June 26, 1962 E. M. BERLY 3,040,498

ELECTROSTATIC PRECIPITATOR

Filed Feb. 4, 1958 3 Sheets-Sheet 1

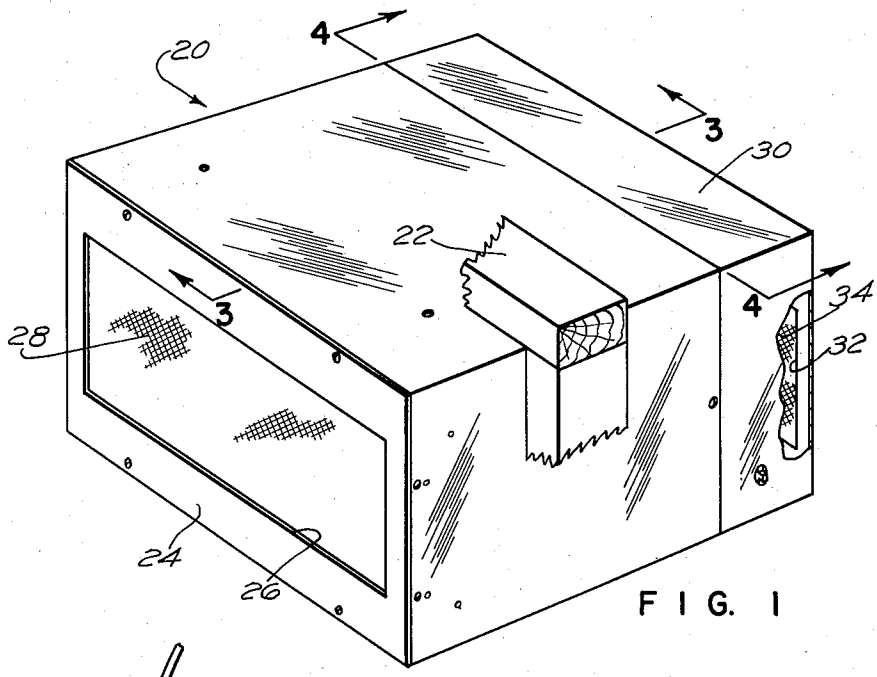


FIG. 1

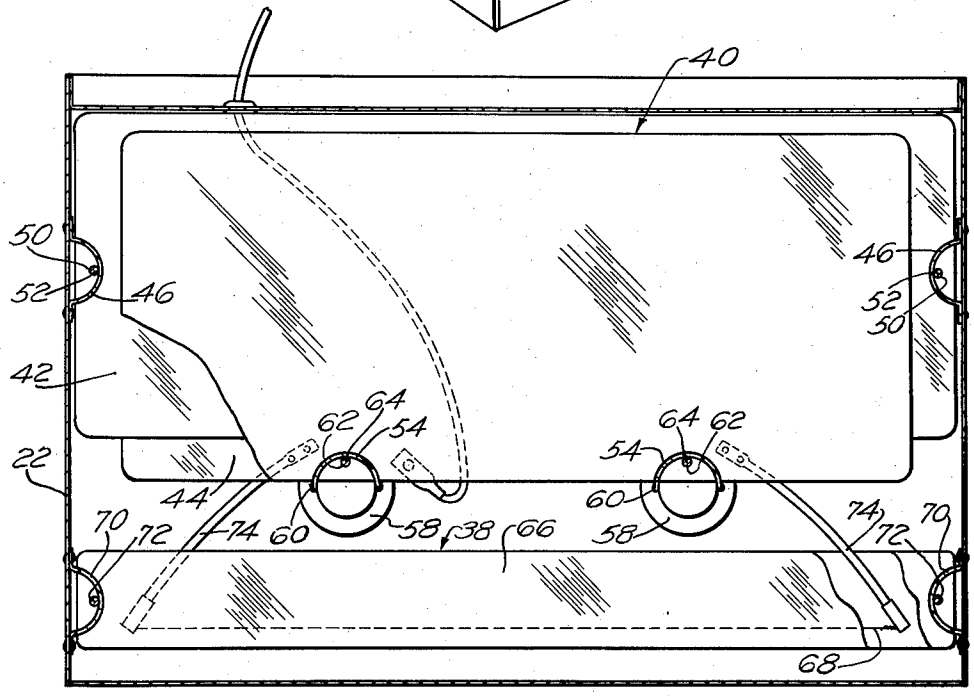


FIG. 2

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June 26, 1962 E. M. BERLY 3,040,498

