Dec. 14, 1943. J. L. MILTON 2,336,625

DUST COLLECTOR

Filed Dec. 2, 1940 2 Sheets-Sheet 1

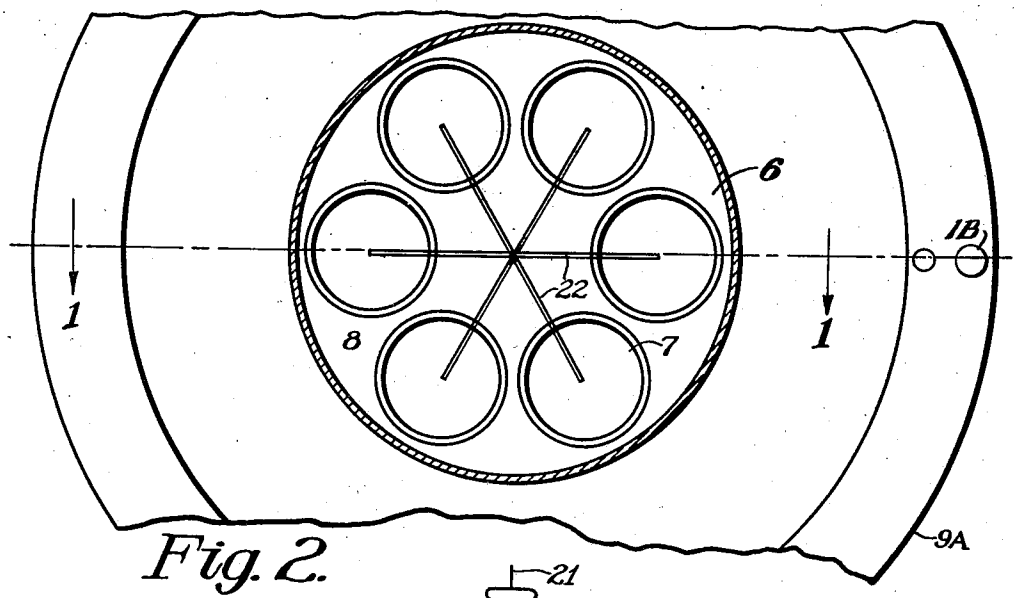


Fig. 2.

