June 16, 1964 H. F. FRUTH 3,137,550

AIR CLEANER

Filed July 22, 1960 2 Sheets-Sheet 1

Fig. 1.

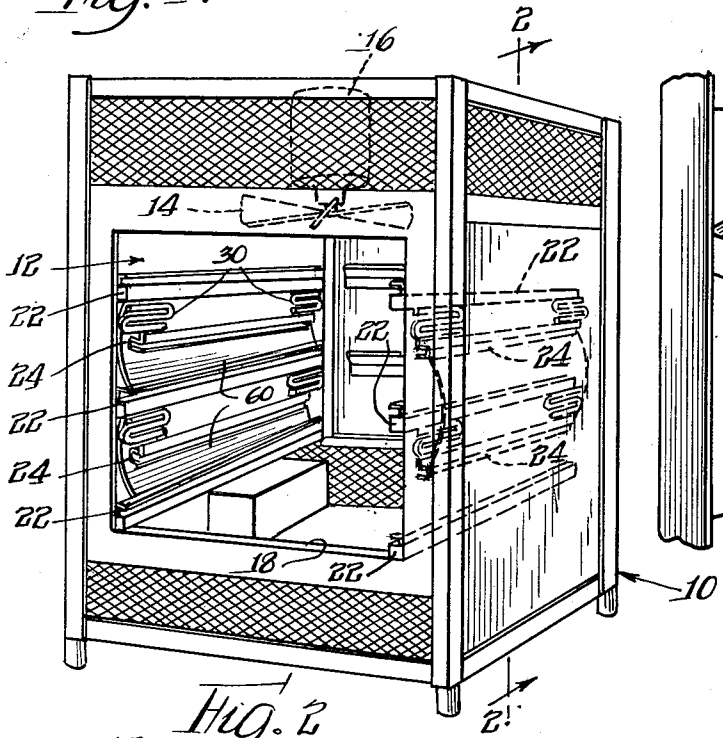


Fig. 3.

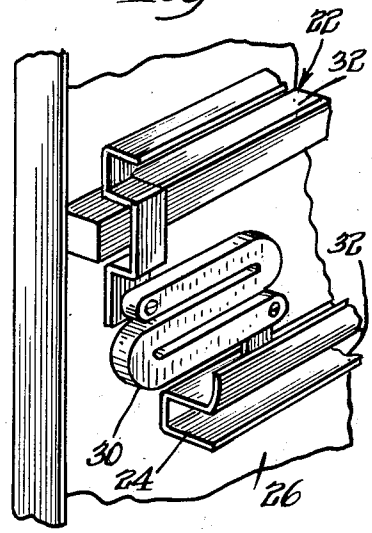


Fig. 2

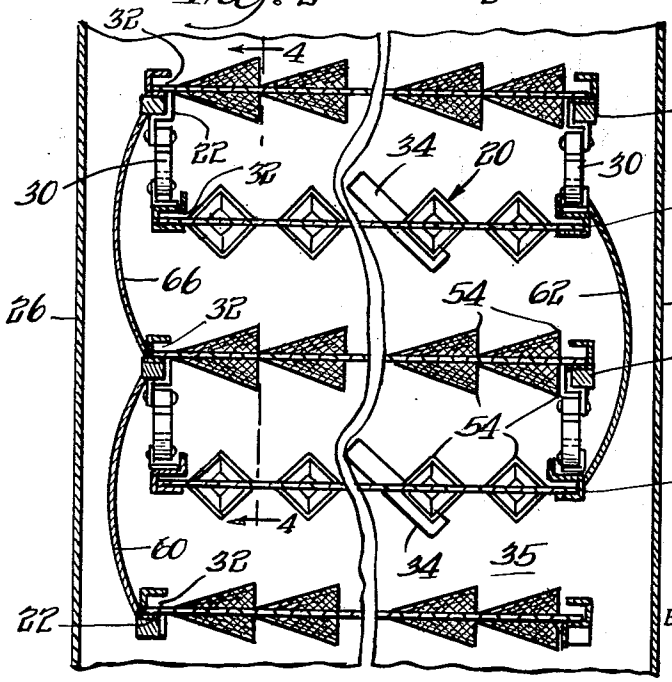
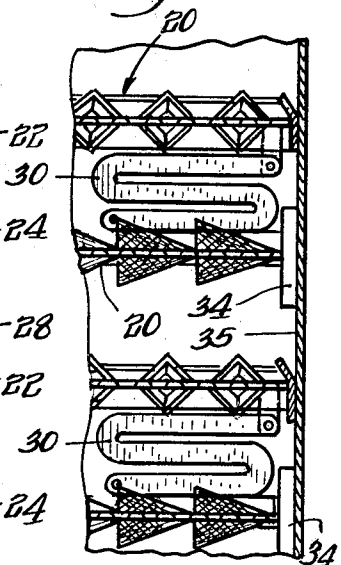


Fig. 4.