ELECTROSTATIC PRECIPITATOR

Filed Feb. 4, 1958 3 Sheets-Sheet 2

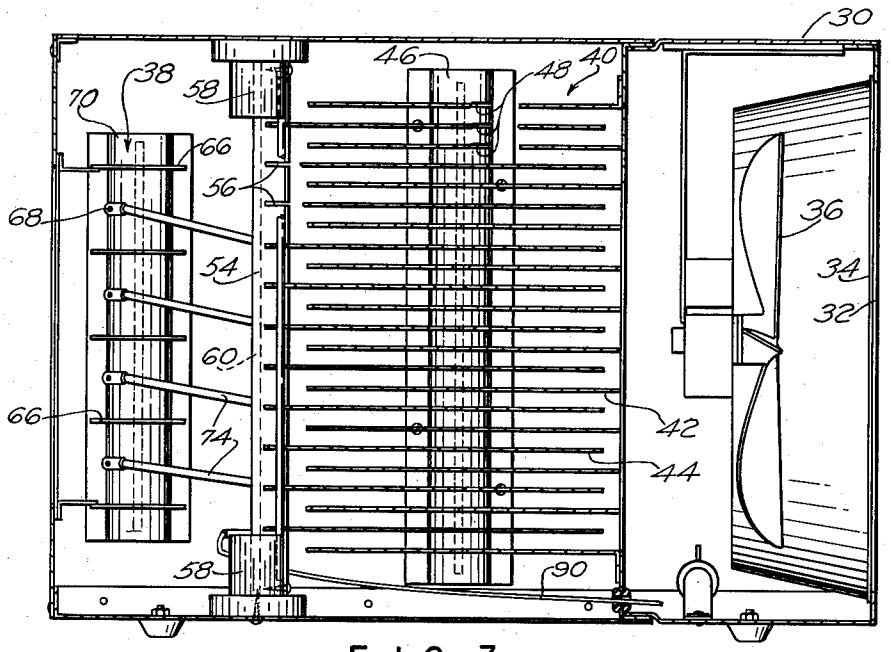


FIG. 3

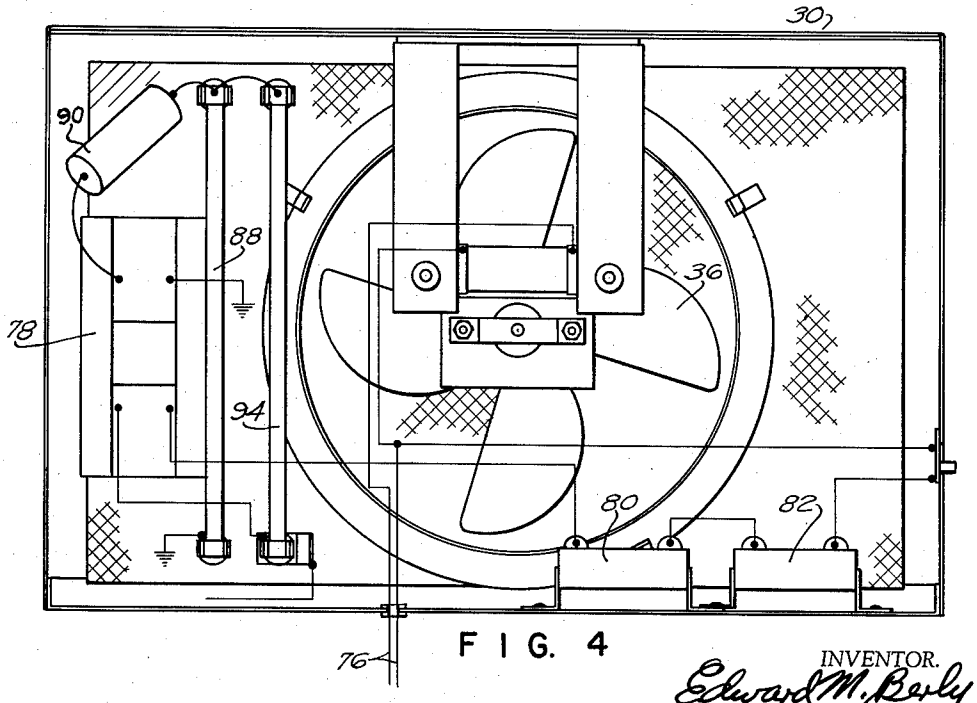


FIG. 4

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June 26, 1962 E. M. BERLY 3,040,498

