# United States Patent [19]

**deSeversky**

[11] **3,742,681**

[45] **July 3, 1973**


[54] **LIQUID DISTRIBUTORS FOR WET ELECTROSTATIC PRECIPITATORS**


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[73] Assignee: **Seversky Electronatom Corporation,** New York, N.Y.



[22] Filed: **July 25, 1972**

[21] Appl. No.: **274,886**

[52] **U.S. Cl.** ..... **55/119,** 55/146, 55/154, 55/DIG. 38, 261/112

[51] **Int. Cl.** ..... **B03c 3/78**

[58] **Field of Search** ..... 55/117, 118, 119, 55/120, 122, 127, 136, 137, 138, 154, 13, 241, DIG. 38; 261/112, DIG. 44, 108, 109, 110, 111



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*Attorney*—Michael Ebert



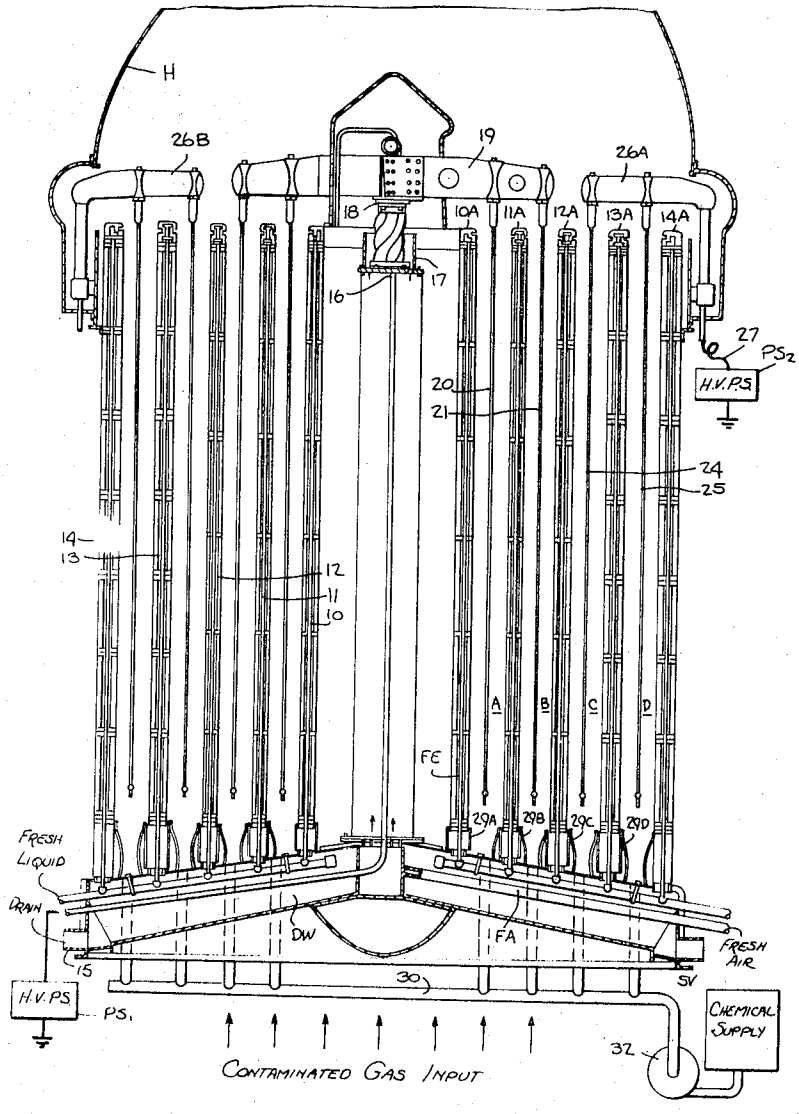
[57] **ABSTRACT**

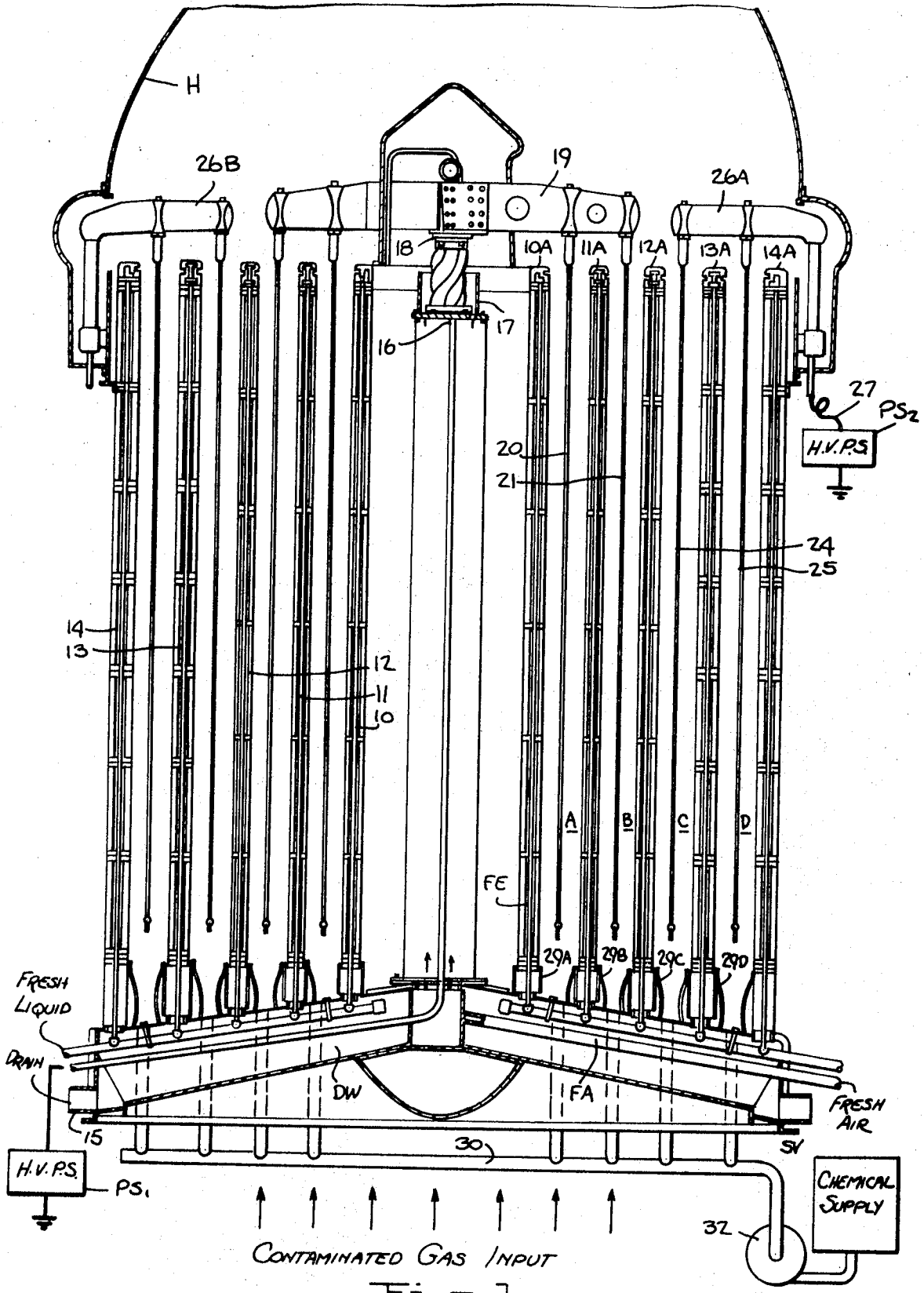
A wet electrostatic precipitator including at least one annular gas passage defined by concentrically-arranged collector tubes having liquid distributors mounted thereabove to produce downwardly-flowing liquid films on the walls of the passage. A discharge electrode structure is disposed in the annular passage, a high voltage being applied between the electrode structure and the liquid films on the collector walls to cause ionized particulates in a contaminated gaseous stream conveyed upwardly through the passage, to migrate toward the films to be carried downwardly thereby for disposal. The liquid distributors are adapted to produce downflowing uniform films of liquid on the surfaces of the collector tubes which line the passage, the films being free of dry spots or splashing.