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June 16, 1964 H. F. FRUTH 3,137,550

AIR CLEANER

Filed July 22, 1960 2 Sheets-Sheet 2

Fig. 5.

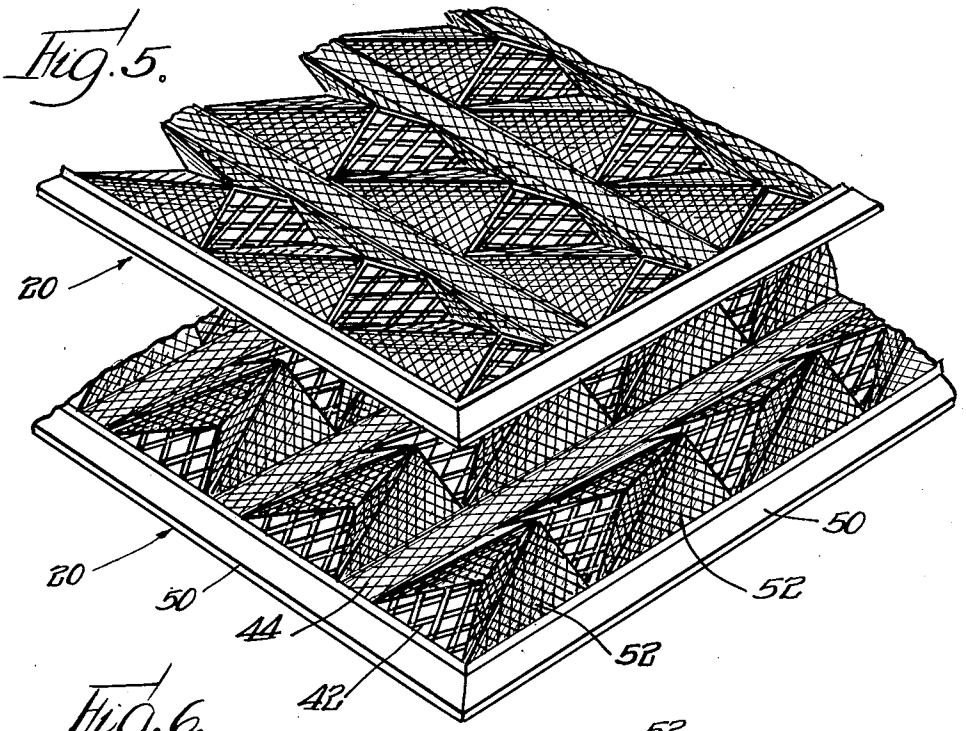


Fig. 6.

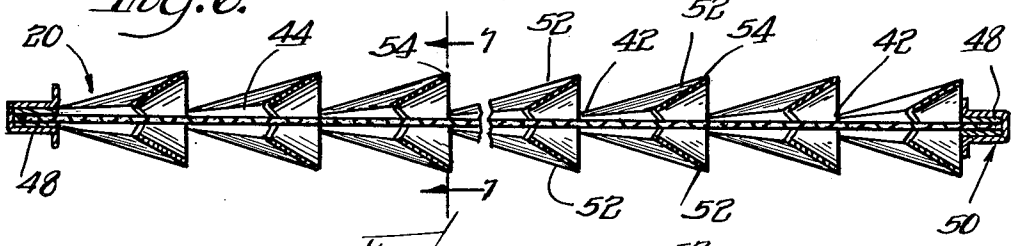


Fig. 7.

