

Sept. 1, 1953

R. L. BARR ET AL
ELECTROSTATIC PRECIPITATOR

2,650,672

Filed April 6, 1948

4 Sheets-Sheet 1

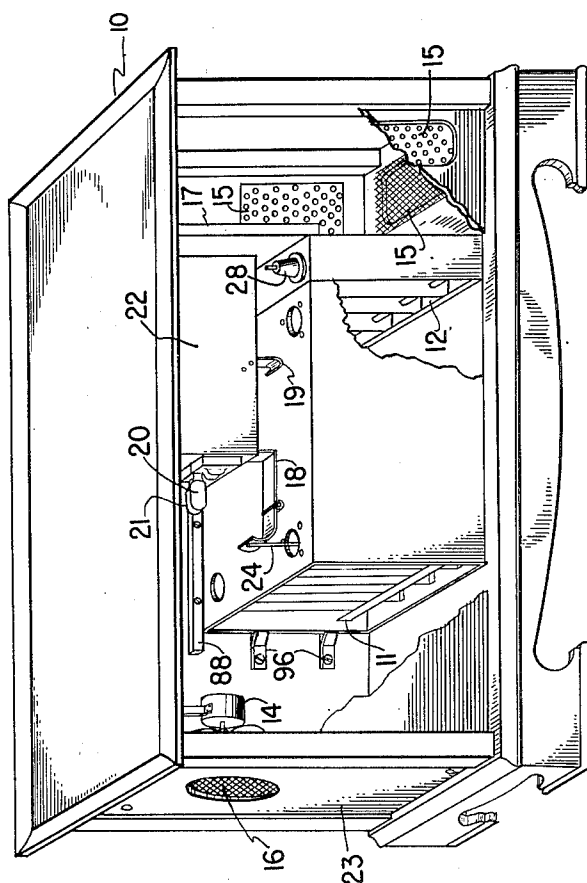


FIG. 1

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FIG. 2

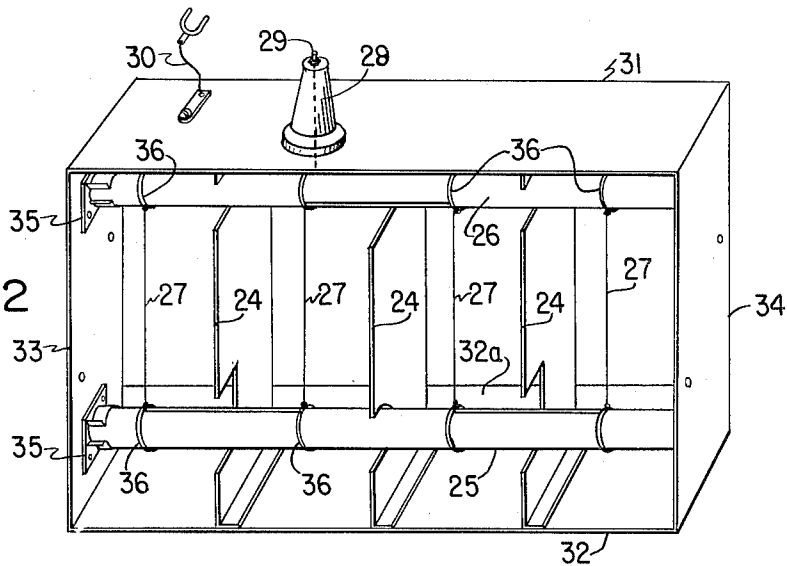


FIG. 3

