US 20130047858A1

(19) **United States**

(12) **Patent Application Publication**

Bohlen et al.

(10) **Pub. No.: US 2013/0047858 A1**

(43) **Pub. Date: Feb. 28, 2013**

(54) **ELECTROSTATIC PRECIPITATOR WITH COLLECTION CHARGE PLATES DIVIDED INTO ELECTRICALLY ISOLATED BANKS**

(76) Inventors: **John R. Bohlen**, Rickman, TN (US); **Fa Jian Zhu**, Shanghai (CN); **Yong Wei Wu**, Shanghai (CN); **Run Gang Xia**, Shanghai (CN); **Xiao Fei Chen**, Shanghai (CN)

(21) Appl. No.: **13/222,735**

(22) Filed: **Aug. 31, 2011**

Publication Classification

(51) **Int. Cl.**

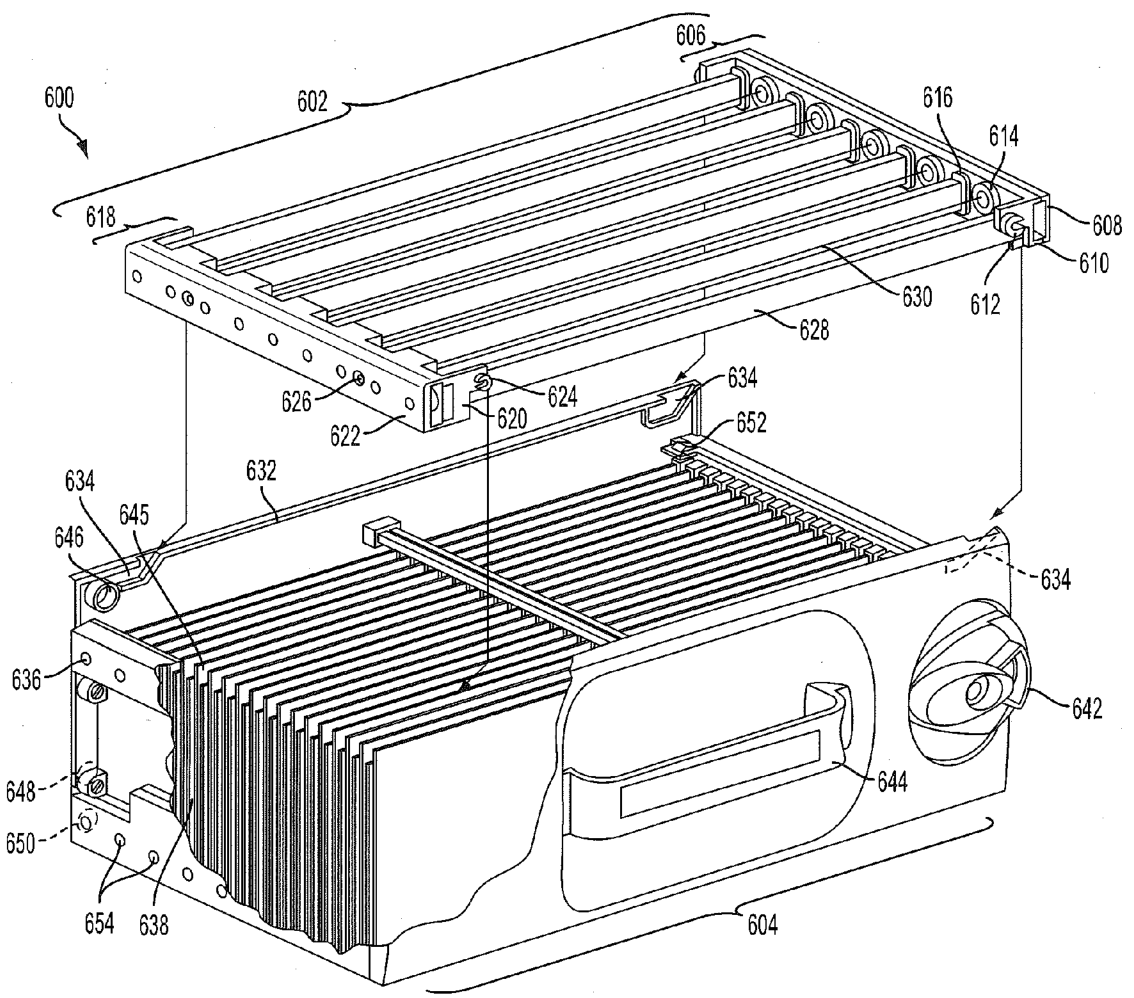
B03C 3/47 (2006.01)

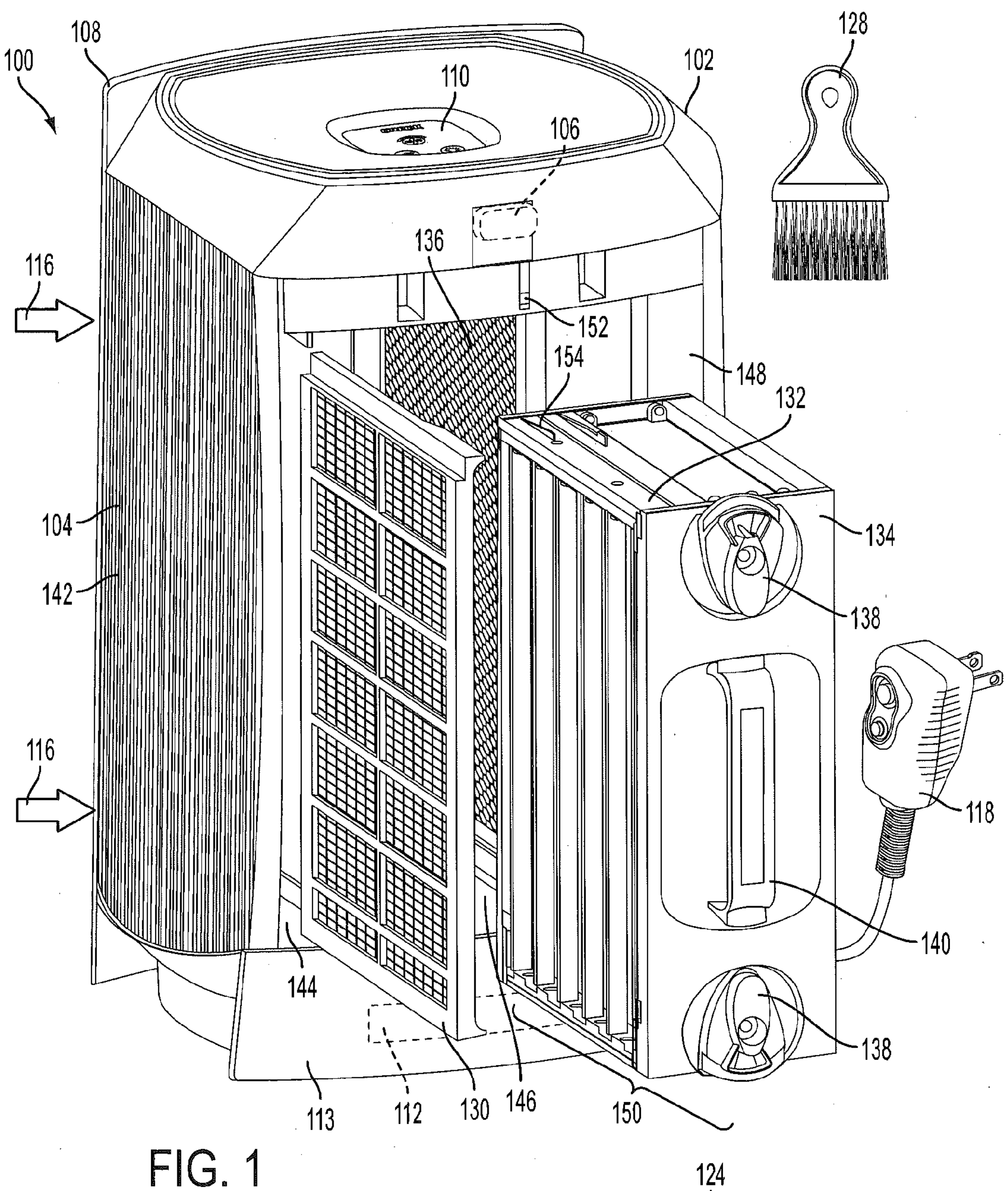
B03C 3/66 (2006.01)

(52) **U.S. Cl.** **96/75**; 96/84; 96/86; 96/80

(57) **ABSTRACT**

An electrostatic precipitator cell containing a collection assembly, a plurality of collection assembly ground plates disposed in the collection assembly, a plurality of banks disposed in the collection assembly, wherein each bank containing a collection assembly charge plate and a voltage isolator is described. Electrically isolating portions of an electrostatic precipitator cell results in reduced arcing and overall increases in cleaning efficiency. As air cleaner utilizing the electrostatic precipitator with isolated banks is also described.




100
108
110
102
106
128
116
136
152
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113
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146
150

FIG. 1

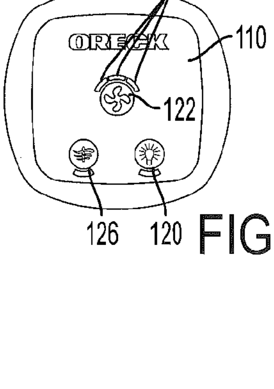
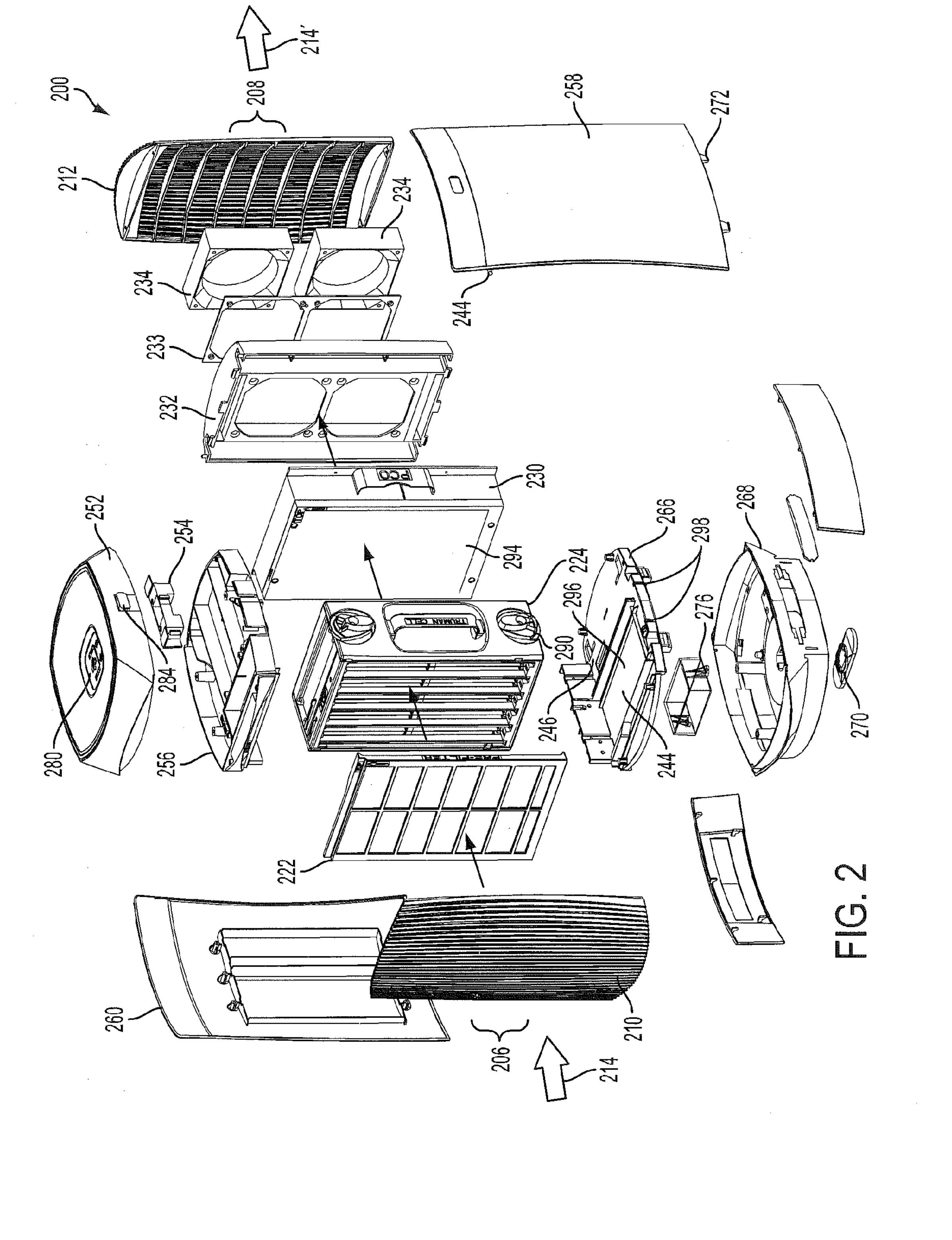