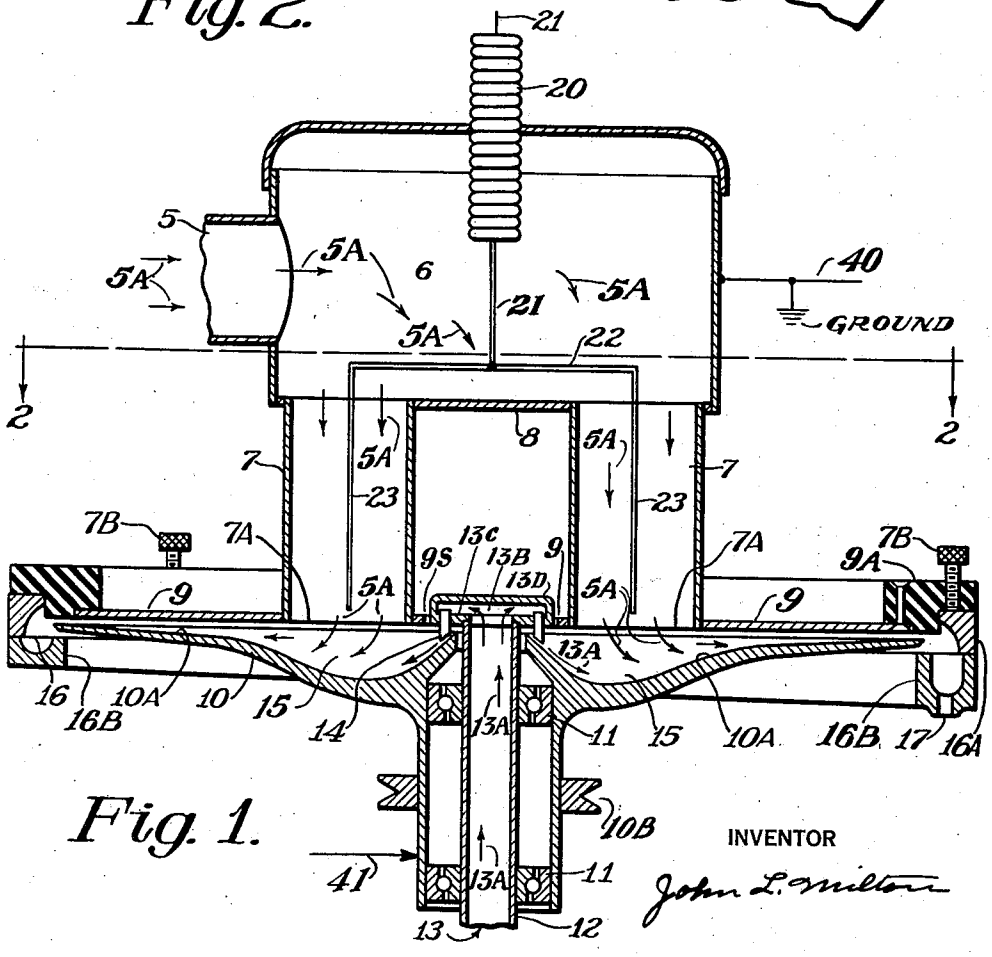


Fig. 1.

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Filed Dec. 2, 1940 2 Sheets-Sheet 2