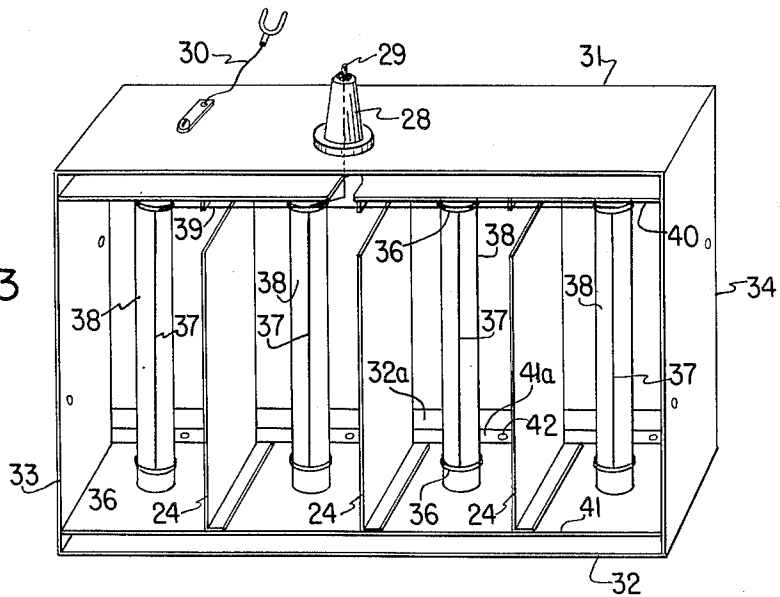
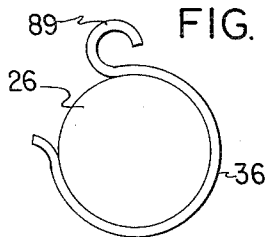


FIG. 4



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FIG. 5

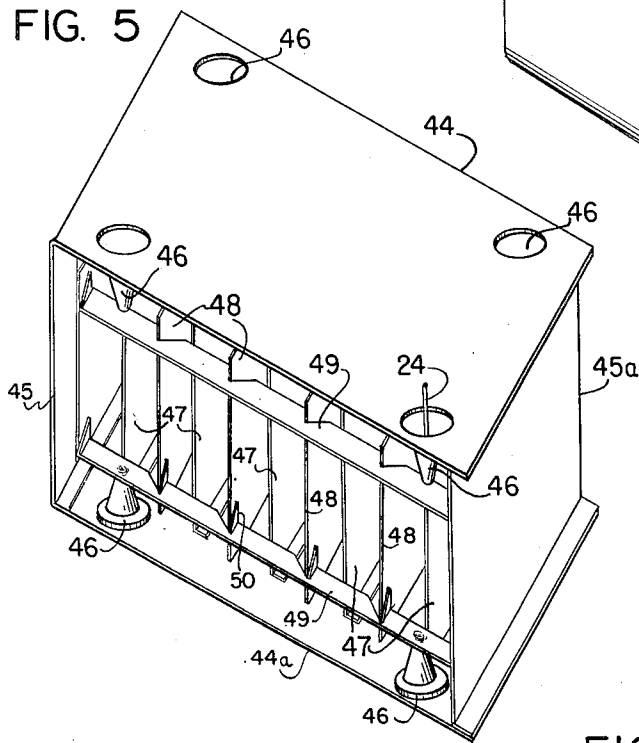


FIG. 13

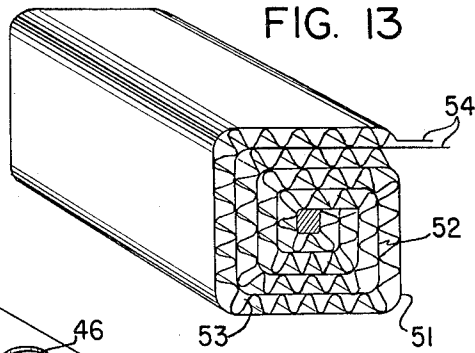
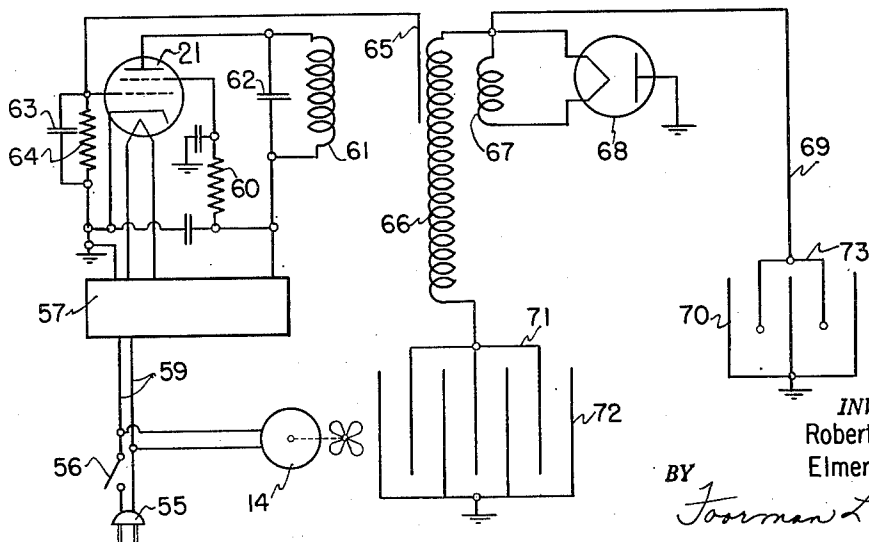