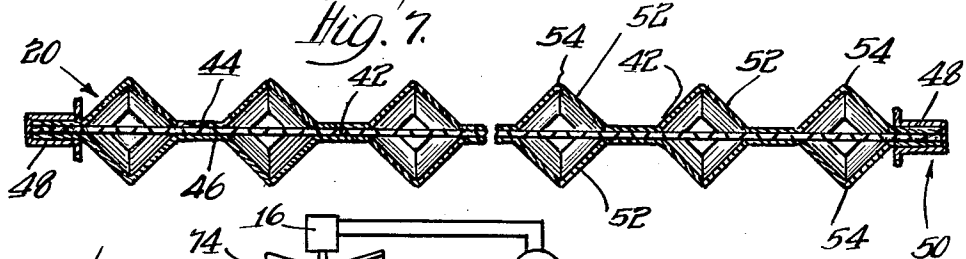
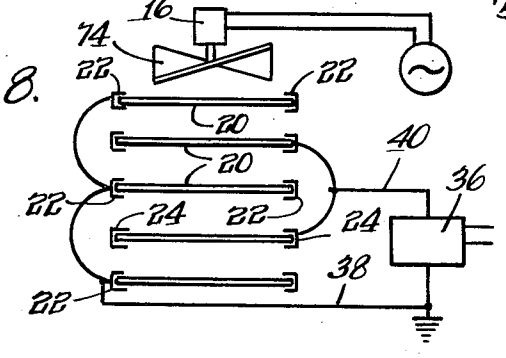


Fig. 8.



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3,137,550

AIR CLEANER

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2 Claims. (Cl. 55—131)

The present invention relates to air cleaning apparatus designed to remove air borne particulates from air, the particulates being any and all air borne particles not in gas or vapor form. Such particulates may be borne by gases or vapors other than air and may be removed from such other gases and vapors in accordance with the invention in the same manner that the particles are removed from air.

One object of the invention is to provide air cleaning apparatus in which a most thorough and efficient removal of particulates from air is achieved by means of a new and improved cleaning structure which acts electrically and aerodynamically on the air in an improved manner to produce an increased incidence of impingement of suspended particles on the collecting surfaces of the collecting structures.

Another object is to provide new and improved air cleaning apparatus which utilizes an electric field to great advantage in effecting a permanent removal of particulates from an air stream in a manner which assures retention of the removed material by the particulate collecting structure independently of the electric field employed in initially precipitating them from the air by means of holding the particulates on and in air adhesive coating covering the collecting surfaces.

Another object is to provide air cleaning apparatus of the above character which is especially well suited to remove particulates from air moved through the collecting structures in that the collecting structure incorporated into the air cleaning apparatus makes effective use of the velocity of the air to produce an aerodynamic action on the air which tends to bring suspended particulates into contact with the outer and inner collecting surfaces of the collecting structures.

Another object is to provide improved air cleaning apparatus in which the incidence of impingement of particulates on collecting surfaces is greatly increased by a highly advantageous correlation of aerodynamic and electrical forces applied to a stream of air by a new and improved collecting structure which makes a most advantageous use of electric potential in ionizing the air being cleaned in a manner which avoids undesirable production of ozone and nitrous oxide by providing many dark discharges from the internal points on the collector elements.

A further object is to provide improved air cleaning apparatus, as recited in the above objects, which is capable of collecting and retaining enormous quantities of contaminants without appreciable loss of air cleaning efficiency or pressure flow resistance build up.

Another object is to provide improved air cleaning apparatus, as set forth in the foregoing objects, which is capable of operating with great efficiency and effectiveness when supplied with an electric potential, even though the potential may be poorly regulated, thus avoiding any necessity for providing an expensive power supply unit capable of regulating the voltage with great accuracy.

Another object is to provide improved air cleaning apparatus in which improved collecting elements used to physically collect and retain particulates, and functioning electrically and aerodynamically to increase the impingement of particulates on the collecting structures has a physical construction which is well suited for economical manufacture.

Other objects and advantages will become apparent from the following description of the exemplary embodiment of the invention illustrated in the drawings, in which:

FIGURE 1 is a perspective view illustrating the housing of the air cleaning apparatus forming the illustrated embodiment of the invention, a front panel of the housing and internal collector elements being removed to more clearly reveal collector element support structure within the housing;

FIG. 2 is a fragmentary sectional view, taken along the line 2—2 of FIG. 1 and illustrating the collector elements in place;

FIG. 3 is a fragmentary perspective view illustrating collector element mounts within the housing;

FIG. 4 is a fragmentary sectional view, taken with reference to line 4—4 of FIG. 2 and illustrating the support of spaced collector elements by the collector element mounts;

FIG. 5 is a fragmentary perspective view illustrating the positional relationship of two adjacent collector elements;

FIG. 6 is a horizontal sectional view of a typical collector element;

FIG. 7 is a sectional view of a collector element taken along the line 7—7 of FIG. 6; and

FIG. 8 is a diagrammatic illustration of the tiered collector elements together with the means used to apply an electric potential to the collector elements, and the means used for moving air through the collector elements.