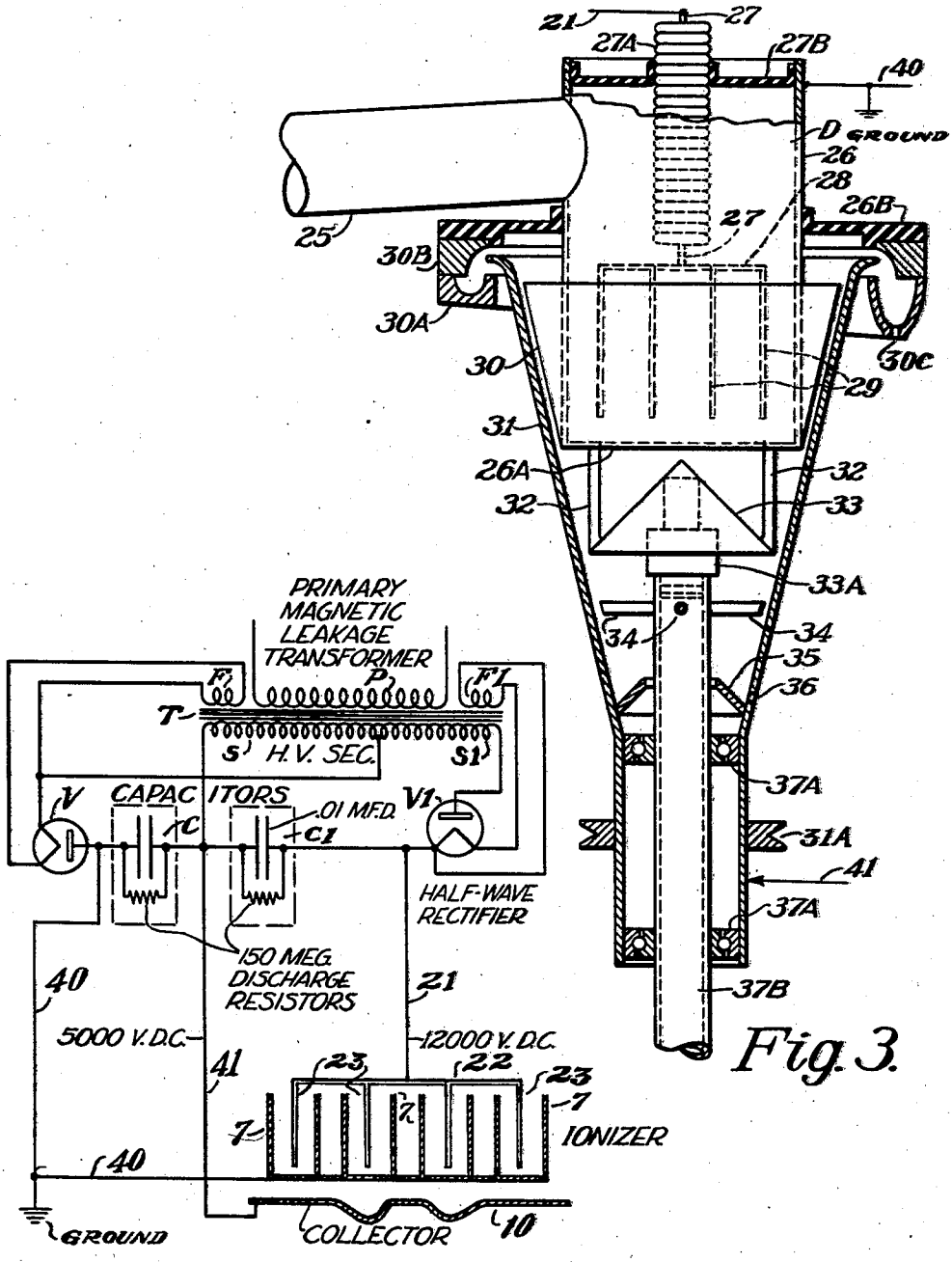


Fig. 3.

Fig. 4.

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Patented Dec. 14, 1943

2,336,625

UNITED STATES PATENT OFFICE

2,336,625

DUST COLLECTOR

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Application December 2, 1940, Serial No. 368,141

1 Claim. (Cl. 183—7)

This invention relates to a method and apparatus for electrostatically precipitating particles from a fluid gas stream, and mixing the precipitated particles with a continuously flowing liquid.

The main object of the invention resides in the substitution of electrostatic precipitation, such as that disclosed in the United States Patent of W. A. Schmidt, No. 1,343,285, for the mechanical principle of separation disclosed in my earlier United States Patent No. 2,186,033, and in the utilization of electrostatic and centrifugal forces in combining and mixing the separated particles with the liquid.

Another object of this invention is to provide a method and apparatus for suspending particles in a gas stream while the gas is confined in a chamber or conducted through a duct, and then passing the gaseous body containing the particles through apparatus containing oppositely charged electrodes, so that the particles, in migrating through the electrostatic field between the said electrodes, will receive an electrostatic charge and thereafter electrostatically precipitate upon the surface of a liquid film maintained continuously flowing over the collecting surface of an appropriately charged collecting electrode.

A further object of the invention resides in the construction and arrangement of the apparatus so that the charged collecting electrode is continuously rotated to maintain the liquid continuously flowing over the collecting surface thereof by centrifugal force and in a film, or thin layer of substantially uniform thickness.

Another object of the invention is to provide apparatus that will function as a self-cleaning, continuously-operating gas-cleaner for removing minute particles from a gas stream as well as relatively large particles.

The advantages of these and other objects will be manifested as the following description is read in connection with the accompanying drawings in which:

Figure 1 is a side-elevational view of an apparatus employing my invention, which view is shown in a section taken along lines 1—1 of Figure 2;

Fig. 2 is a partial plan-view partially shown in section along lines 2—2 of Fig. 1;

Fig. 3 is a side elevational view of another apparatus embodying a modification of that shown in Figs. 1 and 2, which apparatus is also shown partially in section in a plane passing through the vertical axis of the machine; and

Fig. 4 is a schematic diagram showing the electrical circuits of a high-voltage rectifier, and the electrical connections to the various electrodes forming a part of the apparatus shown in Figs. 1 and 2, it being understood that the electrical connections 21, 40 and 41 are similarly connected to corresponding electrodes of Fig. 3.

Referring now to Figs. 1 and 2, it will be observed that one embodiment of my invention employs a stationary assembly consisting of a metal dome 6, metal cylinders 7, metal disc 9, insulating ring 9A, metal ring 16A, and metal ring 16.

It will be observed that the aforesaid embodiment also employs a rotating assembly consisting of a metal collector-plate 10 and pulley 10B, which rotating assembly is journaled upon a stationary column 12 by means of suitable ball bearings 11—11.

It is important to observe that the stationary column 12 is tubular, and that the interior thereof provides a duct or conduit 13 communicating with the interior 13B of a small dome 13D fixedly secured to the upper end of column 12.