FIG. 14



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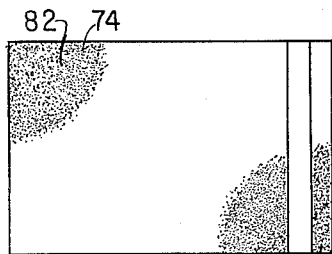


FIG. 8

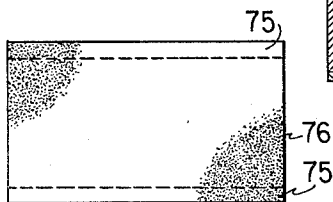


FIG. 9

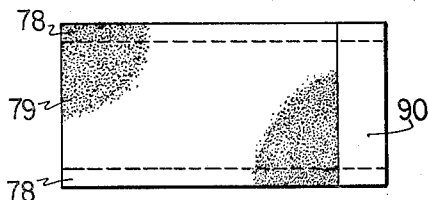


FIG. 10

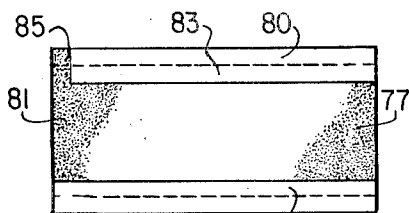


FIG. 11

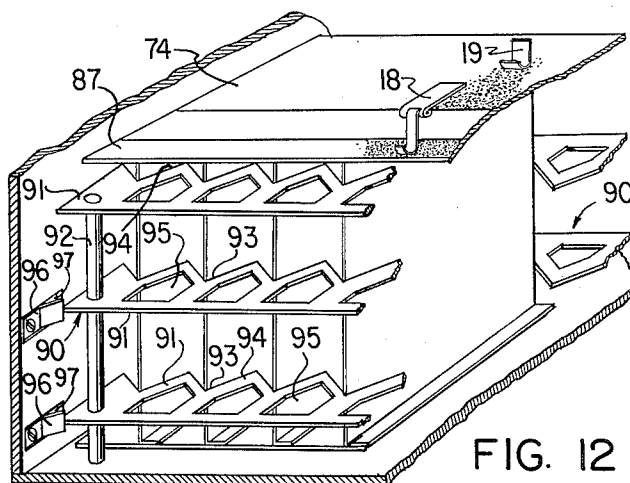


FIG. 12

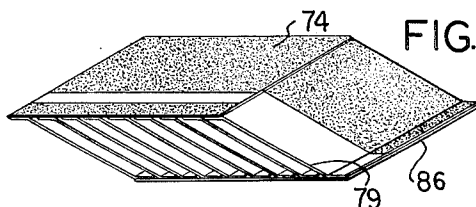


FIG. 7

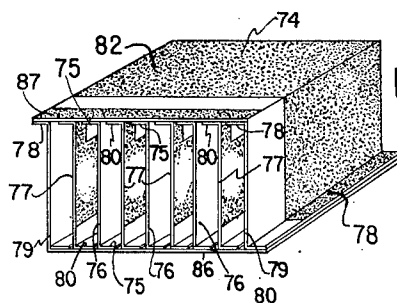


FIG. 6

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UNITED STATES PATENT OFFICE

2,650,672

ELECTROSTATIC PRECIPITATOR

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to Westinghouse Electric Corporation, East
Pittsburgh, Pa., a corporation of Pennsylvania

Application April 6, 1948, Serial No. 19,377

5 Claims. (Cl. 183—7)

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This invention relates to apparatus for removing particles of foreign matter from gases by means of electrostatic precipitation and more particularly to an improved precipitator unit which is suitable for use in homes, offices and the like for cleaning the air that is to be breathed.

