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(54) **ELECTRODE SELF-CLEANING MECHANISMS WITH ANTI-ARC GUARD FOR ELECTRO-KINETIC AIR TRANSPORTER-CONDITIONER DEVICES**

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See application file for complete search history.

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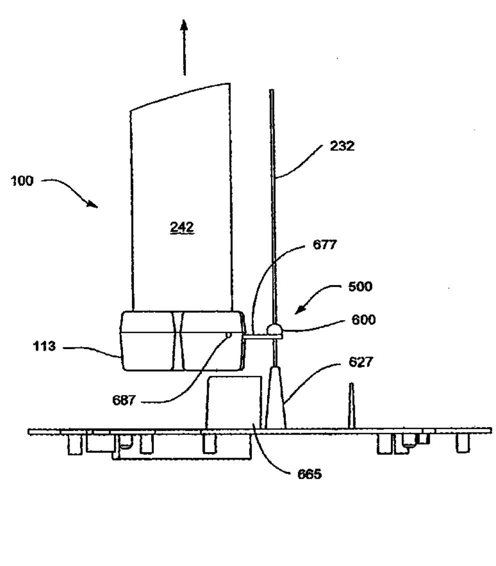
(57) **ABSTRACT**

An electro-kinetic electro-static air conditioner with a bead member having a bore, through which a wire-like electrode passes. The bead is moved along the wire to frictionally clean the wire-like electrode when an electrode array is removed. A bead lifting arm is mounted to the electrode array. The bead lifting arm can move the bead to clean the electrode as the electrode array is removed from the air conditioner for cleaning. The electro-kinetic electro-static air conditioner has insulated parts which protect against high voltage arcing and conductive deposits relative to the electrodes.

5 Claims, 18 Drawing Sheets



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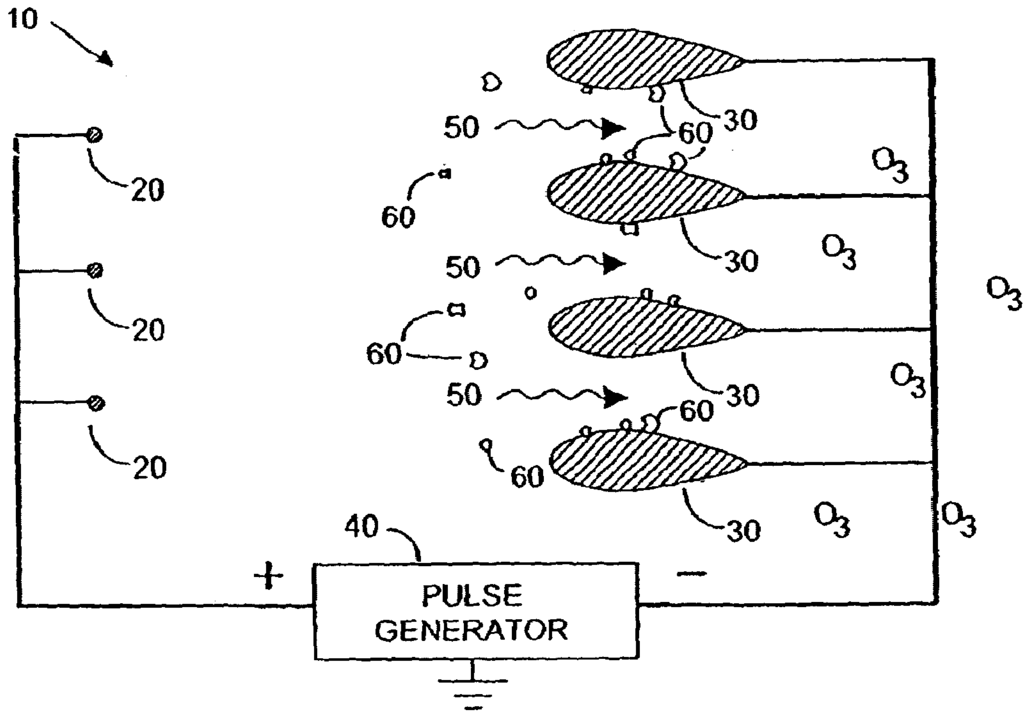


FIG. 1A (PRIOR ART)

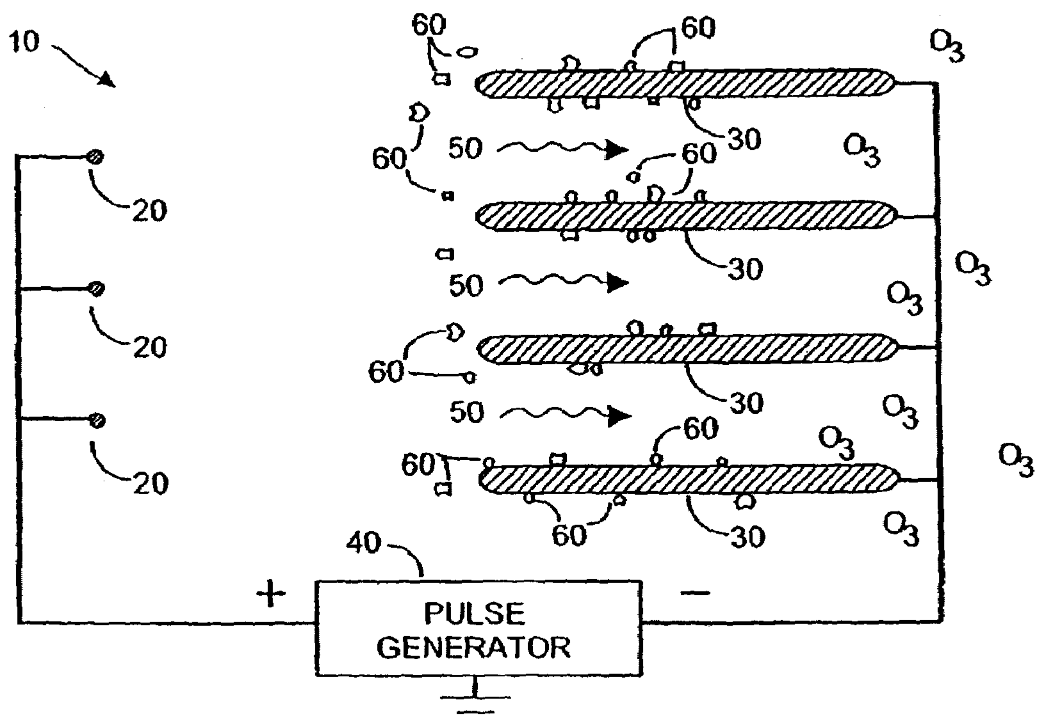


FIG. 1B (PRIOR ART)

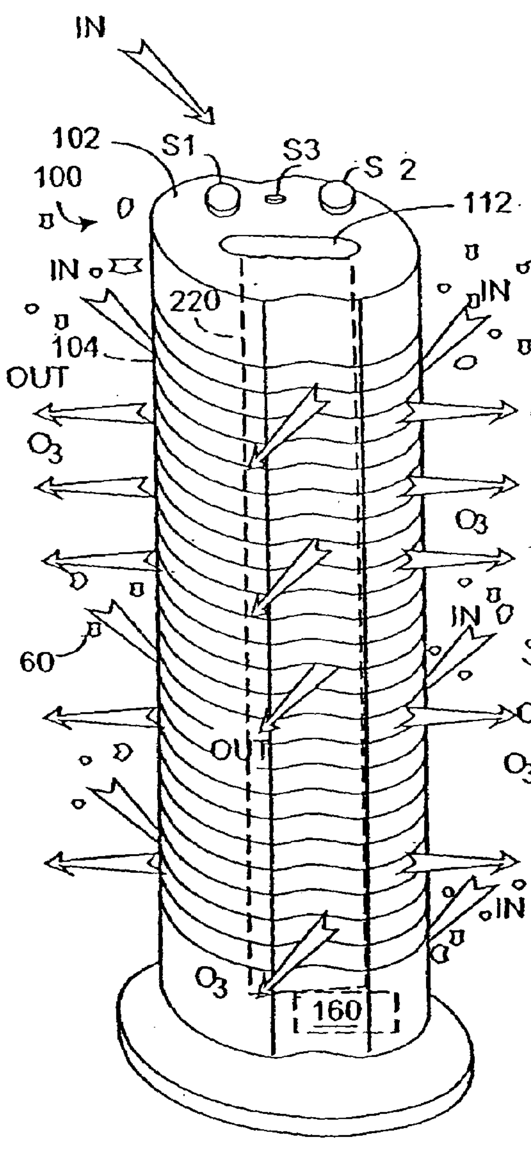

IN
102
S1
S3
S 2
100
112
60
IN
IN
220
104
OUT
OUT
O_3
O_3
OUT
IN
60
60
OUT
OUT
O_3
IN
O_3
160

FIG. 2A

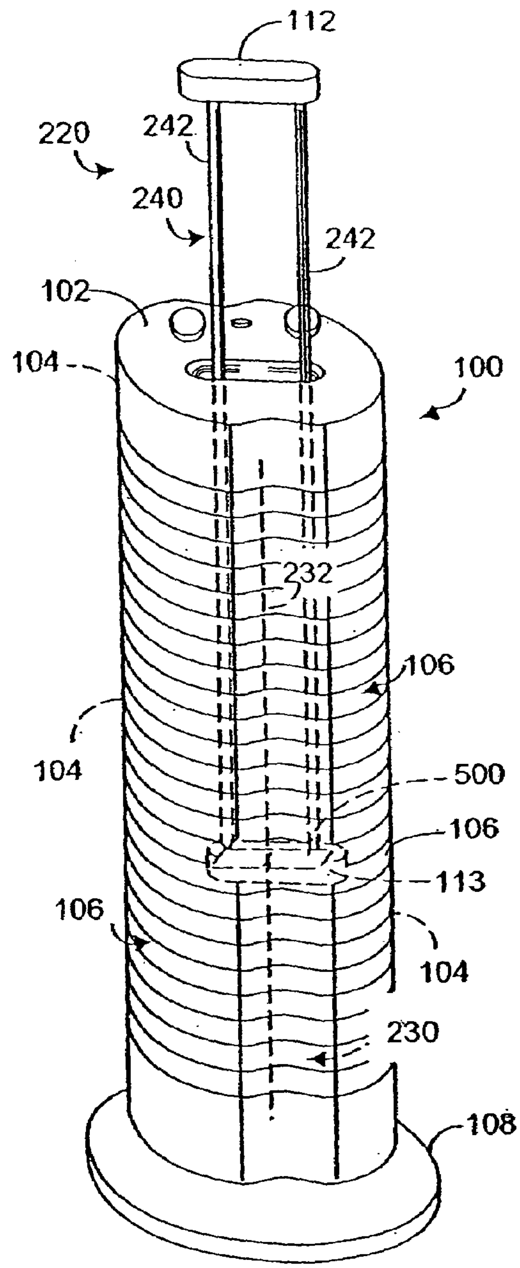
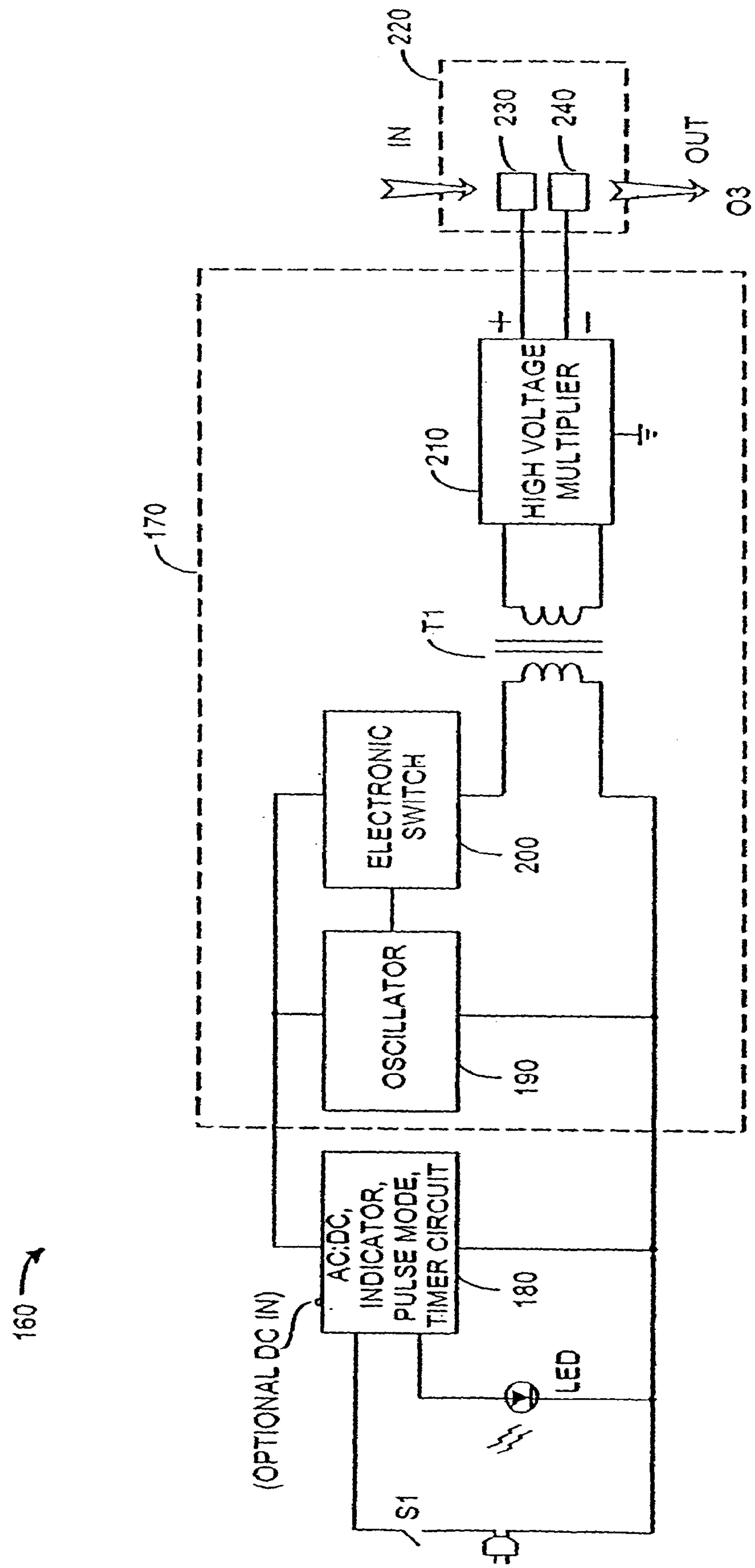
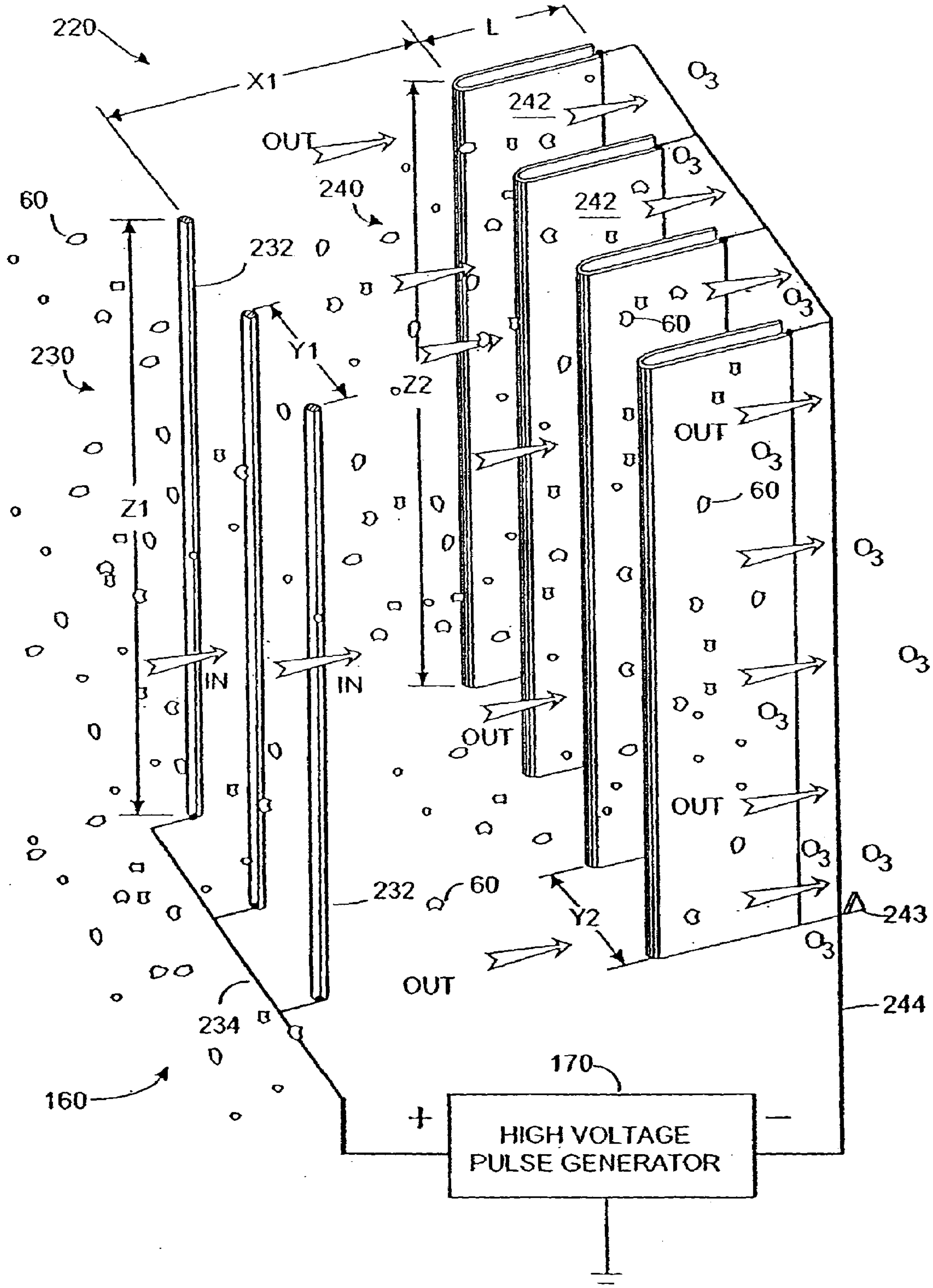