The small dome 13D is provided with a floor member 13C overlying the central portion of the rotating collector-plate 10, which floor member has a plurality of small nozzles 14 through which liquid entering the conduit 13 is discharged upon the collecting surface 10A of the rotating collector-plate 10, as indicated by the arrows 13A.

It is important to observe that the central portion of the stationary disc 9 is apertured so that the small dome 13D extends slightly above the surface of the disc 9.

The centrally located aperture 9S in disc 9 is somewhat larger than the horizontal dimensions of the small dome 13D, so that the disc 9 may be adjusted relative to the rotating collector-plate 10 by means of adjusting screws 7B threaded in the insulating ring 9A, and to provide the required electrical separation between the stationary assembly including disc 9 and the rotating collector-plate 10, since the disc 9 and the collector plate 10 form oppositely charged electrodes for electrostatically precipitating charged particles onto the surface of the liquid flowing over the collecting surface 10A of the collector plate 10.

Therefore, with further reference to Fig. 1, it will be observed that the stationary assembly has an enclosed metal-chamber or dome 6 into which a particle-laden gas-stream is conducted via conduit 5, as indicated by arrows 5A.

The metal-chamber or dome 6 is provided with a metal floor-member 8 having a plurality of metal-cylinders 7—7 depending therefrom, which cylinders are secured to the metal disc 9.

As illustrated in Fig. 1, each metal-cylinder forms a duct or conduit providing a communication between the interior of the enclosed dome 6, and a chamber 15 between the disc 9 and rotating collector-plate 10.

The metal-disc 9 is fixedly secured to the insulating ring 9A, which ring is slidably mounted in the metal ring 16A, so that the metal-disc 9 may be adjustably raised and lowered relative to the rotating collector-plate 10 and retained in its adjusted relation by means of the screws 7B threaded in the insulating ring 9A.

As mentioned hereinbefore, liquid is conducted through the conduit 13 into the interior of the small dome 13D and then discharged upon the surface 10A of the collector plate 10 via a plurality of nozzles or ducts 14, as indicated by the arrows 13A.

The collector-plate 10 is rotatably mounted upon the stationary column 12 by means of ball bearings 11—11, and is rotated at relatively high speeds by means of a suitable belt drive between a prime mover and the V-pulley 10B secured to the collector plate 10.

Therefore, it will be evident that the liquid delivered onto the surface 10A of the collector plate 10, via nozzles 14, will move outwardly over the surface of the plate by centrifugal force and in a film or layer of substantially uniform thickness.

With further reference to Fig. 1, it will be observed that the rings 16A and 16B are constructed and arranged to collect the liquid discharged by centrifugal force from the surface of the collector plate 10. In this respect, it is to be observed that the ring 16B is provided with an aperture 17 through which the collected liquid is discharged, and it is to be understood that a discharge conduit may be connected thereto without departing from the spirit of the invention.

Similarly, it is to be understood that the shape and location of the collecting channel 16, relative to the collector plate 10, may be changed to accommodate various requirements without departing from the spirit of the invention.

As further illustrated in Fig. 1, a tubular high-voltage insulator 20 is mounted in the top of the dome 6, through which a conductor 21 extends and electrically connects a spider 22 constructed preferably from wire, which spider supports and electrically connects an ionizing conductor or wire 23 centrally of each of the cylinders 7.

It is well known that a particle may be removed from an air stream electrostatically, if the particle is given an electrostatic charge and then placed in an electrostatic field between two electrodes having a voltage gradient high enough to attract the charged particle out of the air stream and onto the surface of one of the electrodes.

In the present invention separate ionizing and collecting chambers are provided.

Each of the cylinders 7 form an ionizing chamber, and each metal cylinder 7, and its respective wire 23, constitute the oppositely charged electrodes of each ionizing chamber.

Similarly, the space between the metal disc 9 and the metal collector-plate 10 forms the collecting chamber, and the metal disc 9 and metal collector-plate 10 constitute the oppositely charged electrodes of the collecting chamber.