ELECTROSTATIC PRECIPITATOR

Filed Feb. 4, 1958 3 Sheets-Sheet 3

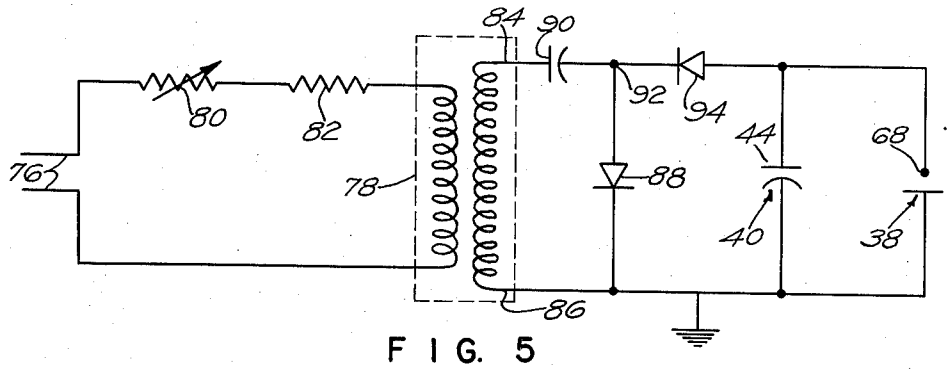


FIG. 5

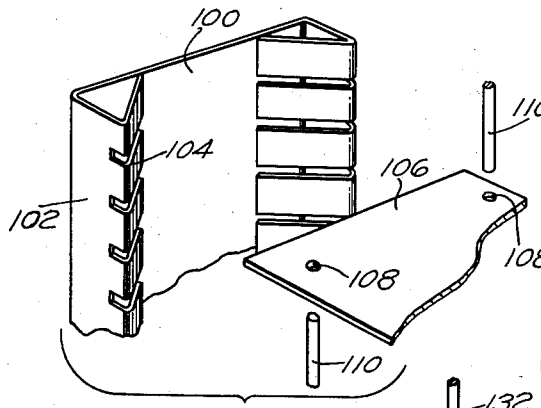


FIG. 6

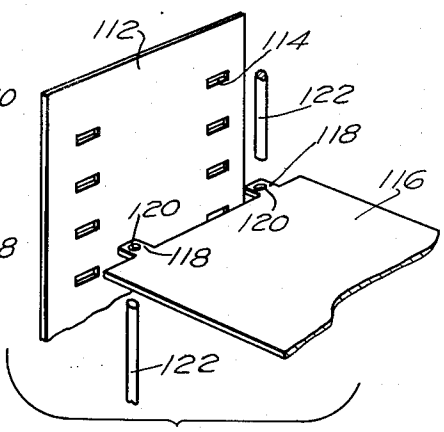


FIG. 7

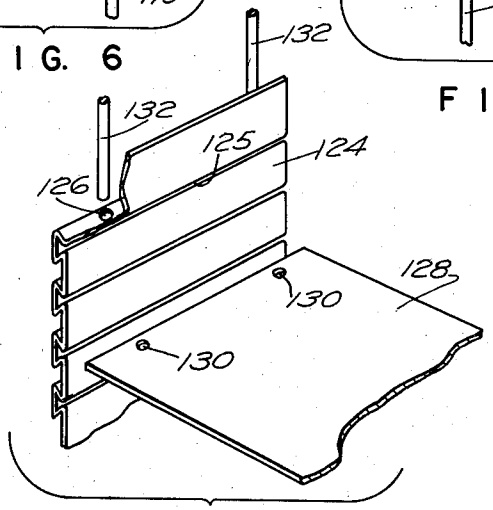


FIG. 8

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3,040,498

ELECTROSTATIC PRECIPITATOR

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15 Claims. (Cl. 55—138)

The present invention relates to air cleaning by electrostatic precipitation and, more particularly, to electrostatic precipitators of the type providing (1) an ionizing zone in which entering air molecules are charged by a non-uniform electrostatic field and accumulate on dust particles that in consequence become charged and (2) a collecting zone in which the charged dust particles, under the direction of a uniform electrostatic field, are deposited on electrodes of opposite polarity. In practice, the ionizing zone is characterized by corona discharge generated about a thin wire by a voltage gradient from the wire to some nearby, usually grounded, surface. In practice, the collecting zone is characterized by parallel but alternately charged positive and negative metal plates. The air leaving the collecting zone, having been cleansed of its dust particles, is recirculated into the air mass being cleansed. The present invention contemplates a novel electrostatic precipitator having conventional high collection efficiency and low pressure drop but having a remarkably simple design that reduces component and fabrication costs and minimizes electrical and mechanical failure.

Primary objects of the present invention are to provide an electrostatic precipitator of the foregoing type: in which the ionizing and collecting plates are mounted in sheet metal slots; in which certain of the plates, which are cantilevered at aligned edges, interlace with other plates, which are supported at their opposite ends; in which the high voltage ionizing wires and the high voltage collecting plates are maintained at the same potential by direct mechanical connection; and in which a control system for adjusting the potential of the ionizing wires and the collector plates ensures efficient performance under all climatic conditions.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the features, properties and the relation of components, which are exemplified in the following detailed disclosure, and the scope of which will be indicated in the appended claims.