124
ORECK
110
122
126
120

FIG. 1A


200
214'
208
212
258
272
234
234
233
232
230
252
254
294
224
266
298
296
290
246
276
244
244
268
270
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284
256
222
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206
214
210

FIG. 2

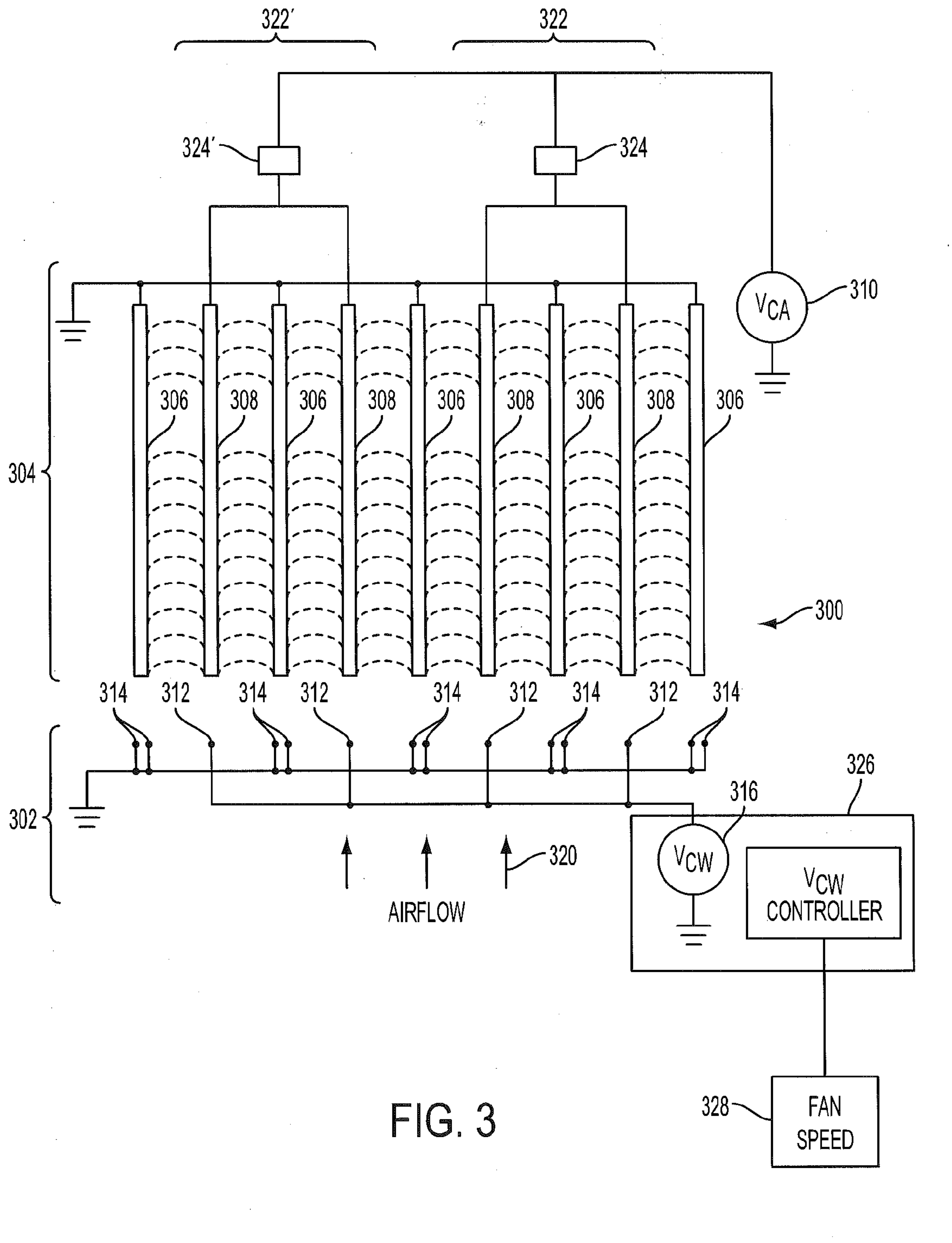
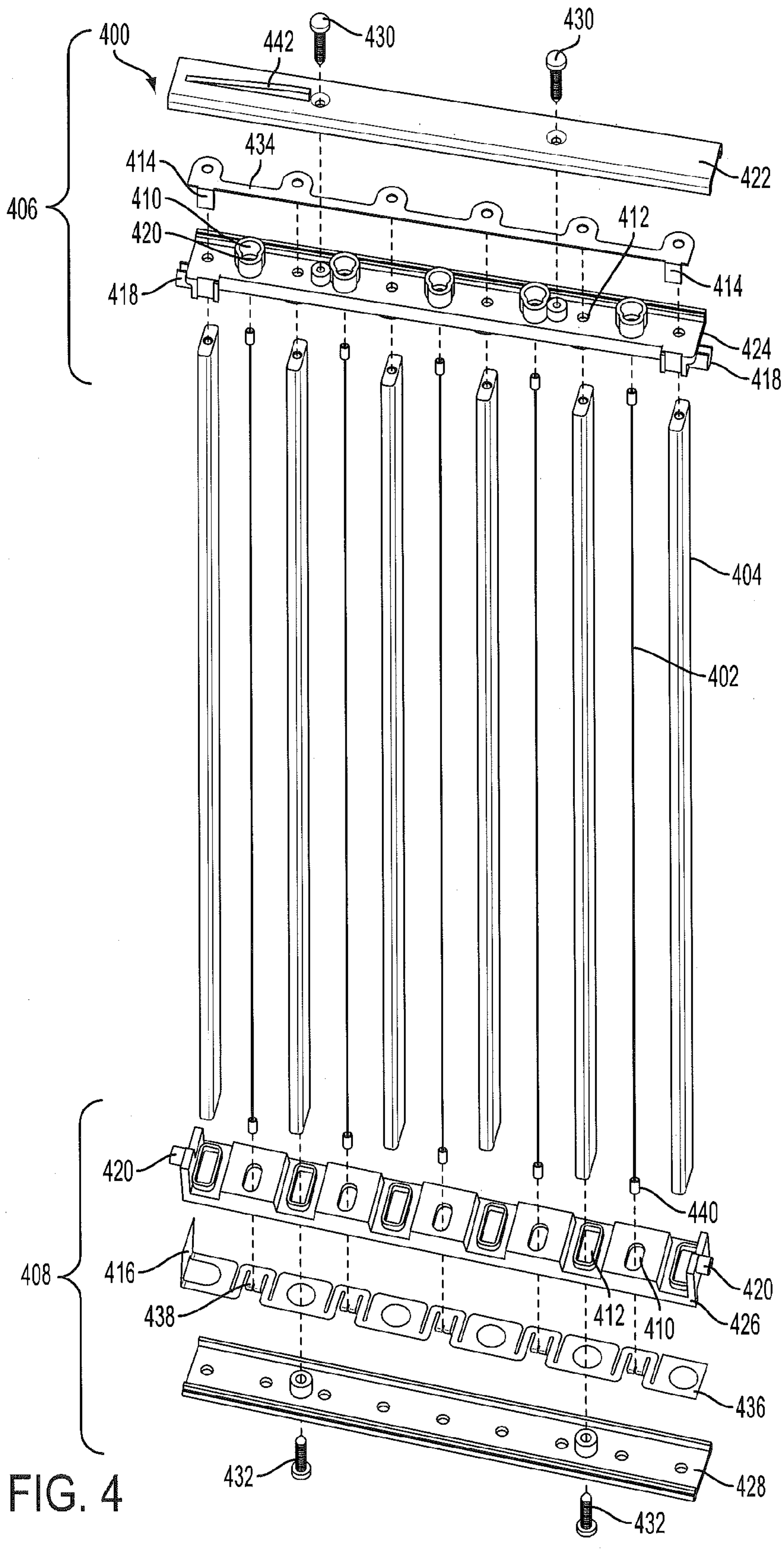

322′
322
324′
324
310
V_{CA}
304
306
308
306
308
306
308
306
308
306
300
314
312
314
312
314
312
314
312
314
326
316
302
V_{CW}
320
V_{CW} CONTROLLER
AIRFLOW
328
FAN SPEED