Referring to the drawings in greater detail, the air cleaning apparatus forming the exemplary embodiment of the invention illustrated comprises a housing **10** defining an internal air-flow space or channel **12** extending vertically through the interior of the housing air-space.

A current or stream of air to be cleaned is moved through the channel **12** by means of a fan or blower **14** mounted, as shown, in the top of the housing **10** and driven by an electric motor **16**. The air moving fan and motor may be located on either side of the air cleaning elements so long as it moves air to be cleaned through the elements.

A large access opening **18** in the front of the housing **10** is normally covered by a removable front panel (not shown).

Particulates suspended in the air moving through the channel **12** are removed from the air by a plurality of collector elements **20** supported within the housing **10** in tiered, generally parallel relation to each other. The collectors **20** are charged to a high potential relative to each other and have a new and improved construction which applies to the air moving through the channel **14** and passing through the collectors mutually coordinated electrical and aerodynamic actions which cause a very high incidence of impingement of the particulates on surfaces of the collectors. Thus, as will presently appear, the collectors **20** operate with great efficiency to initially collect particulates from the passing air stream and serve to retain them on the collectors independently of the electric potential used in initially removing the suspended particulates from the air.

Each individual collector element is substantially symmetrical with respect to a central plane of the collector which is generally flat or coplanar.

The collectors **20** are mounted in the housing **10** on two series of tiered supports or shelf elements **22, 24** positioned inwardly of two opposed side walls **26, 28** of the housing. The collector supports or shelves located along the opposite side walls **26, 28** of the housing are paired together, each pair of supports serving, as will presently appear, to support one collector element.

As illustrated, the series of supports **22** are grounded to the housing **10** by being mounted on the physical structure of the housing. As will presently appear, these

grounded supports or mounts are connected to the grounded side of an electric power supply unit which applies a potential between adjacent collectors mounted in the housing. It will be observed that the collector supports or mounts **22** are disposed in horizontal positions, the individual supports **22** on each side of the housing being disposed in horizontally opposed relation to and in vertical alinement with the corresponding supports on the opposite side of the housing.

The other series of collector supports **24** are suspended in alternate, vertically spaced relation to the grounded supports **22**, as shown in FIGS. 1 to 3. Preferably, each of the supports **24** is supported at opposite ends by reversely curved ceramic insulators **30**. The reversely curved shaping of the insulators **30** illustrated provides for supporting the collector mounts **24** near the collector mounts **22**, while at the same time providing an effective length of each insulator which greatly exceeds the spacing of the adjacent mounts from each other.

The insulated mounts **24** are also disposed in horizontal positions, the mounts **24** on one side of the housing being paired against similar mounts on the other side of the housing.

Preferably, each of the collector supports **22**, **24** is shaped to define a longitudinal channel **32** extending substantially the full length of the support and opening horizontally inward to receive one marginal side edge of a collector **20**, as will appear.

A plurality of insulator blocks **34** are secured to the rear wall **35** of the housing **10** to be engaged by the collectors **20** supported in the insulated collector mounts **24**.

The collectors **20** are removably supported within the housing **10** to extend across the direction of air-flow through the space **12** by sliding the individual collectors horizontally into the opposed pairs of collector mounts **22**, **24** in such manner that opposite side edges of each collector fit into the channels **32** of the supporting mounts. The collectors **20** supported in the insulated mounts **24** are charged to a potential of eight to ten thousand volts with respect to the adjacent collectors supported in the grounded channels **32**. This is effected by means of a power supply unit **36** having a grounded side connected through a conductor **38** with the grounded channel supports **22**, and a direct current output side connected through a conductor **40** with the insulated collector supports **24**.