For a fuller understanding of the nature and objects of the present invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIGURE 1 is a perspective view of an electrostatic precipitator embodying the present invention;

FIGURE 2 is a top plan view of the forward portion of the apparatus of FIGURE 1, with its housing removed;

FIGURE 3 is a cross-sectional view of the apparatus of FIGURE 1, the section being taken along the lines 3—3 of FIGURE 1;

FIGURE 4 is a cross-sectional view of the apparatus of FIGURE 1, the section being taken substantially along the lines 4—4 of FIGURE 1;

FIGURE 5 is a schematic diagram of the electrical circuit of the apparatus of FIGURE 1; and

FIGURES 6, 7, and 8 are modifications of components of the apparatus of FIGURE 1.

Generally, the illustrated embodiment of the present invention contemplates a sheet metal conduit that is rectangular in transverse cross-section, having a forward open end through which air is exhausted by a fan. Connected to or integral with the opposite longitudinal, vertical panels of the conduit are sheet metal portions providing slots that receive the opposite extremities of certain of the ionizer plates and the collector plates. These plates, which are secured by rods extending through apertures therein and abutting against the sheet metal portions, are electrically grounded by virtue of their electrical contact with the sheet metal conduit. Extending between the lower and upper horizontal panels of the conduit and electrically insulated therefrom are sheet metal components providing slots which mount portions of charged collector plates. These plates, which are secured by rods extending through apertures therein and abut against the sheet metal portions, interlace among the grounded collector plates. Ionizer wires are tensioned between the grounded ionizer plates by spring metal arms mechanically and electrically connected to the charged collector plates. By virtue of this simple construction, the electrical potential of the charged collector plates and ionizer wires may be varied readily in order to adjust for the most efficient response under various humidity and other ambient weather conditions.

