United States Patent

[11] 3,581,470

[72] Inventors **Paul Aitkenhead**
Ross Township, Allegheny County;
Robert Ruhlman, Pittsburgh; Lewis G. McClintock, Pittsburgh, all of, Pa.

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[73] Assignee **Electro-Air Division, Emerson Electric Company**
Continuation-in-part of application Ser. No. 530,993, Mar. 1, 1966, now abandoned.

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[54] **ELECTRONIC AIR CLEANING CELL**
18 Claims, 19 Drawing Figs.

[52] **U.S. Cl.** **55/138,** 55/139, 55/143, 55/145, 55/146, 55/151, 55/154
[51] **Int. Cl.** **B03c 3/00**
[50] **Field of Search** 55/138, 139, 143, 145, 146, 151, 154, 137, 136

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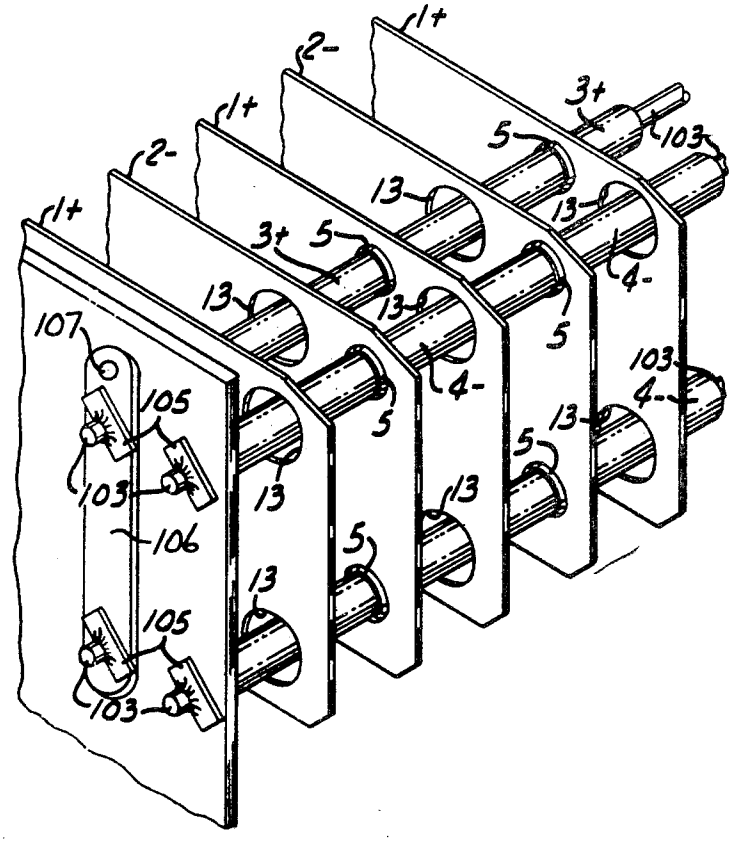
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Primary Examiner—Dennis E. Talbert, Jr.
Attorney—Carothers and Carothers

ABSTRACT: An electronic air cleaner having a series of alternate groups of parallel collecting plates, each group having spaced aligned predrawn holes and clearance holes and sections of metal tubes of equal length expanded and locked in precise position in the aligned drawn holes of each group and passing through the clearance holes of another group of collecting plates. The metal tubes are rigidly held between spaced parallel panels to equally space the groups of collecting plates therebetween and a means to maintain lateral alignment of the metal tubes is provided to maintain the alternate groups of collecting plates in position and equally spaced in parallel relation to each other.

The metal tubes are preferably expanded to a nonround shape such as rifled or polysided to enhance engagement with the plates.

The preferred end panel is conductive with spaced cutouts having overlying insulating plates with at least one tube aligning hole. The plate is loosely attached to the end panel to permit alignment of the holes with selected conductor tubes. Depressions are also provided in the panel for other selected tubes to permit engagement of the tube ends with the end panels in the same plane.



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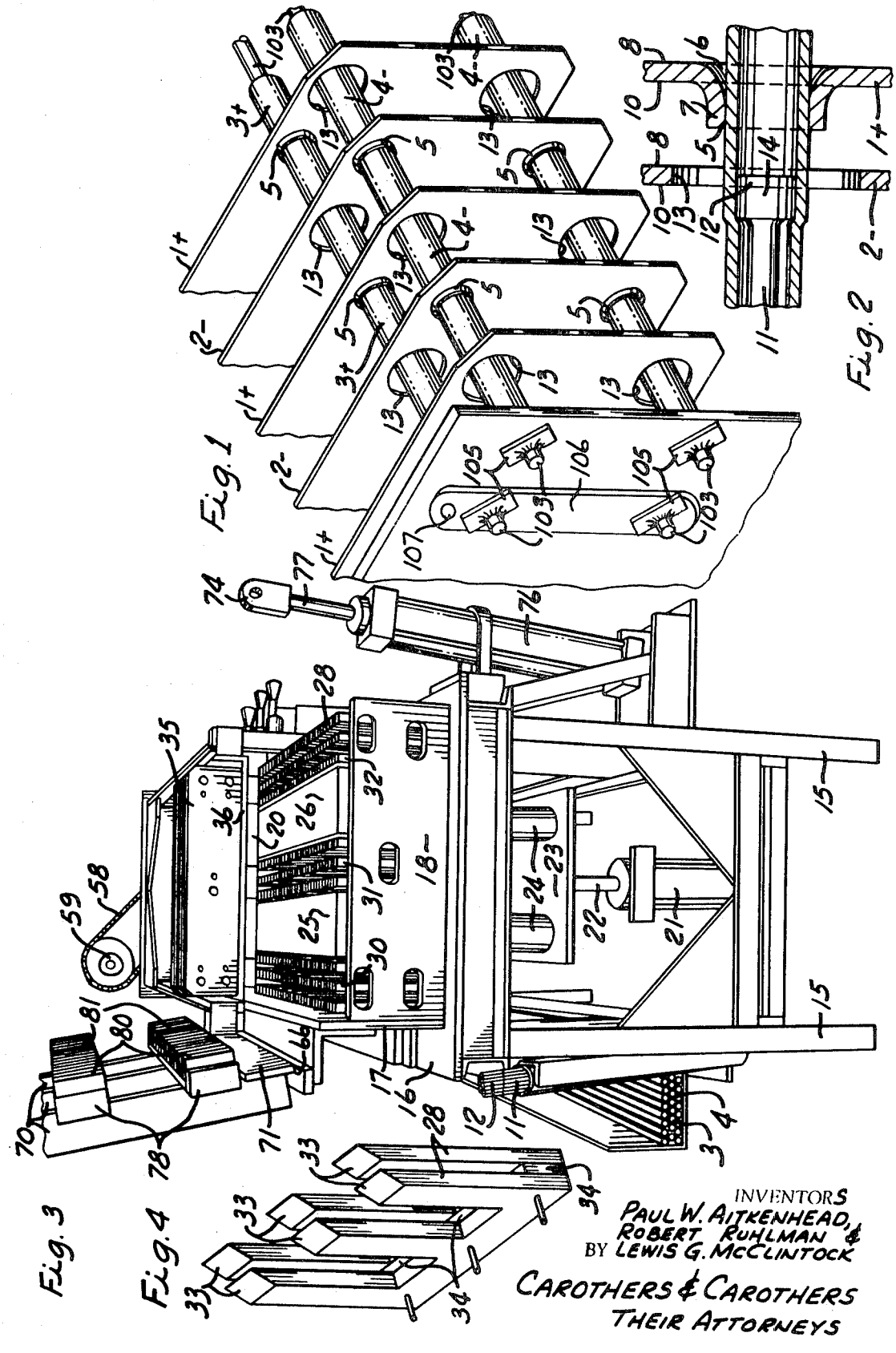


Fig. 1

Fig. 2

Fig. 3

Fig. 4

INVENTORS
PAUL W. AITKENHEAD,
ROBERT RUHLMAN &
BY LEWIS G. McCLINTOCK

CAROTHERS & CAROTHERS
THEIR ATTORNEYS

Fig. 14

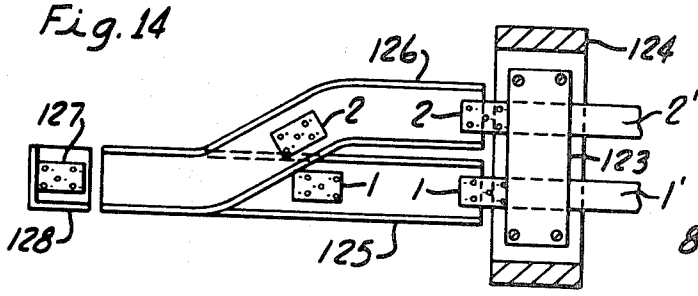
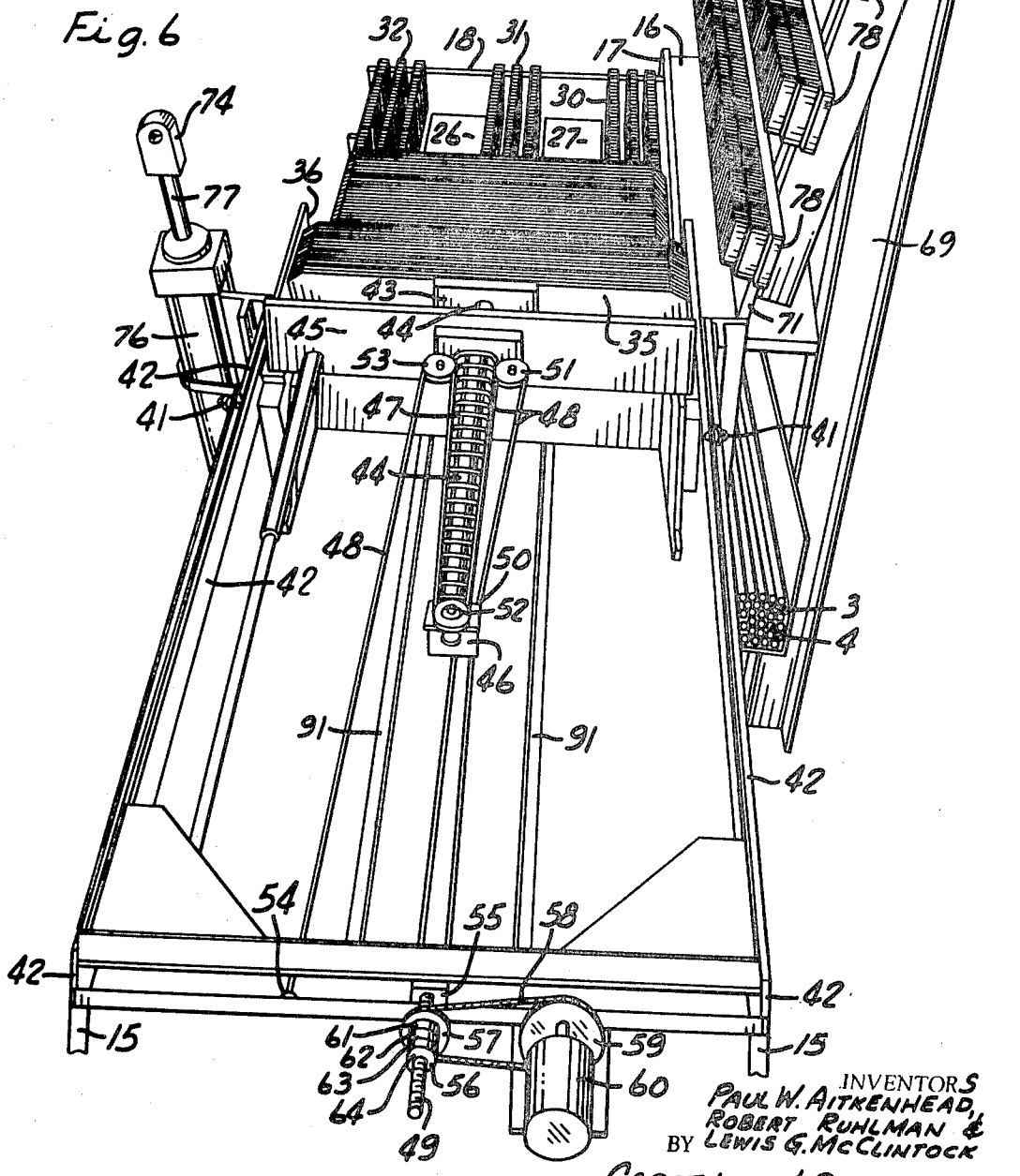