Each of the collector elements **20** has a fenestrated metal construction comprising a pervious metal core, **42**, FIGS. 5 to 7, sandwiched between two thin metal sheaths **44**, **46**. At the respective marginal side edges of each collector **20** the two sheaths **44**, **46** are pressed firmly against the marginal edges of the core **42** and embraced by a narrow metal binding **48** to form marginal edges **50** along the four sides of the collectors which are adapted to fit slidably into the support channels **32** of the collector mounts **22**, **24**.

The pervious metal core **42** of each collector is preferably formed of expanded metal. The metal expanded to form the core is preferably aluminum foil.

The two sheaths **44**, **46** on each collector **20** are also formed of metal foil, preferably aluminum. In order to provide maximum strength in the structure of the sheaths **44**, **46**, and to maximize the particulate collecting capabilities of the sheaths, it is advantageous to form the sheaths of dimpled aluminum foil. This foil is dimpled or quilted by being passed through rollers, or the like.

The sheaths **44**, **46** are shaped into a form such that the sheath structure serves to produce both the desired electrical effect and aerodynamic action by which the present invention achieves a highly efficient removal of air borne particulates.

Structurally, each of the two collector sheaths **44**, **46** are mirror images of each other. Each sheath is shaped to form a plurality of parallel corrugations, each of which projects outwardly from the underlying pervious core **42** to a sharp crest line. The individual sheath corrugations are transversely interrupted along the length of the corrugations to form a plurality of relatively short, longitudinal corrugation segments **52**. Each corrugation segment **52** is folded inwardly toward the underlying core **42** at only one end of the segment, so that the segment has a pyramidal shape, as illustrated in FIGS. 5 to 7, which is inclined away from a perpendicular to the adjacent core **42**. All of the pyramidal corrugation segments **52** of each collector sheath are inclined in the same direction, as shown. Moreover, the corrugation segments **52** formed in the sheathes **44**, **46** on opposite sides of each collector sheath are inclined in the same direction. It will be understood that the word "inclined" here is used to describe the fact that the apex **54** of each pyramidal element **52** is offset from the base area of the pyramidal element. Thus, the elements can be regarded, for purposes of description, as being inclined or tilted with respect to the underlying collector core **42**.

The pyramidal shaped corrugation segments **52** thus formed serve as air-flow deflectors or directors which direct air moving through the adjacent pervious collector core **42** into a path inclined away from a perpendicular to the collector core and making an acute angle with respect to the collector core. Thus, air moving toward one side of a collector engages the sloping surfaces of the deflector elements **52** and is caused to flow into the open ends of the deflectors or corrugation segments **52** in a manner such that the air-flow has a direction making an acute angle with the adjacent core **42** when it reaches the core. As the air emerges from the opposite side of the core it engages the interior inclined surfaces of the deflector elements **52** on the opposite side of the core and is directed away from the core at an acute angle with respect to the core and in a direction generally opposite from the angular direction in which the air approaches the core from the intake side.

The effect of this is to produce a turbulent scrubbing of the air against the interior and exterior surfaces of all the air deflector elements **52** and to effect a turbulent movement of the air passing through the expanded metal previous core **42**, all of which tends to bring suspended particulates into contact with surfaces of the collectors.

The collector corrugation segments or air-flow deflectors **52**, shaped into pyramidal form as described, project outwardly from adjacent the collector core **42** and define apices **54** which are quite sharp. These apices are used to advantage as corona discharge points and in effecting ionization of the air moving through the collector space. Moreover, the apices are formed by the thin metal foil of the collector sheaths and are heated by the electrical discharge in use, as will presently appear, which enhances the desired ionization of the air being cleaned.

In order to make the most effective use of corona discharge in ionizing the air, the air deflector elements **52** are dimensioned so that the apices **54** are spaced at least three-eighths of an inch from the median plane of the underlying pervious core **42**, and are spaced at least three-fourths of an inch from each other. Also, the tiered collector mounts **22**, **24** of the housing **10** are spaced so that the apices **54** on the adjacent collectors **20** have a spacing ranging from three-eighths to three-fourths of an inch.

As previously mentioned, the power supply unit **36** charges the adjacent collectors to a voltage of eight to ten thousand volts with respect to each other. This produces a highly effective ionization of the air passing between two collectors without generating ozone, nitrous oxide, or other noxious gases.