112
220
242
240
242
102
104
100
232
106
104
500
106
113
106
104
230
108

FIG. 2B



220
IN
230
240
OUT
O3
170
+
-
210
HIGH VOLTAGE MULTIPLIER
T1
ELECTRONIC SWITCH
200
OSCILLATOR
190
AC:DC, INDICATOR, PULSE MODE, TIMER CIRCUIT
180
(OPTIONAL DC IN)
LED
S1
160

FIG. 3



220
L
X1
O_3
242
OUT
240
60
232
230
Y1
Z2
Z1
IN
IN
OUT
60
232
60
Y2
243
234
244
160
170
+
−
HIGH VOLTAGE
PULSE GENERATOR

FIG. 4A

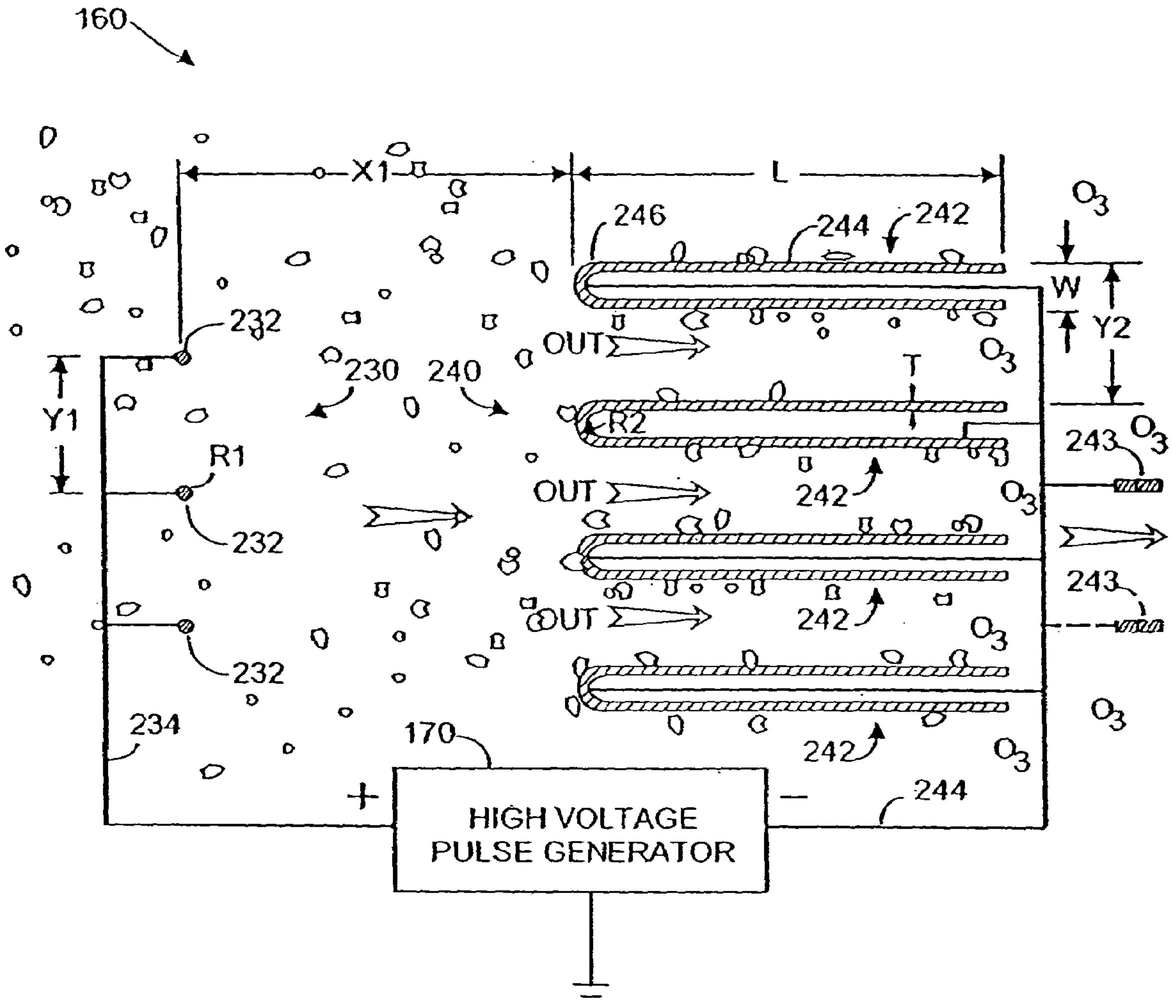

160
X1
L
246
244
242
O_3
W
Y2
232
OUT
230
240
T
Y1
R2
243
R1
OUT
242
232
OUT
242
232
234
170
242
244
+
−
HIGH VOLTAGE
PULSE GENERATOR

FIG. 4B

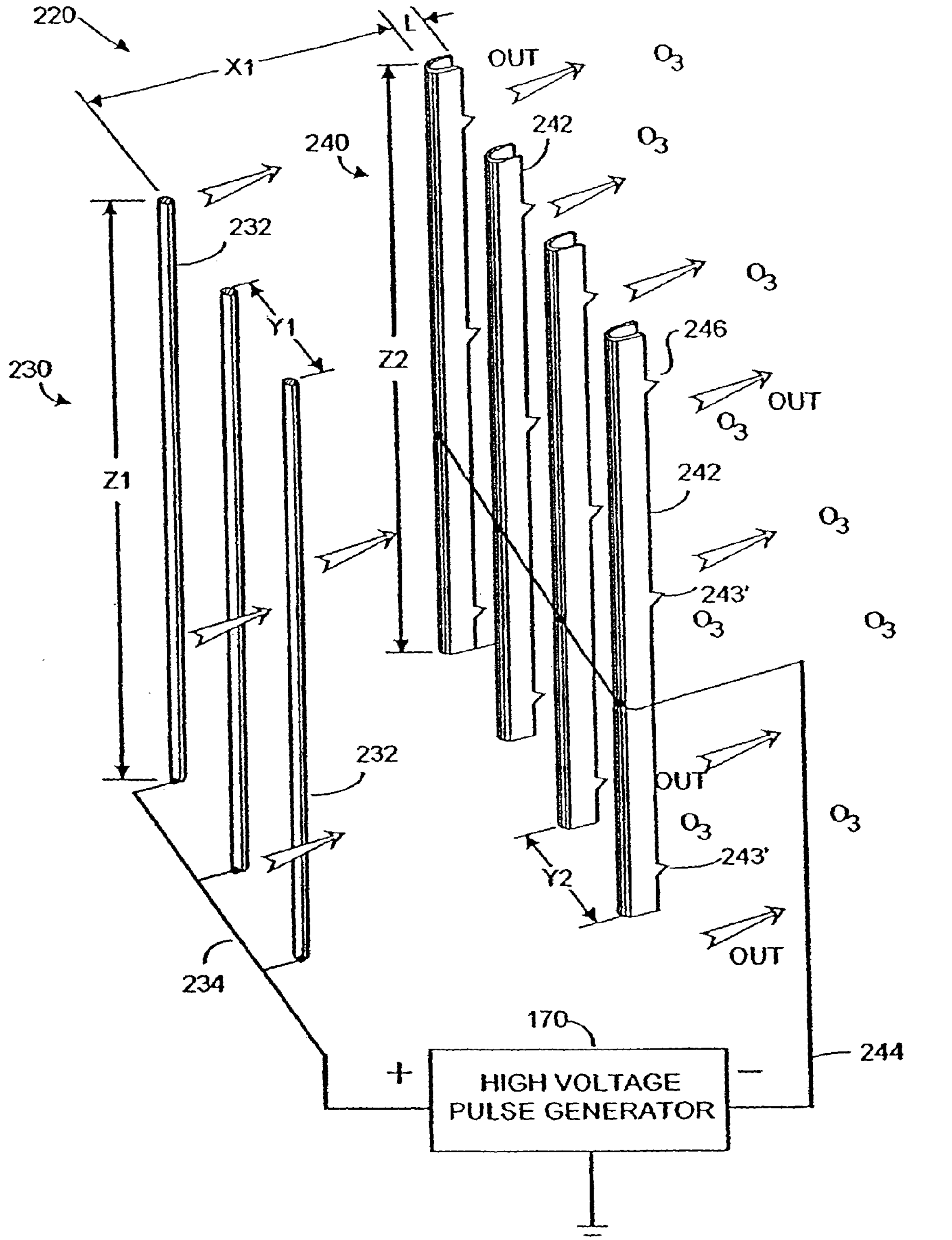

220
X1
L
OUT
O_3
240
242
O_3
232
O_3
Y1
Z2
246
230
OUT
O_3
Z1
242
O_3
243'
O_3
O_3
232
OUT
O_3
O_3
243'
Y2
OUT
234
170
244
+
HIGH VOLTAGE
PULSE GENERATOR
−

FIG. 4C

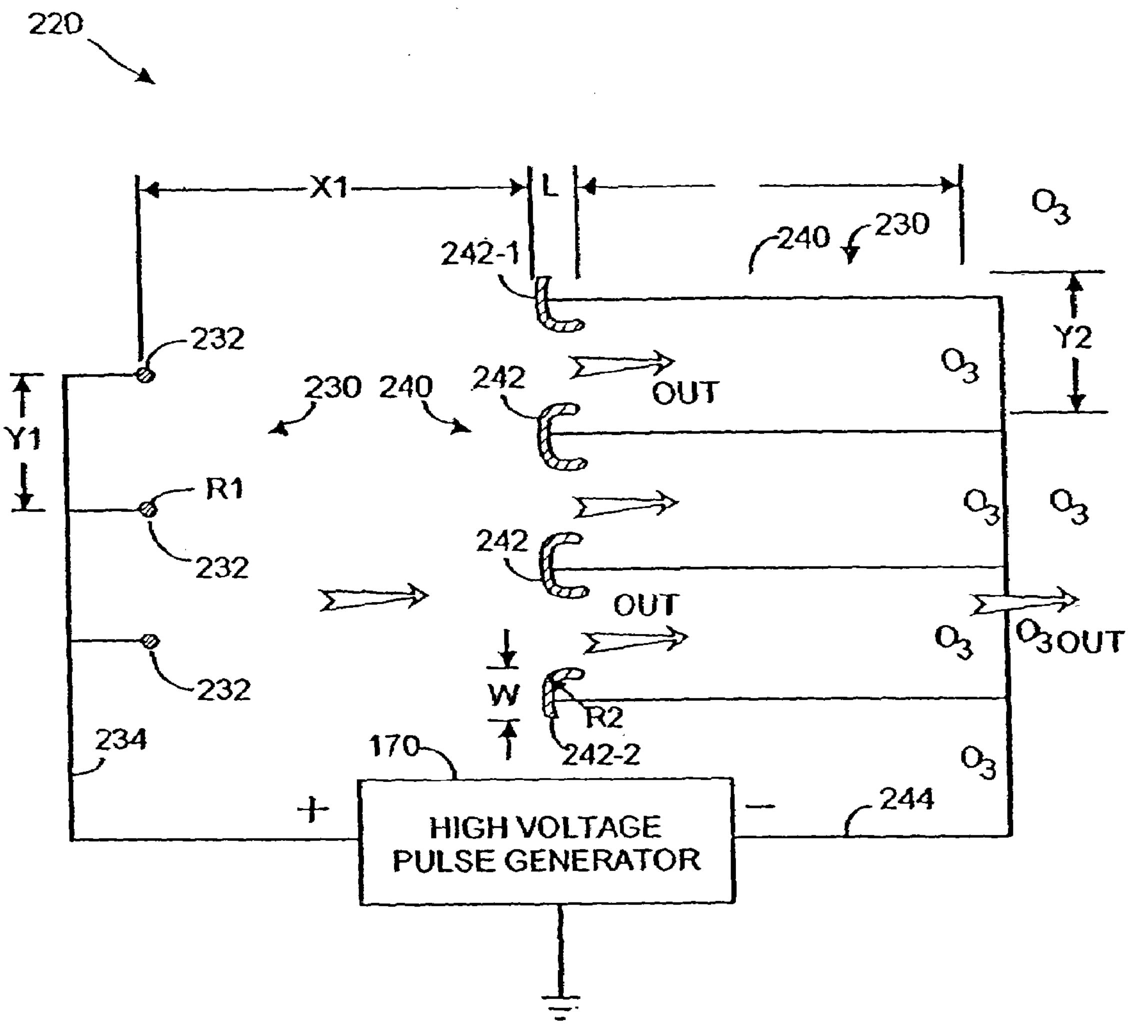

220
X1
L
O_3
240
230
242-1
Y2
232
230 240
242
OUT
O_3
Y1
R1
232
O_3
O_3
242
OUT
O_3
O_3OUT
232
W
R2
242-2
234
170
O_3
244
+
−
HIGH VOLTAGE
PULSE GENERATOR