Fig. 6



INVENTORS
PAUL W. AITKENHEAD,
ROBERT RUHLMAN &
BY LEWIS G. McCLINTOCK
CAROTHERS & CAROTHERS
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Fig. 9

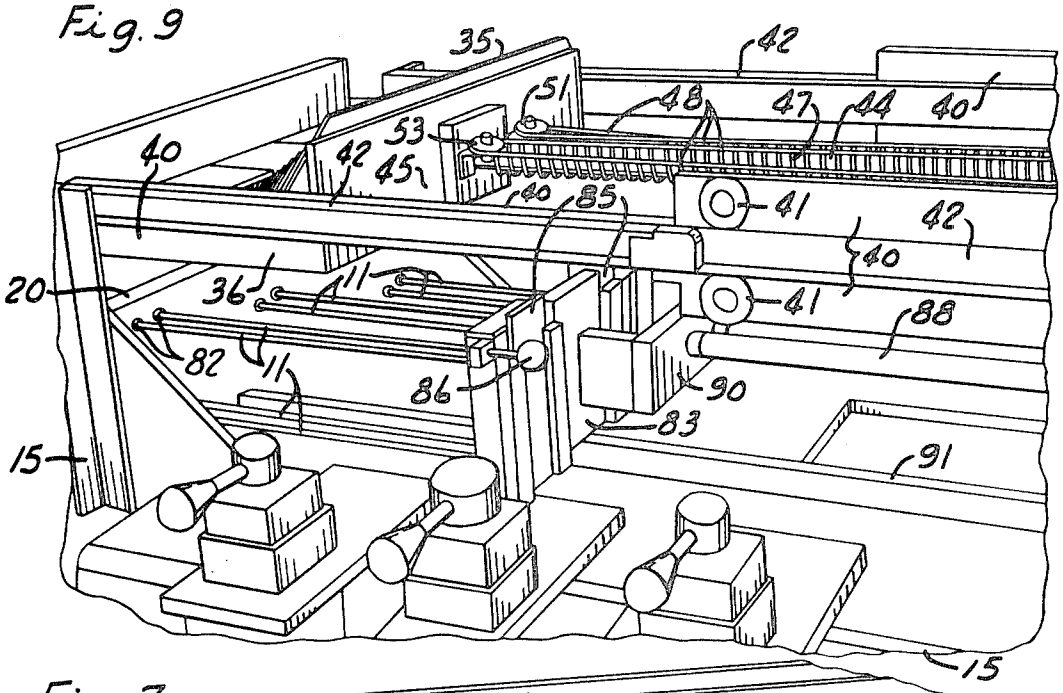
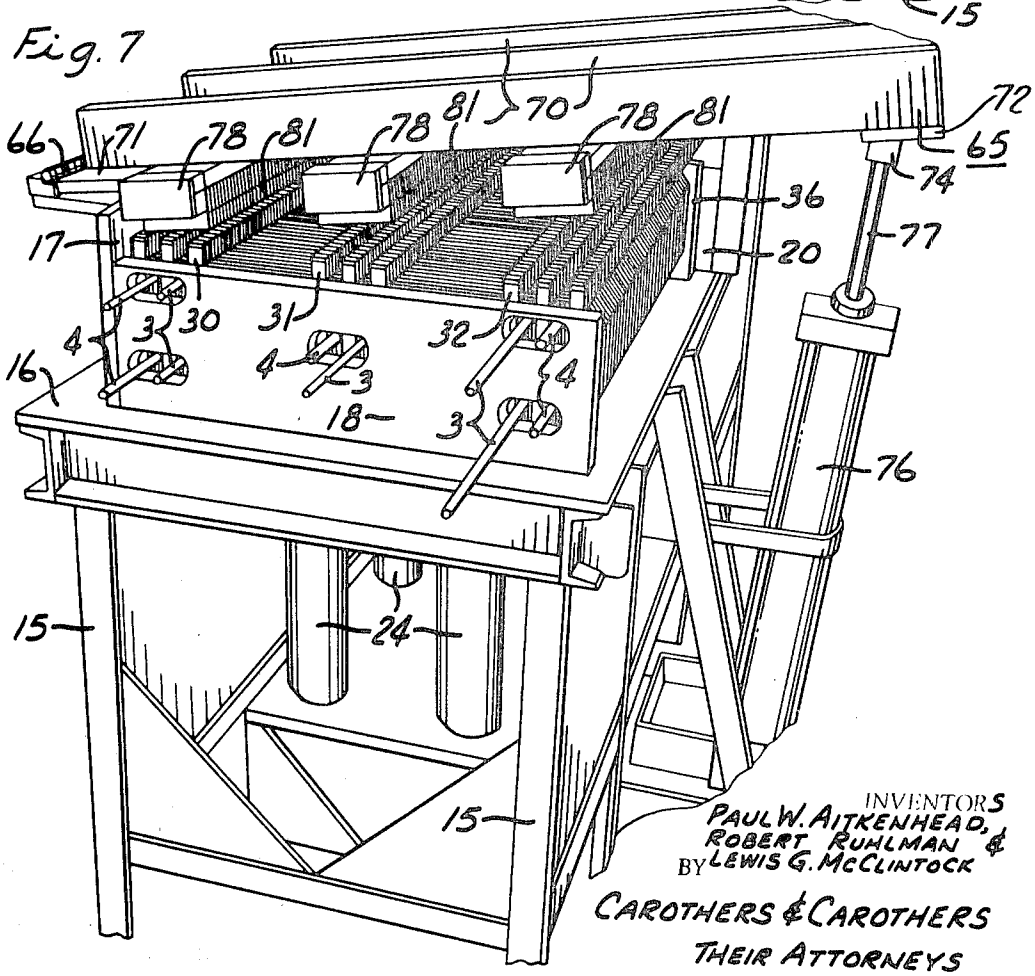