Accordingly, it is important to observe that each metal cylinder 7, metal dome 6 and the metal disc 9 are electrically connected and insulated from the stationary rings 16A and 16B by means of the insulating ring 9A, and electrically insulated from the ionizing wires 23 by means of insulator 20. It is also important to observe that the stationary assembly including disc 9 and cylinders 7 is electrically separated from the rotating collector-plate 10 by means of the mechanical clearance existing between the disc 9 and small dome 13D.

It is well known in the art of electrical precipitation that high-voltage direct-current of opposite polarity must be connected to the electrodes of the ionizing and collecting chambers, and it has been observed that approximately 12,000 volts between ionizing electrodes and approximately 5000 volts between collecting electrodes provides satisfactory operation. However, it is to be understood that the magnitude of these voltages will vary in accordance with the electrical spacing and construction of the various electrodes and that they are suggested only to indicate the approximate magnitude of the voltages required.

While several different types of high-voltage machines have been satisfactorily employed to provide the required high voltage in various commercial precipitators, a conventional electronic-type rectifier is illustrated in Fig. 4 to supply the required high voltage for the operation of the present invention.

With reference to Fig. 4 it will be evident that the half-wave rectifying tubes V and V1, capacitors C and C1, and the transformer T, are electrically connected in a modified voltage-doubling rectifying circuit well known to those skilled in the art.

The filament of the rectifying tube V is supplied current by a small secondary F of the transformer T.

Similarly, the filament of the rectifying tube V1 is supplied current by a small secondary F1 of the transformer T.

The high-voltage secondary of the transformer is tapped, thereby providing two secondary sections S and S1 respectively.

With further reference to Fig. 4, it will be observed that the rectifying tubes V and V1 are connected so that they alternately pass current to the respective capacitors C and C1. Accordingly, current from the secondary S is passed by the rectifying tube V to charge the capacitor C, while the tube V1 is non-conducting.

Similarly, current from the secondary S1 is passed by the rectifying tube V1 to charge the capacitor C1, while the tube V is non-conducting.

In this respect it is to be understood that the capacitors C and C1 each have sufficient capacity to maintain their E. M. F. charge during the non-conducting period of their respective rectifying tubes, and that the output voltage of the secondary S is sufficient to charge the capacitor C to approximately 5000 volts, while the output voltage of the secondary S1 is sufficient to charge the capacitor C1 to approximately 7000 volts.

As illustrated in Fig. 4, each capacitor is provided with a 150 megohm discharge-resistor for discharging the high voltage charge on each respective capacitor when the primary P of the transformer is electrically disconnected from the supply line, and it is to be understood that the value of each discharge resistor is sufficiently high to prevent discharge of the corresponding capacitor in normal operation.

As indicated in Fig. 4, the wire 40 is elec-

trically connected to ground and to the stationary assembly consisting of dome 6, cylinders 7, and disc 9. The two capacitors C and C1 are electrically connected in series and the wire 21 electrically connects the ionizing wires 23 via the supporting spider 22, thereby placing 12,000 volts between the cylinders 7 of the stationary assembly and the ionizing wires 23.

Wire 41 connects the rotating collector-plate 10, thereby placing the 5000 volt charge of the capacitor C between the disc 9 of the stationary assembly and the collector-plate 10.

Accordingly, it will be apparent that all particles migrating through the electrostatic field between the ionizing wire 23 and the respective cylinder 7 will receive an electrical charge and subsequently be precipitated from the fluid airstream and onto the collector plate 10, when the charged particles enter the electrostatic field between the disc 9 and the collector plate 10.

As stated hereinbefore, wires 40 and 41 place a potential of 5000 volts between the stationary assembly consisting of dome 6, cylinders 7, disc 9 etc., and the rotating collector-plate 10. Therefore, since the wire 40 is also electrically connected to ground, it is apparent that the stationary column 12 must be electrically insulated from ground as well as from the stationary assembly 6, 7, 9, etc.

The elements required to electrically insulate the stationary column 12 from ground have not been shown in the drawings, inasmuch as it is believed such expedients are well known to those skilled in the art.

Obviously, the arrangement of the insulating elements may vary without departing from the spirit of this invention, however, one arrangement in accordance with principles well known to those skilled in the art, consists of mounting the column 12, and the liquid container etc. for conducting liquid to the duct 13 upon a stationary base or foundation, which base is electrically insulated from ground by means of conventional high-tension insulators.