FIG. 4D

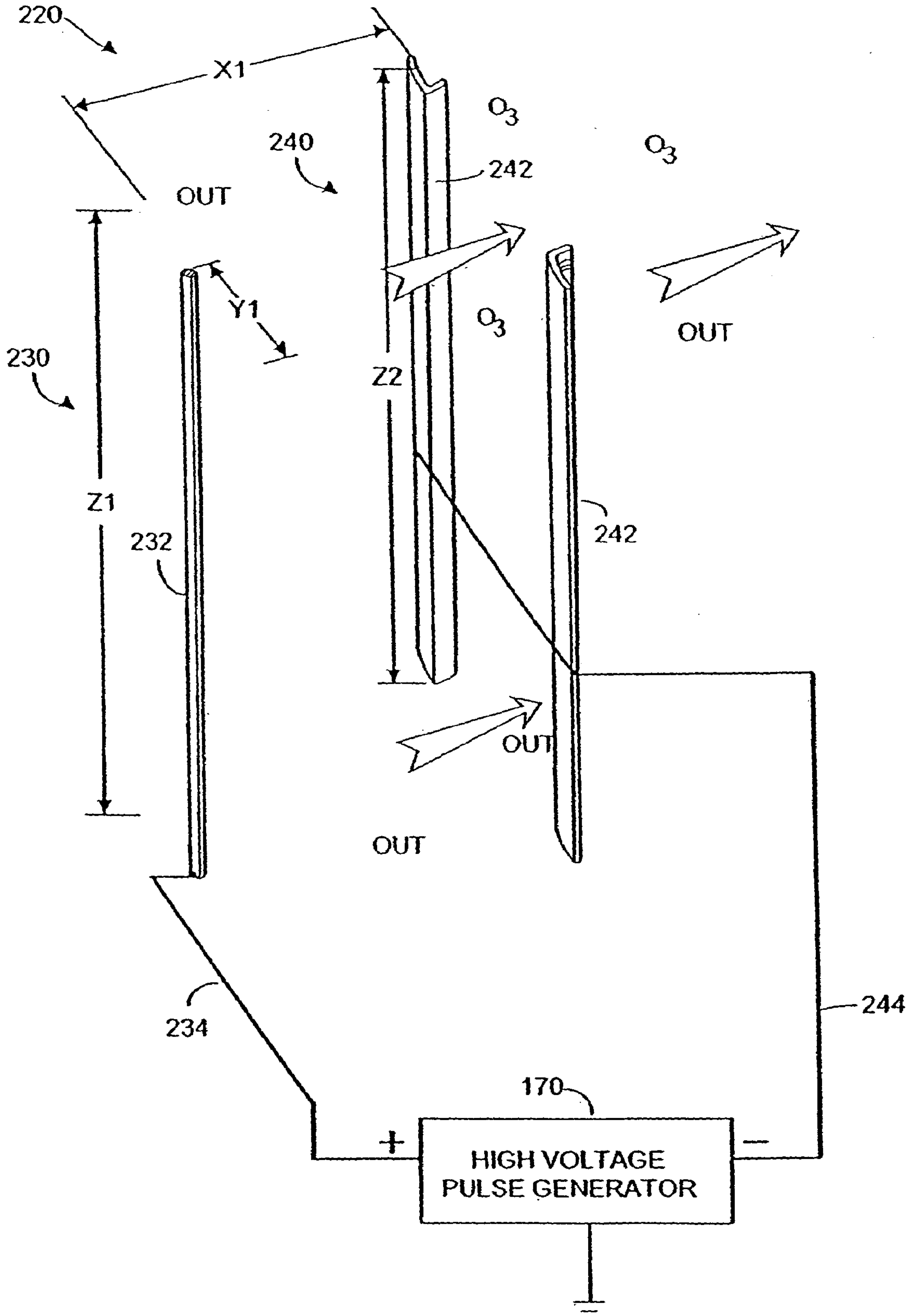

220
X1
240
242
O_3
O_3
OUT
230
Y1
O_3
OUT
Z2
Z1
232
242
OUT
OUT
234
244
170
+
−
HIGH VOLTAGE
PULSE GENERATOR

FIG. 4E

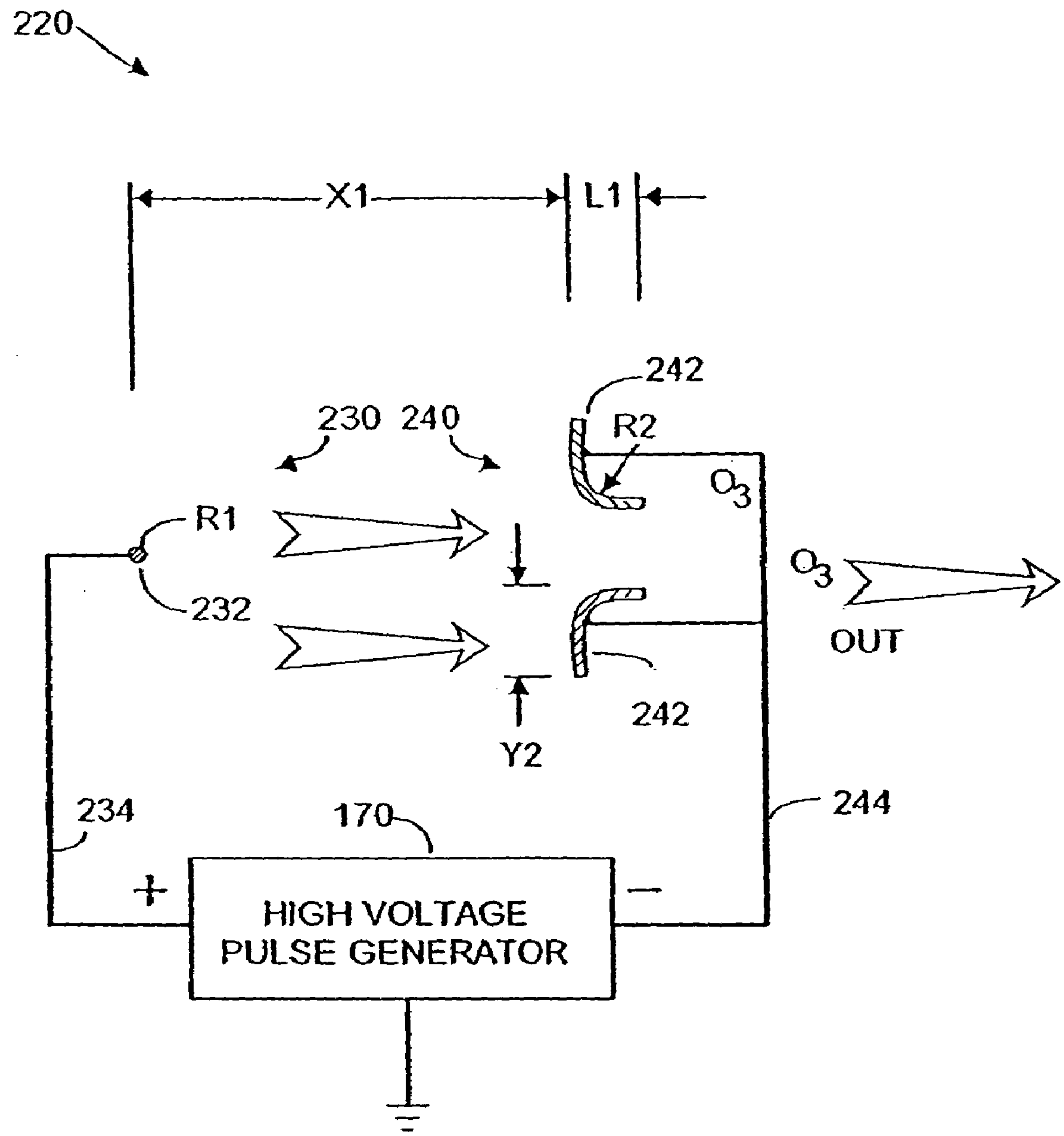

220
X1
L1
242
230 240
R2
O_3
R1
O_3
232
OUT
242
Y2
234
170
244
+
−
HIGH VOLTAGE
PULSE GENERATOR

FIG. 4F

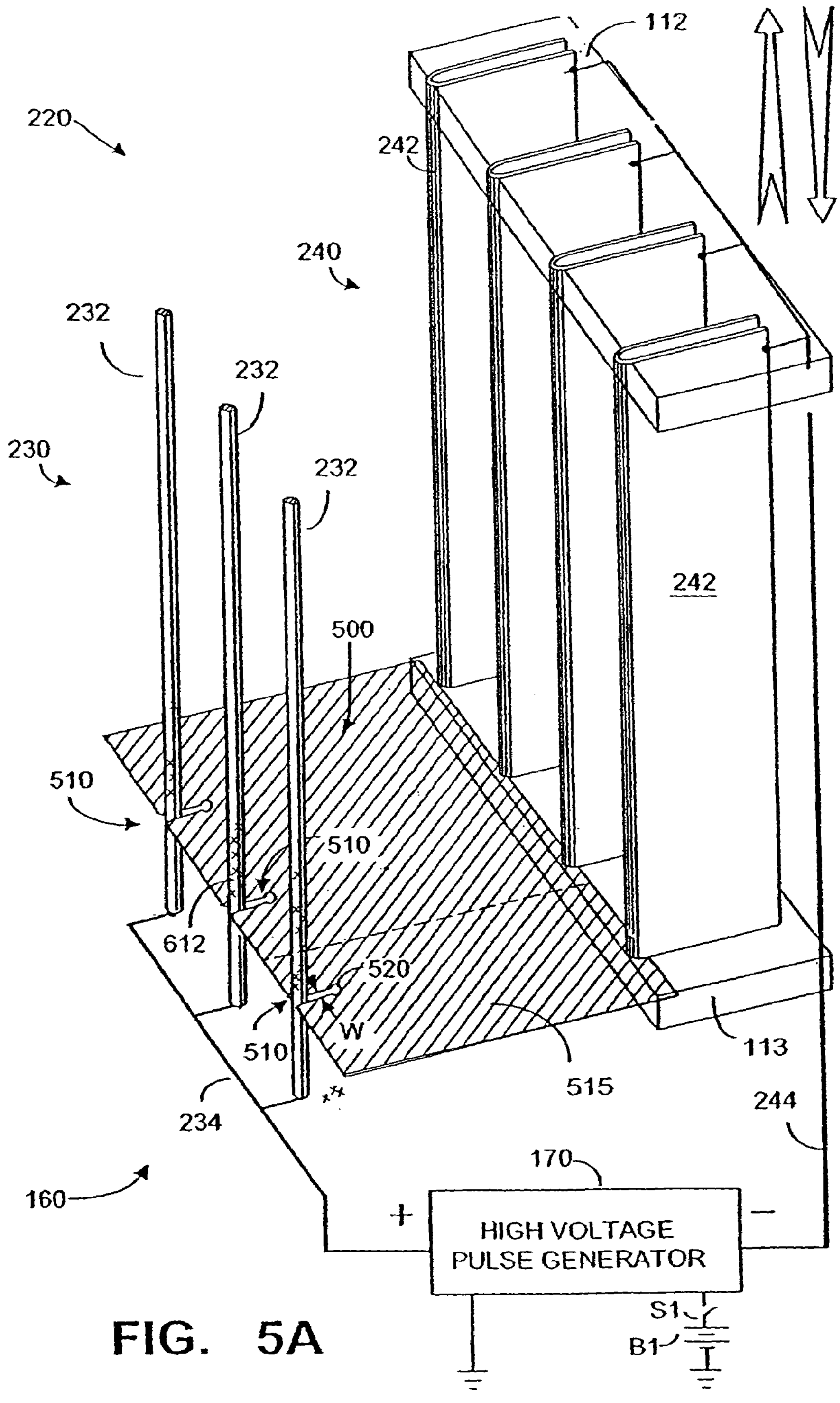

112
220
242
240
232
232
230
232
242
500
510
510
612
520
W
510
113
515
234
244
160
170
+
−
HIGH VOLTAGE
PULSE GENERATOR
S1
B1

FIG. 5A

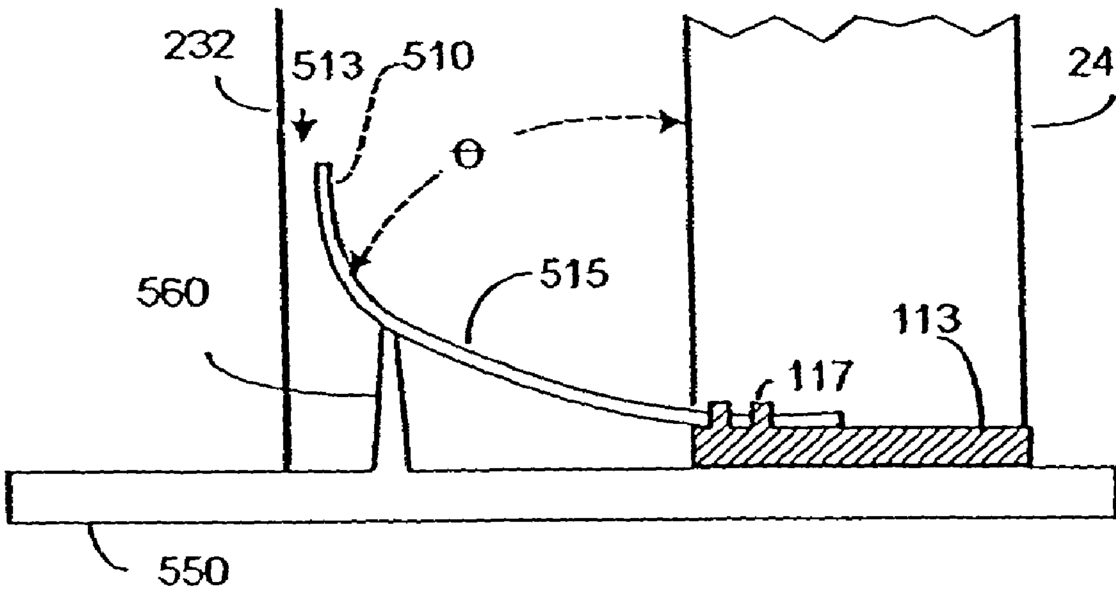


FIG. 5B

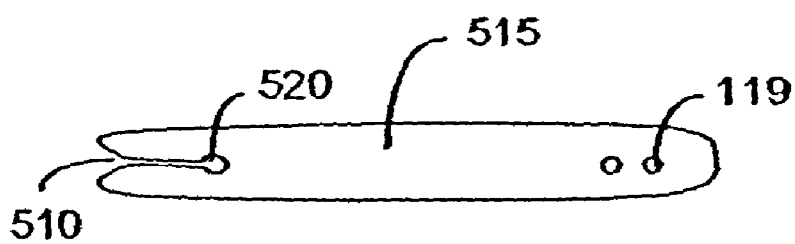


FIG. 5C

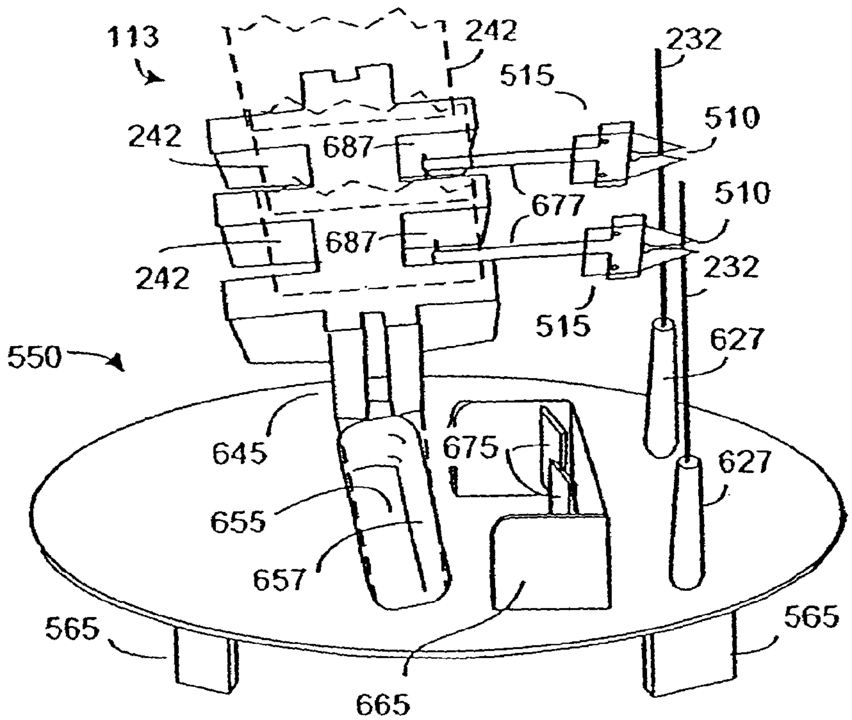

113
242
232
515
510
242
687
677
510
687
242
232
515
627
550
645
675
627
655
657
565
565
665