FIG. 3


400
442
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406
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418
422
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402
408
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416
438
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436
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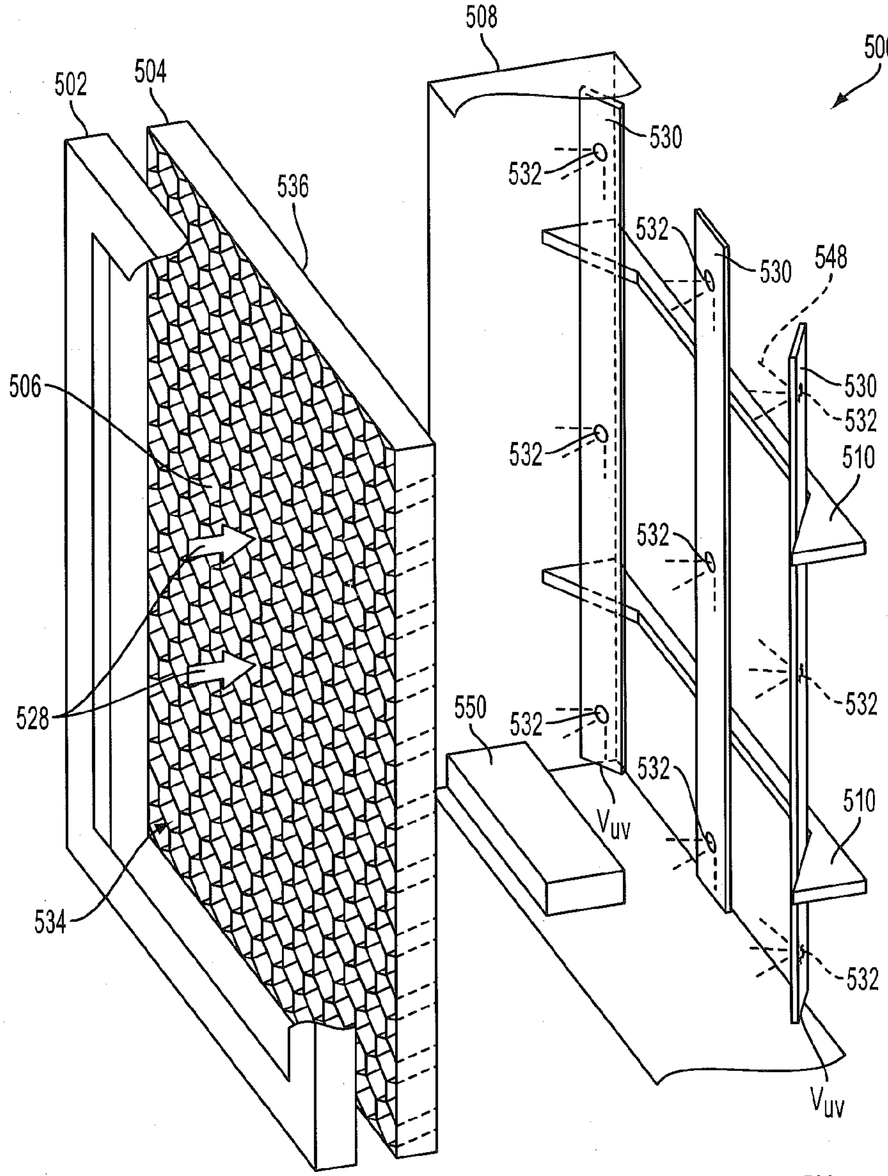
428
432

FIG. 4



500
502
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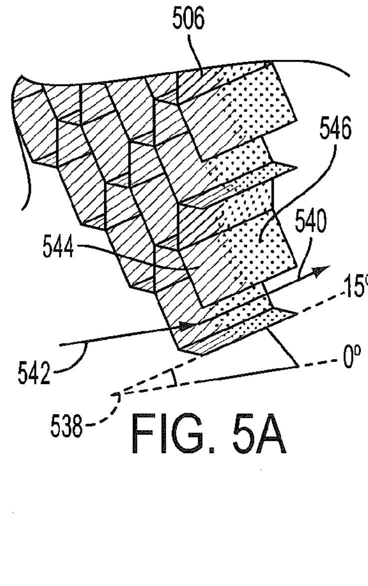
508
530
532
536
548
506
510
528
550
534
V_{uv}

FIG. 5



506
546
540
544
15°
542
0°
538

FIG. 5A

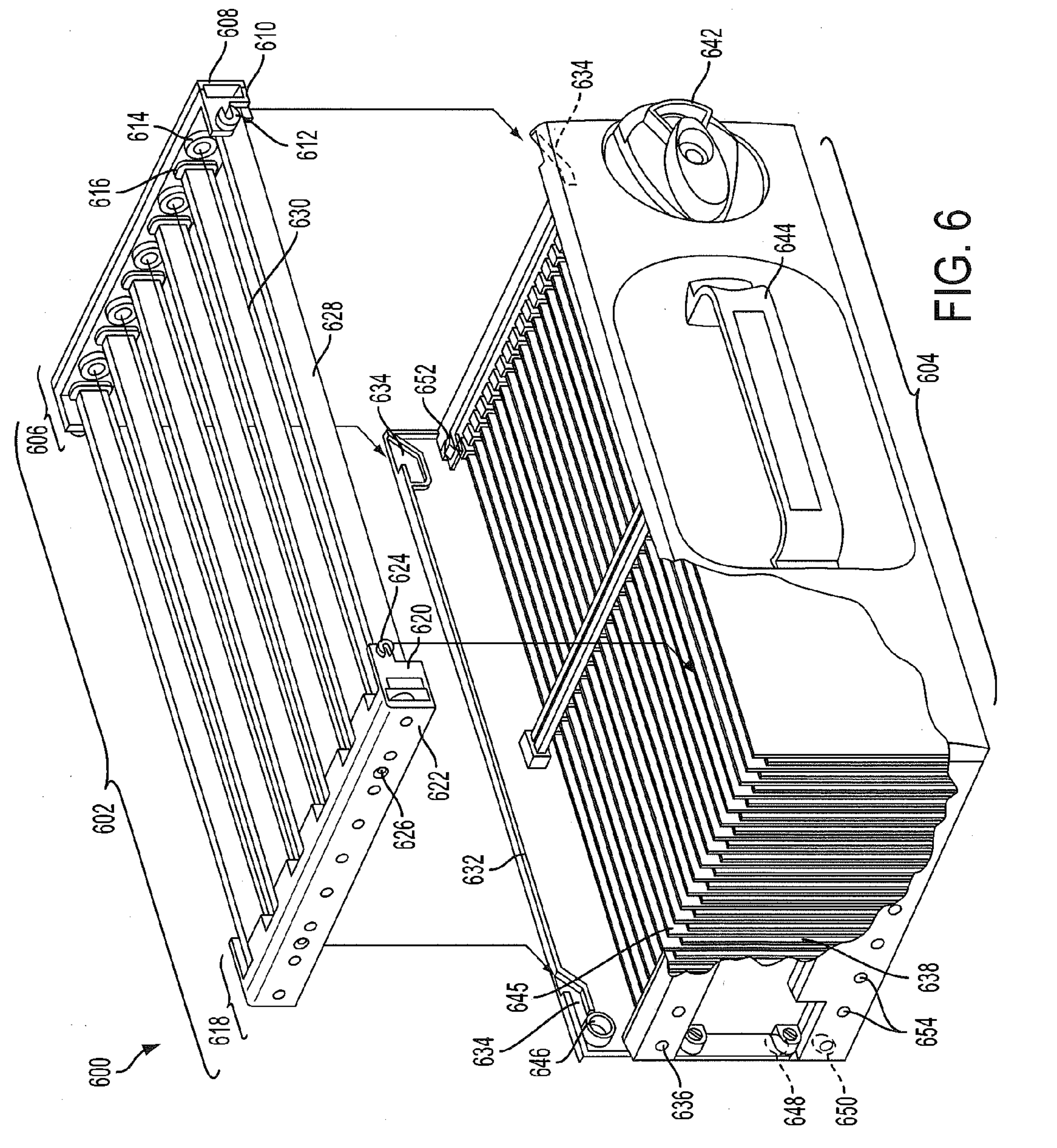

600
602
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FIG. 6

ELECTROSTATIC PRECIPITATOR WITH COLLECTION CHARGE PLATES DIVIDED INTO ELECTRICALLY ISOLATED BANKS

CROSS-REFERENCE

[0001] U.S. Patent Application Publication No. 2011/0033346 A1 (U.S. patent application Ser. No. 12/535,520), filed Aug. 4, 2009 is incorporated herein in its entirety by reference.

TECHNICAL FIELD

[0002] The present teachings are directed toward the improved cleaning capabilities of air cleaners utilizing electrostatic precipitators. In particular, the disclosure relates to an electrostatic precipitator cell that has electrically isolated banks of collection plates that reduce electrical arcing. The reduction can be in the duration, intensity or rate of arcing (arcs per minutes).

BACKGROUND

[0003] Air purifiers are widely used for removing foreign substances from the air. The foreign substances can include dust, dander, pollen, pollutants, smoke, VOCs, ozone etc. In addition, an air cleaner can be used to circulate room air. Air cleaners can be used in many settings, including in homes and offices.

[0004] Air purifiers utilizing electrostatic precipitators function by creating an electrical field. Dirt and debris in the air become ionized when they are brought into the electrical field by an airflow through the air cleaner. Charged positive and negative electrodes in the electrostatic precipitator air cleaner, such as positive and negative plates or positive and grounded plates, create the electrical field and one of the electrode polarities attracts the ionized dirt and debris. Periodically, the electrostatic precipitator can be removed and cleaned. Air purifiers utilizing electrostatic precipitators have many advantages over standard air purifiers utilizing mesh or carbon filters. Electrostatic precipitators can filter air more efficiently and can filter out smaller particles than traditional air purifiers. Further, there is little or no pressure change across an electrostatic precipitator.

[0005] A need has been recognized in the air purifier industry for air purifier units with reduced electrical arcing. Arcing, caused by buildup of debris on collection plates, between electrostatic precipitator plates is a well known problem in the prior art. Some times arcing can span many collection plates, i.e., more than two. Long-term arcing or arcing spanning many plates can reduce the efficiency or terminally break the electronic components of the electrostatic precipitator. As such, many air cleaners provide a shut down circuit to automatically shut the unit down when a particular arcing threshold unit is reached. Once reached, the unit is reset, with the hope that the user cleaned the collection plates to prevent additional arcing. However, arcing is often caused by large particulate buildup only over isolated areas of the collection plates.

[0006] The prior art does not, however, exemplify air purifiers utilizing electrostatic precipitators with electrically isolated portions of the electrostatic precipitator, which reduce arcing of the electrostatic precipitator, and prevents automatic tripping of shut down circuits by removing electricity to some portions of the electrostatic precipitator while maintaining current to the remaining portions.

SUMMARY

[0007] According to one embodiment, an electrostatic precipitator cell comprising a collection assembly, a plurality of collection assembly ground plates disposed in the collection assembly, and a plurality of banks disposed in the collection assembly is described. In some embodiments, each bank comprises a collection assembly charge plate and a voltage isolator.

[0008] In some embodiments, the voltage isolator comprises a resistor. Each bank can comprise a plurality of collection assembly charge plates. The plurality of banks can be electrically connected to one another. The plurality of collection assembly ground plates can be parallel to one another. In some embodiments, the plurality of collection assembly ground plates is interspersed with the collection assembly charge plates.

[0009] In some embodiments, the electrostatic assembly can comprise a corona assembly. In some embodiments, the corona assembly is detachable and the electrostatic precipitator cell includes a receiving slot to receive the pre-ionizer.

[0010] According to various embodiments, an air cleaner comprising an air channel, an electrostatic precipitator cell disposed in the air channel comprising, a collection assembly, a plurality of collection assembly ground plates disposed in the collection assembly, and a plurality of banks is disposed in the collection assembly is described. In some embodiments each bank comprises a collection assembly charge plate and a voltage isolator.

