

[54] **METHOD AND DEVICE FOR THE
COLLECTION OF PARTICLES IN A GAS
WITH PARTICLE-SIZE SEPARATION**

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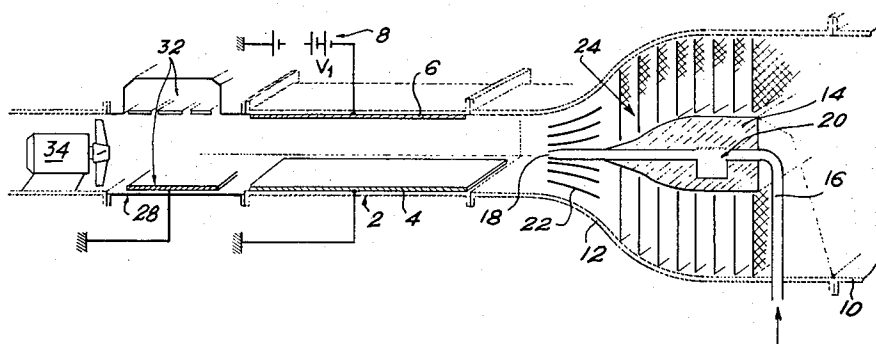
Primary Examiner—Dennis E. Talbert, Jr.

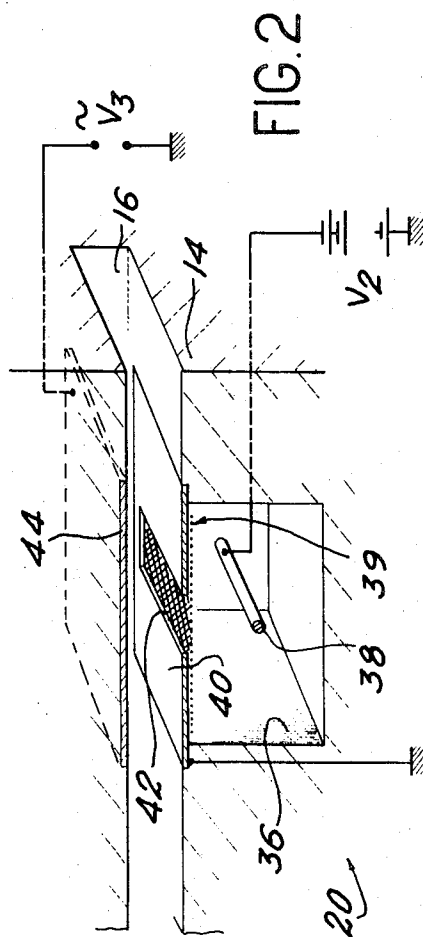
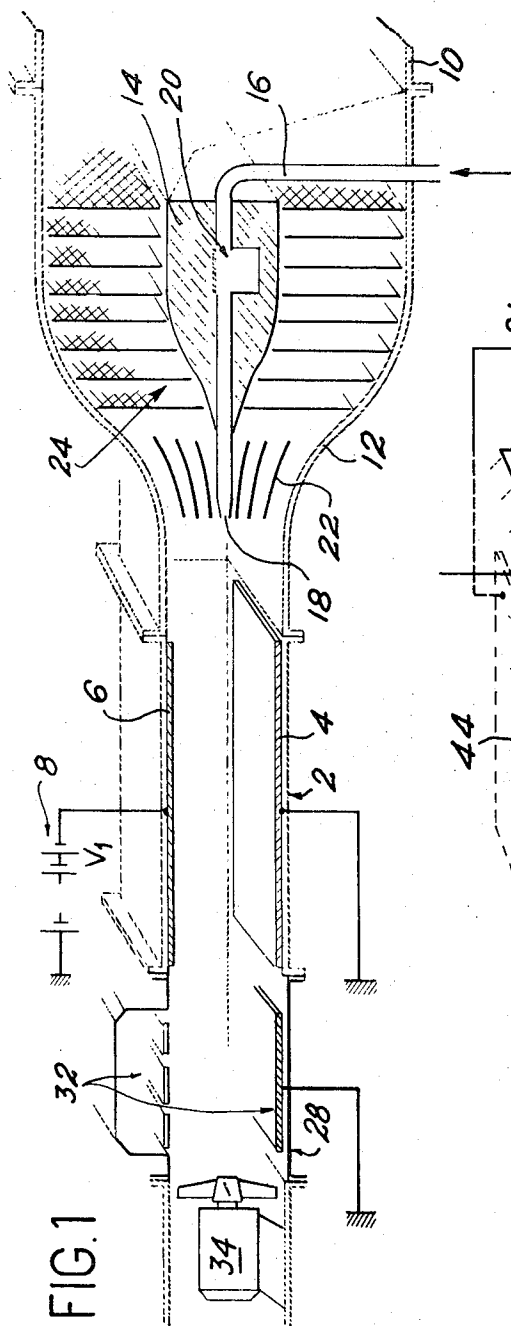
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[57] **ABSTRACT**

