurality of spaced apart driving electrodes therein positioned downstream of said charging and said opposite electrodes; a plurality of collecting electrodes aligned with the space between said driving electrodes in the direction of movement of dust through said chamber; said collecting electrode having a pocket extending lengthwise thereof, said pocket having an open face directed toward said driving electrodes; and a high voltage DC source of electrical energy connected to said charging, opposite, driving and collecting electrodes for creating a field to accelerate dust particles as they move through said chamber and for attracting the particles into said pocket of said collecting electrode.

13. The dust arrester of claim **12** wherein said DC source includes a negative terminal and a positive terminal, said negative terminal being connected to said charging and driving electrodes and said positive terminal being connected to said opposite and collector electrodes.

14. The dust arrester of claim **13** and further including sorption electrodes positioned in said pockets at the open face thereof said sorption electrodes being connected to said positive terminal.

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