It has been found that the operation of such precipitator units has been improved by the use of high frequency energy for ionization. However, a precipitator utilizing a high frequency power supply presents problems in interconnecting the various units because of power loss in corona on interconnecting cables and the detuning effect of lead capacities on the high frequency generator. The high voltages required in precipitator units are a further hazard to persons who may come in contact with the precipitator unit as contact with any portion of the high voltage power supply might result in shock or serious personal injury. The fan for causing circulation of air through the precipitator is another source of danger as accidental contact therewith, especially by children, might cause serious injury. The positioning of the fan in the unit can be arranged to eliminate such danger, but the positioning must be such that a smooth flow of the air to be cleaned over the ionizer and dust collector is provided in order that highly effective precipitation is obtained.

In present precipitator structures, the ionizer and dust collector are relatively complicated with the result that precipitators have been relatively expensive. Such collectors used at present are very difficult to clean, which cleaning is necessary at frequent intervals to provide satisfactory operation of the precipitator unit. In some home installations, hot water pipes are permanently connected to the precipitator and an arrangement is provided whereby the collector may be flushed with hot water when the precipitator is dirty. This results in an expensive and complicated installation, and has not been entirely satisfactory as hot water alone will not clean the collector plates satisfactorily.

It is, therefore, an object of this invention to provide an improved electrostatic precipitator in which the components are arranged so that efficient operation is provided and so that the unit will be entirely safe to be used in a home or the like.

A further object of this invention is to provide an electrostatic precipitator having disposable collector plates which may be easily replaced.

A still further object of this invention is to

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provide an improved ionizing structure which is of simple construction.

A feature of this invention is the provision of an electrostatic precipitator in which the high voltage power supply, the ionizer structure and the collector plates are so positioned that connecting leads are short and a relatively few insulators for the high voltage leads are required.

A further feature of this invention is the provision of a precipitator structure in which the components are so arranged that air may be circulated therethrough in a smooth even flow.

A still further feature of this invention is the provision of a collector structure which may be made of cardboard or similar inexpensive insulation material with conducting areas thereon.

Further objects, features and advantages of the invention will be apparent from a consideration of the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a perspective view of a precipitator unit in accordance with the invention with parts broken away to show the construction;

Fig. 2 is a perspective view of the ionizer structure of Fig. 1;

Fig. 3 illustrates a modified ionizer structure;

Fig. 4 is a cross-sectional view of one of the insulating rods of the ionizing structure of Fig. 2 showing the clip for supporting the ionizing conductor;

Fig. 5 is a perspective view of the collector structure of Fig. 1;

Figs. 6 and 7 illustrate another embodiment of the collector structure;

Figs. 8 to 11, inclusive, show details of the structure of Figs. 6 and 7;

Fig. 12 illustrates an arrangement for supporting the collector structure of Figs. 6 to 11 in a precipitator unit;

Fig. 13 is a perspective view of still another embodiment of the collector structure; and

Fig. 14 is a diagrammatic view showing the electrical circuits of the cleaner of Fig. 1.

In practicing the invention there is provided an electrostatic precipitator unit including a cabinet which is in the form of an end table or the like. The cabinet includes an ionizing structure, collector structure, a power supply for the ionizer and collector, and a fan for circulating air to be cleaned through the precipitator unit. The power supply is positioned above and adjacent to the ionizer and collector so that short leads can be provided simplifying the insulation of the leads and preventing objectionable capac-

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ity loads on the power supply circuit. The position of the ionizing structure and the collector structure in the cabinet is such that a steady flow of air can be provided thereto and also so that the collector structure can be easily removed without moving other components of the precipitator unit. The collector structure may be made of cardboard so constructed that the structure can be folded and shipped or stored in a very small space. Certain portions of the cardboard structure are rendered conducting so that the collector can be energized as will be described hereinafter.

In the drawings, in Fig. 1 there is illustrated the cabinet or case 10 in which the components of the electrostatic precipitator or gas cleaner are housed. The fan 14 draws air successively through the intake openings 15 in the sides and bottom of the cabinet, the ionizing structure 12, and the collector structure 11, and then forces the cleaned air out through exhaust opening 16. The power supply 22 furnishes high voltage unidirectional current for exciting the collector structure 11, and high frequency high voltage superimposed upon the direct current voltage existing across the electrodes of collector 11 for exciting the electrodes of the ionizer structure 12. Baffle 17 prevents the flow of air above the ionizer structure so that all air being drawn through the apparatus must pass through the ionizing structure where it is ionized thus causing any particles of dust, pollen or other foreign matter to become electrically charged. Collector 11 fits tightly against ionizer 12 such that all the air being drawn into the ionizer must go through the collector where any charged foreign particles are caused to move perpendicularly to the flow of air under the forces of the electrostatic fields existing in the collector until said particles strike and adhere to the plates of the collector. The cabinet 10 is provided with a removable end wall 23 which allows the collector 11 to be removed for cleaning or replacement by being drawn under fan 14 through the end of the case.