Particles suspended in polluted gas or atmospheric air to be analyzed are collected and separated according to their effective size by means of an electrostatic device comprising an inlet duct for the supply of "clean" gas, means for damping-out turbulent motion within said duct, and a conduit comprising at least one ionizer through which the polluted gas or air is injected into the clean gas stream. The charged particles are collected as the stream flows between two conductive plates which are substantially parallel to each other and between which is applied a direct-current potential difference.

12 Claims, 3 Drawing Figures





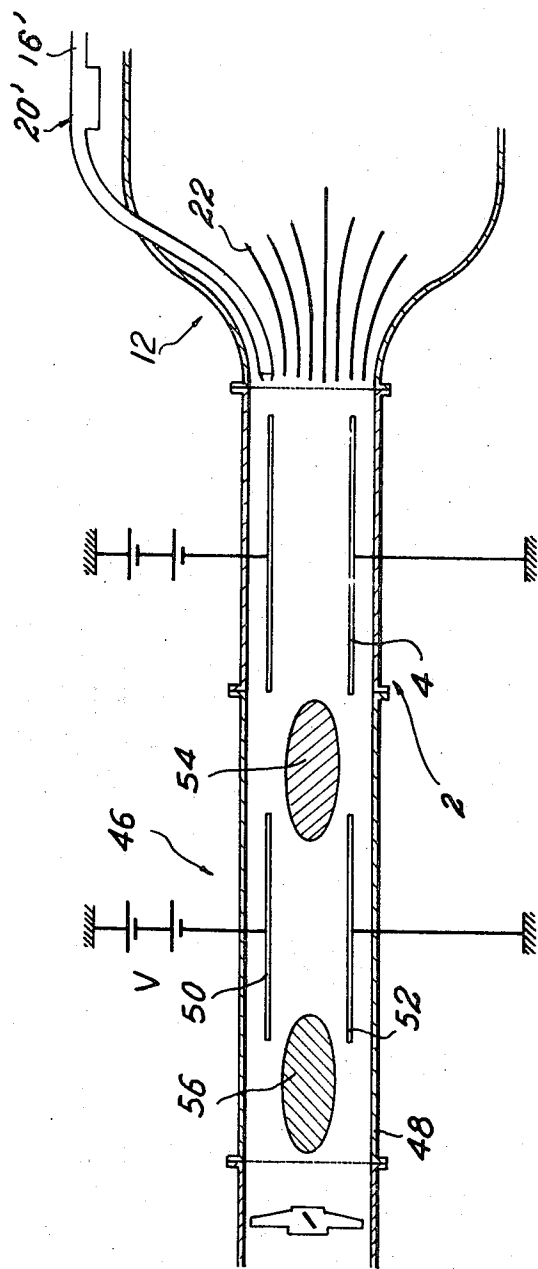


FIG. 3

METHOD AND DEVICE FOR THE COLLECTION OF PARTICLES IN A GAS WITH PARTICLE-SIZE SEPARATION

This invention relates to a method and a device for the collection of particles in a gas together with particle-size separation.

More precisely, the object of the invention is to collect dust or more generally any particles which are suspended in air or in a polluted gas to be analyzed and to separate said particles as a function of their effective size, that is to say as a function of their volume, so as to permit of subsequent chemical analysis of said particles.