It is also well known that the column 12 may be mounted upon the aforesaid stationary base, and that a conduit of insulating material such as glass or rubber, etc., may operatively connect a liquid supply line and the duct 13.

Likewise, since it is not essential for an operator to contact the conductor 21 or the rotating collector plate 10, while the parts are electrically connected for operation, a guard or cage of wire mesh may be employed to surround the machine in accordance with the conventional practice followed in the protection of high-voltage distribution transformers, etc.

Obviously, conventional belting between the pulley 10B and the prime mover is of insulating material, and will therefore serve to electrically insulate the prime mover from the collector plate.

In Fig. 3, a modified arrangement of the ionizing and collecting electrodes is shown.

In Fig. 3, the stationary assembly comprises a cylindrical dome D having metallic walls 26, an inverted metal truncated-cone 30, a metal conical-deflector 33, metal supports 32, an insulating plate 26B, a metal-ring 30A and a metal-ring 30B.

The latter mentioned stationary assembly corresponds to that described in Fig. 1 which includes dome 6, cylinders 7 and disc 9.

It will also be observed that Fig. 3 employs a rotating assembly consisting of a metal collector-plate or rotor 31, and a pulley 31A, which rotating assembly is journaled upon a stationary column 37B by means of suitable ball bearings 37A—37A.

The latter mentioned rotating assembly corresponds to that described for Fig. 1 which includes collector plate 10 and pulley 10B.

It is important to observe that the stationary column 37B is tubular, and that the interior thereof provides a duct or conduit through which liquid is conveyed and discharged upon the collecting surface of the collector plate 31 via nozzles 34. It will also be observed that the upper end of the column 37B is secured to and electrically insulated from the conical deflector 33 by means of an insulator 33A.

A frusto-conical disc 35 is secured to the inner surface of the collector plate 31 to form a channel or pocket for collecting any liquid that may descend from the processing area of the collector plate 31, and it will be observed that the collector plate 31 is apertured at 36 to provide a drain for the liquid collected in the pocket above the disc 35.

The stationary assembly has an enclosed cylindrical-dome or chamber D into which a particle-laden gas-stream is conducted via conduit 25.

The cylindrical dome D has metal side walls 26 and an insulating disc 27B secured thereto and enclosing the upper end thereof.

The lower end of the cylindrical dome D is open, thus the particle-laden gas-stream received therein is discharged upon the conical deflector 33 and deflected outwardly onto the surface of the collector plate 31.

The conical deflector 33 is preferably constructed of metal and electrically connected to the metal wall 26 by means of metallic supports 32 secured to the apertured metallic lower-end 26A of the dome D.

As illustrated in Fig. 3, an inverted truncated cone 30 is also secured to and electrically connected to the wall 26 of dome D.

An insulating plate 26B is also secured to the wall 26 of dome D, which plate has metallic rings 30A and 30B secured thereto.

As mentioned hereinbefore, liquid is conducted through the interior of the stationary column 37B and discharged upon the interior surface of the collector plate 31 via a plurality of nozzles or ducts 34.

The collector plate 31 is rotatably mounted upon the stationary column 37B by means of ball bearings 37A—37A, and is rotated at relatively high speeds by means of a suitable belt drive between a prime mover and the V-pulley 31A secured to the collector plate 31.

Therefore, it will be evident that the liquid delivered onto the surface of the collector plate 31, via nozzles 34, will move upwardly and outwardly over the surface of the plate by centrifugal force and in a film or layer of substantially uniform thickness.

It will be observed that the rings 30A and 30B are constructed and arranged to collect the liquid discharged by centrifugal force from the collector plate 31. In this respect it is to be observed that the ring 30A is provided with an aperture 30c through which the collected liquid is discharged, and it is to be understood that a discharge conduit may be connected thereto without departing from the spirit of the invention.

Similarly, it is to be understood that the shape and location of the collecting channel in the rings 30A and 30B may be changed to accom-

modate various requirements without departing from the spirit of the invention.