For making electrical contact to the collector and permitting easy removal thereof, spring conducting means 19 is provided which presses against the top of collector 11 forming an electrical contact to said top, which is one of the terminals of the collector. A second spring conducting means 18 presses against collector terminal 24 in the same manner as the contact 19 so that contact is broken and made successively as the collector is removed from and replaced in the case. The fan 14 is mounted directly in front of exhaust opening 16 where it effectively prevents the projection of any conducting object through the opening to make contact with the electrodes of collector 11 thereby causing electrical shock to the holder of said conducting object. As the fan rotates in a direction to exhaust the air it will tend to push any object out of the cabinet rather than draw it in. A suitable grille may be provided over the exhaust opening to further prevent entry of foreign material. By being mounted above the collector 11, the fan need not be moved upon withdrawal of the collector.

The power supply 22 may be mounted on the top wall of the cabinet immediately above the ionizing structure 12 and the collector 11 so that connections can be made thereto by relatively short leads. This reduces undesired couplings through the leads and also reduces the number

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of high voltage insulators required for supporting the leads. The oscillator tube 21 of the power supply and the low voltage rectifying tube 20 used in the production of direct current for the oscillator plate supply from an alternating current power line are located such that they can be replaced without opening the power supply box. The operation of the power supply 22 will be described more in detail hereinafter.

The ionizing structure 12 is shown in greater detail in Fig. 2. End plates 33 and 34 are held in position by top and bottom members 31 and 32 respectively. A plurality of separating plates 24 are held substantially parallel to plates 33 and 34 by being spot welded or otherwise fastened to the members 31 and 32. Insulating rods 25 and 26 are held by spring clips 35 which are supported on the end plates 33 and 34. The rods 25 and 26 are mounted so that they pass through recesses in the separating plates 24 and are held substantially parallel to top and bottom plates 31 and 32. A plurality of clips 36 support the thin conductor 27 on the rods 25 and 26 so that the conductor 27 is suspended between and substantially parallel to the conducting plates 24. The detailed structure of the clips 36 is shown in Fig. 4. The clips include loops 89 through which the conductor 27 can be hooked. Conductor 29 held in place by electrically insulating bushing 28 extends through top plate 31 to make contact electrically to conductor 27 and forms one terminal of the ionizing structure. Conductor 30 electrically connected to the top plate 31 forms the second terminal of the ionizing structure. One long edge 32a of the bottom plate 32 may be bent upward such that it extends as high as the top of rod 25 and one long edge of top plate 31 may be bent downward such that it extends down as low as the bottom edge of rod 26. The two bent portions of the plates 31 and 32 form baffles which prevent air from being drawn through the ionizing structure through paths other than between conductors 27 and plates 24 where the ionization is the most intense.

In Fig. 3 there is shown a second form that the ionizing structure 12 may take in which relatively large conductive electrodes 24 are held in position by members 40 and 41 to which they are spot welded or otherwise fastened. Members 40 and 41 have long edges bent respectively down and up which may be fastened to the baffling edges of plates 31 and 32 respectively. The edge of member 41 is indicated by 41a and is secured to the baffle edge 32a by screws 42. The edges of member 40 and plate 31 do not show in the drawing. Dielectric rods 38 extend through openings in the plates 40 and 41 such that they bear against plates 31 and 32 which latter plates prevent their slipping out of the openings in plates 40 and 41. A plurality of conductive means 37 are held near the dielectric rods 38 by clip means 36 as used in the structure of Fig. 2 and illustrated in Fig. 4. Conductor means 39 connects all conductors 37 together and to the ionizer terminal 29. The dielectric rods 38 increase the electrical stress concentration along portions of conductors 37 when a high frequency component of voltage is applied between terminals 29 and 30 of the ionizing structure thus increasing the amount of ionization produced. This is disclosed and claimed in the copending application of Elmer G. Hills, Serial No. 731,734, filed March 1, 1947, now Patent 2,585,777 dated February 12, 1952.