Control of the aerosol content of air is a problem to which considerable importance is attached. For this reason, devices for control of particulate material already exist in a very wide range of categories for the application of the different methods. Among the principal types can be mentioned the following:

the systems for filtering through porous fabrics; these systems retain all the particles having sizes larger than the diameter of the pores. These filters have a disadvantage in that they cause a very substantial drop in gas pressure and become very rapidly clogged.

inertial systems based on gravity settling, particle impact or centrifugal force; these systems can permit selection of particles according to their mass if this latter is sufficiently high to ensure that the inertia forces are not negligible. At equal volume, the constituents which have a lower mass per unit volume are precipitated with lower efficiency than the others, and all particles of less than one micron in size escape from precipitation.

the thermal precipitation systems whereby a selection of particles can be carried out according to the square or the cube of their size if this latter is sufficiently small to ensure that the particles are sensitive to the forces applied (bombardment of photons). With this method the rate of flow of the polluted gas is limited (a few millimeters per second), which calls for a very long period of use in order to collect a sufficient quantity of constituents.

electrostatic precipitation; the particles are charged by means of a bombardment of ions which are emitted by an ion source and precipitated by means of an electric field, the selection of particles being carried out according to their dimensions or the square of their dimensions in proportion to the electric charge acquired. In the majority of these types of apparatus, the electrostatic pressure which results from the ion charge density produces a turbulent electric wind which, if it exists within the aerosol precipitation zone, disturbs the conditions of collection of said particles and therefore prevents any possibility of selection as a function of particle size. Devices which are not subject to this disadvantage do in fact exist but the flow rate of polluted gas for which they are designed is such that the quantity of particles collected is not sufficient to permit quantitative or only qualitative analysis of the constituents.

The precise object of the present invention is to provide a method and a device for collecting particles in a gas with particle-size separation which overcome the

disadvantages attached to the techniques of the prior art.

The method essentially consists in injecting into a gas stream in non-turbulent regime a flow of polluted gas in which the suspended particles have previously been charged within an ionizer, and in collecting said charged particles by passing said gas stream between two conductive plates which are substantially parallel to each other and to the axis of propagation of the air stream and between which is applied a direct-current potential difference.

In an alternative embodiment, after the gas stream has passed between the conductive plates, the particles which are still contained in said stream are charged and precipitated for subsequent retention in a second ionizer.

The method is therefore divided into two parts; in a first step, the particles contained in the gas to be analyzed are charged and said gas is injected into a gas stream while ensuring a flow regime having very low turbulence within the duct. In a second step, the particles are precipitated on a conductive plate as a result of the application of the transverse electrostatic field which arises from the direct-current potential difference. This precipitation takes place at a greater or lesser speed according to the charge conferred on the particles and therefore according to the effective size of these latter. A separation of particles as a function of their size is thus obtained on the receiving plate. In an alternative embodiment, a second ionizing field can be applied to said particles, with the result that the particles of very small size which had not been collected on the first plate can accordingly be retained on the receiving plate of the ionizer.

The device is characterized in that it comprises:

a conduit for the admission of polluted gas, which is provided with at least one ionizer;

a duct of larger cross-sectional area and having the shape of an aerodynamic converging cone for the supply of a gas stream, which is fitted with means for damping-out the turbulence and in which said conduit is placed, the orifice of said conduit being oriented in the same direction as the downstream portion of the converging cone ;

a chamber of tubular shape having the same longitudinal axis as said duct and connected at one end to the downstream portion of the converging cone, said chamber being provided in the longitudinal direction with at least two conductive surfaces to which is applied a direct-current potential difference and between which the two gases are circulated ;

means for circulating the two gas streams.

In a first alternative embodiment, the other end of the chamber is connected to a suction device, the suction power of which is regulated so as to produce within said chamber a flow having small and damped-out turbulence.

A second alternative embodiment consists in placing between the chamber and the suction device, a second ionizer which is intended to precipitate the unseparated particles.

In a first form of construction, the conduit for the admission of polluted gas is placed in the axis of the converging cone of the supply duct.

In a second form of construction, the admission conduit is placed in the vicinity of a wall.

By virtue of the separation between the ionization of the particles and the reception of said particles, and also by virtue of the precautions taken to ensure that the gas stream does not have any turbulence at the moment when this latter passes between the receiving plates, deposition of the particles on the receiving plate depends only on the charge acquired by each particle. Separation of the particles is therefore significant.

A clearer understanding of the invention will in any case be obtained from the following description of one embodiment of the invention which is given by way of non-limitative example, reference being made to the accompanying figures, wherein:

FIG. 1 is a longitudinal sectional view showing one example of construction of the device;

FIG. 2 is a detail view of the ionizer;

FIG. 3 is a longitudinal sectional view showing an alternative form of construction of the device.