The combined electrical and aerodynamic action of the collector elements **20** on the air moving through the collectors effects a very thorough cleaning of the air by causing particles to contact all surfaces of the collector elements. Thus, the air is effectively cleaned of sus-

pended particles including particles of the following materials and sizes.

Table

	Particle sizes in microns
Solids or dusts of organic or inorganic material	20 to 40
Pollens:	
Ragweed	14 to 20
Other	2 to 14
Spores and molds	1 to 5
Bacteria and microorganisms	½ to 2
Viruses	1/10 to 1
Aerosols:	
Sneezes, atomized droplets, smoke and smog fumes	1/10 to 20

Particulates which contact the collector surfaces are wet out and encapsulated and caused to adhere to the collector surfaces by means of an adhesive and absorbing coating on the surfaces which enables the collectors to collect and retain a very large volume of particulates without substantially diminishing the air cleaning efficiency of the structure. The surfaces of each collector element **20** are substantially covered with a coating of a suitable water soluble adhesive which is generally non-volatile and which remains fully effective over an indefinite period of time to wet out and encapsulate particulates which are brought in contact with the collector surfaces. Moreover, the coating of adhesive serves to retain the particulates on the collectors independently of the elecrtic voltage supplied to the collectors, thus preventing the collected materials from returning to the air, even though the forced circulation of air continues after the voltage is removed.

The capacity of the collectors **20** to collect and retain large volumes of air contaminants is greatly enhanced by the large volumetric capacity of each collector element to contain material within the spaces between the apices **54** on opposite sides of the collectors. Moreover, the pyramidal deflecting elements **52** on opposite sides of the collectors, together with the expanded metal core **42** provide a very extensive surface area to which an adhesive and absorbent coating is applied to collect and hold the particulate. The dimpled surfaces of the sheaths **44**, **46** provide pockets which tend to store fluid for forming the adhesive coating.

Since the adhesive coating applied to the collectors **20** to adhere to and quench the particles is water soluble, the collectors **20** can be cleaned easily by removing the collectors from the housing **10** and washing them in water.

It is also noteworthy that turbulent scrubbing of the air against the collectors **20** is enhanced by orienting adjacent collectors in the housing **10** so that the directions in which the air is directed by the adjacent collectors are turned at an angle of at least 90° with respect to each other. As shown, the collectors **20** are square. Hence adjacent collectors can be turned at angles of 90 or 180° with respect to each other, so that the deflectors **52** on adjacent collectors are turned to a large angle with respect to each other.

An efficient yet turbulent flow of air through the flowspace **12** is enhanced by air directors **60** connected between the grounded collector mounts **22** on one side of the housing **10** and an air director **62** connected between the insulating collector mounts **24** on the opposite side of the housing, as shown in FIGS. 1 and 2. The medial portions of the air directions **60** and **62** bow outwardly from the collector mounts intervening between the mounts at opposite edges of the individual air directors. Preferably, the last collector **20** in the flow stream of the air passing through the space **12** is grounded, as shown.

The invention is claimed as follows:

1. An air cleaning device comprising, in combination, a housing, a plurality of particulate collector elements each being formed of a fenestrated metal construction, two series of collector element mounts positioned in said housing in alternate spaced relation to each other to support said plurality of collector elements in said housing in spaced generally coextensive relation to each other, power supply means connected to said respective series of collector element mounts to effect charging of alternate collectors on the mounts to a high voltage with respect to each other, each of said collector elements comprising a pervious metal core sandwiched between two metal foil sheaths, each of said sheaths being corrugated to define a plurality of parallel corrugations each of which protrudes outwardly to a sharp crown, each of said protruding corrugations being transversely severed at longitudinal intervals therealong to form longitudinal corrugation segments, each of said corrugation segments being folded inwardly at one end only to form an air directing deflector means extending outwardly to a sharp point at an acute angle to the adjacent collector core, each said deflector means being of pyramidal shape having two sides and an open end, and a water soluble and substantially non-volatile particulate collecting film substantially covering the surfaces of each of said collector elements, said sharp points promoting a dark discharge between adjacent collector elements substantially free of generation of ozone and nitrous oxide.

2. An air cleaning device as set forth in claim 1 wherein successive collector elements are oriented so that the corrugations of one element are at right angles to the corrugations of adjacent collector elements, said air directing deflector means thereby being at right angles in successive collector elements, the deflector means of alternate collectors being parallel and opening in the same direction.

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