The collector structure 11 of Fig. 1 is shown in

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more detail in Fig. 5. Collector plates 47 and 48 are supported on top and bottom plates 44 and 44a which are fastened to side plates 45 and 45a. The collector plates 48 are insulated from the supporting structure by insulator bushing 46. The top and bottom edges of plates 45 and 45a are formed or bent such that they are substantially parallel to plates 44 and 44a and these edges are spot welded or otherwise fastened to the top and bottom plates. Similarly collector plates 47 have their top and bottom edges bent and fastened to plates 44. Interleaved between plates 47 and insulated therefrom are plates 48 which are maintained in position by being spot welded or otherwise fastened to strips 49 by triangular shaped corners 50 which are bent substantially at right angles to the strips 49 such that they are substantially parallel to the plates 48. Strips 49 are maintained in position by the insulating bushings 46 which hold the strips substantially parallel to plates 44 and 44a. Collector plates 48 are not as high as plates 47 and are spaced therefrom by a distance greater than the spacing between plates 48 and 47. This is necessary as high stress concentrations would exist along the relatively sharp edges of plates 48 which would cause electrical arcs to plates 44 and 44a although the voltage existing between plates 47 and 48 would be less than the arc over voltage for the spacings of the plates. An electrical conductor 24 extends through a hole in plate 46 and through one of the bushings 46 to make contact with one of the conducting strips 49 thus forming one terminal of the collector structure. The other terminal is formed by the supporting structure. The connection of the collector in the precepitator unit is illustrated in Fig. 1.

A modified collector structure is illustrated in Figs. 6 to 12 which is of inexpensive construction so that it can be disposed of after use. Disposable collector structures are disclosed and claimed in the copending application of Robert L. Barr, Serial No. 719,893, filed January 2, 1947. The structure of Figs. 6 to 12 is a simplified structure which includes a top plate 74, two sets of collector plates 76 and 77, end plates 79 and a bottom plate 86. The top plate or supporting member 74 is held by staples, glue, or other means to one of the edges 75 of each of the plates 76 which edge is folded at substantially right angles to the main portion of the plate 76 when the collector is in opened condition. In a similar manner the top plate 74 is held to one of the edges 76 of each of two end plates 79, and is held to the folded edge 80 of each of the plates 77 which plates are interleaved between the plates 76 of the first set. In a similar manner a bottom plate 86 is fastened to the other folded edge of each of the plates 76, 77 and 79.

The top plate 74 is rendered conducting over a large portion 82 thereof and includes a narrow conducting strip 87 which is insulated from the conducting portion 82 (Fig. 8). The end plates 79 are rendered conducting over a portion substantially coextensive with the portion 82 of the top plate as shown in Fig. 10. The plates 76 of the first set may be identical with the end plates 79 or may be of the construction shown in Fig. 9 in which the plates 76 are shorter than the other plates being substantially coextensive with the conducting portion 82 of the top plate. In this case the plates are rendered conducting over their entire area. The plates 77 of the second set are

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rendered electrically conductive throughout a substantial portion of their areas, as shown by 81 in Fig. 11, but are left non-conducting throughout the non-shaded areas 80, 83 and 84. Plates 77 are so oriented in the structure that the conducting portion 85 at the top of each plate contacts the strip 87 of the top plate which is rendered conducting. The strip 87 forms one terminal of the collector structure. Insulated portions 83 and 84 along the edges of plates 77 insulate the conducting portions 81 from the conducting portion 82 of the top plate 74 and, therefore, from plates 76 and 79. The plates 79 (Fig. 10) have insulated portions 90 such that the folded portions 85 of the outer two plates 77 will not provide short circuits to the end plates 78 through which an electrical discharge might take place.