A general view of the device for collecting particles in a gas in accordance with the invention is given in FIG. 1. This device comprises a chamber 2 of rectangular cross section and formed of insulating material, the horizontal faces of said chamber being covered with conductive metallic plates 4 and 6. An electric generator 8 serves to apply a direct-current potential difference V_1 between the plates 4 and 6. The chamber 2 is connected at one end to the duct 10 for the supply of clean gas through a converging cone 12. A member 14 having a profile which is substantially parallel to that of the converging cone 12 and placed along the axis of this latter is provided with a conduit 16 for the admission of polluted gas which is placed along the axis of said member and terminates in a nozzle 18. In addition, the member 14 is provided internally with an ionizer 20 which will be described in detail hereinafter. In the example of construction shown in FIG. 1, the member 14 is provided with only one ionizer 20 but it is readily apparent that a plurality of identical ionizers could readily be placed in series along the conduit 16. The converging cone 12 is preceded by a series of grids 22 and has a honeycomb structure 24 before the point of junction with the chamber 2.

The other end of the chamber 2 is connected to a duct 28 which has the same cross-sectional area as the chamber 2.

The duct 28 is provided with an ionizer 32. Finally, the free end of the duct 28 is connected to an adjustable suction device 34 of known type.

The apparatus hereinabove described corresponds to one form of construction which is given by way of example. The device for collecting atmospheric dust particles need not be provided with the duct 28, in which case the chamber 2 may be connected to the suction device 34. This makes it possible to employ the atmospheric air or the polluted gas which has previously been filtered in order to inject it into the inlet duct 10.

FIG. 2 is a detail view of the ionizer 20; there is again shown in this figure the member 14 which is traversed by the conduit 16. The member 14 is formed of insulating material and provided with a cavity 36 which is located at right angles to the axis of the conduit 16 and communicates with this latter. The ionizer 20 proper is made up of three electrodes: a conductive wire 38 placed along the axis of the cavity 36; a conductive metallic grid 39 which closes the cavity 36 and is partially covered by a sheet-metal plate 40 in which is formed

a slot 42 in directly overhead relation to the wire 38; a conductive surface constituted in this form of construction by a conductive sheet-metal plate 44 which is placed on the other wall of the conduit 16 in oppositely facing relation to the grid 39.

A direct-current potential difference V_2 is applied between the wire 38 and the grid 39; and an alternating-current potential difference V_3 is applied between the grid 39 and the plate 44.

In the example which is more especially described, the nozzle 18 of the conduit 16 has its opening at the center of the converging cone 12 but it will be readily understood that said nozzle 18 could be located off-center with respect to the converging cone 12 without thereby departing from the scope of the invention.

In one particular embodiment, the potential difference V_2 can advantageously be within the range of 2 to 40 kV whereas the potential difference V_3 can be within the range of a few volts to a few kV with a frequency between 50 and 10,000 cps. With regard to the direct-current potential difference V_1 , said difference can advantageously be within the range of 4 to 20 kV.

By way of indication, the chamber 2 can have a rectangular cross section within the range of 5 to 50 cm² and a length within the range of 20 to 100 cm. With regard to the velocity of the gas stream within the chamber 2, this can advantageously be within the range of 20 to 400 cm/second.

The operation of the device for collecting particles in the gas is very simple. The polluted gas which is injected into the conduit 16 is charged by the ionizer 20. By virtue of the structure of the ionizer, the disturbances or in other words the turbulent velocity fluctuations of the polluted gas are reduced to the width of the slot 42. Within the chamber 2, the turbulent velocity fluctuations of the gas stream are practically reduced to zero by means of the device which is placed within the converging cone 12. By virtue of this shape of ionizer, the maximum dispersion of the charge acquired by particles having the same dimensions is within the range of 10 to 20 percent, which represents a maximum dispersion of 20 to 30 percent of the distance over which the ionized particles travel within the chamber 2 prior to precipitation on the collecting plate 4. The spherical particles are thus completely separated on the collecting plate if the diameters of these latter are in a ratio of 1:2 and larger than 0.5 micron. The volume of polluted gas processed in 12 hours is sufficient to permit analysis of qualitative and quantitative spectra of pollution of atmospheric air in an urban area. In the alternative embodiment which comprises the duct 28, if the atmospheric air which is injected into the inlet duct 10 is replaced by clean air, all the non-precipitated particles within the chamber 2 (namely particles which are smaller in diameter than 0.5 micron), can be recovered within the ionizer 32.

At the time of tests performed with Dow-Latex mixed beads having diameters of 0.8 micron and of 2 microns, the beads were precipitated respectively at 30 ± 8 cm and at 16 ± 4 cm from the beginning of the receiving plate 4 and formed two perfectly separate precipitation spots on the collecting plate 4.