With reference now to the drawings, a preferred embodiment of the present invention is disclosed in FIG. 1 as comprising a housing **20**, which supports and encloses the remaining mechanical and electrical components. Housing **20** includes a medial section in the form of a sheet metal conduit **22** that is rectangular in transverse cross-section. Conduit **22** is integrally formed from a folded sheet metal blank. The forward open end of conduit **22** is covered by a plate **24** that presents a window **26** provided with a screen **28**. The rearward open end of conduit **22** is associated with a sub-housing **30**, the upper, lower and side panels of which continue the upper, lower and side panels of conduit **22** and the rear face of which presents a window **32** provided with a screen **34**. Sub-housing **30** supports and encloses electrical supply and control circuit elements to be described in detail below. In reference to FIG. 3, the primary components of the device include an ionizer **38**, a collector **40** and a fan **36** for drawing air in sequence through the ionizer and the collector.

Collector **40** includes a plurality of interspersed grounded negative and charged positive plates, designated **42** and **44**, respectively. It is apparent that the grounded and charged plates must be interconnected mechanically but isolated electrically in such a way that critical spacing is maintained for the purposes of ensuring maximum efficiency and preventing arcing. In accordance with the present invention, the grounded and charged plates are simply assembled and securely installed by virtue of the construction now to be described. Riveted to the inner faces of the vertical side panels of conduit **22** are a pair of opposed sheet metal columns **46** that are substantially semi-circular in horizontal cross-section. Each of columns **46** is provided with predeterminedly spaced slots **48**. Pairs of slots in the pair of columns are co-planar for the reception of the opposite ends of grounded plates **42**. These ends of plates **42** are provided with holes **50** that are spaced apart a distance slightly less than the shortest distance between the remote surfaces of pair of columns **46**. Plates **42** become rigidly secured in predetermined positions when rods **52** are forced through holes **50** in abutment against the remote surfaces of columns **46**. The columns, by virtue of their spatial relationships, thereby become slightly deformed so as to exert a centering bias on the rods. Slotted columns **46** can be manufactured, for example, by a continuous punch operation or by a simple multiple punch and die operation. The construction is not only mechanically precise but also provides perfect electrical contact between the plates.

A pair of sheet metal columns **54** cantilever the forward

edges of plates 44, the remaining portions of plates 44 being interspersed freely among plates 42. Each of sheet metal columns 54 is substantially semicircular in horizontal cross-section and provides a series of slots 56. Pairs of slots 56 in the two columns are co-planar for the reception of portions of the forward edges of the plates. The upper and lower extremities of columns 54 are secured against the cylindrical shanks of a pair of insulators 58. The outer flat surfaces of the heads of insulators 58 are secured predeterminedly to the inner faces of the upper and lower wall panels of conduit 22. The vertical free edges of columns 54 are reversely rolled as at 60 to provide stops for the forward edges of plates 44. These forward edges of plates 44 are provided with holes 62 that are spaced from the forward edges of plates 44 by a distance slightly greater than the maximum distance between the forward surface of column 54 and the rearward edge of roll 60. Plates 44 are predeterminedly and rigidly secured in slots 56 by rods 64 which, when forced into holes 62, slightly deform columns 54. Rods 64, which become centered, predeterminedly position the plates. In consequence, perfect electrical contact is ensured between plates 44 and columns 54. Because of the cantilever mounting of plates 44, it is preferred that the distance between the forward and rearward edges of plates 44 be considerably less than the distance between the side edges of plates 44 for the purpose of achieving adequate area of the plates while minimizing gravitational deflection of the plates.