Fig. 7



INVENTORS
PAUL W. AITKENHEAD,
ROBERT RUHLMAN &
BY LEWIS G. McCLINTOCK
CAROTHERS & CAROTHERS
THEIR ATTORNEYS

Fig. 13

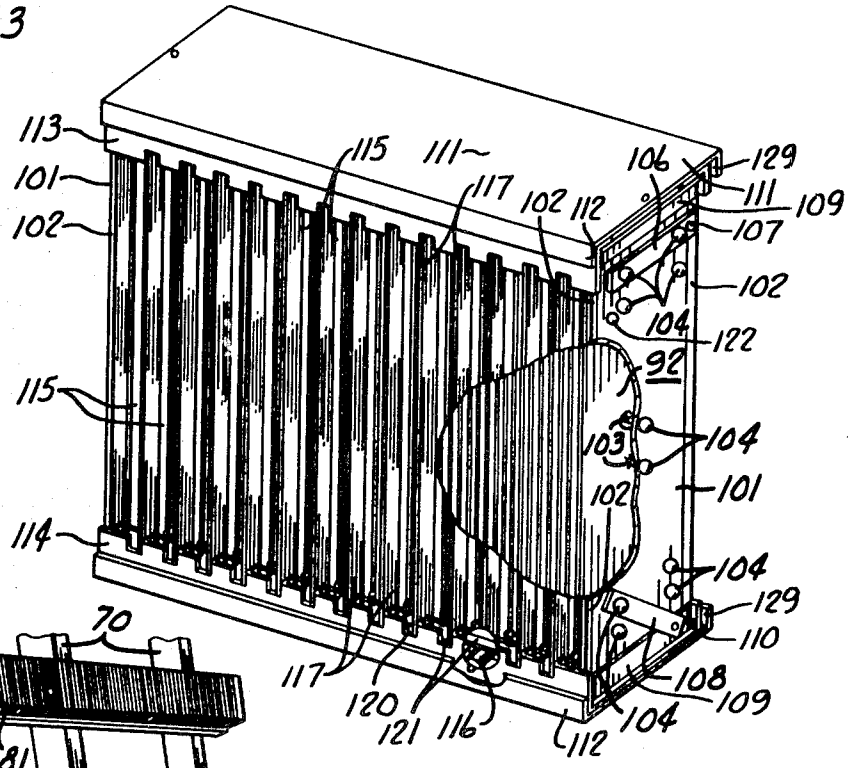
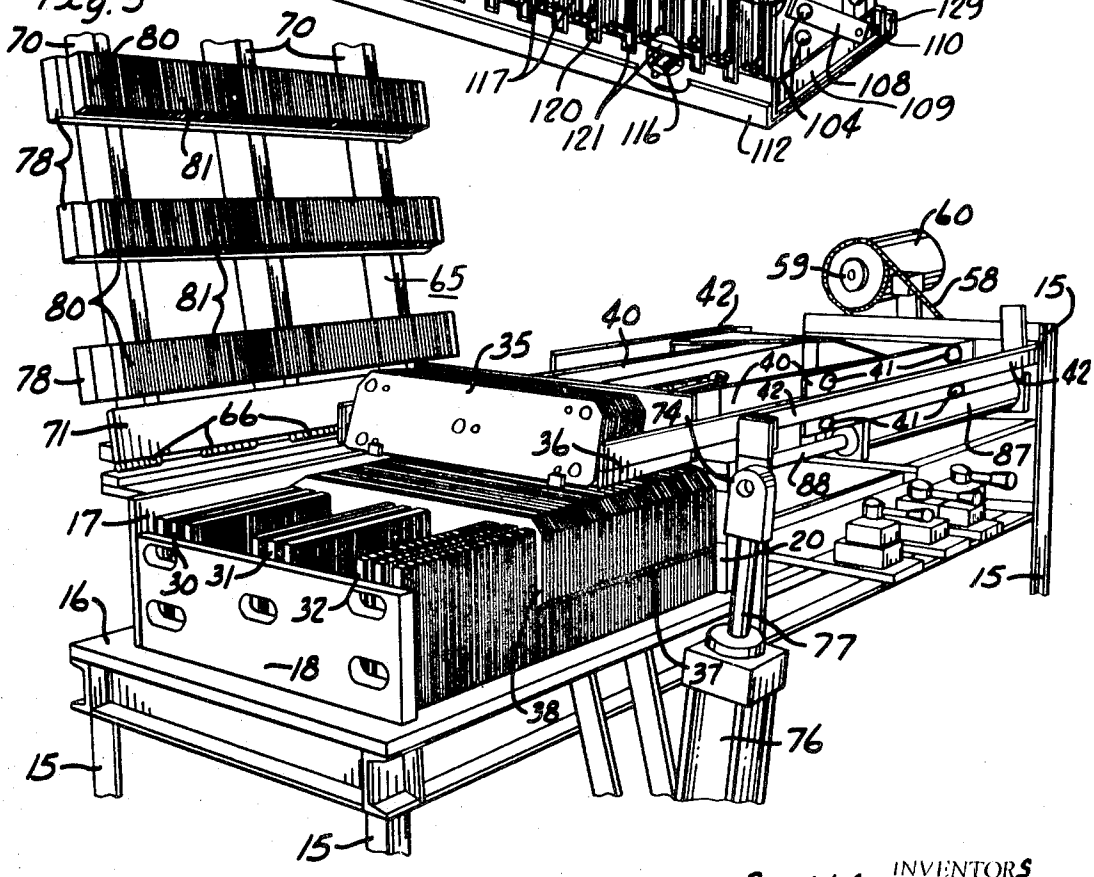


Fig. 5



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PAUL W. AITKENHEAD,
ROBERT RUHLMAN &
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CAROTHERS & CAROTHERS
THEIR ATTORNEYS

Fig. 11

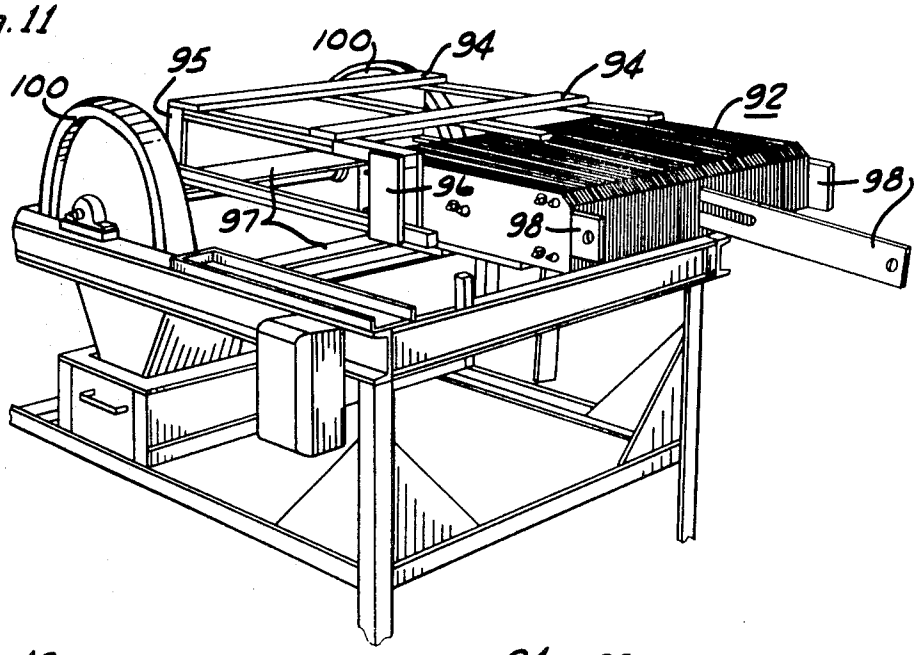


Fig. 12

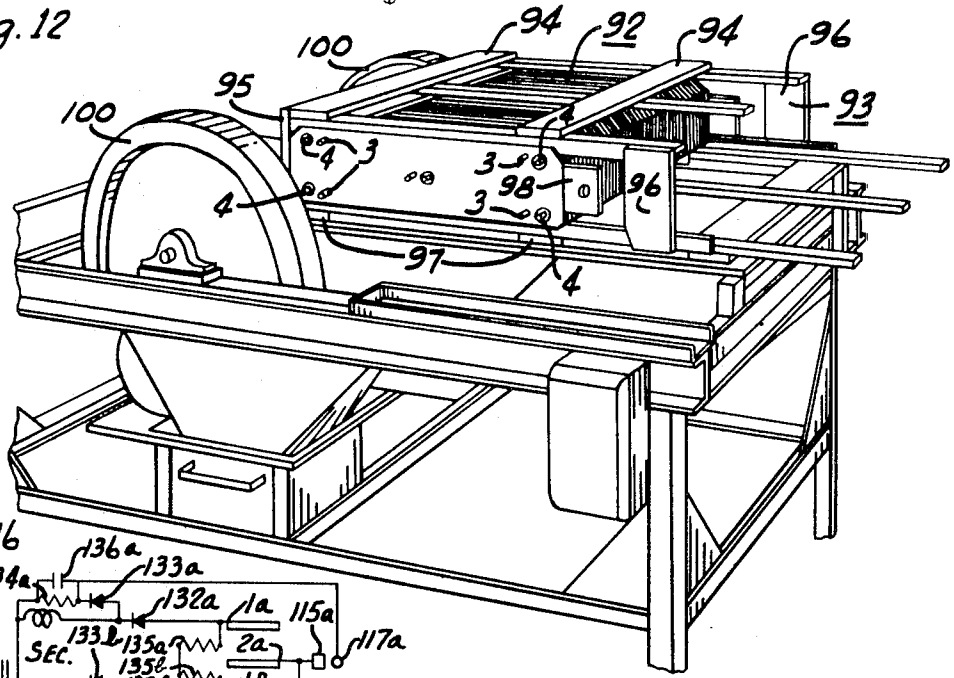
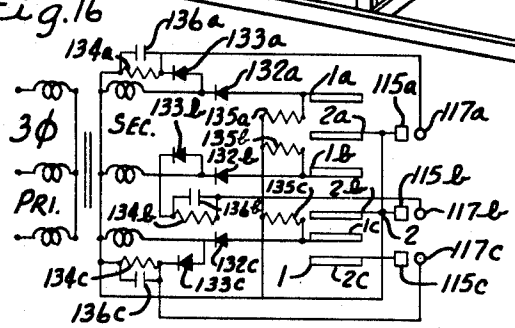