[0011] In some embodiments, the electrostatic precipitator cell further comprises a high voltage power supply, an electrical contact on the electrostatic precipitator cell, and an electrostatic precipitator cell receiver including an electrical contact on the air cleaner, wherein contact between the electrical contact on the electrostatic precipitator cell and the electrical contact on the electrostatic precipitator cell receiver connects the corona wire assembly to the high voltage power supply.

[0012] In some embodiments, the air cleaner further comprises a fan operable at different speeds, wherein an amplitude of an electrical current supplied to the corona wire assembly by the high power voltage supply correlates to the fan speed.

[0013] In some embodiments, the air cleaner further comprises an actuator disposed on the electrostatic precipitator cell and a switch disposed in the electrostatic precipitator cell receiver, wherein actuation of the switch is necessary prior to supplying voltage to a high voltage power supply. In some embodiments, the electrostatic precipitator cell is detachable.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The same reference number represents the same element on all drawings. It should be noted that the drawings are not necessarily to scale. The foregoing and other objects, aspects, and advantages are better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

[0015] FIG. **1** illustrates an air cleaner that includes an electrostatic precipitator according to one embodiment;

[0016] FIG. **1**A illustrates an air cleaner control according to one embodiment;

[0017] FIG. **2** illustrates an exploded view of an air cleaner according to one embodiment;

[0018] FIG. **3** illustrates a schematic of an electrostatic precipitator including a corona wire assembly and a collection assembly according to one embodiment;

[0019] FIG. **4** illustrates an exploded view of a detachable corona wire assembly according to one embodiment;

[0020] FIG. **5** illustrates an exploded view of a photo-catalytic oxidizing (PCO) assembly according to one embodiment;

[0021] FIG. **5**A is an exploded view of a PCO substrate included in a PCO assembly; and

[0022] FIG. **6** illustrates a detailed view of an electrostatic precipitator cell according to one embodiment.

DETAILED DESCRIPTION

[0023] FIGS. **1-6** and the following descriptions depict specific embodiments to teach those skilled in the art how to make and use the best mode of the teachings. For the purpose of teaching these principles, some conventional aspects have been simplified or omitted. Those skilled in the art will appreciate variations from these embodiments that fall within the scope of the teachings. Those skilled in the art will also appreciate that the features described below can be combined in various ways to form multiple variations. As a result, the teachings are not limited to the specific embodiments described below, but only by the claims and their equivalents.

[0024] The present teachings provide air purifiers utilizing electrostatic precipitators including a corona wire assembly with improved longevity and cleaning features. The essential structure of the air purifier comprises an electrostatic precipitator and a corona wire assembly. The electrostatic precipitator is disposed in the air flow path of the air cleaner. The corona wire assembly is releasably or detachably retained proximate to or within the electrostatic precipitator.

[0025] As used herein, the term "filter" refers to the extraction or removal of impurities or particulates from the air. The impurities or particulates can include, but are not limited to dust, dirt, debris, volatile organic compounds, ozone, carbon dioxide, radon, carbon monoxide, pollen, spores, microbes, viruses, etc. The impurities or particulates can be macroscopic or microscopic.

[0026] FIG. **1** shows an air cleaner **100** according to an embodiment. Air cleaner **100** includes a housing **102**, which can include an air inlet **104**, a remote sensor **106**, a sidewall **108**, a control panel **110**, a night light **112** and an air outlet (not shown) disposed therein or thereupon. An air inflow **116** is drawn in through air inlet **104** by fan assembly **148**. Air inlet **104** is covered by a front panel grill **142**. The drawn in air is substantially cleaned inside air cleaner **100**, and the cleaned air is exhausted from the air outlet (not shown). Additionally, a power cord **118** can extend from housing **102**. Power cord **118** can include a GFCI plug. A night light **112** disposed on housing **102** can be visible through transparent portion **113**. Accessories, such as a brush **128** can be included with air cleaner **100** in order to aid in cleaning and maintaining one or more components of air cleaner **100**.

[0027] Air cleaner **100** can also comprise various air filtering components. For example, in one embodiment, air cleaner includes a pre-filter **130**, a corona wire assembly **132**, a collection assembly **134**, and a photo-catalytic oxidizing assembly **136**. The combination of corona wire assembly **132** and collection assembly **134** form an electrostatic precipitator cell **150**. The filter components can be disposed within housing **102** in various receptacles. For example, pre-filter **130** can be housed in a pre-filter receptacle **144**. The electrostatic precipitator cell **150** can be housed in an electrostatic precipitator cell receptacle **146**. The electrostatic precipitator cell **150** can include a handle **140** for easy insertion and removal of the electrostatic precipitator cell **150** from housing **102**. One or more knobs **138** allow the electrostatic precipitator cell **150** to be secured into housing **102**. In some embodiments, an electrostatic precipitator cell actuator **154** can be disposed on corona wire assembly **132**. Without actuation of a switch (not shown) corresponding to electrostatic precipitator cell actuator **154**, the power to electrostatic precipitator **150** can be disabled.

[0028] In one embodiment, knob **138** can be rotated 90 degrees and a portion of knob **138** can extend into electrostatic precipitator cell receptacle **146** to secure electrostatic precipitator cell **150** therein. A door (not shown) can enclose the filter components to complete housing **102**. When the door is in place, it can actuate a door safety switch **152**. In some embodiments, air cleaner **100** cannot be activated without actuating door safety **152**.

[0029] In various embodiments, air cleaner **100** can be substantially rectangular-cuboidal, substantially elliptical, substantially cuboidal, or substantially cylindrical, or combinations thereof, in shape. The exterior or outer face of housing **102** can be planar, circular, curvilinear, arcuate, or combinations thereof, in shape. Air inlet **104** can be planar, circular, curvilinear, arcuate, or combinations thereof, in shape. Air outlet (not shown) can be planar, circular, curvilinear, arcuate, or combinations thereof, in shape. In one embodiment, air inlet **104** can be arcuate and air outlet (not shown) can be arcuate in shape. Advantageously, in some embodiments, air cleaners **100** or **200** can be substantially rectangular-cuboidal in shape, only slightly taller than wide. Such dimension not only allows for increased stability of the air cleaner **100**, but surprisingly allows for an electrostatic precipitator cell **224** (FIG. **2**) with larger surface area of collection plates than conventional table top or floor air cleaners that utilize electrostatic precipitators.

[0030] FIG. **1**A illustrates an exploded view of an air cleaner control panel **110** according to an embodiment. Air cleaner control panel **110** can include buttons for an air ionizer **126**, fans **122**, and/or a night light **120**, for example. Control panel **110** may further optionally include indicator lights which alert the user to clean pre-filter **130**, electrostatic precipitator cell **150**, photo-catalytic oxidizing assembly **136**, or to selectively enable or disable a UV LED assembly. Control panel **110** can also include indicator lights **124** to display a fan speed. Control panel **110** can be advantageously disposed on outer top of housing **102**, thus allowing a user to easily view the indicators.

[0031] FIG. **2** shows an exploded view of air cleaner **200**. Air cleaner **200** includes a housing which can comprise an outer top **250**, a latch assembly **254**, an inner top housing **256**, a front panel **258**, a rear panel **260**, an air inlet grill **210**, an air outlet grill **212**, a bottom inner housing assembly **266**, an outer bottom assembly **268**, and a cord wrap cleat **270**. In some embodiments, front panel **258** can be removable or can include a door. Front panel **258** can include tabs **272** that can be received by bottom inner housing assembly **266**. Front panel **258** can include tabs **274** that can be received by inner top housing **256** to complete the housing. Front panel **258** can be latched by latch assembly **254**, for example, by friction fit. In some embodiments, front panel **258** can use hinges and be latched. Front panel **258** opens, for example, by pushing up on front panel **258** with enough energy to disengage tabs **272**

and **276**. Advantageously, the removal of front panel **258** allows for easy access to all interior components for maintenance or repair. A high voltage power supply module **276** can be provided in air cleaner **200**. Outer top housing **252** can include a control panel overlay **280** to receive user commands, LED lenses **282** for indicator lights, and an infrared (IR) lens **284** for receiving commands from a remote control.

[0032] The housing can define an air channel **204** extending from air inlet **206** to air outlet **208**. Air channel **204** can extend substantially linearly between air inlet **206** and air outlet **208**. Obstructions or obtrusions into air channel **204** are minimized. In an embodiment, air inlet **206** is substantially opposite of air outlet **208**. Air inflow **214** enters air cleaner **200** through air inlet **206**. A cleaning brush can be provided to clean air inlet grill **210** or air outlet grill **212**.

[0033] In some embodiments, air cleaner **200** can include a pre-filter **222**, an electrostatic precipitator cell **224** including a collection assembly and a corona wire assembly, a photo-catalytic oxidizing assembly **230**, a fan mounting panel **232**, a fan gasket **233**, and one or more fans **234**, all disposed in air channel **204**. In an embodiment, airflow **204** encounters electrostatic precipitator cell **224** after encountering pre-filter **222**. In an embodiment, airflow **204** encounters photo-catalytic oxidizing assembly **230** after encountering electrostatic precipitator cell **224**. In some embodiments, airflow **204** encounters a UV Light Emitting Diode (LED) assembly (shown in FIG. **5**) after encountering photo-catalytic oxidizing assembly **230**. In some embodiments, airflow **214** does not encounter a UV LED assembly.

[0034] Pre-filter **222**, electrostatic precipitator cell **224** containing collection assembly and corona wire assembly, and photo-catalytic oxidizing assembly **230** can be independent units. Pre-filter **222**, electrostatic precipitator cell **224**, and photo-catalytic oxidizing assembly **230** can comprise units that are removably disposed in air channel **204**. Pre-filter **222**, electrostatic precipitator cell **224**, and photo-catalytic oxidizing assembly **230** can comprise non-limiting combinations of removable and non-removable units that are mounted in air channel **204**. Due to the independent nature of pre-filter **222**, electrostatic precipitator cell **224**, and photo-catalytic oxidizing assembly **230**, each can be independently installed and independently removed. In addition, air cleaner **200** can be assembled into various configurations by selection of the various cleaning components for a particular application.

[0035] Each of pre-filter **222**, electrostatic precipitator cell **224**, and photo-catalytic oxidizing assembly **230** can be received in air cleaner **200** by some manner of receptacle(s), slot(s), rail(s), etc., and can be inserted and removed easily and quickly. In one embodiment, pre-filter **222** is received in a pre-filter receptacle **242** in air channel **204**. In one embodiment, electrostatic precipitator cell **224** is received in an electrostatic precipitator cell receptacle **244**. In one embodiment, photo-catalytic oxidizing assembly **230** is received in a photo-catalytic oxidizing assembly receptacle **246**. One or more of the various receptacles can comprise drop-in receptacles. One or more of the various receptacles can comprise slide-in receptacles. One or more of the various receptacles can comprise receptacles that fixedly receive a component. It should be understood that other receptacle configurations are contemplated and are within the scope of the description and claims. The various receptacles can hold their respective units so that they are replaceable by a consumer or where services of a technician are required.