All the plates of the entire collector structure can be made of cardboard, or some similar material sufficiently stiff to support its own weight, which has been rendered electrically conductive as by a printing process, by having metallic foil fastened to at least one side, by a chemical process, or by any other means. The insulating material may preferably be rendered fireproof and non-hygroscopic so that the insulating properties thereof are improved. The lines along which the edges of plates 76, 77 and 79 are folded may be flexible enough to allow the entire structure to collapse as indicated in Fig. 7 in which the structure is in a partial state of collapse. Such a collapsible collector structure could be held in an open condition by the shape of the precipitator case and by runners 88 as illustrated in Fig. 1. To prevent bending of the collector plates when they are made of light, inexpensive material to form a disposable structure, supporting end structures 90, as illustrated in Fig. 12, which are made of insulating material can be used. The structures include a plurality of stamped sheets 91 secured together by spacers 92. The sheets have toothed edges including grooves 93 which support the edges of the collector plates and points 94 for ease in positioning the end structures relative to the plates. By providing openings 95 in the sheets, the paths along the sheets for leakage currents between the plates are increased. The end structures do not materially offset the free flow of air through the collector structure. In Fig. 12 there is shown spring clips 96 which may be provided for holding the collector structure in position in the case of the precipitator unit. The clips are positioned in recesses 97 in the side walls of the case and the ends thereof may engage the sheets 91 of the end structure 90. By pressing the ends of the clips into recesses 97 the clips may be released to permit removal of the collector structure for cleaning or replacing.

The manner of making electrical connection to the disposable collector structures is also shown in Fig. 12. In this figure the spring conductor means 18 is shown hinged so that the end thereof contacts the conducting strip 87 of the top plate 74 of the collector structure. Any suitable means can be provided for alternatively securing the hinged portion of the conductor in the positions shown in Figs. 1 and 12.

Another embodiment of the collector structure is shown in Fig. 13 in which two conductive sheets 51 and 52 may be rendered conductive. The sheets may be made of paper, plastic, screen wire or other material which can be rendered electrically conducting. Insulating member 53,

which may be corrugated paper, plastic or other insulating material, maintains a substantially constant separation between sheets 51 and 52 throughout the areas of said sheets while allowing air passages between said sheets. The edges of sheets 51 and 52 are brought out and connected to terminals 54 which are the terminals of the collector structure. The structure lends itself to economy of manufacture by its ability to be rolled into a shape as shown in Fig. 13 out of a sheet constructed somewhat like a sandwich. The air channels existing between sheets 51 and 52 and portions of insulating material 53 are substantially parallel to the axis of the structure into which the collector is rolled.

In the electrical circuit of Fig. 14 standard alternating current power is provided for the precipitator unit from the local power line by plug 55. The power is brought in through interlock switch 56 by means of conductors 59 to low voltage power supply means 57 as well as to electric fan means 14. The interlock switch may be arranged to de-energize the unit when the end 23 of the case 10 is removed. The power supply 57 provides heater and plate power for electron discharge valve 21 and may be of standard construction. A tank circuit composed of inductor 61 and capacitor 62 is connected in the plate circuit of valve 21. Magnetically coupled to inductor 61 is the high voltage secondary coil 66. Electrostatically coupled to the high voltage coil 66 is conductor 65 which provides a feedback path from the plate to the grid circuit of valve 21 so that an electrical oscillator circuit is provided. Grid leak resistor 64 provides a direct current path to the cathode from the grid of the oscillator to prevent blocking of the grid. Because the conductor 65, the coil 66 and the insulation between them form an electrical condenser through which the feedback energy for exciting the grid of the oscillator passes, a phase shift occurs which decreases the amplitude of oscillation. Condenser 63 connected between the grid and cathode of oscillator 21 corrects for this phase shift. Although the valve 21 is illustrated as a tetrode having a screen grid to which potential is applied through resistor 60, it is obvious that other types of valves can be used.

The high voltage appearing across the terminals of coil 66 due to the coupling of the coil to the tank coil 61 of the oscillator is applied between the cathode of rectifier 68 and one electrode 71 of the collector structure. The anode of rectifier 68 is connected (through ground) to the other terminal of the collector structure such that the rectifier rectifies the output of coil 66 thus applying a unidirectional, pulsating electrical current to the collector structure. Inductor 67 is magnetically coupled to coil 66 such that the proper high frequency voltage is induced in it to heat the cathode of rectifier 68. Because of the electrical capacitance of the collector and the high frequency of the output voltage of coil 66 the voltage appearing between the electrodes of the collector is substantially unidirectional and of constant amplitude. The use of the collector as the filter condenser of the power supply is disclosed and claimed in the copending application of Elmer G. Hills, Serial No. 642,473, filed January 21, 1946. One terminal 70 of the ionizing structure is connected by means of a ground path to the grounded side of the collector structure. The other terminal 73 of the ionizer is connected by means of short, direct conductor 69

to the cathode of the rectifier 68. Because of this connection the voltage applied to the terminals of the ionizing structure is the sum of the substantially direct current voltage existing across the collector and the alternating current voltage of high frequency existing across coil 66. Increased ionization due to the combination of direct current and high frequency alternating current voltages being applied to the ionizing structure is thus realized. At the same time, high intensity constant electrostatic fields are caused to exist between the plates of the collector structure.