Fig. 16



INVENTORS
PAUL W. AITKENHEAD,
ROBERT RUHLMAN &
BY LEWIS G. McCLINTOCK
CAROTHERS & CAROTHERS
THEIR ATTORNEYS

Fig. 8

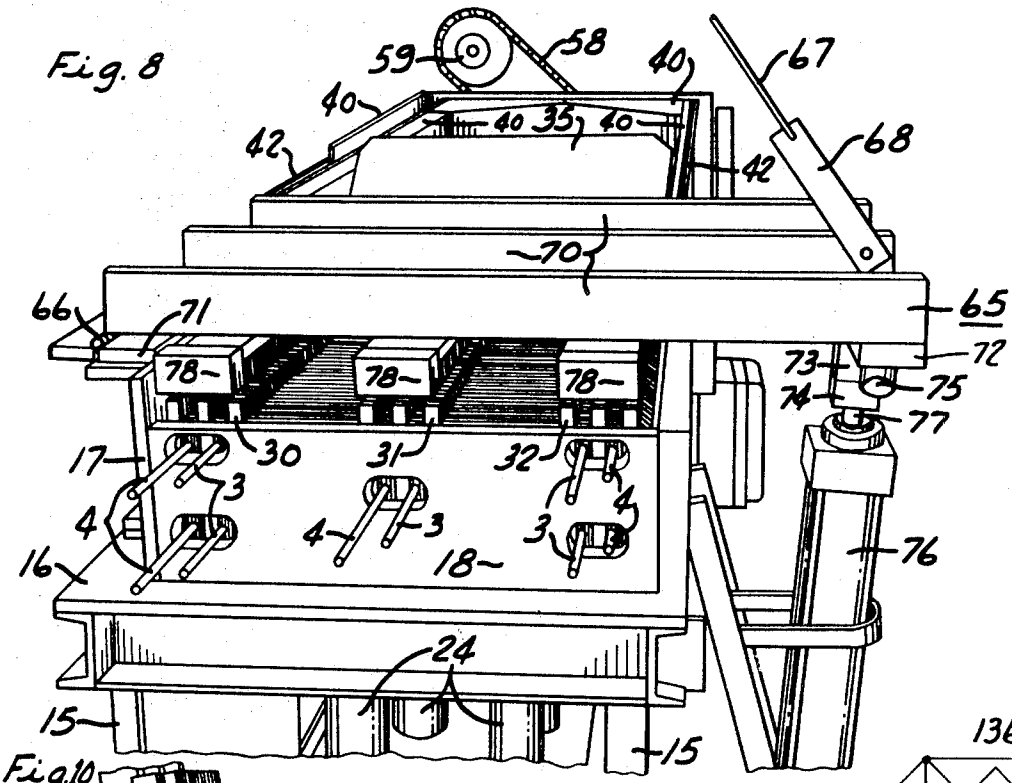


Fig. 10

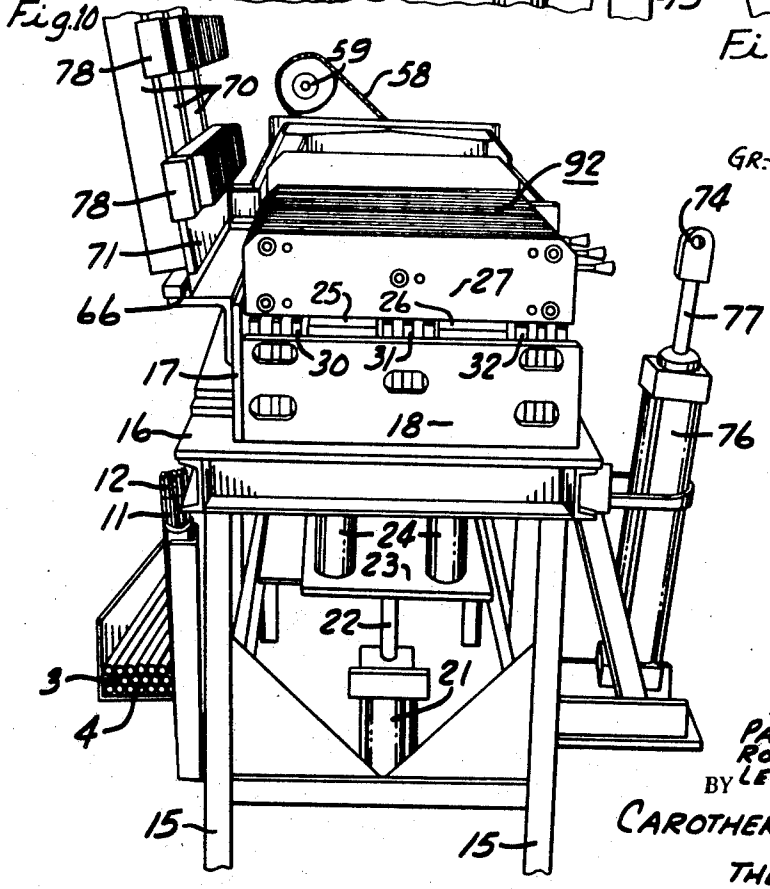
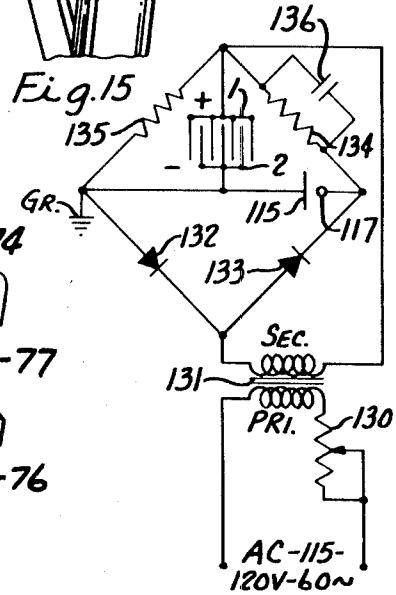


Fig. 15



INVENTORS
PAUL W. AITKENHEAD,
ROBERT RUHLMAN &
BY LEWIS G. McCLINTOCK
CAROTHERS & CAROTHERS
THEIR ATTORNEYS

Fig. 19

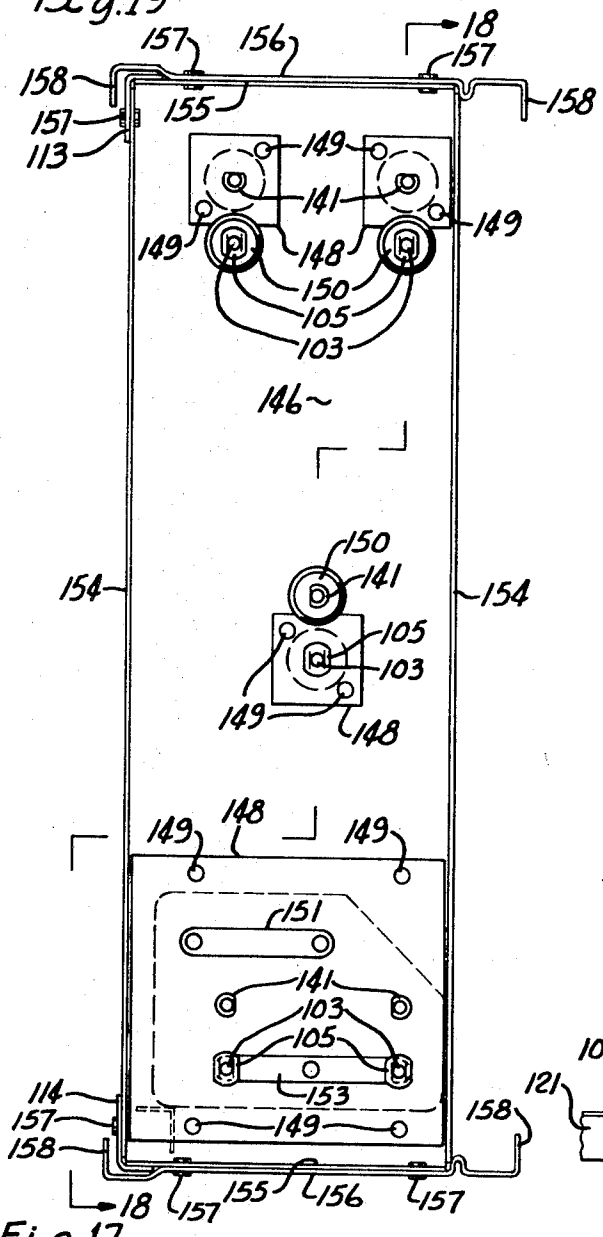


Fig. 18

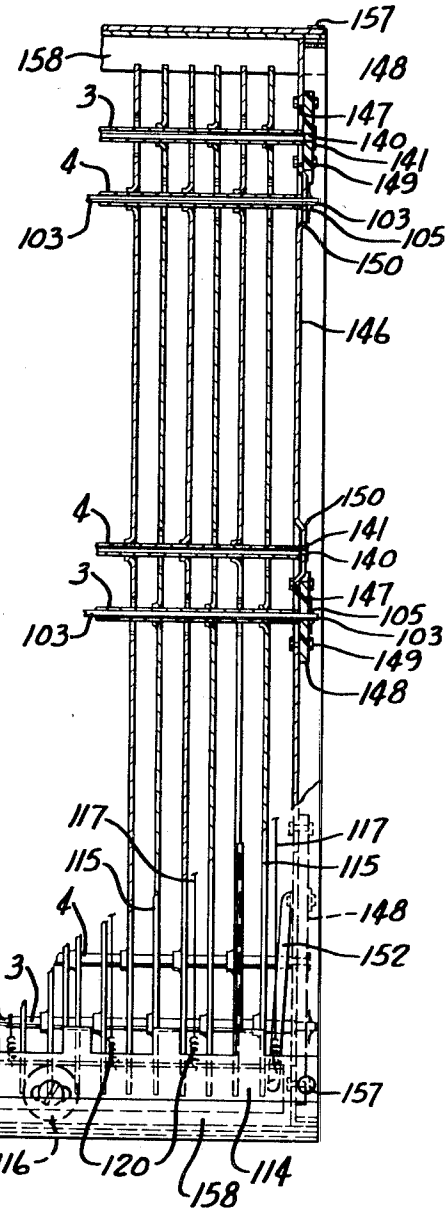
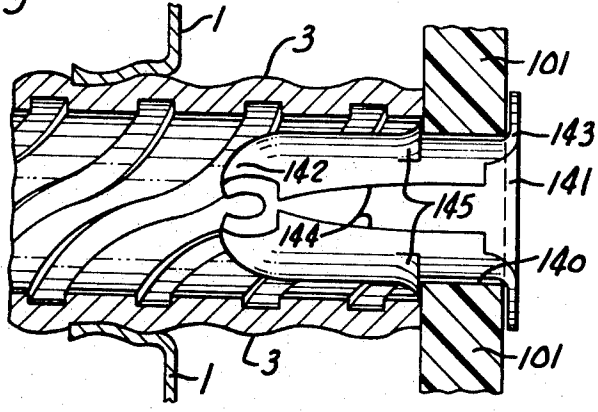


Fig. 17



INVENTORS
PAUL W. AITKENHEAD,
ROBERT RUHLMAN &
LEWIS G. MC CLINTOCK

BY
CAROTHERS & CAROTHERS
THEIR ATTORNEYS

ELECTRONIC AIR CLEANING CELL

CROSS REFERENCE

This application is a continuation-in-part of application Ser. No. 530,993, filed Mar. 1, 1966, now abandoned, for Method and Apparatus for Manufacturing Air Cleaner Cells.

SUMMARY OF INVENTION

This invention relates generally to electronic air cleaners and more particularly to an improved collecting cell.

Electronic-collecting cells usually consist of a series of spaced electrodes insulatingly supporting therebetween an alternate series of positive ionizing wires in front of an alternate series of positively and negatively charged collecting plates which attract the ionized particles of dirt carried therethrough by forced air flow.

It is a serious problem to construct these collecting cells economically and at the same time to make them efficient and uniform in their production.

The principal object of this invention is the provision of a new and improved collecting cell permitting uniform, new and novel production technique to carry out the making of some parts and assembly of the same and to provide a collecting cell which is economical to construct yet has great longevity and dependability.