[0036] A tray **296** can be included in electrostatic precipitator cell receptacle **244** to collect and pool any excess water during routine cleaning of electrostatic precipitator cell **224**. Tray **296** collects and holds the water until it evaporates, protecting any sensitive electronic circuitry and/or high voltage power supply **276** that may be in the air cleaner.

[0037] Pre-filter **222** can comprise a fiber, a mesh, a cloth, a paper, a woven filter, or a combination thereof. Pre-filter **222** can comprise a High Efficiency Particulate Air (HEPA) filter (typically able to remove 99.7% of particulates to about 0.3 micron in diameter), an allergen air filter, an electrostatic air filter, a charcoal filter, an anti-microbial filter, or other filtering media known in the art. In addition, pre-filter **222** can be treated with a germicide, fungicide, bactericide, insecticide, etc. in order to kill germs, mold, bacteria, viruses, and other airborne living organisms (including microorganisms). Pre-filter **222** can have length L, height H, and width W. Pre-filter **222** can be capable of filtering impurities or particulates with an average diameter of at least 0.1, 0.3, 0.5, 1.0, 5.0, 10.0, 100 microns or greater, including impurities or particulates with an average diameter of 0.001, 0.01, 0.1, 1.0 millimeters or greater.

Electrostatic Precipitator

[0038] Electrostatic precipitator cell **224** removes dirt and debris from the airflow by electrostatic attraction. An electrostatic precipitator cell operates by creating a high voltage electrical field. Dirt and debris in the air become ionized when they are brought into the electrical field by the airflow. Charged electrodes in an electrostatic precipitator cell air cleaner, such as positive and negative plates or positive and grounded plates, attract the ionized dirt and debris. Because the electrostatic precipitator cell comprises electrodes or plates through which airflow can easily and quickly pass; only a low amount of energy is required to generate the airflow. As a result, foreign objects in the air can be removed efficiently and effectively. Electrostatic precipitator cells can comprise corona wires or corona plates for ionizing the air particles. Electrostatic precipitator cell **224** can have length L, height H, and width W. Electrostatic precipitator cell **224** can be capable of filtering impurities or particulates with an average diameter of at least 0.1, 0.3, 0.5, 1.0, 5.0, 10.0, 100 microns or greater including impurities or particulates with an average diameter of 0.001, 0.01, 0.1, 1.0 millimeters or greater.

[0039] Electrostatic precipitator cell **224** can further comprise one or more highly visible knobs **290**. Knobs **290** can be turned so as to lock electrostatic precipitator cell **224** into air cleaner **200**. Electrostatic precipitator cell **224** can comprise a handle **294** that can be used to easily grasp electrostatic precipitator cell **224** for installation and removal from electrostatic precipitator receptacle **246** for cleaning or replacement.

[0040] FIG. **3** shows an electrostatic precipitator cell **300** with corona wire assembly **302** and collection assembly **304** according to one embodiment. Collection assembly **304** includes one or more collection assembly charge plates **308**, one or more collection assembly ground plates **306**, and a first voltage source **310**. The corona wire assembly **302** includes one or more corona charge elements **312**, two or more corona ground elements **314**, and a second voltage source **316**. The corona ground elements **314** can be arranged in a substantially parallel orientation and the corona charge elements **312** can be substantially centered between adjacent corona ground elements **314**. The corona charge elements **312** can be substantially equidistant from adjacent corona ground elements **314** and the corona charge elements **312** can be substantially laterally centered on the adjacent corona ground elements **314**.

[0041] According to one embodiment, in operation, a first voltage potential V_{CA} is placed across the electrostatic collection assembly **304** by the first voltage source **310**, creating one or more first electrical fields between one or more collection assembly charge plates **308** and one or more collection assembly ground plates **306**. In addition, a second voltage potential V_{CW} is placed across the corona wire assembly **302** by the second voltage source **316**, creating a second electrical field between one or more corona charge elements **312** and two or more corona ground elements **314**. Therefore, an airflow **320** traveling through the electrostatic precipitator cell **300** (from bottom to top in the figure) is ionized by the second voltage potential V_{CW} as airflow **320** passes through the corona wire assembly **302**. As a consequence, dirt and debris entrained in airflow **320** are charged (typically a positive charge) and the charged dirt and debris are attracted to the one or more collection assembly ground plates **306**. Airflow **320**, now substantially without the dirt and debris, exits electrostatic precipitator **300** and is exhausted from the electrostatic precipitator **300** in a substantially cleaned condition.

[0042] In some embodiments, the electrostatic precipitator **300** is provided with a voltage sufficient to ionize and collect air particulates. In some embodiments, the voltage to the electrostatic precipitator ranges from about 8000 volts to about 3000 volts. In a preferred embodiment, the voltage to the electrostatic precipitator **300** ranges from about 3900 volts to about 4000 volts. The second voltage source **316** can provide the same or different voltage potential than the first voltage source **310** (i.e., $V_{CA}=V_{CW}$ or $V_{CA}\neq V_{CW}$). In one embodiment, the second voltage source **316** provides a higher voltage potential than the first voltage source **310** (i.e., $V_{CW}>V_{CA}$). For example, the second voltage source **316** can provide about twice the voltage level as the first voltage source **310**, such as about 8,000 volts versus about 4,000 volts in one embodiment. However, it should be understood that the second voltage potential V_{CA} can comprise other voltage levels.

[0043] It should be understood that the corona wire assembly **302** can be formed of any number of corona ground elements **314** and corona charge elements **312**. The corona ground elements **314** can be positioned in a substantially coplanar alignment with the collection assembly ground plates **306** of collection assembly **304** while the corona charge elements **312** can be positioned in a substantially coplanar alignment with the collection assembly charge plates **308**. Each corona charge element **312** can be substantially centered between two opposing corona ground elements **314**. A corona charge element **312** in one embodiment can be substantially vertically centered in the figure with regard to the corona ground elements **314** in order to optimize the produced electrical field.

[0044] In operation, the corona wire assembly **302** forms electrical fields between the corona charge elements **312** and the corresponding pair of corona ground elements **314**. The dashed lines in the figure approximately represent these electrical fields, and illustrate how the electrical field lines are substantially perpendicular to the airflow and are substantially uniform between the corona charge elements **312** and the corresponding corona ground elements **314**. The electrical field of the corona wire assembly **302** can ionize the airflow before the airflow travels through the collection assembly **304**. In addition, the second voltage potential V_{CW} placed on the corona wire assembly **302** by second voltage source **316** can be independent of the first voltage potential V_{CA} placed on the collection assembly **304** by the first voltage source **310**. Consequently, the second voltage potential V_{CW} can be greater or much greater than the first voltage potential V_{CA}.

[0045] In some embodiments, collection assembly charge elements **308** can be grouped into banks **322** and **322'** of collection assembly charge elements. Each bank **322** and **322'** can be connected to a first voltage source **310** with voltage potential V_{CA}. A voltage isolator **324** and **324'** can electrically isolate bank **322** from bank **322'**. In some embodiments, voltage isolators **324** and **324'** can comprise one or more resistors. The resistors can be 1 Megaohms or greater.

[0046] V_{CW} provided by second voltage source **316** can be varied by a controller **326**. In some embodiments, controller **326** can sense a fan speed **328**. Controller **326** can request a higher V_{CW} for higher fan speeds. In some embodiments, controller **326** can request a decreased V_{CW} for lower fan speeds. Controller **326** can use a pulse width modulation (PWM) circuit to determine the duty cycle of a fan. The duty cycle can determine the voltage requested from second voltage source **316**.

Corona Wire Assembly

[0047] FIG. **4** shows a corona wire assembly **400** according to one embodiment. The corona wire assembly **400** includes one or more corona charge elements **402**, two or more corona ground elements **404**, first supporting member **406**, and second supporting member **408**. The corona ground elements **404** can be arranged in a substantially parallel orientation and the corona charge elements **402** can be substantially centered between adjacent corona ground elements **404**. The corona charge elements **402** can be substantially equidistant from adjacent corona ground elements **404** and the corona charge elements **402** can be substantially laterally centered on the adjacent corona ground elements **404**.

[0048] First supporting member **406** includes corona charge element apertures for receiving corona ground elements **404** and corona charge elements **402**. For example, first supporting member **406** includes one or more corona charge element receiving apertures **410** and corona ground element receiving apertures **412**. The shape of the apertures may be substantially the same as the corona ground elements **404** or corona charge elements **402**, and may be substantially circular, oval, rectangular, square, etc. Corona charge element receiving aperture **410** of first supporting member **406** can also include retaining slot **420**. The distal ends of corona charge elements **402** are thus retained in retaining slot **420**.

[0049] Second supporting member **408** includes corona charge element apertures for receiving corona ground elements **404** and corona charge elements **402**. For example, second supporting member **408** includes one or more corona charge element receiving apertures **410** and corona ground element receiving apertures **412**. The shape of the apertures may be substantially the same as the corona ground elements **404** or corona charge elements **402**, and may be substantially circular, oval, rectangular, square, etc. Alternatively, the shape of the apertures may be substantially different from the corona ground elements **404** or corona charge elements **402**, and may be substantially circular, oval, rectangular, square, etc.

[0050] First supporting member **406** may include one or more electrical contacts **414** on an outer planar surface of first supporting member **406** for conducting electrical current to a collection assembly (not shown). Second supporting member **408** may include one or more electrical contacts **416** on an outer planar surface of second supporting member **408** for conducting electrical current from the air cleaner (not shown).

[0051] First supporting member **406** may include one or more retaining devices **418** on an outer planar surface of first supporting member **406** for retaining the first supporting member to a collection assembly (not shown). Second supporting member **408** may include one or more retaining devices **420** on an outer planar surface of second supporting member **408** for retaining the second supporting member **408** to a collection assembly (not shown). Retaining devices **418** and/or **420** may be projections, tabs, fins, ears, etc.

[0052] Retaining devices **418** and **420** cooperate with the collection assembly (not shown) in order to hold the corona wire assembly **400** to a collection assembly (see FIG. **6**). The retaining devices fit into the collection assembly (not shown), and can be held in a collection assembly by any manner of slots, ears, springs, fasteners, heat staking, welds, etc. In one embodiment, retaining devices **418** and **420** are tabs and can be inserted into corresponding receiving slots (shown in FIG. **6**) of a collection assembly.

[0053] First supporting member **406** can include upper portion **422** and lower portion **424**. Second supporting member **408** can include upper portion **426** and lower portion **428**. The upper and lower portions of first supporting member (**422** and **424**, respectively) can be assembled to form first supporting member **408** using any suitable manner, include fastener **430**. The upper and lower portions of second supporting member (**426** and **428**, respectively) can be assembled to form second supporting member **408** using any suitable manner, include fastener **432**.

[0054] First supporting member **406** can house electrical contact strip **434** which connects corona ground elements **404**. A corona ground element **404** can be secured to first supporting member lower housing **424** and electrical contact strip **434** via fasteners **430**. Second supporting member **408** can house electrical contact strip **436** which connects corona charge elements **402** via electrical contact **416**. A corona ground element **404** can be secured to second supporting member upper housing **426** via fasteners **432**. A distal end of corona charge element **402** can be secured to second supporting member upper housing **420** via retention slots **438** in electrical contact strip **436**.