FIG. 6A

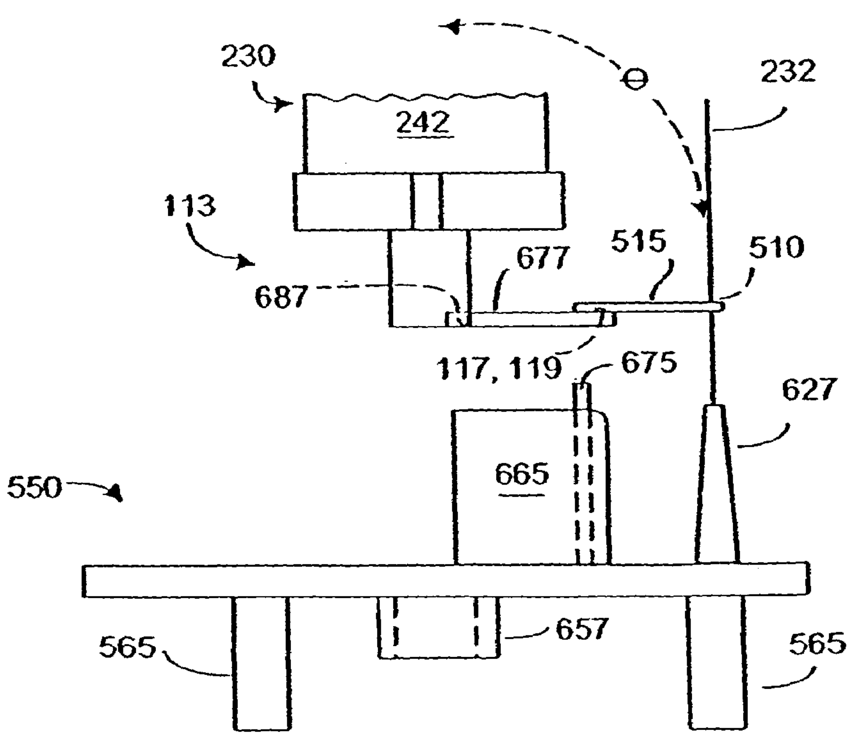

θ
232
230
242
113
677
515
510
687
117, 119
675
627
665
550
657
565
565

FIG. 6B

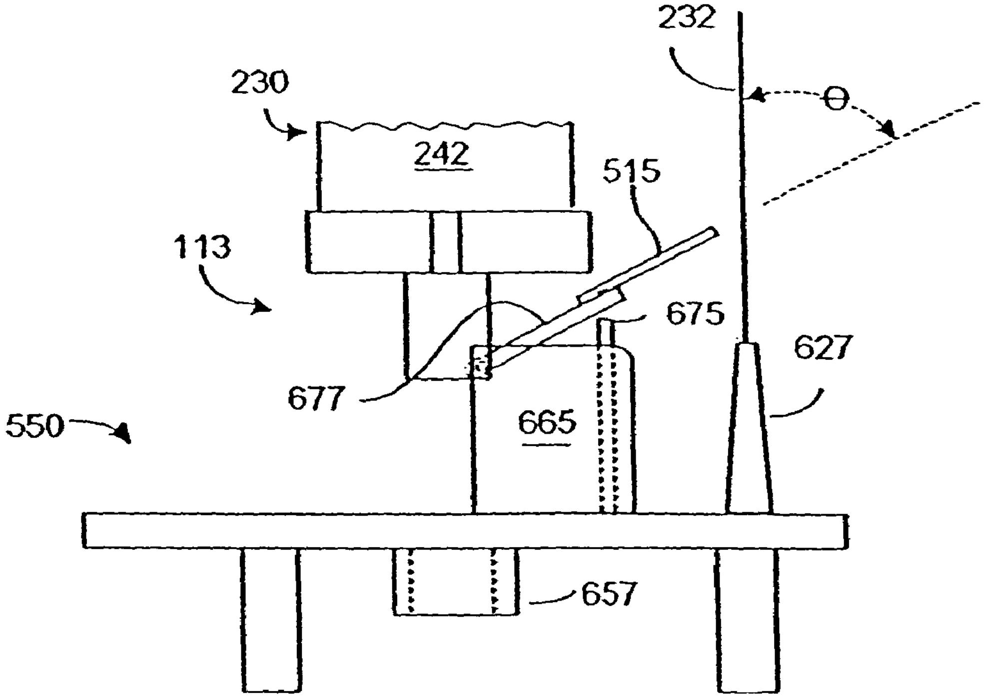

232
230
242
515
113
675
627
677
665
550
657

FIG. 6C

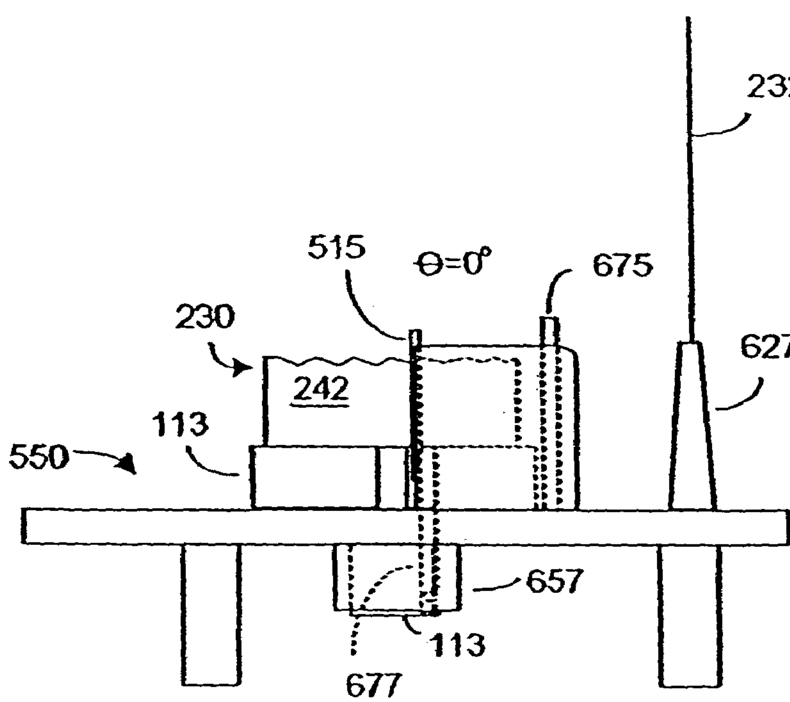

232
515
$\Theta=0°$
675
230
627
242
113
550
657
113
677

FIG. 6D

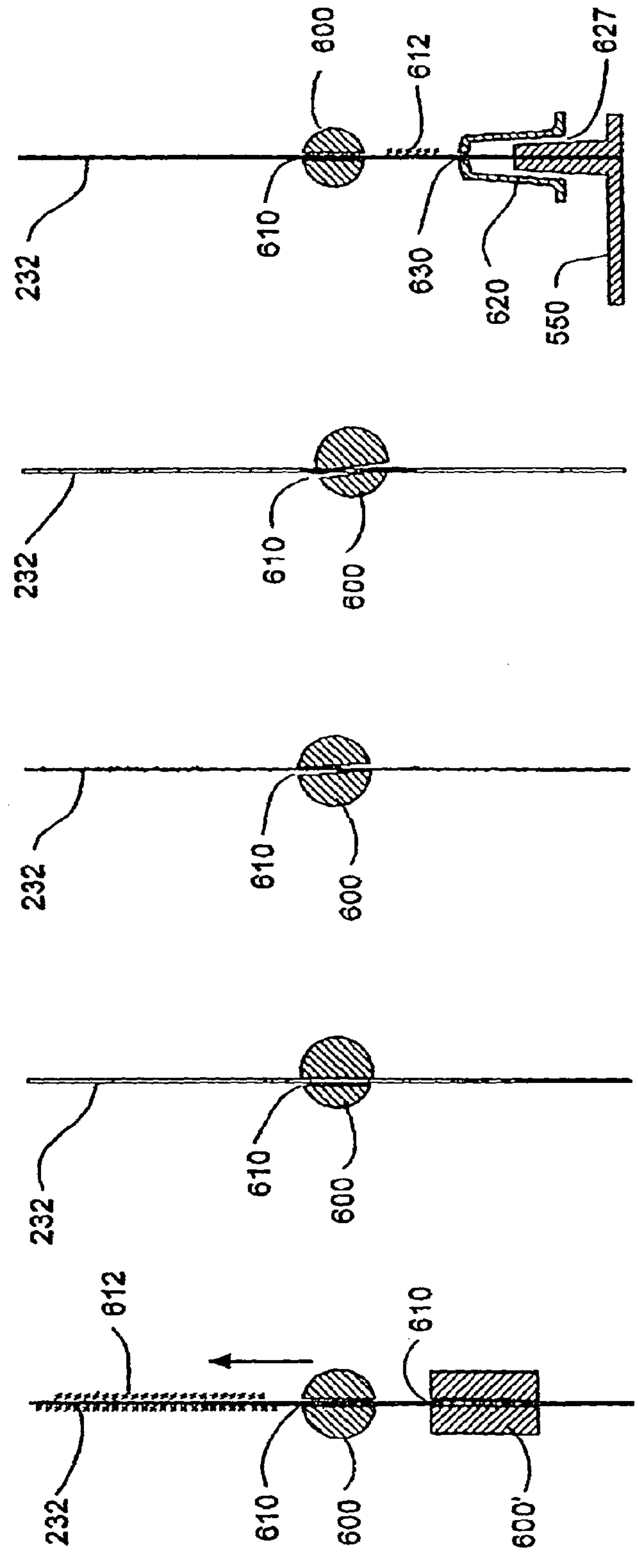


FIG. 7A FIG. 7B FIG. 7C FIG. 7D FIG. 7E

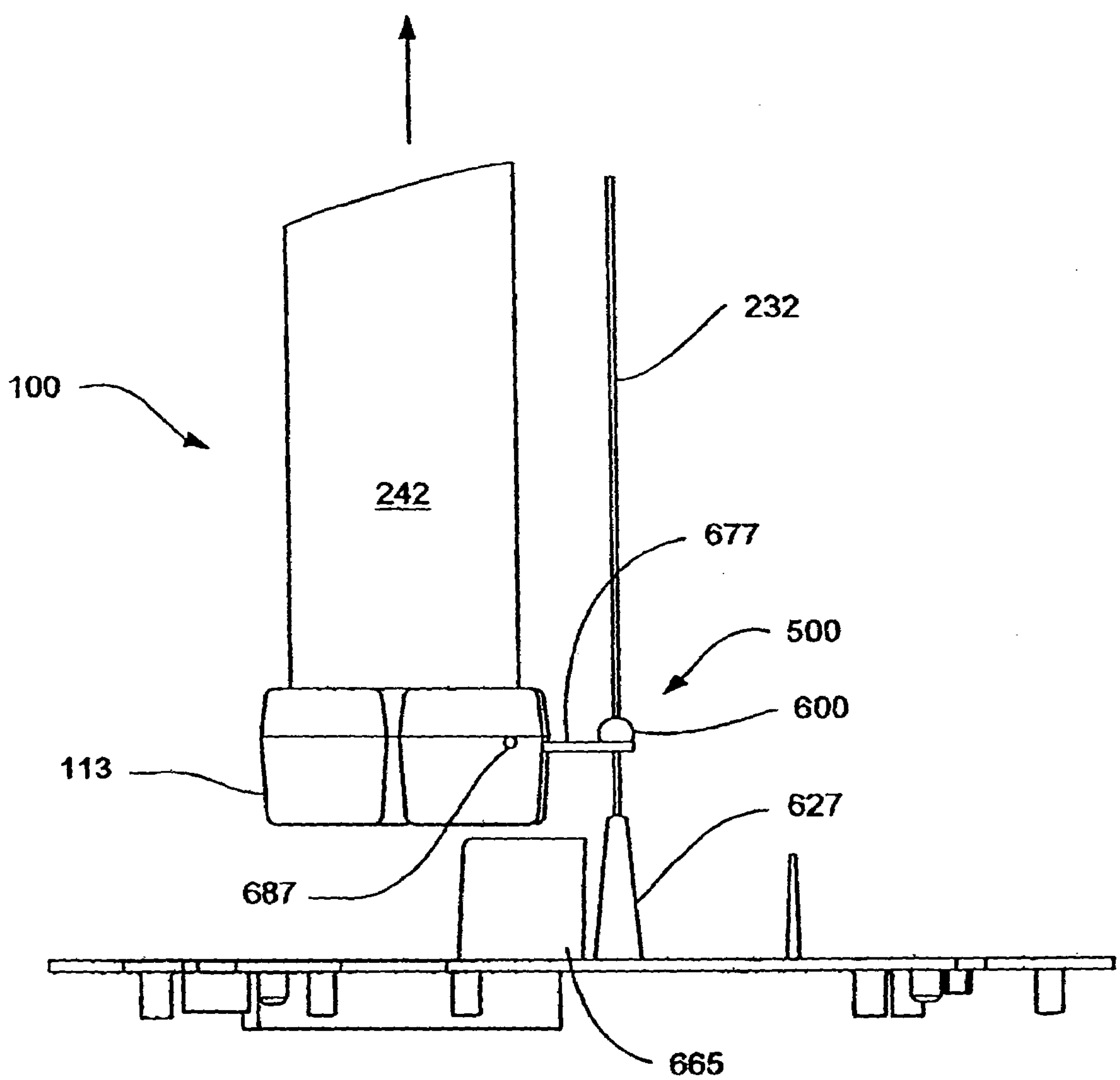


FIG. 8A

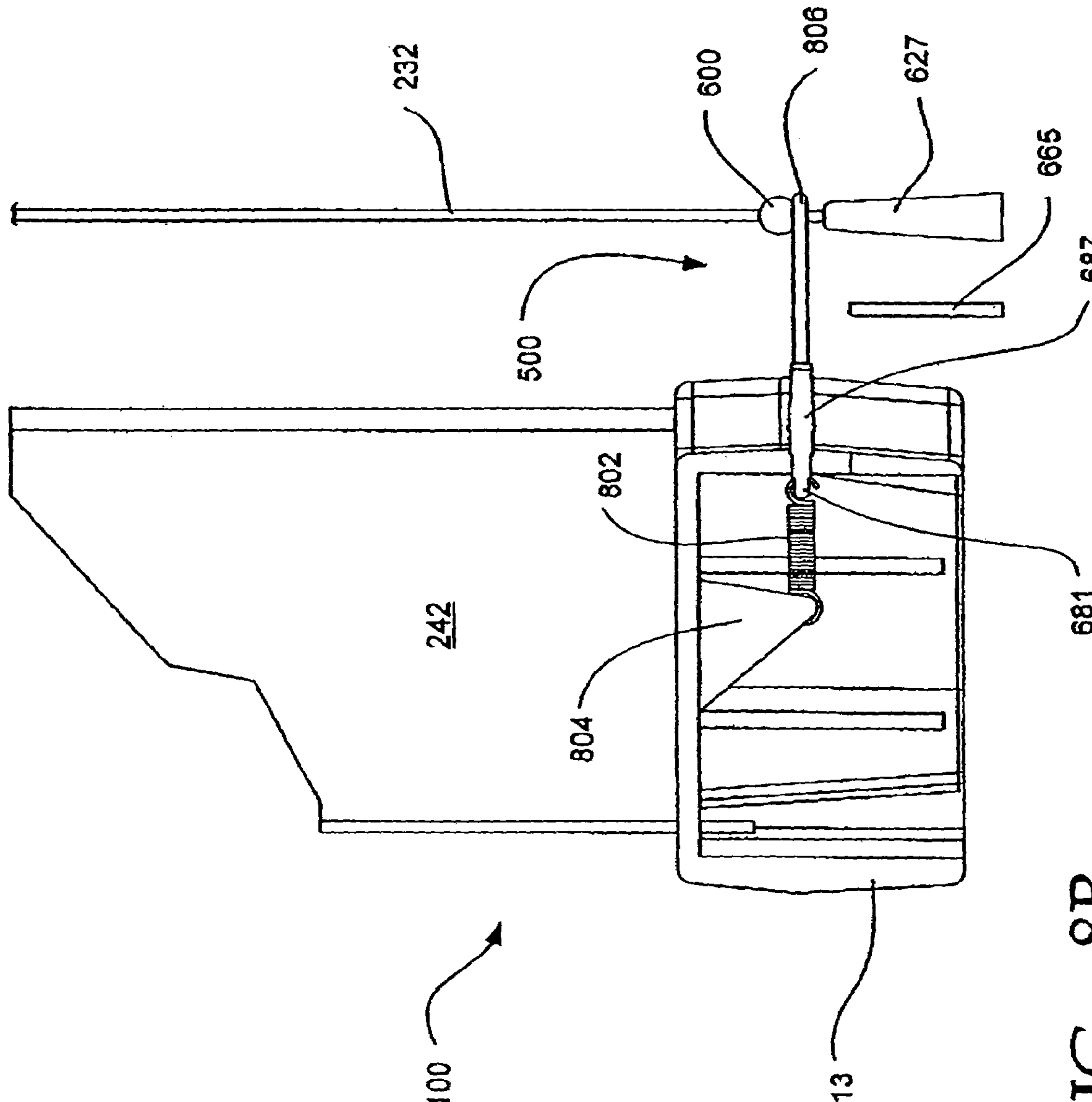


FIG. 8B

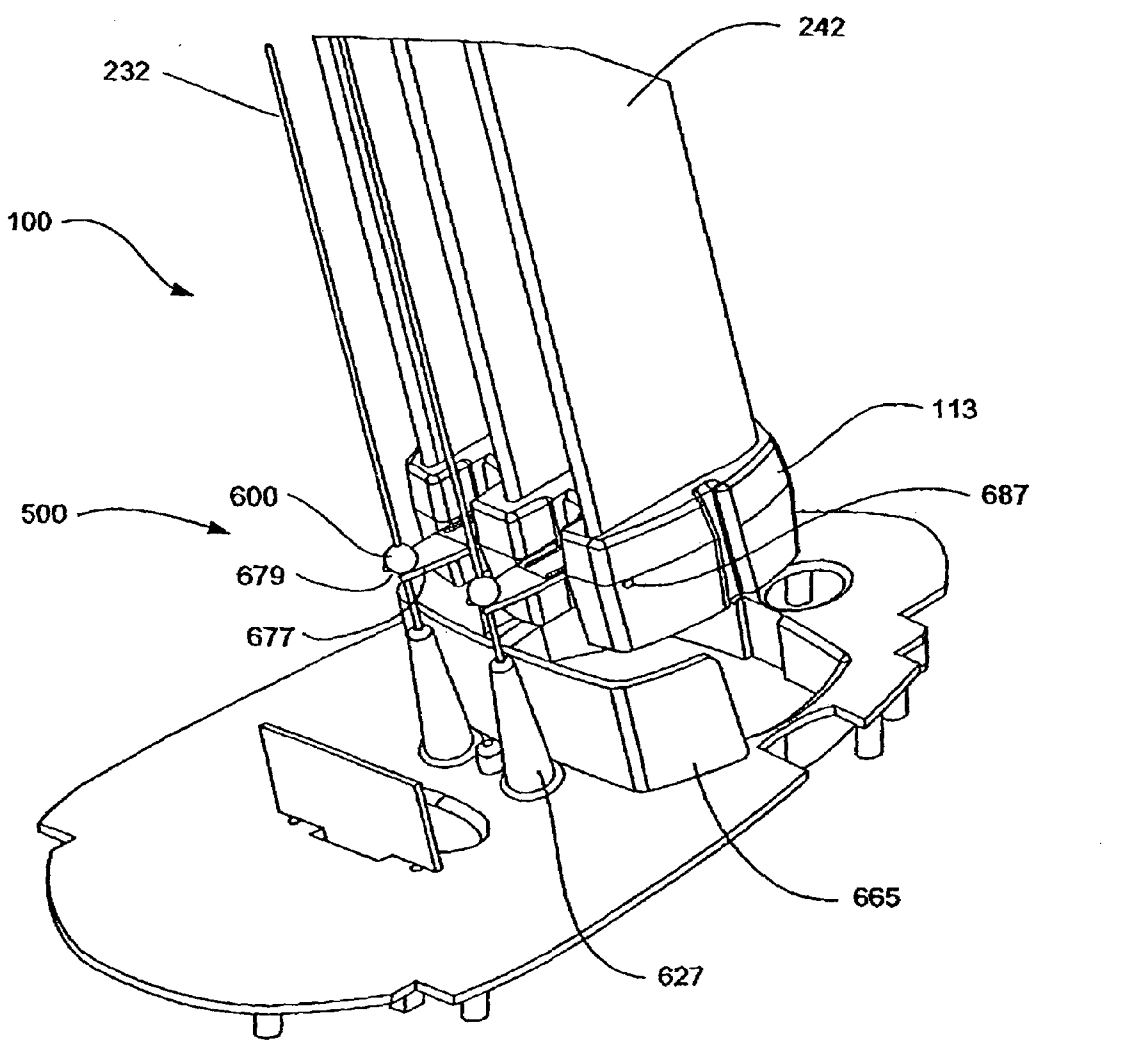


FIG. 8C

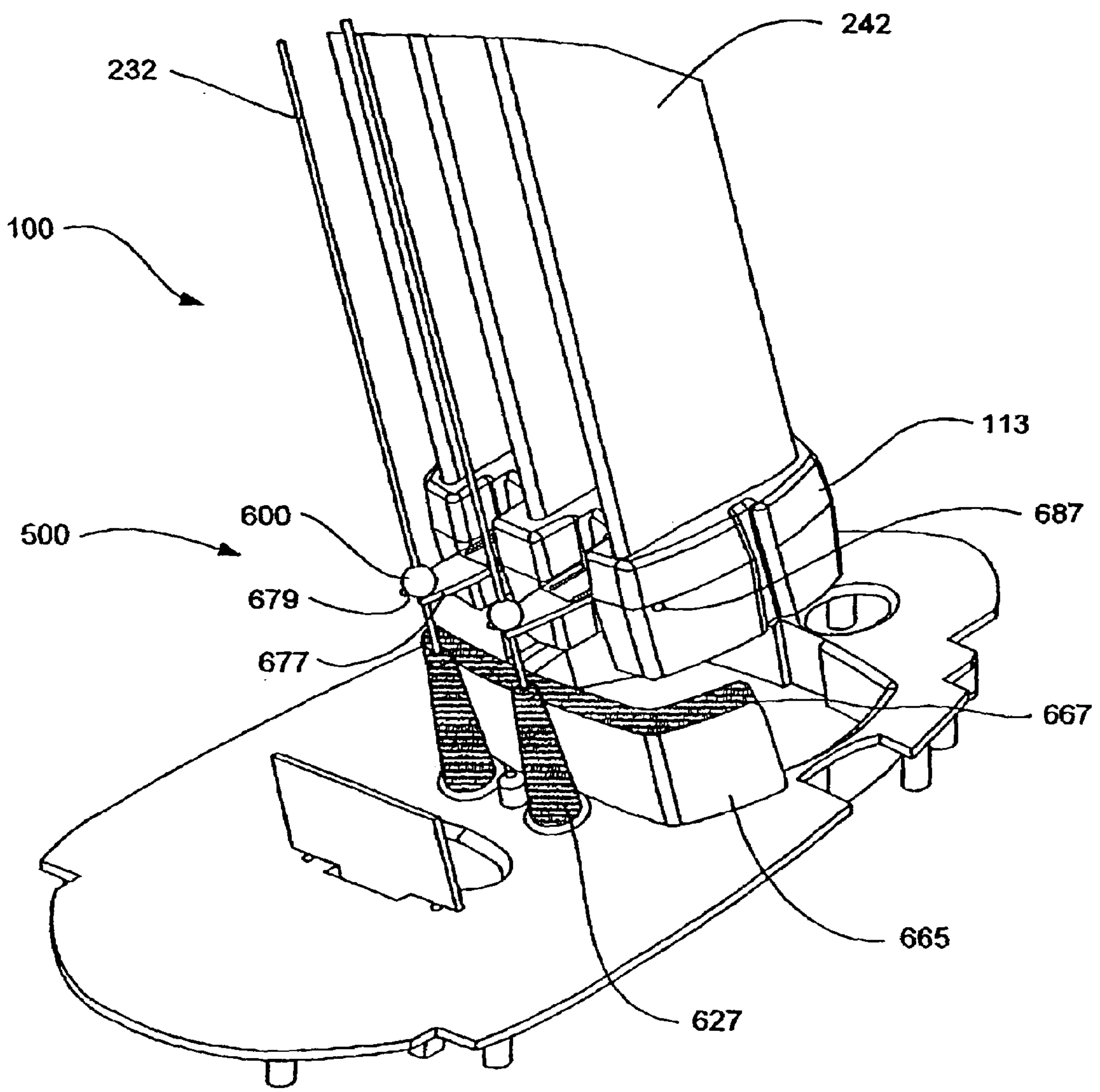


FIG. 8D

ELECTRODE SELF-CLEANING MECHANISMS WITH ANTI-ARC GUARD FOR ELECTRO-KINETIC AIR TRANSPORTER-CONDITIONER DEVICES

PRIORITY CLAIM

This application claims priority from U.S. Provisional Patent Application No. 60/470,519, filed May 14, 2003; is a continuation-in-part of U.S. patent application Ser. No. 10/278,193, filed Oct. 21, 2002, now U.S. Pat. No.6,749,667 which claims benefit of U.S. Provisional Patent Application No. 60/391,070, filed Jun. 20, 2002. This application is a continuation-in-part of U.S. patent application Ser. No. 10/074,347, filed Feb. 12, 2002, now U.S. Pat. No. 6,911, 186, which claims priority to U.S. Provisional Patent Application Ser. No. 60/340,702, filed Dec. 13, 2001; U.S. Provisional Application Ser. No. 60/306,479, filed Jul. 18, 2001; is a continuation-in-part of U.S. patent application Ser. No. 09/774,198, filed Jan. 29, 2001, now U.S. Pat. No. 6,544, 485; and is a continuation-in-part of U.S. patent application Ser. No. 09/924,624, filed Aug. 8, 2001, which is a continuation of U.S. patent application Ser. No. 09/564,960 filed May 4, 2000, now U.S. Pat. No. 6,350,417, which is a continuation-in-part of U.S. patent application Ser. No. 09/186,471 filed Nov. 5, 1998, now U.S. Pat. No. 6,176,977. Each of the patents and applications cited above is hereby incorporated herein, in its entirety, by reference.

CROSS-REFERENCE To RELATED APPLICATIONS

This application is related to U.S. patent application Ser. No. 09/924,600 filed Aug. 8, 2001, now U.S. Pat. No. 6,709,484, which is a continuation of U.S. patent application Ser. No. 09/564,960 filed May 4, 2000, now U.S. Pat. No. 6,350,417 B1 which is a continuation-in-part of U.S. patent application Ser. No. 09/186,471, filed Nov. 5,1998, now U.S. Pat. No. 6,176,977. This application is also related to U.S. patent application Ser. No. 09/730,499 filed Dec. 5, 2000, now U.S. Pat. No. 6,713,026, which is a continuation of U.S. application Ser. No. 09/186,471 filed Nov. 5, 1998, now U.S. Pat. No. 6,176,977. This application is also related to U.S. Provisional Patent Application No. 60/391,070, filed Jun. 20, 2002. All of the above references are incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates generally to devices that produce ozone and an electro-kinetic flow of air from which particulate matter has been substantially removed, and more particularly to cleaning the wire or wire-like electrodes present in such devices.

BACKGROUND OF THE INVENTION

The use of an electric motor to rotate a fan blade to create an air flow has long been known in the art. Unfortunately, such fans produce substantial noise, and can present a hazard to children who can be tempted to poke a finger or a pencil into the moving fan blade. Although such fans can produce substantial air flow, e.g., 1,000 ft^3/minute or more, substantial electrical power is required to operate the motor, and essentially no conditioning of the flowing air occurs.

It is known to provide such fans with a HEPA-compliant filter element to remove particulate matter larger than perhaps 0.3 μm. Unfortunately, the resistance to air flow presented by the filter element can require doubling the electric motor size to maintain a desired level of airflow. Further, HEPA-compliant filter elements are expensive, and can represent a substantial portion of the sale price of a HEPA-compliant filter-fan unit. While such filter-fan units can condition the air by removing large particles, particulate matter small enough to pass through the filter element is not removed, including bacteria, for example.

It is also known in the art to produce an air flow using electro-kinetic techniques, by which electrical power is directly converted into a flow of air without mechanically moving components. One such system is described in U.S. Pat. No. 4,789,801 to Lee (1988), depicted herein in simplified form as FIGS. **1**A and **1**B. Lee's system **10** includes an array of small area ("minisectional") electrodes **20** that are spaced-apart symmetrically from an array of larger area ("maxisectional") electrodes **30**. The positive terminal of a pulse generator **40** that outputs a train of high voltage pulses (e.g., 0 to perhaps +5 KV) is coupled to the minisectional array, and the negative pulse generator terminal is coupled to the maxisectional array.

The high voltage pulses ionize the air between the arrays, and an air flow **50** from the minisectional array toward the maxisectional array results, without requiring any moving parts. Particulate matter **60** in the air is entrained within the airflow **50** and also moves towards the maxisectional electrodes **30**. Much of the particulate matter is electrostatically attracted to the surface of the maxisectional electrode array, where it remains, thus conditioning the flow of air exiting system **10**. Further, the high voltage field present between the electrode arrays can release ozone into the ambient environment, which appears to destroy or at least alter whatever is entrained in the airflow, including for example, bacteria.

In the embodiment of FIG. **1**A, minisectional electrodes **20** are circular in cross-section, having a diameter of about 0.003" (0.08 mm), whereas the maxisectional electrodes **30** are substantially larger in area and define a "teardrop" shape in cross-section. The ratio of cross-sectional radii of curvature between the maxisectional and minisectional electrodes, from Lee's figures, appears to exceed 10:1. As shown in FIG. **1**A herein, the bulbous front surfaces of the maxisectional electrodes face the minisectional electrodes, and the somewhat sharp trailing edges face the exit direction of the air flow. The "sharpened" trailing edges on the maxisectional electrodes apparently promote good electrostatic attachment of particular matter entrained in the airflow. Lee does not disclose how the teardrop shaped maxisectional electrodes are fabricated, but presumably it is produced using a relatively expensive mold-casting or an extrusion process.