The electronic air-cleaning collector cell of the present invention consists of a series of alternate parallel collecting plates providing plate groups of different polarity. The plates are provided with a plurality of aligned mounting holes and clearance holes in each group of collecting plates with conductor tubes positioned in the mounting holes to support their respective group of collecting plates of one polarity and passing through the clearance holes of alternate groups of collecting plates of different polarity. Parallel end panels are provided with holes matching the location of the bores of the conductor tubes, but the holes are smaller than the outside diameters of the conductor tubes. The conductor tubes are aligned with their respective end panel holes and secured such that the tube ends about the inside faces of the end panels. Thus when the end panels are thus secured or drawn in towards each other to engage all conductor tube ends, the alternate groups of collecting plates will automatically be aligned and placed in equally spaced parallel relation with each other in the electronic air-cleaning cell. Insulating means are provided on the end panels to insulate the conductor tubes of different polarity.

Thus, assuming that the opposed inside surfaces of the end panels which engage the tube ends are each respectively equally spaced, then each conductor tube is of equal length. Thus, before the end panels are applied to the collecting cell unit, the spacing between the adjacent collector plates may be gauged and the tubes then simultaneously cut to equal length. When the cell is inserted between the end panels and the end panels are brought together against the ends of the tubes and there secured, the correct spacing will automatically be assumed and maintained.

Bolt means may be extended through the end panels and selected of the conductor tubes to clamp the end panels against the conductor tubes.

The mounting holes in the collector plates which receive and tightly engage the conductor tubes, are preferably predrawn to provide a frustoconical opening that does not have a cylindrical surface but always changes along the cone. The drawn holes are punched to provide a smaller opening drawn into a bell with a frustoconical section that has a steep angle to provide greater surface engagement on the tube than the mere thickness of the material of the plate. This drawn frustoconical hole is thus tightly seized and clamped when the tube is expanded therein without deflecting the surface planes of the plates. This is due to the fact that the outer portion of the frustoconical drawn section engages the tube whereas the bell-shaped portion of the drawn hole is free of the tube. When the tube is expanded it does not engage within the parallel planes of the plate and thus does not misshape the same.

The expanded conductor tubes are preferably expanded to a nonround outer surface thereby providing a novel and much more secure interlock with their respectively reshaped collector plate mounting holes thus providing assured engagement and spacing. The conductor tubes may be expanded to their nonround shape to engage the predrawn holes by rifling the tube bore with a rifling expansion mandrel or by expanding it to a polysided configuration. Thus engagement with the conductor plates is enhanced over the structure which is constructed by drawing a rounded mandrel through the conductor tubes to expand the same.

Furthermore, the drawing of a rounded mandrel through the conductor tube bores causes the tubes to stray or bend laterally from their axial position away from each other thereby distorting the flat conductor plates. This takes place particularly adjacent the ends of the cell. The rifling expanded conductor tubes of the collector cell of the present invention provide a collecting cell unit which has no distorted plates as the expansion by rifling prevents lateral wandering or bending of the tubes.

Each tube is abutted against the spaced parallel end panels of the cell and selected of them are secured by headed coaxial rods in the tubes with a speed nut. The top and bottom of these insulating plates are secured together by flanged metal angular sections to support the ionizing frame at the front of the cell, an optional large mesh screen at the front and the removable screen at the back to catch the large gobs of dirt that are apt to be blown from the plates after being permitted to accumulate too long a period of time.

The collecting cell unit is also provided with a unitary ionizer ground plate having upper and lower parallel bars with rearwardly struck uniformly spaced parallel ionizing electrodes. Spaced insulators are provided on each bar carrying opposed bus rods above and below the ionizing electrodes with ionizing wires suspended between the bus rods and substantially centered between the ionizing electrodes. Opposed top and bottom panels are provided having inturned marginal side flanges which extend beyond the sides of the end panels to form opposed troughs on the up and down stream sides of the cell to receive mechanical filter screens and add to the rigidity of the cell structure. These top and bottom panels are secured at their ends to their end panels. To facilitate this, the end panels are provided with end flanges.

The end panels are preferably and novelly metal panel members provided with spaced cutouts. Insulating plates overlay selected of these cutouts and are provided with at least one aligning hole. The insulating plates secured loosely to the end panel members to permit alignment of the holes with selected collecting plate conductor tubes. Depressions are provided in the same panel members for other selected collecting plate conductor tubes in order to place the face of the bottom wall of such depressions which will contact a tube end in the same plane as the insulating panel faces which will also engage tube ends thereby compensating for the depth of the cutouts. This structure provides a much more economical end panel with ease of manufacture.

Those conductor tubes not having a bolt passing therethrough may be aligned and secured relative to their respective end panel holes by tapered cylindrical-shaped lock lugs which may be forced into the alignment holes in the end panels and on into the bore of the tubes. Such lock lugs are provided with flanges which engage the inside surface of the end panels upon insertion thereby preventing dislodgment.

Conductor straps may be provided on the outside of a selected insulating plate and connected to selected of the conductor tubes to permit lateral electrical cell connection to an energy source.

Other objects and advantages appear hereinafter in the following description and claims.

The accompanying drawings show, for the purpose of exemplification without limiting the invention or the claims thereto,

certain practical embodiments illustrating the principles of this invention wherein.

FIG. 1 is an enlarged perspective view of a portion of pairs of metal collecting plates showing clearance holes and predrawn holes secured to tubes and fastened to an insulating panel.

FIG. 2 is an enlarged sectional view through a pair of collecting metal plates showing the drawn hole and the expanding mandrel.

FIG. 3 is a perspective view of an open stacking jig with a plate feeding tray showing the cell elevator in its raised position.

FIG. 4 is a perspective view of two E-shaped jig members with a spacer therebetween.

FIG. 5 is a perspective view of the open stacking jig with the plate-feeding tray forward and a portion of the plates stacked in the jig.

FIG. 6 is a perspective view looking over the plate feeding tray on top of the open stacking jig.

FIG. 7 is a perspective view of the closing of the stacking jig illustrating the relative position of the top spacers about to enter the spacers supporting the plates in the jig.

FIG. 8 is a perspective view of the closed stacking jig with the tubes partially inserted in their respective aligned predrawn holes.

FIG. 9 is a perspective view of the act of expanding the tubes in the predrawn holes of the plates locked in the jig.

FIG. 10 is a perspective view of the open jig with the elevators having raised the interleaved plates free of the jig spacers.

FIG. 11 is a perspective view of a jig to properly space the interleaved plates from each other on a carriage to prealign the tubes.

FIG. 12 is a perspective view of moving the interleaved and jigged held plates through dual saws to make the tubes gauging points.

FIG. 13 is an enlarged perspective view of a portion of a completed cell with parts broken away.

FIG. 14 is a diagrammatic plan view of the punching and stacking apparatus.

FIG. 15 is a circuit diagram for energizing the electronic air cleaning cell of this invention.

FIG. 16 is a circuit diagram for energizing a three phase electronic air cleaner cell of this invention.

FIG. 17 is an enlarged view partly in section showing a conductor tube with a spiral bore of predetermined configuration abutting an insulating end panel with a spring locking lug holding the same in position.

FIG. 18 is a front elevational view in section with portions broken away showing an electronic air cleaning collector cell with the collector plates supported by conductor tubes and having metal end panels with insulated inserts. The vertical front section is taken along line 18–18 of FIG. 19 for the upper two thirds of the figure.

FIG. 19 is a view in side elevation of the metal end panel of the cell shown in FIG. 18.

Referring to FIGS. 1 and 2 of the drawings the energized or positively charged plates 1 are spaced from the grounded or negatively charged plates 2 by the interlocking between each of the respective plates and their corresponding tubes. The tubes 3 are secured to the positive plates 1 and the tubes 4 are secured to the negative plates 2. This is more clearly demonstrated in the enlarged view of FIG. 2 wherein the plate, regardless of which plate it might be, is provided with a drawn hole 5 which consists in a bell end 6 and a frustoconical end 7, which before the tube is expanded in the predrawn hole having a frustoconical section 7, is truly a frustoconical section preferably without any cylindrical sections along the bore thereof. It should be noted that the predrawn hole of frustoconical section including the bell 6 is completely offset or beyond the parallel planes 8 and 10 which define the opposite sides of a plate.

The tubes 3 and 4 before being inserted into the predrawn holes 5 has a three-eighths or 0.1875 of an inch outside diameter. The inner diameter of the tubes 3 and 4 are approximately 0.305 which is slightly less than five-sixteenths which is 0.3125 of an inch. Thus the tubes will readily move into the bell 6 and through the drawn opening 5 of a stacked section of plates without much resistance and when the mandrel 11 with its head 12 is drawn therethrough it is gauged to increase the size of the tube approximately 1/64 or 0.11312 of an inch which is sufficient for the expanded tube to grasp a substantial portion of the bell predrawn hole 5 and lock it firmly in position providing a good mechanical connection as well as a good electrical connection.

As shown in FIG. 1 for every series of drawn holes 5 there is a corresponding clearance hole 13 as each of the tubes 3 and 4 are preferably adjacent each other and parallel. Although the end of the frustoconical portion of the drawn hole 5 may extend approximately halfway between adjacent plates, the clearance hole 13 is of sufficient size to provide substantially the same distance between the end of the frustoconical portion of the drawn hole 5 and the actual tube surface passing through the clearance hole 13 as shown in FIG. 2.

The mandrel 11 has a head 12 which is provided with an initial tapered section and a trailing tapered section with an intermediate cylindrical gauging section 14. This section 14 is longer than either the tapered sections fore and aft beginning at a diameter equivalent to that of the inner diameter of the tube. Of course, the stem of the mandrel is much smaller than the inner diameter of the tube but the important initial tapered section only becomes effective when its diameter reaches the inner diameter of the tube. Different other modes of expanding the tubes may be practiced. One that is very old in the art is the use of a ball with a hydraulic fluid. However, in this application there are 10 tubes in all and they may be expanded at the same time by employing the mandrel 11 each provided with an expanding head 12.

A jig is shown in FIG. 3 for receiving each of the plates having been punched with a required alternate series of drawn holes 5 and clearance holes 13. The jig, generally speaking, is provided with a stand 15 which supports a table 16 that carries a back gauge plate 17 and a front plate 18 and a rear plate 20. These plate members are secured together to the table and are preferably made of heavy stock for long wear and for enabling a tight clamping arrangement of the inserted plates of the cell.