[0055] The electrical contact strip **436** in one embodiment is formed of a flexible, electrically conductive material or at least partially of an electrically conductive material. For example, the electrical contact strip **436** can be formed of a metal material or a metal alloy. Alternatively, the electrical contact strip **436** can be formed of a flexible material that includes an electrically conductive layer, such as a metal plating layer. However, it should be understood that the electrical contact strip **436** can be formed of any suitable material, and various material compositions are within the scope of the description and claims.

[0056] Referring again to FIG. **2**, electrostatic precipitator cell **224** is capable of generating ozone as a by-product of ionization. The ionization transforms stable (O_2) molecules in the air into ozone molecules (O_3). Subsequently, the third oxygen atom of the ozone molecules enters into destructive reactions with contaminants in the vicinity by oxidizing compounds into which they come into contact. The oxidation can add oxygen molecules to these contacted compounds during the oxidation reaction. Ozone is a powerful oxidizer because it is not a stable molecule. Ozone molecules spontaneously return to a stable molecular state by releasing their third oxygen atoms. However, the spontaneous breakdown of ozone does not occur immediately, and substantial amounts of ozone can linger in the airstreams for some time. One of the great advantages of ozone is that it is not selective in the reactions it initiates. Ozone neutralizes harmful volatile organic compounds (VOCs) by oxidizing them. Ozone also destroys pathogens (microorganisms) either by reducing or destroying them or by cell lysing or oxidation. Another beneficial effect of ozone is that ozone treatment of the air can remove some troublesome odors.

Collection Assembly

[0057] As shown in FIG. **3**, collection assembly **304** can have at least one voltage potential placed across the collection assembly creating one or more electrical fields. In one embodiment, a single voltage potential creates an electrical field over the entire collection assembly. In some embodiments, banks **322** and **322'** are in series. In alternate embodiments, banks **322** and **322'** are in parallel. Preferably, banks **322** and **322'** are in parallel. The separated banks deter large arcing between the collection assembly charge plates and ground plates.

[0058] In some embodiments, the individual banks **322** and **322'** all have the same voltage potentials. In some embodiments, the individual banks **322** and **322'** all have different voltage potentials. It should be recognized that it may be beneficial to have some voltage potentials be equal to others, but different than the rest. A variety of combinations of voltage potentials is possible, and can be determined by a skilled artisan, depending upon the needs of the unit.

[0059] As illustrated in FIG. **3**, collection assembly **304** can include between about 2 and 20 collection assembly charge plates **308** and between about 2 and 20 collection assembly ground plates **306** within any individual collection bank. In a preferred embodiment, collection assembly **304** can include about 10 collection assembly charge plates **308** and about 10 collection assembly ground plates **306** within a single collection bank. As a result, collection assembly **304** preferably can have as many as 40 collection assembly ground plates **306** and **40** collection assembly charge plates **308**. The surface area of one side of one collection assembly charge plate **308** or collection assembly ground plate **306** is about 0.0204 m^2. In a preferred embodiment, there can be about 41 collection assembly charge plates **308** or collection assembly ground plates **306** (e.g., 82 collection faces) which results in a collection surface area of about 1.67 m2 ($82*0.0204\ m^2=1.67\ m^2$). This surface area increases the cleaning efficiency of the air cleaner surprisingly without requiring any additional current or voltage requirements for performance.

[0060] Additionally, the height between collection assembly charge plates **308** and collection assembly ground plates **306** must be sufficient enough to allow adequate ionization of air particulates without increasing pressure within the unit, and cannot be so close as to promote unnecessary arcing of the unit. The distance between collection assembly charge plates **308** and collection assembly ground plates **306** can range from about 3 mm to about 5 mm. Preferably, the distance between collection assembly charge plates **308** and collection assembly ground plates **306** is about 4 mm. It was identified that this distance allows for maximum air flow, with minimum air pressure increase and arcing between the charge and ground plates.

[0061] As shown in FIG. **2**, electrostatic precipitator cell **224** can also include one or more knobs **290**. In order to remove electrostatic precipitator cell **224** from air cleaner **200**, both knobs **290** must be released. Knobs **290** can be made from the same material as the electrostatic precipitator cell, including non-conductive materials. While a single knob **290** may be sufficient to secure the electrostatic precipitator cell **224** to the electrostatic precipitator receptacle **244**, multiple knobs **290** increase the security of the electrostatic precipitator cell **224** within air cleaner **200**, and ensure proper contact between electrical contacts (not shown) on the electrostatic precipitator cell **224** with air cleaner **200**. As such, the electrostatic precipitator cell, having a collection assembly and corona wire assembly, functions properly and most efficiently.

[0062] FIG. **6** also shows an electrostatic precipitator cell **600** according to one embodiment. Electrostatic precipitator cell **600** can include corona wire assembly **602** and collection assembly **604**. Corona wire assembly **602** can include a first supporting member **606** and a second supporting member **618**. First supporting member **606** can include first supporting member upper housing **608** and first supporting member lower housing **610**. Second supporting member **618** can include second supporting member upper housing **620** and second supporting member lower housing **622**. In some embodiments, the various portions of first supporting member **606** or the second supporting member **618** are secured via fasteners **626**. Secured between first supporting member **606** and second supporting member **618** are corona wire ground elements **628** and corona wires **630**.

[0063] Collection assembly **604** can include electrostatic precipitator cell frame **632**. Electrostatic precipitator cell **600** can include knobs **642** to secure the electrostatic precipitator **600** into an air cleaner housing (not shown). Additionally, electrostatic precipitator **600** can include handle **644** in order to easily insert and remove the electrostatic precipitator cell **600** from an air cleaner housing (not shown).

[0064] Collection assembly **604** preferably can have as many as about 40 collection assembly ground plates **640** and about 40 collection assembly charge plates **638**. In a preferred embodiment, collection assembly **640** has 21 collection assembly ground plates **640** and about 20 collection assembly charge plates **638**. The result of the increased amount of collection assembly charge plates **638** and collection assembly ground plates **640** results in a total surface area of 1.67 m^2.

[0065] Additionally, the height between collection assembly charge plates **638** and collection assembly ground plates **640** must be sufficient enough to allow adequate ionization of air particulates without increasing pressure within the unit, and cannot be so close as to promote unnecessary arcing of the unit. The distance between collection assembly charge plates **638** and collection assembly ground plates **640** can range from about 3 mm to about 5 mm. Preferably, the distance between collection assembly charge plates **638** and collection assembly ground plates **640** is about 4 mm. It was identified that this distance allows for maximum collection surface area and air flow with a minimum air pressure increase and arcing between electrodes. Thus, the electrostatic precipitator cell described herein has an increased particulate collection efficiency compared to prior art models because the air cleaner has an increased surface area—both in dimension of plates and number of plates.

[0066] As mentioned above, electrostatic precipitator cell **600** can include corona wire assembly **602** and collection assembly **604**. Corona wire assembly **602** can include retainer devices **612** and **624**, which when inserted into corresponding receiving slots **634** in collection assembly **604** can secure corona wire assembly **602** to collection assembly **604**. Retainer devices **612** are offset from the center of the outer side surface of first supporting member **606** and second supporting member **618**. As a result, retainer devices **612** on corona wire assembly **602** and corresponding receiving slots **634** in collection assembly **604** ensure that the corona wire assembly **602** is properly inserted into the collection assembly. When the corona wire assembly **602** is properly inserted into collection assembly **602**, electrical contacts (not shown) on the first supporting member **608** of the corona wire element **602** contact electrical contact **652** on the collection assembly **602** to ground the collection assembly **604**. Attempts to insert the retaining devices **612** in the wrong orientation will not allow the corona wire assembly **602** to be seated into the collection assembly **604**, thus connection between electrical contact **652** on the first supporting member **608** will not contact electrical contact **652** on collection assembly **604**, and the electrostatic precipitator **600** will not function.

[0067] Electrostatic precipitator cell frame **632** has several electrical contact apertures **646**, **648** and **650**, which permit electrical contact between the electrostatic precipitator cell **600** and a high voltage power supply (not shown) in the air cleaner. The electrical contact apertures **646**, **648** and **650** can be for the corona wire assembly **602** alone, for the collection assembly alone **604**, or for both the collection assembly **604** and the corona wire assembly **602**.

[0068] A "dry mode" operating circuit can be configured to dry the electrostatic precipitator cell **600** after cleaning. While in "dry mode" air cleaner fans can operate but no power is supplied to the electrostatic precipitator cell **600** (discussed further below). Weep holes **636** and **654** allow excess water from the collection assembly charge plates **638** and collection assembly ground plates **640** to escape from the electrostatic precipitator cell **600**. A water reservoir (not shown) can be included in the air cleaner housing as a section of the electrostatic precipitator receptacle to collect and pool any excess water. The water reservoir collects and holds the water until it evaporates, protecting any sensitive electronic circuitry and high voltage power supply that may be in the air cleaner.

Photo-Catalytic Oxidizing Assembly

[0069] As illustrated in FIG. **5**, photo-catalytic oxidizing assembly **500** can comprise a photo-catalytic oxidizing assembly frame **502** adapted to support a photo-catalytic oxidizing assembly substrate **504**. Air flow **528** can travel through a plurality of air passages **506** from a first outer surface **534** of photo-catalytic oxidizing assembly substrate **504** to a second outer surface **536** of PCO substrate **504**. In some embodiments, photo-catalytic oxidizing assembly **500** can comprise metal. Photo-catalytic oxidizing assembly **500** can comprise any manner of desired filter element. In one embodiment, PCO substrate **504** can comprise a fiber, a mesh, a woven filter, a paper, a cloth, a porous material, or a porous structure, for example. Photo-catalytic oxidizing assembly **500** can comprise a HEPA filter, an allergen air filter, an electrostatic air filter, a charcoal filter, or an anti-microbial filter, as previously described. Photo-catalytic oxidizing assembly **500** can be treated with a germicide, fungicide, bactericide, insecticide, etc. Photo-catalytic oxidizing assembly **500** can have length L, height H, and width W. Photo-catalytic oxidizing assembly **500** can be capable of filtering impurities or particulates with an average diameter of at least 0.1, 0.3, 0.5, 1.0, 5.0, 10.0, 100 microns or greater, including impurities or particulates with an average diameter of 0.001, 0.01, 0.1, 1.0 millimeters or greater.

[0070] In certain embodiments, photo-catalytic oxidizing assembly **500** can include one or more of an odor filtration, VOC and/or ozone filtration element. Photo-catalytic oxidizing assembly **500** can use a catalyzing compound for generating and removing ozone. Photo-catalytic oxidizing assembly **500** can use a catalyzing compound for removing VOCs. Photo-catalytic oxidizing assembly **500** includes air passages **506** which filter odors, VOCs or ozone. Air passages **506** may be formed by series of substantially serpentine sheets interspersed with substantially planar divider sheets that can comprise any suitable materials and can be formed to a desired shape and size. In some embodiments, air passages **506** can include any cross-sectional shape, including octagonal, hexagonal, circular, irregular, etc. In one embodiment, PCO substrate **504** is formed of a metal matrix, such as an aluminum matrix, for example. The aluminum matrix allows some compression wherein the aluminum matrix can accommodate some shaping. In another embodiment, PCO substrate **504** is formed of a ceramic/paper matrix. The ceramic/paper matrix advantageously can be impregnated with a higher concentration of removal components than a metal matrix.