There is shown in FIG. 3 one example of construction of the device in which the duct 28 and its ionizer 32 are replaced by an electrostatic precipitator 46 which is identical with the device claimed in U.S. Pat. applica-

tion Ser. No. 316,522, filed Dec. 19, 1972 and assigned to Commissariat a l'Energie Atomique in respect of "Electrostatic precipitator for the collection of particles contained in a gas."

The precipitator 46 essentially comprises a duct 48 5 connected to the chamber 2 in which a conductive wire 50 is placed opposite to a receiving plate 52. A potential difference V is applied between these two electrodes in order to produce a corona discharge between these two conductors. The deflectors 54 and 56 serve 10 to define two gas streams, one of which surrounds the electrode 50. In this type of apparatus, the clean air is replaced by the polluted air to be analyzed. This air, which is not ionized, passes through the chamber 2 and deposits its particles on the plate 52.

In the complete device, there is thus carried out simultaneously a particle-size analysis within the chamber 2 and a general collection within the duct 48, in which there can be carried out an automatic weighing operation by means of a piezoelectric strip, for example, 20 and a chemical analysis.

It is readily apparent that this invention is not limited to the example which has been more especially described with reference to the drawings. On the contrary, the invention extends to all alternative forms. In particular, the ionizer as hereinbefore described can be 25 replaced by a radioactive source on condition that the particles having a given polarity are trapped and the other particles of opposite polarity are collected.

What we claim is:

1. A method for the collection of particles in a polluted gas with particlar-size separation comprising the steps of charging the suspended particles of polluted gas in an ionizer, injecting into a gas stream in non-turbulent regime a flow of said charged polluted gas 35 and collecting said charged particles by passing said gas stream between two substantially parallel conductive plates parallel to the axis of propagation of the gas stream and applying a direct-current potential difference between said plates.

2. A method according to claim 1, including the steps after the gas stream has passed between said conductive plates, of again charging the particles remaining in said stream in a second ionizer and precipitating the particles.

3. A method according to claim 1 including the steps of automatically weighing the deposits as collected and corresponding to each particle size.

4. A device for the collection of particles in a polluted gas with particle size separations comprising: 50
a conduit for the admission of polluted gas; at least one ionizer in said conduit;
a duct of larger cross-sectional area than said conduit, said duct having the shape of an aerodynamic converging cone for the supply of a gas stream, 55 means in said duct for damping-out the turbulence,

said conduit opening into said means, an orifice for said conduit oriented in the same direction as the downstream portion of said converging cone;
a tubular chamber having the same longitudinal axis as said duct and connected at one end to the downstream portion of said converging cone, at least two conductive surfaces in said chamber extending in the longitudinal direction of said chamber, means for applying a direct-current potential difference between said surfaces;
and means for circulating the two gas streams between said surfaces.

5. A device according to claim 4, including a suction means connected to said chamber, and means for regulating the suction power of said suction means to produce within said chamber a flow having small and damped-out turbulence.

6. A device according to claim 4 wherein each ionizer in the conduit for the admission of polluted gas has three electrodes:

the first electrode having conductive surface placed longitudinally within said conduit and connected to an alternating-current voltage source;

the second electrode having grid, a plate covering said grid, a slot in said plate, the generating-lines of said surface and of said plate being substantially parallel, said grid and said plate being disposed longitudinally within said conduit and maintained at a direct-current potential;

and the third electrode being a wire, a cavity having an opening opposite said slot, said cavity, receiving said wire, means for maintaining said wire at a direct-current potential different from that of said grid, said grid and said plate being disposed over said opening and connecting said cavity to said conduit and through said grid and said slot.

7. A device according to claim 4 wherein said conduit for the admission of polluted gas is disposed coaxial with the axis of the converging cone of said supply duct.

8. A device according to claim 4 wherein said conduit for the admission of polluted gas is adjacent a wall of said chamber.

9. A device according to claim 4 wherein said ionizer 45 comprises a radioactive source.

10. A device according to claim 4 including means for automatic weighing of the deposits of different particle size comprising piezoelectric strips operatively associated with said collecting conductive surfaces.

11. A device according to claim 4 including between the chamber and the suction means an ionizer to precipitate the unseparated particles.

12. A device according to claim 6, said ionizer to precipitate the uncollected particles comprising a radioactive source.

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