Ionizer 38 includes a plurality of grounded plates 66 and charged wires 68. The extremities of plates 66 are received by slots in columns 70, which are generally similar to columns 46, described above, and are secured thereto by rods 72 in the manner described above. Wires 68 are tensioned between the forward ends of pairs of resilient arms 74, the rearward ends of which are mechanically and electrically connected to charged collector plates 44. It is apparent that the same potentials are employed in both the ionizer and the collector. In practice, ionizer plates 66 and collector plates 42, as indicated above, are grounded to conduit 22 and fine wire 68 and plates 44 are maintained at a potential of from 6000 to 7000 volts above ground. The simplicity of arms 74, which provide both support and spring tension, renders the ionizer inexpensive to assemble and simple to service. Since arms 74 are attached directly to the charged collector plates, no additional insulators or interconnecting leads are required and a single lead from the power supply is capable of charging both the collector and the ionizer.

The electrical supply and control system is shown mechanically in FIG. 4 and electrically in FIG. 5.

In general, the power supply is a voltage doubler circuit energized by a high reactance transformer and utilizing plates 40 and 44 as one of the high voltage filter capacitors.

Alternating current is applied through input leads 76 which energize the primary of a transformer 78 through a variable resistor 80 and a fixed resistor 82. Neglecting the small voltage drop across resistors, for example, an applied 115 volts is transformed to 3000 volts by transformer 78. Ideally, the voltage across the secondary is a sine wave with a root mean square value of 3000 volts and a maximum amplitude of 4250 volts. When junction 84 is decreasing with respect to junction 86, diode 88 is biased so that its anode is positive in respect to its cathode. Accordingly, current flows through the diode, charging capacitor 90 so that junction 92 becomes positive with respect to junction 84. Capacitor 90 charges to the peak value of the sine wave. When the input voltage starts to decrease from its peak value, the cathode of the diode 88 becomes more positive than its anode and the charging current into capacitor 90 ceases. The peak value of the voltage remains on capacitor 90 until bled off by leakage or some load resistance. However, it will be noted that the voltage across diode 88 in the reverse direction is the sum of the voltages across capacitor 90 and across the secondary of transformer 78. With no losses, this value would be 4250 volts D.C. plus the peak transformer voltage of 4250 volts or the peak-to-peak value of the incoming sine wave. A second diode 94 and a second capacitor, in the form of the plates 44 of collector 40, are connected across diode 88. Second diode 88 conducts, charging capacitor 40, as soon as its anode is positive in respect to its cathode, the driving voltage for this circuit being the sum of the voltages across capacitor 90 and the secondary of transformer 78.

In practice, provision is made to limit any transient currents that may occur when either collector 44 or ionizer 38 flashes over. Two types of limiting are employed in this power supply: reactive limiting by the use of a transformer with a large amount of leakage reactance between the primary and secondary; and resistive limiting by use of resistor 82 to damp out any oscillators produced between the leakage reactance and the circuit capacitors. The output voltage is reduced from the peak-to-peak value of the transformer secondary voltage by the action of the charging currents flowing through the limiting impedance. The output voltage of this power supply is 6200 volts D.C. when 250 microamps are flowing in the ionizer load.

Variable resistor 80, in series with the fixed resistor, can be adjusted at the control panel by the user so that the unitary ionizer and collector voltage can be varied in accordance with ambient requirements. Thus, on very humid days or at high elevations, when the resistivity of air falls off to the point where frequent and annoying arcing occurs, the variable resistor may be adjusted to reduce the voltage to an extent necessary to eliminate arcing. This simple control makes it possible for the present device to be marketed for all possible climates. Furthermore, in view of the face that the present maximum potentials are within the range of from 6000 to 7000 volts rather than within the usual range of from 10,000 to 15,000 volts, the rate of deterioration of the electrical components is reduced sharply.

