

PATENT SPECIFICATION

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(54) IMPROVED ELECTRONIC AIR CLEANER

(71) We, ALPHA DENSHI KABUSHIKI KAISHA, a Japanese Body Corporate of 4-7-11, Iidabashi, Chiyoda-ku, Tokyo-to, Japan and HITACHI JIDOSHABUHANBAI KABUSHIKI KAISHA, a Japanese Body Corporate of, 4-6-50, Konan, Minato-ku, Tokyo-to, Japan do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to an improved electronic air cleaner, and more particularly to a cleaner utilizing the dust electrification phenomenon caused by electric discharge.

There are well known electronic air cleaners, or dust arrestors, which comprise a cell for electrifying the dust particles by electric discharge, and a cell for collecting the electrified particles. These dust arrestors may be operated either with a positive or negative supply voltage, and the arrestor with a negative voltage has 1.5 to 2 times better efficiency than that with a positive voltage if the absolute values of those discharge voltages are equal to each other, although the ozone generated by the former is thrice as much as that by the latter. For this reason, air cleaners which must avoid polluting by generating ozone usually employ a positive discharge voltage, sacrificing efficiency, while negative discharge voltages are often used in smoke eliminators where the main importance is placed on the dust collecting efficiency.

The discharge electrodes in the discharge cell are usually wires of 100 microns or more in diameter for mechanical rigidity. Wires of this thickness need a positive supply voltage of at least 10 kilovolts to discharge sufficient electricity so as to obtain the desired efficiency.

Moreover, nearly all the charged dust particles must be collected to maximise the dust collecting efficiency.

As is described above, the dust particles charged at a positive or a negative potential in

the charger cell are attracted to the grounded electrode in the collector cell. The electrode must be so constructed as not to disturb the flow of air in the collector cell. To that end, the collector electrode is usually formed as an assembly of parallel metallic plates spaced apart appropriately for the flow of air.

In the collector electrodes of known structures, the dust particles arrested at the collector electrodes have the same potential as that of the electrodes, and therefore those electrodes tend to allow a part of the arrested dust to disperse again into the air when their retentive capacities are exceeded. To prevent dust dispersion and retain the collected dust at the electrodes, it has been proposed that oil is applied to the surface of the collector electrodes. In this case, periodic cleaning of the collector electrodes is required to avoid clogging, which may increase the pressure drop of the air; and so to maintain a good dust collection performance. Furthermore, the above mentioned cleaning work needs manpower and cleaning apparatus (e.g., an ultrasonic washer), resulting in increased costs. The requirement for cleaning can easily be appreciated from the fact that there are now some independent companies doing this work.

According to this invention, there is provided an electronic air cleaner, comprising: a casing of insulating material having an air inlet and an air outlet; an electric fan seated in said casing and operable to cause a flow of air along a path from said air inlet to said air outlet; a mechanical pre-filter placed in said casing at the air inlet; a grounded conductive protection net located in said casing behind said mechanical pre-filter in the direction of air flow; a plurality of thin-wire electrodes less than 50 microns in diameter arranged at substantial right angles to the air path and transversely spaced apart relative thereto; a plurality of grounded conductive plates each having one end attached to said protection net and extending along the air path in the direction of air flow between

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adjacent pairs of said thin-wire electrodes, said thin wire electrodes together with said protection net and part of said grounded plates forming a discharge cell; an electrostatic collector cell behind the discharge cell in the direction of air flow and including said extending parts of said grounded conductive plates and a plurality of negative high voltage conductive plates respectively connected to said thin-wire electrodes and extending between said grounded conductive plates; a chemical filter placed in said casing behind said electrostatic collector cell in the direction of air flow; and a negative direct-current high voltage power source of less than 4.2 kilo-volts connected between the ground and said high negative voltage conductive plates.

Advantages of this arrangement include the following:-

(1) The rate of ozone generation can be decreased with decreasing discharge voltage, regardless of the polarity of the supply voltage. Thus the ozone generation can be almost suppressed at a negative voltage of about 4.2 kilovolts or less.

(2) The thin wire forming the discharge electrode in the discharge cell can discharge enough electricity and give the dust enough electric charge for the desired dust arresting performance at a relatively lower discharge voltage, and therefore the dust collection efficiency is improved.