[0071] In some embodiments, air passages **506** can be parallel to (or co-linear with) the airflow **528**. In other words, air passages are zero degrees to a horizontal airflow. In some embodiments, air passages can be angled down between zero and up to 90 degrees from a horizontal airflow. In a preferred embodiment, air passages are angled 15 degrees down. Surprisingly, the downward angle permits the UV light to penetrate further and blocks the UVA from being visible to users. As such, the air cleaner unit is more efficient at ozone and VOC removal, and safer to use than conventional air cleaners.

[0072] PCO substrate **504** (such as a three-dimensional matrix, for example) can include a PCO layer deposited on substrate **504**. The PCO layer is activated by UV light supplied by, for example, a UV LED assembly (FIG. **5**). PCO layer may react with water vapor from the air to release hydroxyl radicals. Photo-catalytic oxidation utilizes ultraviolet or near-ultraviolet radiation to promote electrons from the valence band into the conduction band of a metal oxide semiconductor. Decomposition of VOCs takes place through reactions with molecular oxygen or through reactions with hydroxyl radicals and super-oxide ions formed after the initial production of highly reactive electron and whole pairs. Thus, a catalyst layer extends the life of photo-catalytic oxidizing assembly **500**. For example, photo-catalytic oxidizing assembly **500** can comprise an ozone catalyst layer deposited on PCO substrate **504**. In this embodiment, photo-catalytic oxidizing assembly **500** can remove a significant amount of the ozone in the airflow. Photo-catalytic oxidizing assembly **500** can also include a VOC decomposition layer deposited on substrate **504**. As a result, photo-catalytic oxidizing assembly **500** removes VOCs in an airflow by a process of catalysis. Photo-catalytic oxidizing assembly **500** can further remove odors from the airflow. The odor removal can be by catalysis or adsorption. Because photo-catalytic oxidizing assembly **500** substantially removes ozone, VOCs, and odors from an airflow, an air cleaner can remove a very high proportion of contaminants that can cause odors, irritation, or health problems. In addition, VOCs are substantially removed from the air, removing the health risks that they represent. In some embodiments, a portion of substrate **504** is not covered by a PCO layer. The portion of substrate **504** that includes a PCO layer can be illuminated by a UV LED (**532**). The illumination from UV LED **532** can catalyze the photo-catalytic oxidation reaction.

[0073] The ozone decomposing catalyst layer can be deposited over the entire substrate, or a portion thereof. The ozone decomposing catalyst layer can be deposited over 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, or 100 percent of the entire substrate of photo-catalytic oxidizing assembly **500**. The VOC decomposing catalyst layer can be deposited over the entire substrate, or a portion thereof. The VOC decomposing catalyst layer can be deposited over 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, or 100 percent of the entire substrate of photo-catalytic oxidizing assembly **500**. The PCO catalyst layer can be deposited over a portion of the surface area of the entire substrate. The PCO catalyst layer can be deposited over 10, 20, 30, 40, 50, 60, 70, 80, 90, or 95 percent of the entire substrate of a photo-catalytic oxidizing assembly. In an embodiment, the PCO catalyst layer can be deposited over 50 percent of the surface of the substrate. The remaining 50 percent of the surface of the substrate can comprise the VOC decomposing catalyst layer. The catalyst layers can be applied simultaneously or sequentially. The catalyst layers can be applied in any order. In some embodiments, the PCO catalyst is the outside layer for a portion of the surface area of the substrate, for example, 50% of the surface area. In some embodiments, the ozone removal layer can be applied prior to the VOC removal layer that is applied prior to the PCO catalyst layer. In some embodiments, the VOC removal layer can be applied prior to an application of an ozone removal layer that is applied prior to the PCO catalyst layer.

[0074] For example, photo-catalytic oxidizing assembly **500** can include some manner of carbon, zeolite, or potassium permanganate filter or filter component for odor removal. In addition, photo-catalytic oxidizing assembly **500** can include an odor emitting element. For example, photo-catalytic oxidizing assembly **500** can include a perfume packet or cartridge portion that emits a desired perfume (or other scent). Therefore, photo-catalytic oxidizing assembly **500** can comprise one or more of a mechanical filter element, an odor filtration element, and an odor emitting element.

[0075] Additionally, in one embodiment, an ozone decomposing material can include a metal oxide material deposited on substrate **504**. Ozone reacts with the metal oxide and decomposes in a catalytic reaction. In one embodiment, an ozone decomposing material can comprise manganese oxide (MnO_2). In another embodiment, an ozone decomposing material can comprise titanium dioxide (TiO_2). However, it should be understood that an ozone decomposing material can comprise any manner of suitable metal oxide, such as, but not limited to Al_2O_3, SiO_2, TiO_2, Fe_2O_3, and ZnO. In another embodiment, the ozone decomposing catalytic material includes two or more catalytic materials for ozone removal.

[0076] In some embodiments, photo-catalytic oxidizing assembly **500** can comprise a single VOC removal material. In another embodiment, the VOC catalytic material includes two or more catalytic materials for VOC removal. Photo-catalytic oxidizing assembly **500** can comprise a MnO_2 material. However, it should be understood that the VOC removal material can comprise any manner of suitable metal oxide, such as, but not limited to Al_2O_3, MnO_2, SiO_2, TiO_2, Fe_2O_3, and ZnO. Thus, photo-catalytic oxidizing assembly **500** may optionally include a single removal element that simultaneously removes ozone, VOCs, and odors from the airflow.

[0077] For example, FIG. **5**A shows an exploded view of a PCO substrate **504**. Air passages **506** of PCO substrate **504** can include a first catalyst, e.g. a PCO catalyst layer **546**. The first catalyst can cover a portion of the sidewalls comprising air passage **506**, e.g., about 70% of the surface area of air passage **506**. Air passages **506** of PCO substrate **504** can also include a second catalyst, e.g., a non PCO catalyst layer **544**. The second catalyst can cover a portion of the sidewalls comprising air passage **506**, e.g., about 30% of the surface area of air passage **506**. Air passages **506** are co-linear with a direction **540**. The primary direction of travel for air flow **528** encountering substrate **506** can be co-linear with a direction **542**. As such, air flow **528** can travel into air passages **506** in direction **542** and exit air passages **506** in direction **540**. Direction **540** and **542** can intersect at an angle **538**. For example, when an air cleaner is placed on the ground for use, angle **538** of about 15 degrees is sufficient to block or limit viewing of the UV light source by a user in a sitting or standing position. The 15 degree angle is sufficient to reduce the angle of viewing of the UV light during normal operation of the air cleaner.

UV-Light Assembly

[0078] As shown in FIG. **5**, a UV LED assembly **530** can radiate UV light on PCO element **504** using a UV LED **532**. UV LED **532** can comprise a plurality of UV LEDs. One or more of UV LED assembly **530** can be disposed in an air cleaner. The quantity of UV LEDs **532** and/or UV LED assemblies **530** can be optimized to provide the correct intensity of illumination 548 to PCO element **504**. In some embodiments, UV LED **532** can provide light in the UV-A spectrum.

[0079] The UV illumination can be supplied by UV LED assembly **530**, and may be configured to irradiate a variety of infestation agents that may be present within airflow. These agents are capable of passing through a pre-filter, electrostatic precipitator, and photo-catalytic oxidizing assembly **500**, or alternatively generate ozone. In general, UV light wavelengths are considered to have a wavelength that is about 100 to about 400 nm UV light is considered beyond the range of visible light. The UV light waves can have wavelengths of 400-320 nm, 320-280 nm, or 280-100 nm, and are normally referred to as UV-A, UV-B, and UV-C waves respectively. Preferably, the UV light waves are UV-A with wavelengths of 400-320 nm. The dosage of UV light (in terms of millijoules per square centimeter or "mJ/cm") is a product of light intensity (or irradiance) and exposure time. Intensity is measured in microwatts per square centimeter ($\mu W/cm^2$), and time is measured in seconds. The light source may be, for example, a generally U-shaped, 35-watt, high-output, no-ozone bulb (not shown) suitable for radiating light in the selected UV wavelength range of light, or a series of LED UV lights **532** as seen in FIG. **5**. In some embodiments, a single linear bulb or multiple linear or shaped bulbs can be employed. If UV LEDs are used, the LEDs may comprise 1, 2, 3, 4, 5, 6, or more UV LEDs. The lights may be configured in series or in parallel. The loss of power to one bulb may or may not be sufficient to shut down the remaining bulbs.

[0080] FIG. **5** also illustrates a UV LED assembly **530** that can include multiple LEDs **532**. One or more circuit boards (not shown) can be electrically connected to a power distributor **550** to provide one or more UV LEDs **532** with a voltage potential Vuv. UV illumination **548** from UV LED assembly **530** can be contained wholly within photo-catalytic oxidizing assembly housing frame **508**. UV light assemblies can be secured to photo-catalytic oxidizing assembly housing frame **508** via LED supports **510**. LED supports **510** can be shaped to direct UV light onto PCO substrate **504** sufficiently. LED supports **510** can have an angled portion to facilitate and direct UV light from UV light assembly **530** onto PCO substrate **504**.

[0081] In some embodiments, UV LED assembly **530** provides a high-density distribution of UV LEDs **532**. In some embodiments, UV LEDs **532** can comprise low intensity UV LEDs. A high-density distribution can increase the intensity of the illumination provided by UV LEDs **532**. In some embodiments, UV LEDs **532** can provide light in the UV-A spectrum.

[0082] In alternate embodiments, UV LED assembly **530** provides a sparse or low-density distribution of UV LEDs **532**. In some embodiments, UV LEDs **532** can comprise high intensity UV LEDs. A sparse distribution can provide a desired intensity of UV illumination without using a large number of UV LEDs **532**. In some embodiments, UV LEDs **532** can provide light in the UV-A spectrum.

Air Path

[0083] As seen in FIG. **2**, air inlet **206** can comprise a substantially rectangular inlet, wherein air inflow **214** travels substantially linearly into air inlet **206**, through grille **210** and through pre-filter **222**. Substantially cleaned air outflow **214'** can travel substantially linearly outward from air outlet **208** through grille **210**. Substantially cleaned air outflow **214'** can travel substantially horizontally. Grille **210** or **212** can include louvers, slats, bars, mesh, or wire. The louvers, slats, bars, mesh, or wire of grille **210** or **212** can be permanent, or replaceable or combinations thereof. The louvers, slats, bars, mesh, or wire can be fixed or stationary, or combinations thereof, and are capable of directing the airflow into air channel **204** through air inlet **206**, and out of air outlet **208**. The direction of airflow out of air outlet **208** can be 180, 160, 140, 120, 90, 60, 45, 30, or less degree away from air cleaner **200**.