In another embodiment shown herein as FIG. **1**B, Lee's maxisectional sectional electrodes **30** are symmetrical and elongated in cross-section. The elongated trailing edges on the maxisectional electrodes provide increased area upon which particulate matter entrained in the airflow can attach. Lee states that precipitation efficiency and desired reduction of anion release into the environment can result from including a passive third array of electrodes **70**. Understandably, increasing efficiency by adding a third array of electrodes will contribute to the cost of manufacturing and maintaining the resultant system.

While the electrostatic techniques disclosed by Lee are advantageous over conventional electric fan-filter units, Lee's maxisectional electrodes are relatively expensive to fabricate. Further, increased filter efficiency beyond what

Lee's embodiments can produce would be advantageous, especially without including a third array of electrodes.

The invention in applicants' parent application provided a first and second electrode array configuration electro-kinetic air transporter-conditioner having improved efficiency over Lee-type systems, without requiring expensive production techniques to fabricate the electrodes. The condition also permitted user-selection of acceptable amounts of ozone to be generated.

The second array electrodes were intended to collect particulate matter and to be user-removable from the transporter-conditioner for regular cleaning to remove such matter from the electrode surfaces. However, in this configuration, the user must take care to ensure that if the second array electrodes are cleaned with water, that the electrodes are thoroughly dried before reinsertion into the transporter-conditioner unit. If the unit were turned on while moisture from newly cleaned electrodes was allowed to pool within the unit, and moisture wicking could result in high voltage arcing from the first to the second electrode arrays, with possible damage to the unit.

The wire or wire-like electrodes in the first electrode array are less robust than the second array electrodes. (The terms "wire" and "wire-like" shall be used interchangeably herein to mean an electrode either made from a wire or, if thicker or stiffer than a wire, having the appearance of a wire.) In embodiments in which the first array electrodes were user-removable from the transporter-conditioner unit, care was required during cleaning to prevent excessive force from simply snapping the wire electrodes. But eventually the first array electrodes can accumulate a deposited layer or coating of fine ash-like material.

If this deposit is allowed to accumulate, eventually efficiency of the conditioner-transporter will be degraded. Further, for reasons not entirely understood, such deposits can produce an audible oscillation that can be annoying to persons near the conditioner-transporter.

Further, there is a need for a mechanism by which the wire electrodes in the first electrode array of a conditioner-transporter can be periodically cleaned. Preferably such cleaning mechanism should be straightforward to implement, should not require removal of the first array electrodes from the conditioner-transporter, and should be operable by a user on a periodic basis.

SUMMARY OF THE INVENTION

The present invention is directed to improvements with respect to the state of the art. In particular, the present invention includes an air cleaner having at least an emitter electrode and at least a collector electrode. An embodiment of the invention includes a bead or other object having a bore therethrough, with the emitter electrode provided through said bore of the bead or other object. A bead or object moving arm is provided in the air cleaner and is operatively associated with the bead or object, in order to move the bead or object relative to the emitter electrode in order to clean the emitter electrode.

In another aspect of the invention, the collector electrode is removable from the air-cleaner for cleaning and the bead or object moving arm is operatively associated with the collector electrode such as the collector electrode is removed from the air cleaner, the bead or object moving arm moves said bead or object in order to clear said emitter electrode.

In a further aspect of the invention, the air cleaner includes a housing with a top and a base, wherein the collector electrode is movable through the top in order to be cleaned, and wherein such collector electrode is removed from the top, said bead or object moving arm moves said bead or object towards the top in order to clean the emitter electrode.

In yet a further aspect of the invention, the emitter electrode has a bottom end stop on which said bead can rest when the bead is at the bottom of the emitter electrode. The bead moving arm is moveably mounted to the collector electrode such that with the bead or object resting on said bottom end stop, said bead or object moving arm can move past said bead or object and reposition under said bead or object in preparation for moving said bead or object to clean said emitter electrode.

In a further aspect of the invention, a method to clean an air-cleaner, which air cleaner has a housing with a top and base, and wherein said air cleaner includes a first electrode, a second electrode array, and a bead or object mounted on the first electrode and a bead or object moving arm mounted on the second electrode array, includes the steps of removing said second electrode array from the top of said housing, and simultaneously moving said bead or object along the first electrode as urged by the bead or object moving arm in order to clean said first electrode.

A further aspect of the invention includes insulation of main elements to prevent high voltage arcing, namely the pylons that support the emitter electrodes, the barrier wall between the emitter and collector electrodes and adjacent to the collector electrodes, or the lip on the upper edge of the barrier wall, and the beads used for cleaning the emitter electrodes. In particular, care is taken to prevent high voltage arcing caused by insects attracted to the UV light from a UV light source. Accordingly, in this embodiment of the invention, insulation is used either to cast or coat the barrier wall and the pylons to avoid electrical discharge.

Other features and advantages of the invention will appear from the following description in which embodiments have been set forth in detail, in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a plan, cross-sectional view, of a first embodiment of a prior art electro-kinetic air transporter-conditioner system, according to the prior art.

FIG. **1**B is a plan, cross-sectional view, of a second embodiment of a prior art electro-kinetic air transporter-conditioner system, according to the prior art.

FIG. **2**A is a perspective view of an embodiment of the present invention.

FIG. **2**B is a perspective view of the embodiment of FIG. **2**A, with the second array electrode assembly partially withdrawn depicting a mechanism for self-cleaning the first array electrode assembly, according to the present invention.