As shown in FIG. 3 a hoist or lifting cylinder 21 is shown underneath the table surface 16 and provided with a piston rod 22 that operates the crosshead 23 carrying at least four guide members 24 that are connected together at the crosshead 23 and also at the elevator platform sections 25 and 26. As shown in FIG. 3 these elevator platform sections are raised above the jig which is shown fully extended for the purpose of lifting the cell out of the jig which is illustrated in FIG. 10. Wherein the cell 27 is supported by the elevators 25 and 26 above the whole of the jig.

In the open jig shown in FIG. 3 there are illustrated sets of spacer members 28, one row at the back of the jig indicated at 30, one row at the center of the jig as indicated at 31 and one row at the front of the jig as indicated at 32. These E-shaped members 28 have their upper ends cut at a slant as illustrated at 33 in FIG. 4 and when stacked in the jig are bolted together along their lower end by means of bolts passing through appropriate holes to tightly clamp them together and to the front and rear plates 18 and 20. A spacer plate 34 is positioned between the horizontal common connecting bar of the E that has the upwardly projecting fingers forming the E-shaped spacers 28. Thus the bottom of the E-shaped spacers 28 are separated by a spacer 34 that may be the same gauge as the plates 1 and 2 or may be slightly heavier gauging than these plates depending upon the capability of tightly clamping these plates in position. Each of the plates are uniformly stamped and alternately stacked as indicated at 35, as a positive and negative plate but they are preferably gauged so as to have the same total width and length and when each plate is independently inserted between the groove made by the sloping faces 33 of the E-shaped member they are shoved to the bottom or

the surface of the spacer 34 as the gauge surface and at the same time against the rear gauge plate 17. Thus the bottom spacers 34 and the rear gauge plate 17 function to square each of the plates inserted in the jig. This automatically aligns the dual sets of holes and when the plates 1 and 2 are alternately positioned progressively in this jig each of the proper drawn holes 5 will be aligned and the alternate plates with their clearance holes 13 also will be properly aligned.

As previously stated when the plates are inserted in the jig, the bell 6 of the drawn holes 5 all face the same direction which would be toward the front plate 18 since this is the end that the mandrels 11 with their heads 12 are inserted.

As shown in FIG. 3 a stack 35 of alternate plates 1 and 2 is placed on the movable tray 36 and sloped slightly to the back of the stack. These punched plates are readily inserted in the jig but first the elevator platforms 25 and 26 must be lowered to a position below the gauged spacers 34. It may be desirable to use the elevator surfaces 25 and 26 as the gauge surfaces in which case the elevator is provided with adjustable stops so that the top surface of the members 25 and 26 function as the gauge for the insertion of the plates which may be slightly above the surface of the spacers 34 or halfway up the jig.

Referring now to FIG. 5 the elevator has been depressed to lower the surfaces 25 and 26 so as to admit the alternate plates 1 and 2 of the stack 35 down in between the adjacent E-shaped spacers in the three rows 30, 31 and 32. As shown in FIG. 5 the plates have been inserted for substantially half of the jig and as illustrated these plates extend only halfway down the jig because the plates shown at 37 are not as deep as the jig. As shown in FIG. 5 the cell has not be completed and additional plates will be inserted from the tray 36 to finish this cell. It will also be noted that the exposed end of the plates protrude from the ends of the E-shaped spacers showing a space indicated at 38.

The tray 36 is mounted on the carriage 40 which is supported by the wheels 41 and journaled on the stationary frame member 42. Thus the frame 42 may extend the carriage tray 36 forwardly out over the jig to substantially the front wall 18.

As shown in FIG. 6 the back of the tray 36 is provided with a sloping push plate 43 which in turn is mounted on the end of a rod 44 that passes through the backplate 45 of the tray 36 and extends rearwardly to the crosshead member 46. A coil spring 47 encircles the rod 44. A cable 48 is secured at one end indicated at 50 to the crosshead 46 and has its first pass on the pulley 51 supported from the mounting plate on the rear of the backplate 45 and thence on its next pass to the pulley 52 pivotally supported from the crosshead 46 and the next pass travels to the third pulley 53 on the mounting plate on the rear of the backplate 45 and thence rearwardly to where it is fastened at 54 to a stationary frame 15 of the machine. A motor 60 is mounted on the frame 15 and is provided with a rotary electrical clutch mechanism indicated at 56 supplied by current through spaced collector rings and brushes. The motor 60 may continuously rotate the sprocket 57 and when the clutch 56 is energized, the clutch 56 will chuck the threaded rod 49 to feed the tray 36 forward as the tray is fed forward by the threaded rod 49 secured to the carriage frame 40 at 55. Thus, the clutch 56 is provided with threaded arcuate clamp members for threaded engagement with the threaded rod. The clutch 56 is driven by the gear 57 operated by the chain 58 which in turn is driven from the sprocket 59 of the motor 60.

The rotary clamping chuck 56 is provided with a pair of slip rings 61 and 62 which when energized through the brushes 63 and 64 will actuate the chuck to clamp on the threaded rod to function as a pushrod to feed the carriage 40 forwardly. As the carriage 40 moves forwardly the tray 36 at its other end moves out over the jig due to the cable 48 sliding the rod 44 forward through the backplate 45 and at the same time the plate 43 moves the stack 35 forwardly on the tray at a predetermined rate to properly present each of the plates on the front of the stack tray for insertion in the jig. At the same time the spring 47 becomes compressed because of the cable 48 secured at 54 to the frame 15 at one end and to the crosshead 46 at its other end. When the clutch 56 is released the spring 47 returns the carriage 40 and the plate 43 to their rearmost positions on the support by the spaced rollers 41 mounted on stationary rails at the rear of the machine frame 15.

When the jig has been completely filled with the number of plates that are necessary as illustrated in FIG. 7 the jig is ready for closing as clearly shown in this figure as well as in FIGS. 5 to 10. The lead or top 65 is hinged at 66 to the rear gauge plate 17 which is beefed up by additional members and is also provided with a tower 69, shown in FIG. 6, for supporting a counterweight with a line to the front of the top 65 as illustrated at 67 and as secured by the plate 68 to the top 65 as shown in FIG. 8. The line 67 passes upwardly over a pulley adjacent the top of the tower and thence to a weight which counterbalances the actual weight of the jig top when supported on hinge 66. The top member is made in the form of a frame having three transverse members 70 which are secured at their hinged end to the hinged plate 71 and at the front and to the pillow plate 72 which in turn is provided with a block 73 having a vertical opening to receive the eye of the member 74 and a pin 75 which passes through the block and the eye of the member 74. When the head is locked downwardly, the cylinder 76 is energized to pull the piston 77 downwardly and thus tightly force the jig top member 65 in position as shown in FIG. 8.

When it is desired to open the jig the cylinder 76 is energized in the opposite direction to raise the same and when partially raised the locking pin 75 is withdrawn and the top 65 may be raised to its vertical position as shown in most of the figures such as FIGS. 5 and 10 giving free access to the upwardly open jig. As shown in FIGS. 3 and 5 three bars 70 are provided with plates 78 which support a stack of spacing bars 80 and interleaved therebetween a steel spacer plate 81 for insertion which also engages the sloping faces 33 of the spacers 28 while the spacer members 80 interlock with the sloping faces 33 to insure proper adjustment of the plates in the jig and to retain them against any movement during the drawing operation. To allow for discrepancy the spacers 80 and their counter plate spacers 81 are bolted together in each row and they are suspended on springs to allow the whole assembly to move back and forth so that they will seek their own proper position with the lower half of the jig spacer members and thus become properly interlocked to tightly secure the spacers that have the plates positioned therebetween. It is believed more important to have the spacers tighter when the jig is closed than the plates themselves for the simple reason that the plates 1 and 2 cannot go anywhere if the spacers 28 and 80 are locked at top and bottom.

When the die has been closed as shown in FIG. 8 the tubes 3 and 4 which are the same are inserted through the large openings in the front gauge plate 18 and threaded through the corresponding bells 6 of the drawn holes 5 in the plates 1 and 2 and pass rearwardly to the rear plate 20 as shown in FIGS. 3 and 5. The holes in the rear plate 20 are insufficient size to receive the tubes but are sufficient to receive the heads 12 of the expanding mandrels 11. When all of the tubes have been shoved home they pass inwardly beyond the inner face of the forward member 18 and are stopped when they abut the inner face of the rear wall member 20. At this time the mandrels 11 with their trailing heads 12 are inserted in the tubes and they are moved rearwardly through the aligned holes 82 in the wall 20 and interlock in the crosshead 83 on the rear side of the plate 20 as shown in FIG. 9. The leading ends of the mandrels 11 are provided with a reduced portion 84 which provides a forward shoulder that is interlocked in the connected and laterally slidable plates 85 which are actuated by the lever 86 that is shown in FIG. 9. The plates 85 are provided with bayonet-type slots, the large portion of which is open when the control knob 86 is pulled away from the machine. This permits the leading end of each of the mandrels 11 to pass through the plates 85 after they have been fully inserted. The knob 86 is moved inwardly to engage in the reduced section 84 as shown

in FIG. 9 and thereby lock each of the mandrels 11 to the crosshead 83. At this time the cylinder 87 as shown in FIG. 5 is energized to pull its piston rod 88 as shown in FIGS. 5 and 9 rearwardly. The piston rod 88 is secured to the bridge member 90 that is in turn secured to the crosshead 83 and when the piston draws the crosshead 83 rearwardly on the track 91 each of the mandrels are drawn through the tubes 3 and 4 with their heads 12 expanding the same as illustrated in FIG. 2 for securely locking each drawn hole 5 to its respective tube. The force of drawing is applied to the inner surface of the rear wall member 20 and each of the tubes 3 and 4 have the same length and they are precut so that they are substantially the same length so when they engage the rear wall they will protrude equidistant beyond the end plates of the cell when out of the jig, as in FIG. 10. As shown in FIG. 9 each of the mandrels 11 are drawn rearwardly until they pass through the openings 82 which clear the head 12 of each mandrel.

Thus with this single operation all of the tubes in the cell are expanded simultaneously when the plates of the cell are clamped in the jig in proper spaced relation. Thus the expansion of the tubes in each plate of the cell prepositions these plates relative to each other in accordance with the spacers 28 of the jig. When the mandrels 11 clear the rear end wall 20, the knob 86 is drawn away from the machine to unlock the leading end of each mandrel from the crosshead 83 and permit the mandrels to again be returned to the stack at the front of the machine as shown in FIG. 3.