[0084] As shown in FIG. **2**, fans **234** can be controlled to create and regulate the airflow. Fans **234** can include variable speed settings including low, medium and high speeds. Fan speed can direct the amount of current directed to corona wire assembly **304**. For example, the lower the fan speed, the lower the current sent to corona wire assembly **304**. Current to the corona wire assembly **304** can be limited via pulse width modulation signals through a power supply. Table 1 shows a preferred example of power parameters sent to corona wire assembly **304** as determined by fan speed.

TABLE 1

Fan Speed	Plate Voltage (kV)	Wire Current (uA)	Wire Voltage (kV)
Low	3.9	130	5.9
Med	3.9	175	6.1
High	3.9	250	6.3

[0085] As a result, the ozone generation by the corona wire assembly **304** is reduced with lower fan speeds. Also, this runs the corona wire assembly **304** at a lower current density, which extends the life of the corona charge elements (wires) **312** within the corona wire assembly **304**. Fans **234** can be removably or permanently affixed to fan mounting panel **232**. Further, all fans **234** are activated when power to fans is provided.

Controls

[0086] As shown in FIGS. **1** and **1**A, a control panel **110** may be located on housing **102**. Control panel **110** optionally includes buttons, switches, dials, and indicator lights and the like. Control panel **100** may optionally include buttons for an air ionizer **126**, fans **122**, and/or a night light **120**, for example. In some embodiments, buttons can be used to control a UV LED assembly. Control panel **110** may further optionally include indicator lights and which alert the user to clean pre-filter **130**, electrostatic precipitator cell **150**, photocatalytic oxidizing assembly **136**, or to change a UV LED assembly. Control panel **110** can include indicator lights **124** to display a fan speed. Control panel **110** can be advantageously disposed on outer top of housing **102**, thus allowing a user to easily view indicators. Air cleaner **100** can be provided with a remote sensor **106** (shown in FIG. **1**) and a remote control (not shown) to control remotely air cleaner **100**. Air cleaner **100** can be configured to receive power from an external power source or battery. The external power source can generate a direct current (DC) high voltage for an electrostatic precipitator cell. The voltage is typically on the order of thousands of volts or even tens of thousands of volts.

[0087] In one embodiment, air cleaner **200** (as shown in FIG. **2**) can comprise a control circuit (not shown) that can control the overall operation of air cleaner **200**. The control circuit can be connected to control panel overlay **280** as shown in FIG. **2**. In some embodiments, the control circuit can accept user input from a remote control via a remote sensor. The control circuit can receive user inputs through control panel overlay **280**. The control circuit can generate outputs to the control panel overlay **280**, such as lighting indicator lights, for example. In addition, in some embodiments the control circuit is connected to fans **234**, the high voltage power supply (not shown), UV light bulb assembly (not shown), front panel **258** or rear panel **260** and/or a shut-down circuit (not shown). The control circuit, in some embodiments, can sense a state of one or more of these components. The control circuit, in some embodiments, can send signals, commands, or the like to one or more of these components. The control circuit, in some embodiments, can receive signals, feedback, or other data from these components. The control circuit, in some embodiments, is coupled to and communicated with the shut-down circuit. The control circuit can shut down power to fans **234**, electrostatic precipitator cell **224**, and/or the high voltage power supply module **276** when front panel **258** or rear panel **260** is opened. In one embodiment, only when electrostatic precipitator cell safety switch actuator **154** activates a safety switch (not shown) in housing **102** when the electrostatic precipitator cell **150** is properly inserted into electrostatic precipitator cell receptacle **146** can electricity be provided to the electrostatic precipitator cell **150**. In an alternate embodiment, only when door safety switch actuators (not shown) on front panel **258** (see FIG. **2**) activate a door safety switch (**152**) on housing **102** when the front panel **258** is properly inserted into the housing can electricity be supplied to control panel **110**. In some embodiments, the control circuit can shut down power to fans **234**, electrostatic precipitator cell **224**, and/or the high-voltage power supply module **276** when one of the filtering components needs cleaning or servicing.

[0088] The shut-down circuit can be configured to monitor an electrical current supplied to electrostatic precipitator cell **224**, to remove electrical power to electrostatic precipitator cell **224** if the electrical current exceeds a predetermined cell current threshold for a predetermined time period, and to generate an indication, such as due to arcing. The shut-down circuit can be located between the high voltage power supply and electrostatic precipitator cell **224**, wherein the shut-down circuit can interrupt the electrical power that is supplied to electrostatic precipitator cell **224**. As a result, the shut-down circuit can make or break the power lines between the high voltage power supply and electrostatic precipitator cell **224**. It should be noted that electrical power to fans **234** can be maintained or can be terminated when the electrical power to electrostatic precipitator cell **224** is removed. The control circuit can illuminate a clean electrostatic precipitator assembly indicator based on a run time of electrostatic precipitator cell **224**. In some embodiments, air cleaner **200** can be operated without electrostatic precipitator cell **224** disposed therein. When air cleaner **200** operates without electrostatic precipitator cell **224**, the control circuit can be programmed to not increment the run-time of electrostatic precipitator cell **224**.

[0089] After an arc or short has exceeded the predetermined time period, an indication can be generated. The indication in one embodiment comprises a light that is illuminated. The indication can include a steady illumination or a blinking illumination. Alternatively, other trouble indications can be generated including audible signals. The indication can be generated until a power cycle of air cleaner **200** occurs.

[0090] The shut-down circuit can be configured to monitor the open or closed status of front panel **258** or rear panel **260** and to remove electrical power to a UV LED assembly if front panel **258** or rear panel **260** is removed when the power is on. Alternately, the shut-down circuit can be configured to monitor the open or closed status of front panel **258** or rear panel **260** and remove electrical power to fans **234** if front panel **258** or rear panel **260** is removed when the power is on. It should be noted that electrical power to fans **234** can be maintained or terminated when the electrical power to a UV LED assembly is removed. Alternatively, it should also be noted that electrical power to a UV LED assembly can be maintained or terminated when the electrical power to fans **234** is removed. The shut-down circuit can be configured to monitor the open or closed status of front panel **258** or rear panel **260** and to remove electrical power to a UV LED assembly and fans **234** if front panel **258** or rear panel **260** is removed when the power is on.

[0091] Power can be restored to the circuit when a power cycle occurs. The power cycle can comprise a person pressing the power button. In addition or alternatively, the power cycle can comprise a person unplugging air cleaner **200** from a power outlet. Other power cycle actions are contemplated and are within the scope of the description and claims.

[0092] Once a power cycle has occurred, electrical power is restored to the component that had been interrupted. Thus, power is restored to electrostatic precipitator cell **224**, fans

234, a UV light bulb assembly, etc., and the specific component, therefore, resumes operation. In addition, the indication is terminated.

[0093] A "dry mode" operating circuit can be configured to dry the electrostatic precipitator cell **224** after cleaning. While in "dry mode" fans **234** run on medium speed, and no power is supplied to the electrostatic precipitator cell **224**. Once "dry mode" is selected for a use, fans **234** can run for a pre-determined time period. For example, fans may run for 15, 30, 45, 60, or more minutes. Additionally, the dry mode operating circuit may sense moisture within electrostatic precipitator cell **224**. Multiple cycles of fan runs may be programmed depending upon moisture levels. Once the fans **234** have run for the pre-set run time, or when the circuit senses a sufficient level of dryness, power to the electrostatic precipitator cell **224** may be reestablished. Further, selection of "dry mode" may be indicated by an indicator light dedicated to "dry mode" on control panel overlay **280**. Alternatively, selection of "dry mode" may produce a blinking pattern on an existing light on the control panel.

Accessories

[0094] Additionally, an air cleaner may contain additional accessories which aid in the function or maintenance of the air cleaner. Non-limiting examples of such accessories include remote controls, cleaning brushes, handles, screw drivers, cords, etc. The air cleaner housing may optionally be configured to further house optional accessories in discrete interior or exterior drawers, compartments or chambers, allowing for immediate access and use of any accessory. The optional accessories may be held in the drawers, compartments or chambers via tie-downs, clamps, cut-outs, etc.

[0095] The air cleaner can be implemented according to any of the embodiments in order to obtain several advantages, if desired. The invention can provide an effective and efficient air cleaner with increased cleaning surface area, increased efficiency and increased safety. Advantageously, overall arcing of the air cleaner unit is reduced, and arcing sufficient to trip shut-down circuits is drastically reduced. The various embodiments described above are provided by way of illustration only and should not be construed to limit the invention. Those skilled in the art will readily recognize the various modifications and changes which may be made to the present invention without strictly following the exemplary embodiments illustrated and described herein, and without departing from the true spirit and scope of the present invention, which are set forth in the following claims.

What is claimed is:

1. An electrostatic precipitator cell comprising:
a collection assembly;
a plurality of collection assembly ground plates disposed in the collection assembly;
a plurality of banks disposed in the collection assembly, wherein each bank comprises a collection assembly charge plate and a voltage isolator.

2. The electrostatic precipitator cell of claim **1** with the voltage isolator comprising a resistor.

3. The electrostatic precipitator cell of claim **1** with each bank comprising a plurality of collection assembly charge plates.

4. The electrostatic precipitator cell of claim **1** further comprising a corona assembly.

5. The electrostatic precipitator cell of claim **4** with the corona assembly being detachable and the electrostatic precipitator cell including a receiving slot to receive the preionizer.

6. The electrostatic precipitator cell of claim **1** with the plurality of banks being electrically connected to one another.

7. The electrostatic precipitator of claim **1** with the plurality of collection assembly ground plates being parallel to one another.

8. The electrostatic precipitator of claim **1** with the plurality of collection assembly ground plates being interspersed with the collection assembly charge plates.

9. An air cleaner comprising:
an air channel;
an electrostatic precipitator cell disposed in the air channel comprising:
a collection assembly;
a plurality of collection assembly ground plates disposed in the collection assembly;
a plurality of banks disposed in the collection assembly, wherein each bank comprises a collection assembly charge plate and a voltage isolator.

10. The air cleaner of claim **9** with each bank comprising a plurality of collection assembly charge plates.

11. The air cleaner of claim **9** with the electrostatic precipitator cell further comprising a detachable corona assembly.

12. The air cleaner of claim **9** with the plurality of collection assembly ground plates being parallel to one another.

13. The air cleaner of claim **9** with the plurality of collection assembly ground plates being interspersed with the collection assembly charge plates.

14. The air cleaner of claim **9**, further comprising:
a high voltage power supply;
an electrical contact on the electrostatic precipitator cell; and
an electrostatic precipitator cell receiver including an electrical contact on the air cleaner,
wherein contact between the electrical contact on the electrostatic precipitator cell and the electrical contact on the electrostatic precipitator cell receiver connects the corona wire assembly to the high voltage power supply.

15. The air cleaner of claim **14** further comprising a fan operable at different speeds, wherein an amplitude of an electrical current supplied to the corona wire assembly by the high power voltage supply correlates to the fan speed.

16. The air cleaner of claim **9** further comprising an actuator disposed on the electrostatic precipitator cell and a switch disposed in the electrostatic precipitator cell receiver, wherein actuation of the switch is necessary prior to supplying voltage to a high voltage power supply.

17. The air cleaner of claim **9** with the electrostatic precipitator cell being detachable.

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