FIG. **3** is an electrical block diagram of the present invention.

FIG. **4**A is a perspective block diagram showing a first embodiment for an electrode assembly, according to the present invention.

FIG. **4**B is a plan block diagram of the embodiment of FIG. **4**A.

FIG. **4**C is a perspective block diagram showing a second embodiment for an electrode assembly, according to the present invention.

FIG. **4**D is a plan block diagram of a modified version of the embodiment of FIG. **4**C.

FIG. **4**E is a perspective block diagram showing a third embodiment for an electrode assembly, according to the present invention;

FIG. **4**F is a plan block diagram of the embodiment of FIG. **4**E;

FIG. **5**A is a perspective view of an electrode assembly depicting a first embodiment of a mechanism to clean first electrode array electrodes, according to the present invention.

FIG. **5**B is a side view depicting an electrode cleaning mechanism as shown in FIG. **5**A, according to the present invention.

FIG. **5**C is a plan view of the electrode cleaning mechanism shown in FIG. **5**B, according to the present invention.

FIG. **6**A is a perspective view of a pivotable electrode cleaning mechanism, according to the present invention;

FIGS. **6**B–**6**D are side views depicting the cleaning mechanism of FIG. **6**A in various positions, according to the present invention.

FIGS. **7**A–**7**E depict cross-sectional views of bead-like mechanisms to clean first electrode array electrodes, according to the present invention.

FIG. **8**A depicts a cross sectional view of another embodiment of a cleaning mechanism of the invention illustrating a bead positioned atop a bead lifting arm.

FIG. **8**B depicts a cut away view of the embodiment of the invention of FIG. **8**A illustrating the bead lifting arm.

FIG. **8**C depicts a perspective view of the embodiment of the invention depicted in FIGS. **8**A and **8**B.

FIG. **8**D depicts a perspective view of the embodiment of the invention illustrated in FIGS. **8**A, **8**B, and **8**C, and depicting an insulated barrier, lip of barrier, and pylons.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The following description is presented to enable any person skilled in the art to make and use the invention. Various modifications to the embodiments described will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the present invention as defined in the appended claims. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein. To the extent necessary to afford a complete understanding of the invention disclosed, the specification and drawings of all patents and patent applications cited in this application are incorporated herein by reference.

As a general introduction, applicants' parent application provides an electro-kinetic system for transporting and conditioning air without moving parts. The air is conditioned in the sense that it is ionized and contains appropriate amounts of ozone and removes at least some airborne particles. The electro-kinetic air transporter-conditioner disclosed therein includes a louvered or grilled body that houses an ionizer unit. The ionizer unit includes a high voltage DC inverter that boosts common 110 VAC to high voltage and a generator that receives the high voltage DC and outputs high voltage pulses of perhaps 10 KV peak-to-peak, although an essentially 100% duty cycle (e.g., high voltage DC) output could be used instead of pulses. The unit also includes an electrode assembly unit comprising first and second spaced-apart arrays of conducting electrodes, the first array and second array being coupled, respectively, preferably to the positive and negative output ports of the high voltage generator.

The electrode assembly preferably is formed using first and second arrays of readily manufacturable electrode configurations. In the embodiments relevant to this present application, the first array included wire (or wire-like) electrodes. The second array comprised "U"-shaped or "L"-shaped electrodes having one or two trailing surfaces and intentionally large outer surface areas upon which to collect particulate matter in the air. In the preferred embodiments, the ratio between effective radii of curvature of the second array electrodes to the first array electrodes was at least about 20:1.

The high voltage pulses create an electric field between the first and second electrode arrays. This field produces an electro-kinetic airflow going from the first array toward the second array, the airflow being rich in preferably a net surplus of negative ions and in ozone. Ambient air including dust particles and other undesired components (germs perhaps) enter the housing through the grill or louver openings, and ionized clean air (with ozone) exits through openings on the downstream side of the housing.

The dust and other particulate matter attaches electrostatically to the second array (or collector) electrodes, and the output air is substantially clean of such particulate matter. Further, ozone generated by the transporter-conditioner unit can kill certain types of germs and the like, and also eliminates odors in the output air. Preferably the transporter operates in periodic bursts, and a control permits the user to temporarily increase the high voltage pulse generator output, e.g., to more rapidly eliminate odors in the environment.

Applicants' parent application provided second array electrode units that were very robust and user-removable from the transporter-conditioner unit for cleaning. These second array electrode units could simply be slid up and out of the transporter-conditioner unit, and wiped clean with a moist cloth, and returned to the unit. However on occasion, if electrode units are returned to the transporter-conditioner unit while still wet (from cleaning), moisture pooling can reduce resistance between the first and second electrode arrays to where high voltage arcing results.

Another problem is that over time the wire electrodes in the first electrode array become dirty and can accumulate a deposited layer or coating of fine ash-like material. This accumulated material on the first array electrodes can eventually reduce ionization efficiency. Further, this accumulated coating can also result in the transporter-conditioner unit producing 500 Hz to 5 KHz audible oscillations that can annoy people in the same room as the unit.

In a first embodiment, the present invention extends one or more thin flexible sheets of MYLAR (polyester film) or KAPTON (polyamide) film type material from the lower portion of the removable second array electrode unit. This sheet or sheets faces the first array electrodes and is nominally in a plane perpendicular to the longitudinal axis of the first and second array electrodes. Such sheet material has high voltage breakdown and high dielectric constant, is capable of withstanding high temperature, and is flexible. A slit is cut in the distal edge of this sheet for each first array electrode such that each wire first array electrode fits into a slit in this sheet. Whenever the user removes the second electrode array from the transporter-conditioner unit, the sheet of material is also removed. However, in the removal process, the sheet of material is also pulled upward, and friction between the inner slit edge surrounding each wire tends to scrape off any coating on the first array electrode.

When the second array electrode unit is reinserted into the transporter-conditioner unit, the slits in the sheet automatically surround the associated first electrode array electrode. Thus, there is an up and down scraping action on the first electrode array electrodes whenever the second array electrode unit is removed from, or simply moved up and down within, the transporter-conditioner unit.

Optionally, upwardly projecting pillars can be disposed on the inner bottom surface of the transporter-conditioner unit to deflect the distal edge of the sheet material upward, away from the first array electrodes when the second array electrode unit is fully inserted. This feature reduces the likelihood of the sheet itself lowering the resistance between the two electrode arrays.

In a presently preferred embodiment, the lower ends of the second array electrodes are mounted to a retainer that includes pivotable arms to which a strip of MYLAR or KAPTON type material is attached. Alternatively two overlapping strips of material can be so attached. The distal edge of each strip includes a slit, and the each strip (and the slit therein) is disposed to self-align with an associated wire electrode. A pedestal extends downward from the base of the retainer, and when fully inserted in the transporter-conditioner unit, the pedestal extends into a pedestal opening in a sub-floor of the unit. The first electrode array-facing walls of the pedestal opening urge the arms and the strip on each arm to pivot upwardly, from a horizontal to a vertical disposition. This configuration can improve resistance between the electrode arrays.

Yet another embodiment provides a cleaning mechanism for the wires in the first electrode array in which one or more bead-like members surrounds each wire, the wire electrode passing through a channel in the bead. When the transporter-conditioner unit is inverted, top-for-bottom and then bottom-for-top, the beads slide the length of the wire they surround, scraping off debris in the process. The beads embodiments may be combined with any or all of the various sheets embodiments to provide mechanisms allowing a user to safely clean the wire electrodes in the first electrode array in a transporter-conditioner unit.

Further, as evident from a review of the current specification, embodiments of the invention include a bead and a bead lifting arm, which is operatively associated with both the bead and the collector electrodes. When the collector electrodes are removed for cleaning, the bead lifting arm engages the bead in order to urge the bead upwardly along the emitter electrode in order to clean the emitter electrode. As the collector electrodes are removed from the housing, the bead lifting arm disengages from the bead, allowing the bead to fall to the bottom of the emitter electrode. When the collector electrodes are reinserted into the housing, the bead lifting arm re-engages the bead, which is now located at the bottom of the emitter electrode.

FIGS. **2**A and **2**B depict an electro-kinetic air transporter-conditioner system **100** whose housing **102** includes rear-located intake vents or louvers **104**. Additionally housing **102** includes front and side-located exhaust vents **106**, and a base pedestal **108**. Internal to the transporter housing is an ion generating unit **160**, powered by a power supply that is energizable or excitable using switch S**1**. Suitable power supplies include for example, AC:DC power supply. Ion generating unit **160** is self-contained in that other than ambient air, nothing is required from beyond the transporter housing, save external operating potential, for operation of the present invention.

The upper surface of housing **102** includes a user-liftable handle member **112** to which is affixed a second array **240** of electrodes **242** within an electrode assembly **220**. Electrode assembly **220** also comprises a first array of electrodes **230**, shown here as a single wire or wire-like electrode **232**. In the embodiment shown, lifting member **112** in the form of a handle, enables the user to lift the second array electrodes **240** up and, if desired, out of unit **100**, while the first electrode array **230** remains within unit **100**. In FIG. **2**B, the bottom ends of second array electrode **242** are connected to a base member **113**, to which is attached a mechanism **500** for cleaning the first electrode array electrodes, here electrode **232**, whenever handle member **112** is moved upward or downward by a user. FIGS. **5**A–**7**E, described below, provide further details as to various mechanisms **500** for cleaning wire or wire-like electrodes **232** in the first electrode array **230**, and for maintaining high resistance between the first and second electrode arrays **230**, **240** even if some moisture is allowed to pool within the bottom interior of unit **100**.

The first and second arrays of electrodes are coupled in series between the output terminals of ion generating unit **160**, as best seen in FIG. **3**. The ability to lift handle **112** provides ready access to the electrodes comprising the electrode assembly, for purposes of cleaning and, if necessary, replacement.

The general shape of the invention shown in FIGS. **2**A and **2**B is provided for purpose of illustration. Other shapes can be employed without departing from the scope of the invention. The top-to-bottom height of an embodiment is perhaps 1 m, with a left-to-right width of perhaps 15 cm, and a front-to-back depth of perhaps 10 cm, although other dimensions and shapes can of course be used. A louvered construction provides ample inlet and outlet venting in an economical housing configuration. There need be no real distinction between vents **104** and **106**, except its location relative to the second array electrodes, and indeed a common vent could be used. These vents serve to ensure that an adequate flow of ambient air can be drawn into or made available to the unit **100**, and that an adequate flow of ionized air that includes safe amounts of O_3 flows out from unit **100**.

As will be described, when unit **100** is energized with S**1**, high voltage output by ion generator **160** produces ions at the first electrode array, which ions are attracted to the second electrode array. The movement of the ions in an “IN” to “OUT” direction carries with it air molecules, thus electro kinetically producing an outflow of ionized air. The “IN” notation in FIGS. **2**A and **2**B denote the intake of ambient air with particulate matter **60**. The “OUT” notation in the figures denotes the outflow of cleaned air substantially devoid of the particulate matter, which adheres electrostatically to the surface of the second array electrodes. In the process of generating the ionized air flow, safe amounts of ozone (O_3) are beneficially produced. It can be desired to provide the inner surface of housing **102** with an electrostatic shield to reduce detectable electromagnetic radiation. For example, a metal shield could be disposed within the housing, or portions of the interior of the housing could be coated with a metallic paint to reduce such radiation.

As best seen in FIG. **3**, ion generating unit **160** includes a high voltage generator unit **170** and circuitry **180** for converting raw alternating voltage (e.g., 117 VAC) into direct current (“DC”) voltage. Circuitry **180** preferably includes circuitry controlling the shape and/or duty cycle of the generator unit **170** output voltage (which control is altered with user switch S2 shown as **200**). Circuitry **180** preferably also includes a pulse mode component, coupled to switch S3 (not shown), to temporarily provide a burst of increased output ozone. Circuitry **180** can also include a timer circuit and a visual indicator such as a light emitting diode ("LED"). The LED or other indicator (including, if desired, audible indicator) signals when ion generation is occurring. The timer can automatically halt generation of ions and/or ozone after some predetermined time, e.g., 30 minutes indicator(s), and/or audible indicator(s).

As shown in FIG. **3**, high voltage generator unit **170** preferably comprises a low voltage oscillator circuit **190** of perhaps 20 KHz frequency, that outputs low voltage pulses to an electronic switch **200**, e.g., a thyristor or the like. Switch **200** switchably couples the low voltage pulses to the input winding of a step-up transformer T**1**. The secondary winding of T**1** is coupled to a high voltage multiplier circuit **210** that outputs high voltage pulses. Preferably the circuitry and components comprising high voltage pulse generator **170** and circuit **180** are fabricated on a printed circuit board that is mounted within housing **102**. If desired, external audio input (e.g., from a stereo tuner) could be suitably coupled to oscillator **190** to acoustically modulate the kinetic airflow produced by unit **160**. The result would be an electrostatic loudspeaker, whose output air flow is audible to the human ear in accordance with the audio input signal. Further, the output air stream would still include ions and ozone.

Output pulses from high voltage generator **170** preferably are at least 10 KV peak-to-peak with an effective DC offset of perhaps half the peak-to-peak voltage, and have a frequency of perhaps 20 KHz. The pulse train output preferably has a duty cycle of perhaps 10%, which will promote battery lifetime. Of course, different peak-peak amplitudes, DC offsets, pulse train waveshapes, duty cycle, and/or repetition frequencies can instead be used. Indeed, a 100% pulse train (e.g., an essentially DC high voltage) can be used, albeit with shorter battery lifetime. Thus, generator unit **170** can be referred to as a high voltage pulse generator.

Frequency of oscillation is not especially critical, but frequency of at least about 20 KHz is preferred as being inaudible to humans. If pets will be in the same room as the unit **100**, it can be desired to utilize an even higher operating frequency, to prevent pet discomfort and/or howling by the pet. As noted with respect to FIGS. **5**A–**6**E, to reduce likelihood of audible oscillations, it is desired to include at least one mechanism to clean the first electrode array **230** elements **232**.

The output from high voltage pulse generator unit **170** is coupled to an electrode assembly **220** that comprises a first electrode array **230** and a second electrode array **240**. Unit **170** functions as a DC:DC high voltage generator, and could be implemented using other circuitry and/or techniques to output high voltage pulses that are input to electrode assembly **220**.

In the embodiment of FIG. **3**, the positive output terminal of unit **170** is coupled to first electrode array **230**, and the negative output terminal is coupled to second electrode array **240**. This coupling polarity has been found to work well, including minimizing unwanted audible electrode vibration or hum. An electrostatic flow of air is created, going from the first electrode array towards the second electrode array. (This flow is denoted "OUT" in the figures.) Accordingly, electrode assembly **220** is mounted within transporter system **100** such that second electrode array **240** is closer to the OUT vents and first electrode array **230** is closer to the IN vents.

When voltage or pulses from high voltage pulse generator **170** are coupled across first and second electrode arrays **230** and **240**, it is believed that a plasma-like field is created surrounding electrodes **232** in first array **230**. This electric field ionizes the ambient air between the first and second electrode arrays and establishes an "OUT" airflow that moves towards the second array. It is understood that the IN flow enters via vent(s) **104**, and that the OUT flow exits via vent(s) **106**.

It is believed that ozone and ions are generated simultaneously by the first array electrode(s) **232**, essentially as a function of the potential from generator **170** coupled to the first array. Ozone generation can be increased or decreased by increasing or decreasing the potential at the first array. Coupling an opposite polarity potential to the second array electrode(s) **242** essentially accelerates the motion of ions generated at the first array, producing the air flow denoted as "OUT" in the figures. As the ions move toward the second array, it is believed that it pushes or moves air molecules toward the second array. The relative velocity of this motion can be increased by decreasing the potential at the second array relative to the potential at the first array.

For example, if +10 KV were applied to the first array electrode(s), and no potential were applied to the second array electrode(s), a cloud of ions (whose net charge is positive) would form adjacent the first electrode array. Further, the relatively high 10 KV potential would generate substantial ozone. By coupling a relatively negative potential to the second array electrode(s), the velocity of the air mass moved by the net emitted ions increases, as momentum of the moving ions is conserved.

On the other hand, if it were desired to maintain the same effective outflow (OUT) velocity but to generate less ozone, the exemplary 10 KV potential could be divided between the electrode arrays. For example, generator **170** could provide +4 KV (or some other value) to the first array electrode(s) and −6 KV (or some other value) to the second array electrode(s). In this example, it is understood that the +4 KV and the −6 KV are measured relative to ground. Understandably, it is desired that the unit **100** operate to output safe amounts of ozone. Accordingly, the high voltage is preferably fractionalized with about +4 KV applied to the first array electrode(s) and about −6 KV applied to the second array electrodes.