When this has been completed the cylinder 76 is energized to extend the piston 77 until the whole of the head 65 is raised from its interlocked position as shown in FIG. 7 at which time the pin 75 is removed and the counterweight is effective to permit the same to be turned to its uppermost position as shown in FIG. 3.

Since the tubes 3 and 4 clear the inner surface of the front wall by reason of the fact that they are actually within the initial spacers 28 and since the other ends of the tubes are against the inner surface of the far wall, the elevator may be raised by energizing the cylinder 21 to lift the completed cell out of the jig as illustrated in FIG. 10. Here the cell 92 rests on top of the elevator platforms 25 and 26 as shown in FIG. 3 and may be raised free from the jig. Of course, when the cell 92 is raised, the plates may move together in one direction or the other because there is nothing holding them from moving the tubes 3 and 4 longitudinally relative to each other.

The cell 92 is then lifted to the carriage 93 which is supported on rollers and is provided with the top crossbars 94, the forward end members 95, the rear end members 96 and a platform made of two bottom transverse members 97 shown in FIGS. 11 and 12. The upper surface of the crossmembers 97 and the under surface of the crossmembers 94 are provided with opposed grooves to receive spacer members 98. At least two of these spacer members may be slid into the grooves at each end and in the center of the stack. The spacer members 98 have long bifurcated sections to fit above or below each of the tubes 3 and 4 and they are of the proper gauge and thickness which when inserted in the grooves will maintain the adjacent plates the same distance apart as that of the jig shown in FIG. 3 without distorting the plates or otherwise straining the fastening between the tubes 3 and 4 and their respective drawn holes 5.

After the gauge plates 98 have been positioned the carriage 93 is moved forward between the saws 100 which trim the ends of each of the tubes 3 and 4 and the cell 92 is thus held in proper position. This trimming operation is merely a trimming operation. Just a small amount of metal is trimmed from each end of the tube so as to properly gauge all of the tubes and after the carriage has passed completely between the saws the ends of each of the tubes 3 and 4 at opposite ends have been cut to uniform length and provide the same distance between the ends of the tubes and the respective plates at the end of the cell.

The carriage is then drawn rearwardly and the gauge members 98 are withdrawn to release the cell from the carriage leaving the cell properly gauged for mounting.

As shown in FIG. 13 each cell has mounted on each end thereof an insulating end wall panel 101 which is provided with molded marginal side flanges 102 to provide rigidity in these insulating members. A series of holes are formed in each insulating member 101 which are aligned with the respective tubes 3 and 4 of the cell 92. The stem of each headed rod 103 is sufficiently small to pass through the respective tubes 3 and 4 and is inserted through the holes in both of the insulating end panels 101 and their length is such that when the head 104 engages its respective insulating end wall panel and its opposite end projects approximately three-sixteenths of an inch through the other insulating end wall panel or sufficient distance to permit the insertion of the speed nut 105 shown in FIG. 1 at the opposite end of the rod 103 from the head 104 of each insulated end wall panel. The stems of the rods 103 passing through the tubes 3 also pass through a metal conductor strap 106 before the speed nuts 105 are applied. One end of each of these metal conductor straps is provided with a threaded socket 107 which is employed as a positive cell conductor connection, and each of the negative plates 2 in the stack are grounded. As a precautionary measure a second conductor strap 108 is extended from one of the lower rods passing through one of the tubes 4 connecting the same to the lower metal bracket 109 that extends across the upper and lower ends of both insulating end wall panels and is secured thereto.

The lower and upper metal channels 110 and 111 extend across the lower and upper ends of the two insulating end wall panels 101 and are secured to the brackets 109 which retain the lower portions of the cell rigid. Each of these metal channels 110 and 111 are provided with opposed channel flanges 112. The upper and lower channel flanges 112 in the front of the cell overlap the rectangular frame of the ionizing unit.

The ionizing unit comprises a ground plate with two transverse bar members 113 and 114 connected vertically by a series of uniformly spaced vertically disposed parallel negative electrodes 115 which are welded to the upper and lower transverse members 113 and 114 and are ribbed to provide strength. This provides a rigid reinforcing metal member that not only connects the respective lower and upper bracket members 110 and 111 but also provides a mechanically rigid structure in the cell itself.

Two insulators 116 are provided in each of the transverse bar members 113 and 114 for supporting the charged or positive electrodes which are in the form of wires 117 suspended vertically between or on opposite sides of the vertical negative electrodes 115 and one end of which is hooked to a bus bar not shown at the top and the other end of each wire being hooked to an electrical spring 120 the end of which is hooked to the lower bus bar 121. Both bus bars 121 are mounted on the opposite ends of the spaced insulators 116. The ends of the upper bus bar may be turned downwardly and provided with a threaded opening 122 to receive a threaded rod which may pass through either insulated wall member 101 for the purpose of applying a separate positive charge to the top bus bar and thus to each of the positively charged ionizing wires 117.

The metal conductor straps 106 with their threaded socket 107 represent a separate voltage connection for the positively charged plates 1 which in the cell shown in FIG. 13 represents the second conductor strap adjacent the top or bottom of the insulating end wall panel 101 whereas the negatively charged plates 2 represent the inner conductor straps or rows of bolt heads 104 of the cell as illustrated in FIG. 13 and are connected by the conductor strap 108 to at least one metal bracket across the bottom of the insulated end wall panels 101.

Thus each end of the cell may have its positive plates independently connected. Again each end of the cell may have the positive ionizing wires 117 independently interconnected to the charge of the circuit. This permits the charging and control circuit to be mounted on either end of the cell and the mere removal of this unit from the cell entirely disconnects the same which is necessary in order to remove the cell and provides a high degree of electrical safety.

The supply circuit shown in FIG. 15 provides an ordinary potentiometer in the primary circuit of a high voltage transformer 131, the secondary of which has one terminal connected between a bank of solid state rectifiers 132, 133, the anode of one of which is connected to ground and the cathode of the other of which is connected to the ionizer wires 117. The other side of the secondary of the transformer is connected between resistor 134, 135, the other end of one resistor 134 of which is connected to the ionizer wires 117 and has also connected in parallel therewith a capacitor 136. The other end of the secondary winding is also directly connected to the positive plates 1. As previously stated the negative plates 2 and 115 as well as the casing are connected to ground. Such a current supply is connected to the orginary line such as 115—120 volt 60 cycle circuit and there is no connection between the primary and secondary coils of the high voltage transformer. This provides a very efficient operating circuit for electronic air cleaners of this character.

The opposed channels 129 between the upper and lower channels 110 and 111 on the rear side of the cell are arranged to receive a slide, supporting some form of mechanical dust collector that would catch and hold large globules of dirt that would be knocked from the adjacent plates by a partial discharge together with the current of air. Screens of this character are sometimes reusable but more frequently they are the throw-away type employing some form of plastic as the texture for catching the dirt that is freed from the cell.

Referring to FIG. 14, two strips of material 1' and 2' are fed from two rolls of strip to the single die 123 in the punch press 124. This dual die punches the positive and negative plates 1 and 2 at the same time. This dual die punches out the holes 13 and predraws the holes 5 in each of the plates 1 and 2. This may require a single or two-stage punching operation but the only or last stage cuts the plates 1 and 2 from this strip. These plates are shown protruding from the die 123 and during the next stroke of the die they become severed and drop into the upwardly open troughs 125 and 126. Since the trough 125 is straight and has a single sharp slope, the overhanging plate 1 drops onto this straight and steep chute and thus travels to the pile 127 ahead of plate 2 which travels on chute 126 a further distance and is not quite so steep. Thus plate 1 is always ahead of plate 2 and they are alternately stacked automatically in the pile 127 in the tote box 128 which has a bottom and at least a back and one side. In this manner the bottom of each stack is always plate 1 and the top is plate 2 when the stack is removed to the jig for assembly.

The strip is automatically fed to and through the die until the punched and severed plates drop on their respective chutes 125 and 126.

The three-phase circuit of FIG. 17 is merely a duplication of the single phase circuit of FIG. 15 with the secondary of the transformer supplying power from each phase of the three-phase transformer.

Referring now to FIG. 17, the conductor tube 3 shown is provided with a nonround expanded exterior surface which follows the contours of its nonround expanded bore. In this instance, the expanded spiral or rifled bore was produced by a mandrel having six lead teeth on its head. The mandrel is rotated as it is drawn through the tube thereby producing a hexagon cross section on the outer surface of the tube.

These expanded nonround tube surfaces provide many more advantages over the straight or round bore conductor tubes because the points of extreme expansion of the conductor tube outer surface permits greater lateral expansion extremes of the tube than would be permitted with a smooth bore expansion. In other words, when a smooth rounded mandrel is employed to expand the conductor tube, the characteristics of the metal tube will not permit the entire outer surface or circumference of the tube to be stretched and expanded to the extreme radial limit of the outside rifling bulge of the conductor tube 3 illustrated in FIG. 17. However, when the tube is expanded to a nonround shape, the most protruding portions of the expanded tube exterior are permitted by the tube of the same characteristics to stretch to an outer radial limit which is greater than that permissible when the entire tube is uniformly expanded. This therefore permits greater expansion at points about the tube for more secure interlock of the tube exterior with the frustoconical portion of a predrawn hole of a respective collector plate 1 or 2.

Secondly, the uniform cross section configuration of the tube outer diameter assures better interlock with the respective predrawn holes than does a smooth conductor tube outer surface with a smooth predrawn hole interior. Thus the nonround expanded tube configuration of the present invention provides a tighter connection with a greater interlock mechanically as well as electrically.

Another important feature of the spiral or rifled configuration in particular, is that it has been observed that when a smooth headed mandrel is drawn through the conductor tubes to expand the same, that the tubes will no longer remain axially straight and will wander or bend in a direction transverse to their axis. The result is that the collector plates 1 and 2 are warped by reason of the conductor tubes bending away from and towards each other. This phenomenon particularly occurs adjacent the ends of the cell structure. By rifling the bores of conductor tubes 3 and 4 to expand the same, the tubes remain axially straight thereby preventing any warping of the cell plate structure resulting in a unit which is extremely dependable and which will not fail during use by reason of a short occurring between adjacent end collecting plates.