Preferably, the cleaner includes a mechanical after-filter or a honeycomb-type electrostatic collector electrode provided between said electrostatic collector cell and said chemical filter. The honeycomb structure, having sufficient mechanical strength by itself, needs no other reinforcing members, and hence it can be small in size and light in weight, facilitating manufacture and handling.

An example of the present invention will be described with reference to the accompanying drawings, in which:

Figure 1 shows a longitudinal section of a embodiment of the present invention;

Figure 2 is a perspective view including a cut-away part of the discharge and collector cells employed in this invention;

Figure 3 shows part of a horizontal section along a line A-Az in Figure 1;

Figure 4A and 4B are perspective view illustrating the fixing of a thin wire discharge electrode in this embodiment;

Figure 5 shows a longitudinal section of another embodiment of the present invention;

Figure 6 shows a longitudinal section of a still further embodiment of this invention;

Figure 7 is a perspective view of the honeycomb structure of the embodiment shown in Figure 6; and

Figure 8 is an elevational view of another example of the thin-wire discharge electrode in this invention.

With reference to Figures 1 to 4, an

embodiment of the present invention will be described. A casing 18 of insulating material has an air inlet 1, at which a pre-filter 2 is provided for removing coarse particles. At the rear side of the filter 3, is provided a protection net 3 held at the ground potential. Grounded electrodes 4 each consisting of conductor plates extending from the protection net 3 to the inner part are connected to and each supported by conductors 19 and arranged between high negative voltage plate electrodes 7, which are supported by insulators 5 and jointly connected by conductors 6. Each high negative voltage plate electrode 7 has projections 8 forwardly extending to form an E-shaped plate. A thin-wire electrode 9 is supported at the top of the projections 8. Thus, the thin wire 9 is positioned at right angles to the flow of air. The protection net 3, the grounded electrodes 4 and the thin-wire discharge electrodes 9 form a discharge cell (i.e., a dust electrifying cell) 12A, and the grounded electrodes 4 and high-voltage negative electrodes 7 form a collector cell 12B, which attracts the charged dust particles. In a case where the thin wire 9 has a thickness of 50 microns or less, it causes a sufficient amount of negative-voltage discharge under minimum ozone generation. In a preferred embodiment of this invention, the thin-wire discharge electrode 9 is stretched between the wire holders 8 of the negative high voltage plate electrode 7 in accordance with the following procedure (shown in Figure 4) in which an end of each wire holder 8 is partially sheared and its incision edges are rounded as shown in Figure 4A; a thin-wire 9 is wrapped round the remainder part, and then the sheared part is put back in its former position to fixedly support the wire as shown in Figure 4B. This ensures that the thin wire discharge electrode 9 is not accidentally disconnected during the installation work. Another protection net 10 is placed behind the grounded electrodes 4, if necessary, and is kept at the ground potential. The high voltage power source 13 has a negative electrode connected to the electrodes 7 and 9, and a positive electrode connected to the electrode 19 which is placed inside the casing 18 and held at the ground potential. A chemical filter 14 placed at the rear of the protection net 10 contains activated charcoal or catalyzer for removing harmful substances. An electric cross flow fan 15 is provided to take in the polluted air from the air inlet 1 and let out the cleaned air to an air outlet 16. If necessary, a protection net 17 is attached around the chemical filter 14.

In operation, the high voltage power source 13 supplies a negative voltage to the discharge electrodes 9 causing discharge in the discharge cell 12A. The fan 15 serves to take in the polluted air from the air inlet 1. The air loses coarse duct particles when passing through the mechanical pre-filter 2. The remaining fine particles having passed the filter 2 are

negatively charged at the electrifying cell 12A on the principle of electrostatic dust collection. Those particles are attracted to the grounded electrodes 4 in the collector cell 12B and arrested thereupon. When the air finally passes the chemical filter 14, the finer dust particles, smell, and other harmful remainders are eliminated. The air, thus cleaned, is sent out from the air outlet 16.