As noted, outflow (OUT) preferably includes safe amounts of O_3 that can destroy or at least substantially alter bacteria, germs, and other living (or quasi-living) matter subjected to the outflow. Thus, when switch **S1** is closed and battery B**1** has sufficient operating potential, pulses from high voltage pulse generator unit **170** create an outflow (OUT) of ionized air and O_3. When switch **S1** is closed, LED will visually signal when ionization is occurring.

Preferably operating parameters of unit **100** are set during manufacture and are not user-adjustable. For example, increasing the peak-to-peak output voltage and/or duty cycle in the high voltage pulses generated by pulse generator unit **170** can increase air flow rate, ion content, and ozone content. In an embodiment, output flow rate is about 200 feet/minute, ion content is about 2,000,000/cc and ozone content is about 40 ppb (over ambient) to perhaps 2,000 ppb (over ambient). Decreasing the R2/R1 ratio below about 20:1 will decrease flow rate, as will decreasing the peak-to-peak voltage and/or duty cycle of the high voltage pulses coupled between the first and second electrode arrays.

In practice, unit **100** is placed in a room and connected to an appropriate source of operating potential, typically 117 VAC. With switch **S1** energized, ionization unit **160** emits ionized air and preferably some ozone (O_3) via outlet vents **150**. The air flow, coupled with the ions and ozone freshens the air in the room, and the ozone can beneficially destroy or at least diminish the undesired effects of certain odors, bacteria, germs, and the like. The air flow is indeed electro-kinetically produced, in that there are no intentionally moving parts within unit **100**. (As noted, some mechanical vibration can occur within the electrodes.) As will be described with respect to FIG. **4**A, it is desirable that unit **100** actually output a net surplus of negative ions, as these ions are deemed more beneficial to health than are positive ions.

Having described various aspects of the invention in general, a variety of embodiments of electrode assembly **220** will now be described. In the various embodiments, electrode assembly **220** will comprise a first array **230** of at least one electrode **232**, and will further comprise a second array **240** of preferably at least one electrode **242**. Understandably, material(s) for electrodes **232** and **242** should conduct electricity, be resilient to corrosive effects from the application of high voltage, yet be strong enough to be cleaned.

In the various electrode assemblies to be described herein, electrode(s) **232** in the first electrode array **230** are preferably fabricated from tungsten. Tungsten is sufficiently robust to withstand cleaning, has a high melting point to retard breakdown due to ionization, and has a rough exterior surface that seems to promote efficient ionization. On the other hand, electrodes **242** preferably will have a highly polished exterior surface to minimize unwanted point-to-point radiation. As such, electrodes **242** preferably are fabricated from stainless steel, brass, among other materials. The polished surface of electrodes **232** also promotes ease of electrode cleaning.

In contrast to the prior art electrodes disclosed by Lee, discussed supra, electrodes **232** and **242**, used in unit **100** are lightweight, easy to fabricate, and appropriate for mass production. Further, electrodes **232** and **242** described herein promote more efficient generation of ionized air, and production of safe amounts of ozone, O_3.

In unit **100**, a high voltage pulse generator **170** is coupled between the first electrode array **230** and the second electrode array **240**. The high voltage pulses produce a flow of ionized air that travels in the direction from the first array towards the second array (indicated herein by hollow arrows denoted "OUT"). As such, electrode(s) **232** can be referred to as an emitting electrode, and electrodes **242** can be referred to as collector electrodes. This outflow advantageously contains safe amounts of O_3, and exits unit **100** from vent(s) **106**.

It is preferred that the positive output terminal or port of the high voltage pulse generator be coupled to electrodes **232**, and that the negative output terminal or port be coupled to electrodes **242**. It is believed that the net polarity of the emitted ions is positive, e.g., more positive ions than negative ions are emitted. In any event, the preferred electrode assembly electrical coupling minimizes audible hum from electrodes **232** contrasted with reverse polarity (e.g., interchanging the positive and negative output port connections).

However, while generation of positive ions is conducive to a relatively silent air flow, from a health standpoint, it is desired that the output air flow be richer in negative ions, not positive ions. It is noted that in some embodiments, however, one port (preferably the negative port) of the high voltage pulse generator can in fact be the ambient air. Thus, electrodes in the second array need not be connected to the high voltage pulse generator using wire. Nonetheless, there will be an "effective connection" between the second array electrodes and one output port of the high voltage pulse generator, in this instance, via ambient air.

Turning now to the embodiments of FIGS. **4**A and **4**B, electrode assembly **220** comprises a first array **230** of wire electrodes **232**, and a second array **240** of generally "U"-shaped electrodes **242**. The number **N1** of electrodes comprising the first array can differ by one relative to the number **N2** of electrodes comprising the second array. In many of the embodiments shown, N2>N1. However, if desired, in FIG. **4**A, addition first electrodes **232** could be added at the out ends of array **230** such that N1>N2, e.g., five electrodes **232** compared to four electrodes **242**.

Electrodes **232** are preferably lengths of tungsten wire, whereas electrodes **242** are formed from sheet metal, preferably stainless steel, although brass or other sheet metal could be used. The sheet metal is readily formed to define side regions **244** and bulbous nose region **246** for hollow elongated "U" shaped electrodes **242**. While FIG. **4**A depicts four electrodes **242** in second array **240** and three electrodes **232** in first array **230**, as noted, other numbers of electrodes in each array could be used, preferably retaining a symmetrically staggered configuration as shown. It is seen in FIG. **4**A that while particulate matter **60** is present in the incoming (IN) air, the outflow (OUT) air is substantially devoid of particulate matter, which adheres to the preferably large surface area provided by the second array electrodes (see FIG. **4**B).

As best seen in FIG. **4**B, the spaced-apart configuration between the arrays is staggered such that each first array electrode **232** is substantially equidistant from two second array electrodes **242**. This symmetrical staggering has been found to be an especially efficient electrode placement. Preferably the staggering geometry is symmetrical in that adjacent electrodes **232** or adjacent electrodes **242** are spaced-apart a constant distance, **Y1** and **Y2** respectively. However, a non-symmetrical configuration could also be used, although ion emission and air flow would likely be diminished. Also, it is understood that the number of electrodes **232** and **242** can differ from what is shown.

In FIGS. **4**A, typically dimensions are as follows: diameter of electrodes **232** is about 0.08 mm, distances **Y1** and **Y2** are each about 16 mm, distance **X1** is about 16 mm, distance L is about 20 mm, and electrode heights **Z1** and **Z2** are each about 1 m. The width W of electrodes **242** is about 4 mm, and the thickness of the material from which electrodes **242** are formed is about 0.5 mm. Of course other dimensions and shapes could be used. Electrodes **232** can be small in diameter to help establish a desired high voltage field. On the other hand, it is anticipated that electrodes **232** (as well as electrodes **242**) will be sufficiently robust regardless of diameter to withstand occasional cleaning.

Electrodes **232** in first array **230** are coupled by a conductor **234** to a first (preferably positive) output port of high voltage pulse generator **170**, and electrodes **242** in second array **240** are coupled by a conductor **244** to a second (preferably negative) output port of generator **170**. As will be appreciated by those of skill in the art, other locations on the various electrodes can be used to make electrical connection to conductors **234** or **244**. Thus, by way of example FIG. **4**B depicts conductor **244** making connection with some electrodes **242** internal to bulbous end **246**, while other electrodes **242** make electrical connection to conductor **244** elsewhere on the electrode. Electrical connection to the various electrodes **242** could also be made on the electrode external surface providing no substantial impairment of the outflow air stream results.

To facilitate removing the electrode assembly from unit **100** (as shown in FIG. **2**B), the lower end of the various electrodes can be configured to fit against mating portions of wire or other conductors **234** or **244**. For example, "cup-like" members can be affixed to conductors **234** and **244** into which the free ends of the various electrodes fit when electrode array **220** is inserted completely into housing **102** of unit **100**.

The ratio of the effective electric field emanating area of electrode **232** to the nearest effective area of electrodes **242** is at least about 15:1, and preferably is at least 20:1. Thus, in the embodiment of FIG. **4**A and FIG. **4**B, the ratio R2/R1≈2 mm/0.04 mm≈50:1. However, other ratios may be used without departing from the scope of the invention.

In this and the other embodiments to be described herein, ionization appears to occur at the smaller electrode(s) **232** in the first electrode array **230**, with ozone production occurring as a function of high voltage arcing. For example, increasing the peak-to-peak voltage amplitude and/or duty cycle of the pulses from the high voltage pulse generator **170** can increase ozone content in the output flow of ionized air. If desired, user-control S**2** can be used to somewhat vary ozone content by varying (in a safe manner) amplitude and/or duty cycle. Specific circuitry for achieving such control is known in the art and need not be described in detail herein.

Note the inclusion in FIGS. **4**A and **4**B of at least one output controlling electrode **243**, preferably electrically coupled to the same potential as the second array **240** electrodes. Electrode **242** preferably defines a pointed shape in side profile, e.g., a triangle. The sharp point on electrode(s) **243** causes generation of substantial negative ions (since the electrode is coupled to relatively negative high potential). These negative ions neutralize excess positive ions otherwise present in the output air flow, such that the OUT flow has a net negative charge. Electrode(s) **243** preferably are stainless steel, copper, or other conductor, and are perhaps 20 mm high and about 12 mm wide at the base.

Another advantage of including pointed electrodes **243** is that they can be stationarily mounted within the housing of unit **100**, and thus are not readily reached by human hands when cleaning the unit. Were it otherwise, the sharp point on electrode(s) **243** could easily cause cuts. The inclusion of one electrode **243** has been found sufficient to provide a sufficient number of output negative ions, but more such electrodes can be included.

In the embodiment of FIGS. **4**A and **4**C, each "U"-shaped electrode **242** has two trailing edges that promote efficient kinetic transport of the outflow of ionized air and O_3. Note the inclusion on at least one portion of a trailing edge of a pointed electrode region **243'**. Electrode region **243'** helps promote output of negative ions, in the same fashion as was described with respect to FIGS. **4**A and **4**B. Note, however, the higher likelihood of a user cutting himself or herself when wiping electrodes **242** with a cloth or the like to remove particulate matter deposited thereon. In FIG. **4**C and the figures to follow, the particulate matter is omitted for ease of illustration. However, from what was shown in FIGS. **2**A–**4**B, particulate matter will be present in the incoming air, and will be substantially absent from the outgoing air. As has been described, particulate matter **60** typically will be electrostatically precipitated upon the surface area of electrodes **242**. As indicated by FIG. **4**C, it is relatively unimportant where on an electrode array electrical connection is made. Thus, first array electrodes **232** are shown connected together at its bottom regions, whereas second array electrodes **242** are shown connected together in its middle regions. Both arrays can be connected together in more than one region, e.g., at the top and at the bottom. When the wire or strips or other inter-connecting mechanisms are located at the top or bottom or periphery of the second array electrodes **242**, obstruction of the stream air movement is minimized.

Note that the embodiments of FIGS. **4**C and **4**D depict somewhat truncated versions of electrodes **242**. Whereas dimension L in the embodiment of FIG. **4**B was about 20 mm, in FIG. **4**C, L has been shortened to about 8 mm. Other dimensions in FIG. **4**C preferably are similar to those stated for FIGS. **4**A and **4**B. In FIGS. **4**C and **4**D, the inclusion of point-like regions **243** on the trailing edge of electrodes **242** seems to promote more efficient generation of ionized air flow. It will be appreciated that the configuration of second electrode array **240** in FIG. **4**C can be more robust than the configuration of FIGS. **4**A and **4**B, by virtue of the shorter trailing edge geometry. As noted earlier, a symmetrical staggered geometry for the first and second electrode arrays is preferred for the configuration of FIG. **4**C.

In the embodiment of FIG. **4**D, the outermost second electrodes, denoted **242-1** and **242-2**, have substantially no outermost trailing edges. Dimension L in FIG. **4**D is preferably about 3 mm, and other dimensions can be as stated for the configuration of FIGS. **4**A and **4**B. Again, the R2/R1 ratio for the embodiment of FIG. **4**D preferably exceeds about 20:1.

FIGS. **4**E and **4**F depict another embodiment of electrode assembly **220**, in which the first electrode array comprises a single wire electrode **232**, and the second electrode array comprises a single pair of curved "L"-shaped electrodes **242**, in cross-section. Typical dimensions, where different than what has been stated for earlier-described embodiments, are X**1**≈12 mm, Y**1**≈6 mm, Y**2**≈5 mm, and L**1**≈3 mm. The effective R2/R1 ratio is again greater than about 20:1. The fewer electrodes comprising assembly **220** in FIGS. **4**E and **4**F promote economy of construction, and ease of cleaning, although more than one electrode **232**, and more than two electrodes **242** could of course be employed. This embodiment again incorporates the staggered symmetry described earlier, in which electrode **232** is equidistant from two electrodes **242**.

Turning now to FIG. **5**A, a first embodiment of an electrode cleaning mechanism **500** is depicted. In the embodiment shown, mechanism **500** comprises a flexible sheet **515** of insulating material such as a polyester or polyamide film, such as Mylar7 or Kapton7, available from DuPont, or other high voltage, high temperature breakdown resistant material, having sheet thickness of perhaps 0.1 mm or so. Sheet **515** is attached at one end to the base **113** or other mechanism secured to the lower end of second electrode array **240**. Sheet **515** extends or projects out from base **113** towards and beyond the location of first electrode array **230** electrodes **232**. The overall projection length of sheet **515** in FIG. **5**A will be sufficiently long to span the distance between base **113** of the second array **240** and the location of electrodes **232** in the first array **230**. This span distance will depend upon the electrode array configuration but typically will be a few inches or so. Preferably the distal edge of cleaning mechanism **500** will extend slightly beyond the location of electrodes **232**, perhaps 0.5" beyond. As shown in FIGS. **5**A and **5**C, the distal edge, e.g., edge closest to electrodes **232**, of cleaning mechanism **500** is formed with a slot **510** corresponding to the location of an electrode **232**. Preferably the inward end of the slot forms a small circle **520**, which can promote flexibility.

The configuration of the sheets or strips **515** and slots **510** of electrode cleaning mechanism **500** is such that each wire or wire-like electrode **232** in the first electrode array **230** fits snugly and frictionally within a corresponding slot **510**. As indicated by FIG. **5**A and shown in FIG. **5**C, instead of a single sheet that includes a plurality of slots **510**, one can provide individual sheets or strips **515** of cleaning mechanism **500**, the distal end of each strip having a slot **510** that will surround an associated wire electrode **232**. Note in FIGS. **5**B and **5**C that cleaning mechanism **500** or sheets or strips **515** are formed with holes **119** that can attach to pegs **117** that project from the base portion **113** of the second electrode array **240**. Of course other attachment mechanisms could be used including, for example, glue, double-sided tape, inserting the array **240**-facing edge of the sheet into a horizontal slot or ledge in base member **113**, and so forth.

FIG. **5**A shows second electrode array **240** in the process of being moved upward, perhaps by a user intending to remove array **240** to remove particulate matter from the surfaces of its electrodes **242**. Note that as array **240** moves up (or down), cleaning mechanism **500** for sheets or strips **515** also move up (or down). This vertical movement of array **240** produces a vertical movement in cleaning mechanism **500** or sheets or strips **515**, which causes the outer surface of electrodes **232** to scrape against the inner surfaces of an associated slot **510**. FIG. **5**A, for example, shows debris and other deposits **612** (indicated by "x"s) on wires **232** above cleaning mechanism **500**. As array **240** and cleaning mechanism **500** move upward, debris **612** is scraped off the wire electrodes, and falls downward (to be vaporized or collected as particulate matter when unit **100** is again reassembled and turned-on). Thus, the outer surface of electrodes **232** below cleaning mechanism **500** in FIG. **5**A is shown as being cleaner than the surface of the same electrodes above cleaning mechanism **500**, where scraping action has yet to occur.

A user hearing that excess noise or humming emanates from unit **100** might simply turn the unit off, and slide array **240** (and thus cleaning mechanism **500** or sheets or strips **515**) up and down (as indicated by the up/down arrows in FIG. **5**A) to scrape the wire electrodes in the first electrode array. This technique does not damage the wire electrodes, and allows the user to clean as required.

As noted earlier, a user can remove second electrode array **240** for cleaning (thus also removing cleaning mechanism **500**, which will have scraped electrodes **232** on its upward vertical path). If the user cleans electrodes **242** with water and returns second array **240** to unit **100** without first completely drying the array **240**, moisture might form on the upper surface of a horizontally disposed member **550** within unit **100**. Thus, as shown in FIG. **5**B, it is preferred that an upwardly projecting vane **560** be disposed near the base of each electrode **232** such that when array **240** is fully inserted into unit **100**, the distal portion of cleaning mechanism **500** or preferably sheets or strips **515** deflect upward. While cleaning mechanism **500** or sheets or strips **515** nominally will define an angle θ of about 90°, as base **113** becomes fully inserted into unit **100**, the angle θ will increase, approaching 0°, e.g., the sheet is extending almost vertically upward. If desired, a portion of cleaning mechanism **500** or sheets or strips **515** can be made stiffer by laminating two or more layers of suitable film of MYLAR or other material identified above. For example, the distal tip of strip **515** in FIG. **5**B might be one layer thick, whereas the half or so of the strip length nearest electrode **242** might be stiffened with an extra layer or two of film such as MYLAR or other material identified above.