In FIG. 17, the conductor tube 3 is shown abutting end panel 101 which is provided with alignment hole 140 which is smaller than the outside diameter of conductor tube 3 and is axially aligned with the bore thereof. It is not necessary that each and every conductor tube have a connecting bolt 103 passing therethrough as illustrated in FIG. 13. In order to prevent the costly use of more of these bolts 103 than required, selected of the tube ends may be positioned and held in alignment with their respective aligning holes in the end panels by means of spring positioning lock lugs such as illustrated at 141. These lock lugs are cylindrically shaped and slightly tapered at their forward end 142 and are provided with an annular outwardly extending shoulder or lip 143 which engages the outer surface of the insulating panel 101. The spring lug 141 is open for its entire length as indicated at 144 in order to provide spring resiliency in the radial direction of the cylindrical shaped lug. The lug is also provided with outwardly struck locking ears 145 which yield inwardly when the locking lug is initially forced into the opening 140 as viewed from the right-hand side of FIG. 17 and subsequently spring outwardly to their natural position to engage the inside surface of end panel 101 to prevent dislodgment of the locking lug. The tube end is thus maintained and positioned and aligned relative to the other conductor tubes of the cell structure and thus connecting bolts 103 need only be provided for half of the conductor tubes as better illustrated in FIG. 18 and 19.

The collection cell structure of FIGS. 18 and 19 is basically the same as that previously illustrated in FIG. 13 and others with the exception of novel features in the end panels and the other panels making up the outer casing or housing for the collector cell.

The ionizing unit is basically the same as that illustrated in FIG. 13. However, the uniformly spaced vertically disposed parallel electrodes 115 are made as an integral part of transverse bar members 113 and 114. Rather than being welded to the latter, the structure is unitarily constructed by punching out a plate or sheet to provide the rearwardly struck and uniformly spaced parallel ionizing ground electrodes.

A unique feature resides in the end panel 146 which in this instance is metal rather than an insulating material which is much more costly. The panel member 146 is provided with spaced cutouts 147 with insulating plates 148 attached loosely thereover.

These insulating plates 148 are loosely secured to the metal panel member 146 by means of rivets 149 to permit slight movement of the same for required assembly alignment of

their aligning holes 140 with the bores of their respective conductor tubes 3 or 4.

Those conductor tubes 4 which are grounded in this instance, need not be insulated as conductor tubes 3 are and therefore the ends of conductor tubes 4 may directly abut the grounded metal end panel member 146. However, in order to compensate for the depth of the cutouts 147, depressions 150 are provided in the metal end panel member 146 so that the tubes of equal length will abut the end panel in the same vertical plane to provide the proper spacing between alternate groups of the collecting plates.

Referring to the end view of the structure as shown in FIG. 19, it may be observed that the bottom insulating plate or panel 148 is provided with a conductor strap 151 on the outside thereof. This conductor strap is electrically connected through the panel to conductor bar 152, as seen in FIG. 18, which is in turn electrically connected to the ionizing bar member 121 to provide a positive potential on the ionizing wires or conductors 117. Thus, conductor strap 151 permits end electrical connection of the cell unit to an energy source by a spring electrical contact or the like.

The same principal is also applied in the employment of conductor strap 153 on the outer face of the lower insulating panel 148. This conductor strap is electrically connected to the lower positive conductor tubes 3 such that an outside electrical end connection to an energy source may be readily made to the cell structure by an electrical spring contact or the like. These conductive end straps thus eliminate awkward electrical connections when the unit is installed.

End panel member 146 is provided with side flanges 154 and top and bottom flanges 155 which provide rigidity to the structure and available connecting space for securing the end panels to identical top and bottom channel members 156 and the unitary ionizing electrode structure consisting of bars 113, 114 and the vertically disposed negative electrodes 115. As illustrated, these structures are riveted together by means of rivets 157.

Top and bottom channel members 156 have their inturned side flanges 158 overlapping the sides of end panel 146 in order to provide opposed top and bottom troughs both on the upstream and downstream side of the unit to receive mechanical filter screens and to add to the rigidity of the structure.

We claim:

1. An electronic air-cleaning collector cell consisting of a series of alternate parallel collecting plates providing interleaved groups of different polarity, a plurality of aligned mounting holes and clearance holes in each group of collecting plates, conductor tubes in said mounting holes to support their respective group of collecting plates of one polarity and spaced from each other and passing through said clearance holes of alternate groups of collecting plates of different polarity, a pair of spaced opposed end panels on opposite sides of and parallel with said alternate series of collecting plates, said end panels having holes matching the location of the bores of said conductor tubes but smaller than the outside diameters of said conductor tubes, means cooperating with said conductor tubes and panel holes to abut and secure the inside faces of said end panels against the ends of all of said conductor tubes to maintain said alternate groups of collecting plates aligned and in equally spaced parallel relation with each other in said electronic air-cleaning cell, and insulating means on said end panels to insulate said conductor tubes of different polarity.

2. The electronic air-cleaning collector cell of claim 1 which also includes a nonround expanded outer surface on said conductor tubes interlocked in their reshaped respective collector plate-mounting holes.

3. The electronic air-cleaning collector cell of claim 2 which also includes a bore of nonround configuration in said conductor tubes which formed said expanded conductor tube surfaces interlocking their reshaped respective collector plate-mounting holes.

4. The electronic air-cleaning collector cell of claim 3 which also includes a spiraled bore in said conductor tubes which expanded said conductor tube surfaces in their interlocked and reshaped respective collector plate-mounting holes.

5. The electronic air-cleaning collector cell of claim 2 including a nonround polygonal bore as said nonround bore in said conductor tubes which formed said expanded conductor tube surfaces in their interlocked and reshaped respective collector plate-mounting holes.

6. The electronic air-cleaning collector cell of claim 1 including selected of said conductor tubes of matched gauge length.

7. The electronic air-cleaning collector cell of claim 1 wherein all of said conductor tubes supporting said conductor plates are of equal length to space said conductor plates equally from each other.

8. The electronic air-cleaning cleaning collector cell of claim 1 including predrawn mounting holes in said interleaved collector plates each having a frustoconical section extending beyond the plane of its collecting plate, said expanded exterior surface of each conductor tube having changed the shape of said conical section to interlock with said predrawn mounting hole to retain said plates in uniform spaced relation.

9. An electronic air-cleaning collector cell including spaced opposed end panels with outward extending parallel flanges, a series of alternate parallel collecting plates each having aligned clearance and mounting holes, said mounting holes fixed on spaced and expanded conductor tubes of different polarity and of equal length with their ends against the inner faces of said opposed end panels, insulation means between said conductor tubes on said end panels carrying those tubes to receive a charge, and bolt means extending through said end panels and selected of said conductor tubes to clamp said end panels against said conductor tubes to support said series of collector plates for the width of said cell.

10. The structure of claim 9 including a unitary ionizing ground plate shaped to form upper and lower parallel bars with uniformly rearwardly struck equally spaced parallel ionizing electrodes therebetween, spaced insulators on each bar supporting opposed bus rods above and below the ends of said rearwardly struck ionizing electrodes and between which are suspended ionizing wires substantially centered between said ionizing electrodes, a flange extending rearwardly from the top and bottom marginal edges of said upper and lower bars of said ionizing ground plate, and the outer ends of said bars of said ionizing ground plate secured to the front flanges of said end panels.

11. An electronic air-cleaning cell including opposed spaced cell end panels with parallel edge flanges, a series of alternately disposed collector plates providing groups of different polarity and with spaced clearance and predrawn mounting holes, spaced and expanded conductor tubes of equal length with their ends abutting against the inner faces of said end panels, insulation means between said conductor tubes and said end panels to insulatingly support said conductor tubes of different polarity from each other, hole means in said end panels smaller than the outer diameter of said conductor tubes and aligned with the bores of said conductor tubes each to receive an aligning means, selected of said panel hole means and conductor tubes receiving bolt stems with their heads against the outer face of one panel and bolt fastening means against the outer surface of said other panel to secure said end panels in clamping engagement against the ends of said conductor tubes to equally space said collecting plates from each other and support them relative to said parallel flanges, a unitary ionizing ground plate having upper and lower parallel bars with rearwardly struck uniformly spaced parallel ionizing electrodes, spaced insulators on each bar carrying opposed bus rods above and below said ionizing electrodes, ionizing wires suspended between said bus rods and substantially centered between said ionizing electrodes to complete the ionizer, and the opposite ends of said ionizing ground plate bars secured to said parallel flanges of said panels.

12. The electronic air-cleaning cell of claim 11 which also includes a flange extending rearwardly from the top and bottom marginal edges of said upper and lower bars of said ionizing ground plate to overlie top and bottom parallel flanges on said end panels.

13. The electronic air-cleaning cell of claim 11 which also includes an opposed top and bottom having inturned marginal side flanges extended beyond the side flange of said end panels with the intermediate portion of the ends of said top and bottom secured to top and bottom marginal end flanges on said end panels to form opposed troughs on the up and down stream sides of said cell to receive mechanical filter screens and add to the rigidity of said cell.

14. The electronic air-cleaning cell of claim 11 which also includes end panels of insulating material with marginal side flanges, top and bottom cross angles secured to each of said end panels to provide top and bottom end flanges.

15. The electronic air-cleaning cell of claim 11 which also includes opposed upper cutouts in said end panels of metal and closed by overlying attached insulating plates for each upper charge-carrying tube, opposed lower cutouts in said end panels closed by lower attached insulating plates to receive the ends of said conductor tubes, said attached insulated plates loosely attached to said end panels to permit alignment of their aligning conductor tube holes with the bores of said conductor tubes, and independent depressions in said steel panels for selected grounded tubes to compensate for the cutout to equalize the spacing between said end panel surfaces.

16. The electronic air-cleaning cell of claim 15 which also includes a conductor strap means connecting said charged tubes on the outside of said lower insulating plates for lateral electrical cell connection to an energy source.

17. The electronic air-cleaning cell of claim 16 which also includes a conductor strap on each of said lower insulating plates connected to the adjacent end of said ionizing wire bus rod for lateral electrical end connection on either end panel side of said cell to an energy source.

18. An electronic air-cleaning cell end panel comprising a metal panel member having spaced cutouts, insulating plates overlying selected of said cutouts and having at least one aligning hole therethrough, and attachment means loosely securing said insulating plates to said end panel member to permit alignment of said holes with selected collecting plate conductor tubes, and depressions in said panel members for other selected collecting plate conductor tubes to compensate for the depth of said cutouts thereby permitting the ends of said tubes to engage said end panel in the same vertical plane.