The electronic air cleaner according to the present invention generates ozone only at 0.01 ppm rate under a discharge voltage of -4 kilovolts. As the discharge voltage used is low, the insulation against the high voltage is easy so that the power source and other parts supplied with high voltages can be made small and light. As the electronic air cleaner according to the present invention uses a negative voltage, the discharge power source can also be commonly used as the power source of the negative ion generator usually provided in an electronic air cleaner of this kind. This means that the entire structure can be constructed in a small and compact size. A conventional electronic air cleaner, employing a positive voltage discharge power source, needs to provide either another negative power source for the negative ion generation or a power supplying circuit with a special device to make the positive power source available for the negative ion generation.

In accordance with this invention, the discharging phenomenon is easy to occur at a lower voltage, because each discharge electrodes 9 is surrounded by the upper and the lower plate electrodes 4 and the grounded protection net 3 laid across the front ends of the electrodes 9. Thus, the structure described above has the advantage of making it easy to electrify the dust particles. As the thin-wire discharge electrode 9 is covered by the plate electrodes 4 and the protection net 3, it is mechanically protected against disconnection by accidental touch during an inspection work. Besides, the electrodes 4 and the net 3 do not cause any electric shock to an inspector as they are at the ground potential.

With reference to Figure 5, another embodiment of the present invention will next be described. The constitution of this embodiment differs from that of the first embodiment at the point that a mechanical after-filter 11 is inserted between the electrostatic collector cell 12B and the chemical filter 14. In Figure 5, the same parts as those of the first embodiment are given by the same reference numerals. The dust particles are attracted to each other and become coarse particles when passing through the discharge cell 12A, and therefore according to this embodiment the dust particles having passed through the collector cell 12B are arrested at the mechanical after-filter 11. That means the dust collection efficiency is improved.

With reference to Figure 6, another embodiment of this invention will be described. In this

embodiment, a honeycomb type collector electrode 20 is placed between the chemical filter 14 and the electrostatic collector cell 12B. In Figure 6, the same parts as those of the first embodiment are marked with the same reference numerals. The honeycomb electrode 20, being at the ground potential, serves to improve the dust collection efficiency, because it collects in an electrostatic way the charged particles that were not caught at the electrostatic collector cell 12B. The honeycomb collector electrode 20 may be made of aluminium (e.g., a thickness of 0.05 mm) or other metal sheets, metallized papers, or conductive plastics, and is preferably a combination of hexagonal cylinders as shown in Figure 7. The cell size "a" (Figure 7) may be chosen at an appropriate value. The honeycomb type collector electrode 20 employed in this invention can be produced only by cutting in a desired size the honeycomb component part being on sale under the Trade name "Alumi-Honeycomb". Since such part made of very light aluminium with a space factor of only about three percent has the sufficient mechanical rigidity by itself and does not need any special frame or reinforcement, reducing the weight and cost, it is suitable for the application to vehicles, e.g., airplanes and cars, under a low weight and cost. In addition, it may be thrown away after use. Furthermore, the honeycomb collector electrode 20 is easily replaced by a new one, cleaned, or removed, when constructed in a cartridge form.

The discharge electrode 9 may have such structure as shown in Figure 8. The discharge electrode of Figure 8 has a number of short and fine discharge wires 22 (those wires are no more than 50 microns in thickness) fixed in a crosswise form at appropriate intervals on a relatively long and thick conductive support wire, which is strained between the wire holder 8 of the negative high voltage plate 7. This structure can be produced by welding, studding or some other process.

Under this structure, since the discharge fine wires 22 can be minimized in thickness, the mechanical strength of the discharge electrode can be improved by the support wire 21 while producing sufficient discharge at a lower voltage.

As mentioned above, a highly effective electronic air cleaner can be provided in accordance with this invention, which comprises a mechanical after-filter or a honeycomb electrode type filter as well as an electrostatic collector electrode for collecting the charged dust particles. The electrostatic collector electrodes can be formed to be readily renewed and cleaned with a little expense. Moreover, a small and light electronic air cleaner can be provided in accordance with this invention with light and readily replaceable electrostatic collector electrodes having a high dust collection efficiency and suitable for

motor vehicle application.