The inclusion of a projecting vane **560** in the configuration of FIG. **5**B advantageously disrupted physical contact between cleaning mechanism **500** or sheets or strips **515** and electrodes **232**, thus tending to preserve a high ohmic impedance between the first and second electrode arrays **230**,**240**. The embodiment of FIGS. **5**A–**5**D advantageously serves to pivot cleaning mechanism **500** or sheets or strips **515** upward, essentially parallel to electrodes **232**, to help maintain a high impedance between the first and second electrode arrays. Note the creation of an air gap **513** resulting from the upward deflection of the slit distal tip of the cleaning mechanism **500** or the sheets or strips **515** in FIG. **5**B.

In FIG. **6**A, the lower edges of second array electrodes **242** are retained by a base member **113** from which project arms **677**, which can pivot about pivot axle **687**. Preferably axle **687** biases arms **677** into a horizontal disposition, e.g., such that θ≈90°. Arms **645** project from the longitudinal axis of base member **113** to help member **113** align itself within an opening **655** formed in member **550**, described below. Preferably base member **113** and arms **677** are formed from a material that exhibits high voltage breakdown and can withstand high temperature. Ceramic is a preferred material (if cost and weight were not considered), but certain plastics could also be used. The unattached tip of each arm **677** terminates in a sheet or strips **515** of polyester or polyamide film such as Mylar7, Kapton7, or a similar material, whose distal tip terminates in a slot **510**. It is seen that the pivotable arms **677** and sheets or strips **515** are disposed such that each slot **510** will self-align with a wire or wire-like electrode **232** in first array **230**. Electrodes **232** preferably extend from pylons **627** on a base member **550** that extends from legs **565** from the internal bottom of the housing of the transporter-conditioner unit. To further help maintain high impedance between the first and second electrode arrays, base member **550** preferably includes a barrier wall **665** and upwardly extending vanes **675**. Vanes **675**, pylons **627**, and barrier wall **665** extend upward perhaps an inch or so, depending upon the configuration of the two electrodes and can be formed integrally, e.g., by casting, from a material that exhibits high voltage breakdown and can withstand high temperature, such as ceramic, or certain plastics for example.

As best seen in FIG. **6**A, base member **550** includes an opening **655** sized to receive the lower portion of second electrode array base member **113**. In FIGS. **6**A and **6**B, arms **677** and sheet material **515** are shown pivoting from base member **113** about axis **687** at an angle θ≈90°. In this disposition, an electrode **232** will be within the slot **510** formed at the distal tip of each sheet material member **515**.

Assume that a user had removed second electrode array **240** completely from the transporter-conditioner unit for cleaning, and that FIG. **6**A and **6**B depict array **240** being reinserted into the unit. The coiled spring or other bias mechanism associated with pivot axle **687** will urge arms **677** into an approximate θ≈90° orientation as the user inserts array **240** into unit **100**. Side projections **645** help base member **113** align properly such that each wire or wire-like electrode **232** is caught within the slot **510** of a sheet or strip **515** on an arm **677**. As the user slides array **240** down into unit **100**, there will be a scraping action between the portions of sheets or strips **515** on either side of a slot **510**, and the outer surface of an electrode **232** that is essentially captured within the slot. This friction will help remove debris or deposits that can have formed on the surface of electrodes **232**. The user can slide array **240** up and down the further promote the removal of debris or deposits from elements **232**.

In FIG. **6**C the user slid array **240** down almost entirely into unit **100**. In the embodiment shown, when the lowest portion of base member **232** is perhaps an inch or so above the planar surface of member **550**, the upward edge of a vane **675** will strike the a lower surface region of a projection arm **677**. The result will be to pivot arm **677** and the attached slit-containing sheets or strips **515** about axle **687** such that the angle θ decreases. In the disposition shown in FIG. **6**C, θ≈45° and slit-contact with an associated electrode **232** is no longer made.

In FIG. **6**D, the user has firmly urged array **240** fully downward into transporter-conditioner unit **100**. In this disposition, as the projecting bottommost portion of member **113** begins to enter opening **655** in base member **550** (see FIG. **6**A), contact between the inner wall **657** portion of member **550** urges each arm **677** to pivot fully upward, e.g., θ≈0°. Thus in the fully inserted disposition shown in FIG. **6**D, each slit electrode cleaning member **515** is rotated upward parallel to its associated electrode **232**. As such, neither arm **677** nor member **515** will decrease impedance between first and second electrode arrays **230**,**240**. Further, the presence of vanes **675** and barrier wall **665** further promote high impedance.

Thus, the embodiments shown in FIGS. **5**A–**6**D depict alternative configurations for a cleaning mechanism for a wire or wire-like electrode in a transporter-conditioner unit.

Turning now to FIGS. **7**A–**7**E, various bead-like mechanisms are shown for cleaning deposits from the outer surface of wire electrodes **232** in a first electrode array **230** in a transporter-converter unit. In FIG. **7**A a symmetrical bead **600** is shown surrounding wire element **232**, which is passed through bead channel **610** at the time the first electrode array is fabricated. Bead **600** is fabricated from a material that can withstand high temperature and high voltage, and is not likely to char, ceramic or glass, for example. While a metal bead would also work, an electrically conductive bead material would tend slightly to decrease the resistance path separating the first and second electrode arrays, e.g., by approximately the radius of the metal bead. In FIG. **7**A, debris and deposits **612** on electrode **232** are depicted as "x"s. In FIG. **7**A, bead **600** is moving in the direction shown by the arrow relative to wire **232**. Such movement can result from the user inverting unit **100**, e.g., turning the unit upside down. As bead **600** slides in the direction of the arrow, debris and deposits **612** scrape against the interior walls of channel **610** and are removed. The removed debris can eventually collect at the bottom interior of the transporter-conditioner unit. Such debris will be broken down and vaporized as the unit is used, or will accumulate as particulate matter on the surface of electrodes **242**. If wire **232** has a nominal diameter of say 0.1 mm, the diameter of bead channel **610** will be several times larger, perhaps 0.8 mm or so, although greater or lesser size tolerances can be used. Bead **600** need not be circular and can instead be cylindrical as shown by bead **600'** in FIG. **7**A. A circular bead can have a diameter in the range of perhaps 0.3" to perhaps 0.5". A cylindrical bead might have a diameter of say 0.3" and be about 0.5" tall, although different sizes could of course be used.

As indicated by FIG. **7**A, an electrode **232** can be strung through more than one bead **600**, **600'**. Further, as shown by FIGS. **7**B–**7**D, beads having different channel symmetries and orientations can be used as well. It is to be noted that while it can be most convenient to form channels **610** with circular cross-sections, the cross-sections could in fact be non-circular, e.g., triangular, square, irregular shape, etc.

FIG. **7**B shows a bead **600** similar to that of FIG. **7**A, but wherein channel **610** is formed off-center to give asymmetry to the bead. An off-center channel will have a mechanical moment and will tend to slightly tension wire electrode **232** as the bead slides up or down, and can improve cleaning characteristics. For ease of illustration, FIGS. **7**B–**7**E do not depict debris or deposits on or removed from wire or wire-like electrode **232**. In the embodiment of FIG. **7**C, bead channel **610** is substantially in the center of bead **600** but is inclined slightly, again to impart a different frictional cleaning action. In the embodiment of FIG. **7**D, beam **600** has a channel **610** that is both off center and inclined, again to impart a different frictional cleaning action. In general, an asymmetrical bead channel or through-opening orientations are preferred.

FIG. **7**E depicts an embodiment in which a bell-shaped walled bead **620** is shaped and sized to fit over a pillar **550** connected to a horizontal portion **560** of an interior bottom portion of unit **100**. Pillar **550** retains the lower end of wire or wire-like electrode **232**, which passes through a channel **630** in bead **620**, and if desired, also through a channel **610** in another bead **600**. Bead **600** is shown in phantom in FIG. **7**E to indicate that it is optional.

Friction between debris **612** on electrode **232** and the mouth of channel **630** will tend to remove the debris from the electrode as bead **620** slides up and down the length of the electrode, e.g., when a user inverts transporter-conditioner unit **100**, to clean electrodes **232**. It is understood that each electrode **232** will include its own bead or beads, and some of the beads can have symmetrically disposed channels, while other beads can have asymmetrically disposed channels. An advantage of the configuration shown in FIG. **7**E is that when unit **100** is in use, e.g., when bead **620** surrounds pillar **570**, with an air gap therebetween, improved breakdown resistance is provided, especially when bead **620** is fabricated from glass or ceramic or other high voltage, high temperature breakdown material that will not readily char. The presence of an air gap between the outer surface of pillar **570** and the inner surface of the bell-shaped bead **620** helps increase this resistance to high voltage breakdown or arcing, and to charring.

Turning now to another embodiment of the invention, in FIG. **8**A, a side view of a cleaning mechanism **500** is depicted. Cleaning mechanism **500** in this preferred embodiment includes projecting, bead lifting arms **677** extending from the longitudinal axis of collector electrode base **113** into a horizontal disposition. Bead lifting arms **677** include a distal end **679** which is fork-shaped, having two prongs that extend on each side of an emitter or first electrode **232** (FIG. **8**C). Unlike other embodiments, the two prongs of distal end **679** do not engage the electrode **232** as the cleaning is accomplished with the bead **600** as described below. Preferably the bead lifting arm **677** is comprised of an insulating material or other high voltage, high temperature breakdown resistant material. For example ABS plastic can be used to construct bead lifting arm **677**.

In the preferred embodiment, the bead lifting arm **677** is configured so that the arm sits below bead **600** with the collector electrode **242** fully seated in the unit **100** as shown in FIG. **8**B. When the electrodes **242** are removed from the unit **100**, the bead lifting arm **677** lifts the bead **600** upward, away from pylons or electrode bottom end stop **627** along the length of electrodes **232**. It will be appreciated by those of skill in the art that the bead **600** depicted in this figure may take on a variety of shapes and configurations without departing from the scope of the invention. For example, the bead **600** may take on the various configurations as shown in FIG. **7** with respect to orientation of the bore. Similarly, with respect to shape, the bead bore can be spherical, hemispherical, square, rectangular or a variety of other shapes without departing from the scope of the invention as previously discussed. Further, the bead **600** can be comprised of a variety of materials as previously described.

Turning now to FIG. **8**B electrode **242** is shown seated in the unit **100**. In this embodiment, the bead lifting arm **677** is pivotally mounted to the base **113** of the collectors **242** at pivot axis **687**. The end **681** of the bead lifting arm **622** has a spring **802** attached thereto. The other end of spring **802** is attached to a bracket **804** which projects below the collector electrodes **242**. Accordingly the bead lifting arm **677** is capable of deflecting when the electrode **242** is removed from the housing **102**. The spring **802** has enough stiffness to allow the lifting of the bead **600** along the surface of the electrode **232**, when the electrode **242** is removed from the housing **102**. As will be appreciated by those of skill in the art, the bead need not be lifted the entire length of the electrode **242**, but should be lifted along a length of the electrode **242** sufficient to enable the electrode to function as designed.

The embodiment of the invention depicted in FIGS. **8**A, **8**B, **8**C and **8**D operates as follows. With the electrodes **242** in the down or operating position, the base **113** of the electrodes **242** seats behind the barrier wall **665** as shown in FIG. **8**B. In order to reach this position, the bead lifting arm **677** pivots about pivot point **687** as they are deflected around the bead **600** in order to be positioned below the bead **600** as shown in FIGS. **8**A and **8**B. Once the lifting arm **677** has been deflected so that it is urged around and below bead **600**, the lifting arm **677** snaps back into the horizontal position as shown in FIGS. **8**A and **8**B, below and ready to lift the bead **600**.

When it is desired to clean the electrodes, the collector electrodes **242** are lifted from the housing. As this is accomplished, the bead lifting arm **677** lifts the bead **600** from the position shown in FIGS. **8**A and **8**B, to the top of the emitter electrodes **232**, thereby cleaning the emitter electrodes as the beads are lifted. Once the beads are lifted to the top of the emitter electrodes **232**, the lifting arm **677** is deflected around the beads **600** as the bead lifting arm **677** around pivot point **687**. As this occurs, the bead **600** falls away from the lifting arm **677** as the collector electrodes **242** are completely removed from the housing. The bead then drop to the base of the emitter electrode **232** and come in contact with the pylon **627** where the bead rest until the bead again engage with the bead lifting arm **677**. After the electrodes **242** are cleaned, as for example by wiping them with a cloth, the electrodes **242** are reinserted into the housing with the base **113** of the electrodes **242** once again coming into proximity of the barrier wall **665**. As this occurs, the bead lifting arms **677** are again deflected about the bead **600** so that they come into the position between the bead **600** and the pylon **627**, ready again to lift the bead **600** upwardly as and when the collector electrodes **242** are again removed upwardly from the housing in order to clean the electrodes. It is to be understood that the bead **600** operate to clean the emitter electrodes in much the same way as beads **600** operate in FIGS. **7**A–**7**E.

In alternative embodiment, the lifting arms **677** themselves actually engage and clean the emitter electrodes **232** as described in the other embodiments. In this arrangement, the lifting arm **677** can also be configured much as the distal end of the arm **677** in FIG. **6**A as well as the distal end of the strip **515** in FIG. **5**C. In these embodiments, the distal end of the arm **677** engages and cleans the emitter electrode **232** as well as lifts the bead which also cleans the emitter electrode. Also in these alternative embodiments, the arm must be sufficiently stiff so that as well as cleaning the electrode, the arm also is able to lift the weight of the beads **600**.

In another alternative embodiment, the air cleaning unit includes a germicidal UV light source to rid the air of mold, bacteria, and viruses. The UV light can attract insects. When an insect approaches the UV light source, it can fly between the emitter and collector electrodes. The insect may short circuit the electrodes and cause high voltage arcing. The debris from the insect's body can fall toward the bottom of the housing and can also deposit between the emitter and collector electrodes, resulting in a carbon path between the emitter and collector electrodes.

A preferred embodiment depicted in FIG. **8**D insulates key elements to inhibit arcing due to insect remains. The main elements are (1) the pylons **627** that secure the emitter electrodes **232** to the base, (2) the barrier wall, **665** which is located in between the emitter **232** and collector electrodes **242** and adjacent to the collector electrodes, or the lip **667** on the upper edge of the barrier wall, and (3) the beads **600** used for cleaning the emitter electrodes. Insulating materials can include glass, ceramic materials, or both in any combination, with any combination of the key elements. Preferably, the bead **600**, the pylons **627**, the barrier wall **665**, and/or the lip **667** are comprised of glass. The insulation material in addition to glass or a ceramic can include ceramic based composites. Such ceramics can include, by way of example only, ceramic oxides such as, by way of example only, ABS plastics, and preferably a high temperature ABS plastic. Casting or coating of the elements listed above with insulating material are both contemplated as being within the scope of the present invention. It is to be understood that if coating is used to insulate, then a plastic material suitable for consumer electronics will be underneath the insulating coating. Such plastic material could include, by way of example, an engineering plastic. Accordingly, the embodiment of the present invention provides an insulating barrier between the emitter electrodes and the collector electrodes in order to interrupt any potential carbon path which could have been caused by the destroyed insects.

The foregoing description of preferred embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to the practitioner skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention from the various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalence.

What is claimed is:

1. An air cleaning device comprising:

a housing with a top and base;

at least one emitter electrode disposed in the housing;

the emitter electrode secured to the base of the housing;

at least one collector electrode removably disposed in the housing;

a source of high voltage coupled between the emitter electrode and the collector electrode;

a barrier wall situated between the emitter electrode and the collector electrode;

a lip on an upper edge of the barrier wall;

an object with a bore therethrough, through which bore the emitter electrode is provided such that the object can travel along and clean the emitter electrode;

an object-lifting arm movably attached to the collector electrode and operably engageable with the object to move and raise the object along the emitter electrode as the collector electrode is removed through the top of the housing to be cleaned.

2. The air cleaning device in claim **1** wherein the barrier wall is coated with insulation material.

3. The air cleaning device in claim 1 wherein the barrier wall is formed from insulation material.

4. The air cleaner of claim 1 wherein the baffler wall is coated with an insulating material selected from the group consisting of glass, ceramics, and ceramic-based composites.

5. The air cleaner of claim 1 wherein the baffler wall is formed from an insulating material selected from the group consisting of glass, ceramics, and ceramic-based composites.

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