It is seen from the above that we have provided an improved precipitator unit which is of small and compact construction suitable for use in a home. The specific arrangement of the components results in a very efficient unit. The use of the collector as the power supply filter results in decrease in the cost of the unit. The improved collector structures simplify the maintenance of the precipitator unit, the disposable collectors eliminating the difficult cleaning of the collectors which was formerly required. The structure of the disposable collectors is such that they can be inexpensively constructed and folded for storage and shipment in a relatively small space.

In the following claims the word "collector" shall mean any structure into which the gas containing electrically charged particles of foreign matter is drawn and upon the electrodes of which these particles are deposited; the word "ionizer" shall mean any device which causes the gas being drawn through it to become ionized such that particles of foreign matter passing through it will become charged; the word "fan" shall be understood to designate any means for causing a gas flow through the precipitator unit; the word "case" shall be understood to mean any suitable covering or cabinet for housing the gas cleaning apparatus including the various brackets or other means for maintaining the relative positions of the components of the apparatus; the words "power supply" shall be understood to mean the equipment for generating the exciting voltages for the ionizer and collector which itself may receive energy from a source external to the gas cleaning apparatus.

While certain embodiments of our invention have been described for the purpose of illustration, it should be understood that the invention is not limited to the exact circuits and arrangements of apparatus herein described, as modifications thereof may be suggested by those skilled in the art without departure from the essence of the invention as defined in the appended claims.

We claim:

1. An electrostatic gas cleaning apparatus comprising a case, an ionizer, a collector, a fan, and a power supply, said case having top, bottom, end, and side walls, one of said end walls being removable and having an exhaust opening in the upper portion thereof, intake openings in said case adjacent the end opposite said one end, said ionizer and said collector being supported in said case on said bottom wall intermediate the ends thereof with said ionizer adjacent said intake openings and said collector adjacent said exhaust opening, said fan being supported from said top wall of said case in front of said exhaust opening and arranged to draw gas through said intake openings of the case, and through said ionizer and said collector and exhaust said gas through said exhaust opening, said power supply being supported by said top wall of said case

above said ionizer and said collector and including conductor means projecting therefrom, said collector being removable from said case when said one end wall is removed and having terminals thereon adapted to engage said conductor means so that connections to said collector are automatically made and broken when said collector is placed in said case and removed therefrom.

2. Apparatus in accordance with claim 1 in which said collector is disposable and includes a plurality of plates made of material which is sufficiently stiff to support the weight thereof, means for securing said plates together to form a box-like structure including a plurality of plates which are substantially evenly spaced, said securing means being sufficiently flexible to allow said collector to collapse so that said collector forms a flat structure.

3. Apparatus in accordance with claim 1 in which said collector includes a plurality of plates made of insulating material which is sufficiently stiff to support the weight thereof, said plates including a supporting plate and first and second sets of plates supported therefrom and extending at right angles thereto, plates of said first set being interleaved between said plates of said second set with said plates of both sets being substantially evenly spaced, said plates of said first set being rendered conducting throughout a portion of their areas, said plates of said second set being rendered conducting throughout a portion of their areas, said supporting plate being rendered conducting on two portions thereof with one conducting portion contacting said conducting portions of said first set of plates and the other conducting portion contacting said con-

ducting portions of said second set of plates, said conducting portions of said supporting plate forming said terminals of said collector.

4. Apparatus in accordance with claim 1 in which said collector includes a plurality of plates made of relatively thin material, said plates being substantially evenly spaced, and including end structures including a plurality of spaced insulating sheets extending at right angles to said plates and having toothed edges with alternate points and grooves spaced to correspond to the spacing of said plates, said end structures engaging said collector with said grooves determining the position of said plates.

5. Apparatus in accordance with claim 1 in which said collector is disposable and includes a plurality of plates made of insulating material which has been rendered fireproof and non-hydroscopic with said plates being rendered conducting over certain portions thereof.

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ELMER G. HILLS.

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