Modifications in accordance with the present invention of columns 46 and 54 are shown in FIGS. 6, 7 and 8. The modification of FIG. 6 includes a column in the form of a channel having a bight 100, which may be secured to the walls of conduit 22, and a pair of opposed vertical guides each including an intermediate portion 102 and a continuation portion 104. Portion 102 is partially slotted and portion 104 is totally slotted to provide a plurality of fingers between which edges of plates 106 may be secured with the aid of rods 110. Rods 110 project into openings 108 in the plates and abut against the apices of the junctions between portions 102 and 104. In the modification of FIG. 7, a portion 112 of the conduit itself is slotted at 114. Associated with this portion are a series of plates 116 having lugs 118 extending from the edges thereof. Each of lugs 118 is designed to project through one of slots 114 and to be secured therewithin by a rod 112, which projects through a series of aligned openings 120 in aligned lugs 118. FIG. 8 shows a further alternative embodiment of the present invention as comprising a portion 124 of a sheet metal conduit of the above described type, in which is provided a series of grooves 125 which receive a series of plates 128. Openings 126 in the portions defining grooves 125 and openings 130 at the edges of plates 128 are locked in alignment by rods 132.

It is to be expressly understood that each of the embodiments of FIGS. 6, 7 and 8 may be either separate from or integral with the conduit described in connection with FIG. 1. This conduit either may serve as the outer housing of the electrostatic precipitator or may be snugly inserted within a more decorative housing composed for example of an organic plastic or a natural wood.

Since certain changes may be made in the above ap-

paratus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. An electrostatic precipitator comprising a housing, a plurality of interspersed wires and plates defining an ionizing zone, a plurality of interspersed plates defining a collecting zone, and means for directing air through said ionizing zone and said collecting zone, certain of said plates being mounted at their ends in metal slots, others of said plates being cantilevered at aligned edges in order to interlace with said certain of said plates, first metal members providing such slots and being electrically connected to said certain of said plates, second metal members, adjacent to a single edge of said others of said plates, providing slots receiving said others of said plates and being electrically connected to said others of said plates, said second metal members being electrically insulated from said first metal members.

2. The electrostatic precipitator of claim 1 wherein said wires and said others of said plates are maintained at the same potential by direct mechanical connection.

3. The electrostatic precipitator of claim 2 wherein means are provided for adjusting the potential of the ionizing wires and the collector plates in order to ensure efficient performance under all climatic conditions.

4. An electrostatic precipitator comprising a housing including a metal conduit that is rectangular in transverse cross-section and is formed from folded sheet metal having bottom and top and side panels, said conduit presenting at its forward end a window provided with a screen, said conduit presenting at its rearward end a window provided with a screen, a collector including a plurality of interspersed relatively negatively charged plates and relatively positively charged plates, a first pair of opposed sheet metal columns secured to said side panels of said conduit, said opposed sheet metal columns being provided with predeterminedly spaced slots, pairs of slots in said first pair of columns being co-planar for the reception of opposite edges of said relatively negatively charged plates of said collector, said relatively negatively charged plates of said collector being provided with holes that are spaced apart a distance slightly less than the shortest distance between the remote surfaces of said pair of columns, rods projecting through said holes in abutment against said remote surfaces of said pair of columns, said pair of columns being slightly deformed so as to exert a centering bias on said rods, a second pair of opposed sheet metal columns extending between said upper and lower panels of said conduit and being insulated therefrom, said second pair of opposed sheet metal columns being provided with predeterminedly spaced slots, pairs of slots in said second pair of columns being co-planar for the reception of forward edges of said relatively positively charged plates of said collector, portions of said second pair of columns limiting the forward motion of said relatively positively charged plates of said collector, the forward edges of said relatively positively charged plates of said collector being provided with holes that are spaced from the forward edges of said relatively positively charged plates of said collector by a distance slightly greater than the maximum distance between the limiting portions of said second pair of columns and the forward surfaces of said second pair of columns, rods positioned in said last mentioned holes in abutment against said forward surfaces of said second pair of columns, said second pair of columns being slightly deformed so as to exert a centering bias on said rods, the distance between the forward and rearward edges of said relatively positively charged plates being considerably less than the distance between the side edges of said relatively positively charged plates, an ionizer including a plurality of relatively negatively charged plates and relatively positively charged wires, a third pair of opposed sheet metal opposed sheet metal columns being provided with