WHAT WE CLAIM IS:-

1. An electronic air cleanser, comprising: a casing of insulating material having an air inlet and an air outlet; an electric fan seated in said casing and operable to cause a flow of air along a path from said air inlet to said air outlet; a mechanical pre-filter placed in said casing at the air inlet; a grounded conductive protection net located in said casing behind said mechanical pre-filter in the direction of air flow; a plurality of thin-wire electrodes less than 50 microns in diameter arranged at substantial right angles to the air path and transversely spaced apart relative thereto; a plurality of grounded conductive plates each having one end attached to said protection net and extending along the air path in the direction of air flow between adjacent pairs of said thin-wire electrodes, said thin wire electrodes together with said protection net and part of said grounded plates forming a discharge cell; an electrostatic collector cell behind the discharge cell in the direction of air flow and including said extending parts of said grounded conductive plates and a plurality of negative high voltage conductive plates respectively connected to said thin-wire electrodes and extending between said grounded conductive plates; a chemical filter placed in said casing behind said electrostatic collector cell in the direction of air flow; and a negative direct-current high voltage power source of less than 4.2 kilo-volts connected between the ground and said high negative voltage conductive plates.
2. An electronic air cleaner according to claim 1, in which each of said thin-wire

discharge electrodes is stretched between projections of said negative high voltage plates extending towards the inlet.

3. An electronic air cleaner according to claim 2, in which said thin-wire discharge electrodes are each wrapped in sheared gaps provided at the projections.

4. An electronic air cleaner according to claim 1, in which each of said thin-wire discharge electrodes comprises a conductive support wire, stretched between projections of said negative high voltage plates extending towards the inlet, and a number of fine wires fixed on the support wire at intervals and at substantial right angles to said air path.

5. An electronic air cleaner according to any preceding claim, further including a mechanical after-filter provided between said electrostatic collector cell and said chemical filter.

6. An electronic air cleaner according to any of claims 1 to 4, further including a honeycomb type electrostatic collector electrode placed between said electrostatic collector cell and said chemical filter.

7. An electronic air cleaner substantially as hereinbefore described with reference to and as illustrated in any of the accompanying drawings.

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motor vehicle application.

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- 1. An electronic air cleanser, comprising: a casing of insulating material having an air inlet and an air outlet; an electric fan seated in said casing and operable to cause a flow of air along a path from said air inlet to said air outlet; a mechanical pre-filter placed in said casing at the air inlet; a grounded conductive protection net located in said casing behind said mechanical pre-filter in the direction of air flow; a plurality of thin-wire electrodes less than 50 microns in diameter arranged at substantial right angles to the air path and transversely spaced apart relative thereto; a plurality of grounded conductive plates each having one end attached to said protection net and extending along the air path in the direction of air flow between adjacent pairs of said thin-wire electrodes, said thin wire electrodes together with said protection net and part of said grounded plates forming a discharge cell; an electrostatic collector cell behind the discharge cell in the direction of air flow and including said extending parts of said grounded conductive plates and a plurality of negative high voltage conductive plates respectively connected to said thin-wire electrodes and extending between said grounded conductive plates; a chemical filter placed in said casing behind said electrostatic collector cell in the direction of air flow; and a negative direct-current high voltage power source of less than 4.2 kilo-volts connected between the ground and said high negative voltage conductive plates.
- 2. An electronic air cleaner according to claim 1, in which each of said thin-wire

discharge electrodes is stretched between projections of said negative high voltage plates extending towards the inlet.

3. An electronic air cleaner according to claim 2, in which said thin-wire discharge electrodes are each wrapped in sheared gaps provided at the projections.

4. An electronic air cleaner according to claim 1, in which each of said thin-wire discharge electrodes comprises a conductive support wire, stretched between projections of said negative high voltage plates extending towards the inlet, and a number of fine wires fixed on the support wire at intervals and at substantial right angles to said air path.

5. An electronic air cleaner according to any preceding claim, further including a mechanical after-filter provided between said electrostatic collector cell and said chemical filter.

6. An electronic air cleaner according to any of claims 1 to 4, further including a honeycomb type electrostatic collector electrode placed between said electrostatic collector cell and said chemical filter.

7. An electronic air cleaner substantially as hereinbefore described with reference to and as illustrated in any of the accompanying drawings.

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