As further illustrated in Fig. 3, a tubular high voltage insulator 27A is mounted in the insulating disc 27B of dome D, through which a conductor 27 extends and electrically connects a spider 28 preferably constructed from wire, which spider supports and electrically connects a plurality of ionizing conductors or wires 29.

Thus, in the modification shown in Fig. 3, separate ionizing and collecting chambers are provided in accordance with the teachings of Fig. 1.

In this respect it will be apparent that the metallic walls of the cylinder 26 and the wires 29 constitute the oppositely charged electrodes of the ionizing chamber.

Similarly, the space between the surface of the inverted truncated-cone and the collector plate 31, also the space between the metallic end 26A, supports 32, deflector 33 and the collector plate 31 constitutes the collecting chamber, and it will be apparent that the electrically-connected metallic-members 26, 26A, 30, 32 and 33 form one electrode while the collector plate 31 forms the other electrode, of the oppositely charged electrodes of the collecting chamber.

Accordingly, it is to be understood that the high-voltage rectifier shown in Fig. 4 may be electrically connected to the apparatus shown in Fig. 3 by connecting wire 21 of Fig. 4 to wire 27 of Fig. 3; connecting wire 40 of Fig. 3 to ground and to the metallic parts of the stationary assembly comprising members 26, 26A, 30, 32 and 33; and connecting wire 41 of Fig. 4 to collector plate 31 of Fig. 3.

Thus, as described for Fig. 1, it will be apparent that all particles migrating through the electrostatic field between the ionizing wires 29 and the wall 26 of Fig. 3 will receive an electrical charge and subsequently be precipitated from the air-stream and onto the collector plate 31, when the charged particles enter the electrostatic field between the members 26, 26A, 30, 32, 33 and the collector plate 31.

As stated hereinbefore, wires 40 and 41 place a potential of 5000 volts between the stationary assembly 26, etc., and the rotating collector-plate 31. Therefore, since wire 40 is also electrically connected to ground, it is apparent that the stationary column 37B must be electrically insulated from ground.

The elements required to electrically insulate the stationary column 37B from ground have not been shown in the Fig. 3, as it is believed such expedients are well known to those skilled in the art. Therefore, it is apparent that column 37B may be insulated from ground with conventional high-tension insulators similar to that outlined for Fig. 1.

In either Fig. 1 or Fig. 3, it is to be understood that the liquid flowing over the surface of each respective collector-plate 10 or 31 can be varied from a mere wetting to a layer of liquid flowing thereover, or the liquid can be impounded near the discharge edge of each respective collector plate and subsequently discharged by increasing the velocity of the rotating collector-plate.

It will be evident that the construction and shape of the collector plate can be varied; the rate of feed of the liquid can be varied; the velocity of the rotating collector-plate can be varied; or the distance between the electrodes of the collecting chamber varied by means of adjusting screws as illustrated in Fig. 1, to obtain the latter mentioned conditions of operation.

Accordingly, it will be apparent that these and other modifications can be made in accordance with the teachings of this disclosure and which will come within the scope of the appended claim.

Having thus described the invention, I claim:

Apparatus for separating suspended particles from a gas stream and mixing the same with a liquid, comprising, a pair of electrically spaced members; means electrically connecting the said members to opposite electrical polarities for maintaining an electrostatic field therebetween; means operatively associated with one of the said members and adapted to rotate the same; means operatively associated with the said members and adapted to deliver liquid into the electrostatic field therebetween and onto the surface of the said one member substantially adjacent the axis of rotation thereof; another pair of electrically spaced members comprising a charging electrode adapted to facilitate discharge and an opposing electrode adapted to minimize discharge; means electrically connecting the said charging electrode to a polarity opposite to that of the said rotating member, and means electrically connecting the said opposing electrode to a polarity opposite to that of the charging electrode; means operatively associated with the said another members and adapted to deliver a gas stream containing suspended particles into the electrostatic field between the charging electrode and the said opposing electrode so that the particles in migrating therebetween will receive a charge similar to that of the charging electrode; other means operatively associated with the said another members, and adapted to deliver the charged particles into the electrostatic field between the first mentioned members, for electrostatically precipitating the charged particles into the liquid flowing over the said one member; and means operatively associated with the said first mentioned members for collecting the mixture of the particles and the liquid.

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