predeterminedly spaced slots, pairs of slots of said third pair of columns being co-planar for the reception of opposed edges of said relatively negatively charged plates of said ionizer, said relatively negatively charged plates of said ionizer being provided with holes that are spaced apart a distance slightly less than the shortest distance between the remote surfaces of said third pair of columns, rods projecting through said holes in abutment against said remote surfaces of said third pair of columns, said third pair of columns being slightly deformed so as to exert a centering bias on said third rods, pairs of resilient arms extending from said relatively positively charged plates of said collector, said wires being tensioned between the forward ends of said pairs of resilient arms, whereby said wires and said relatively positively charged plates of said collector are at the same potentials, electrical means for energizing said relatively positively charged plates and said wires, variable means for adjusting said electrical means, said housing including an electrically insulating housing surrounding said conduit.

5. The electrostatic precipitator of claim 4 wherein said sheet metal slots are integral with said conduit.

6. The electrostatic precipitator of claim 4 wherein said sheet metal slots are provided by columns secured to said conduit.

7. An electrostatic precipitator comprising a housing, a plurality of interspersed wires and plates defining an ionizing zone, a plurality of interspersed plates defining a collecting zone, means for directing air through said ionizing zone and said collecting zone, means for mounting certain of said collecting plates at their ends in sheet metal slots, means for cantilevering others of said collecting plates at aligned edges in order to interlace said others with said certain of said collecting plates, means for directly mechanically and electrically connecting said wires and said others of said collecting plates in order to maintain the same potential and to maintain each wire under spring tension, and means for adjusting the potential of said wires and said certain of said collecting plates in order to ensure efficient performance under all climatic conditions.

8. The electrostatic precipitator of claim 7 wherein said means for directing air is a fan which draws air in sequence through said ionizing zone, said collecting region and an exhaust zone.

9. An electrostatic precipitator comprising an insulating housing and therein a sheet metal insert in the form of a conduit, a plurality of interspersed wires and plates defining an ionizing zone and a plurality of interspersed plates defining collecting zone, means for drawing air through said ionizing zone and said collecting zone means for mounting certain of said collecting plates at their ends in sheet metal slots, means for cantilevering others of said plates at aligned edges in order to interlace said others with said certain of said collecting plates, means for maintaining said wires and said others of said collecting plates at the same potential and under tension by direct mechanical and electrical connection, and means for adjusting the potential of the wires and said certain of said collector plates.

10. The electrostatic precipitator of claim 9 wherein said sheet metal slots are integral with said conduit.

11. The electrostatic precipitator of claim 9 wherein said sheet metal slots are provided by columns secured to said conduit.

12. The electrostatic precipitator of claim 9 wherein said others of said collecting plates are secured by their edges which project into slots in sheet metal columns.

13. The electrostatic precipitator of claim 9 wherein said certain of said collecting plates are secured in their associated sheet metal slots by rods extending through openings in said certain of said collecting plates and in abutment against the sheet metal defining said sheet metal slots.

14. An electrostatic precipitator comprising a housing, a plurality of interspersed wires and plates defining an

ionizing zone, a plurality of collecting plates defining a collecting zone, means for directing air through said ionizing zone and said collecting zone, means for mounting certain of said collecting plates at a plurality of their edges, means for cantilevering others of said collecting plates at single ones of their edges, said certain ones of said collecting plates and said others of said collecting plates being interlaced, means for directly mechanically and electrically connecting said wires and said others of said collecting plates, and means for adjusting the potential on said wires and said certain of said collecting plates.

15. An electrostatic precipitator comprising a housing, a plurality of interspersed wires and plates defining an ionizing zone, a plurality of collecting plates defining a collecting zone, means for directing air through said ionizing zone and said collecting zone, means for mounting certain of said collecting plates at a plurality of their edges, means for cantilevering others of said collecting plates at single ones of their edges, said certain ones of said collecting plates and said others of said collecting plates being interlaced, and means for directly mechanically and electrically connecting said wires and said others of said collecting plates.

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