**7 Claims, 10 Drawing Figures**

**United States Patent** [19]
**deSeversky**

[11] **3,742,681**
[45] **July 3, 1973**




H
26B
19
26A
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10A
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PS2
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29A
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29C
29D
FRESH LIQUID
DRAIN
DW
FA
FRESH AIR
15
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SV
H.V.P.S.
PS1
CHEMICAL SUPPLY
32
CONTAMINATED GAS INPUT

Fig. 1.

Fig. 2.

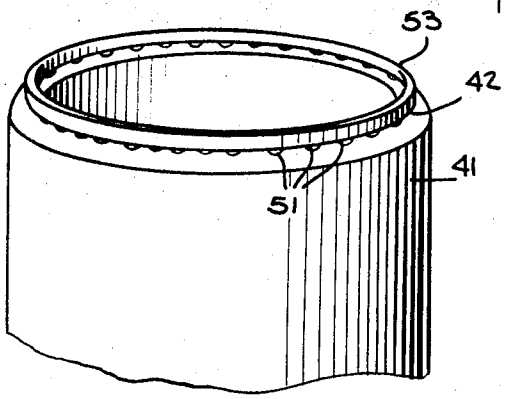



Fig. 3.

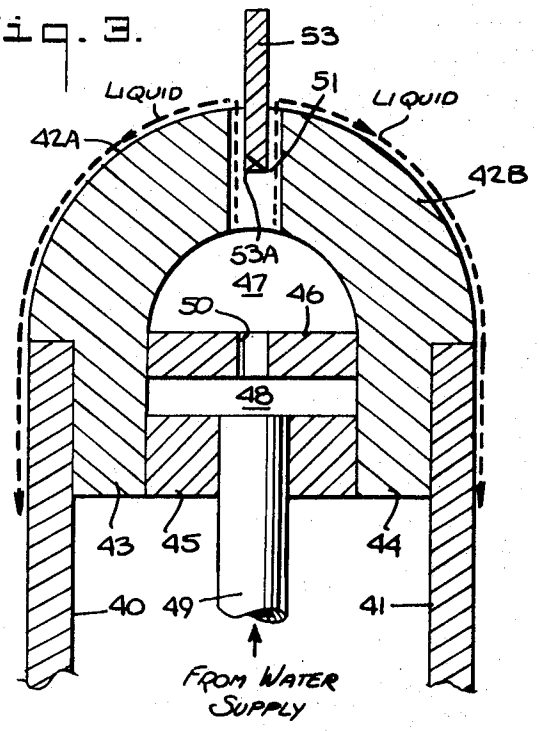



Fig. 4.

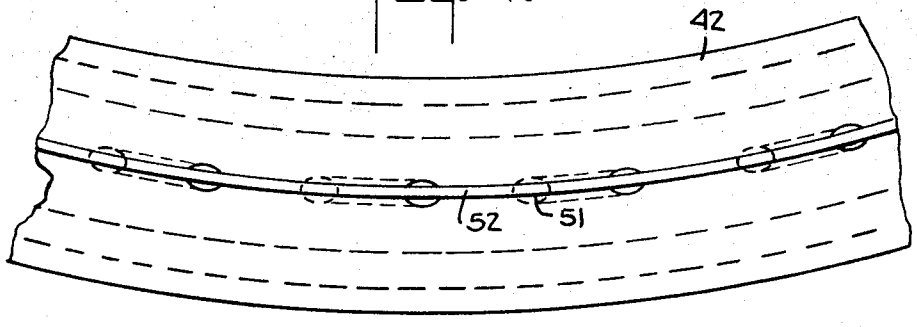
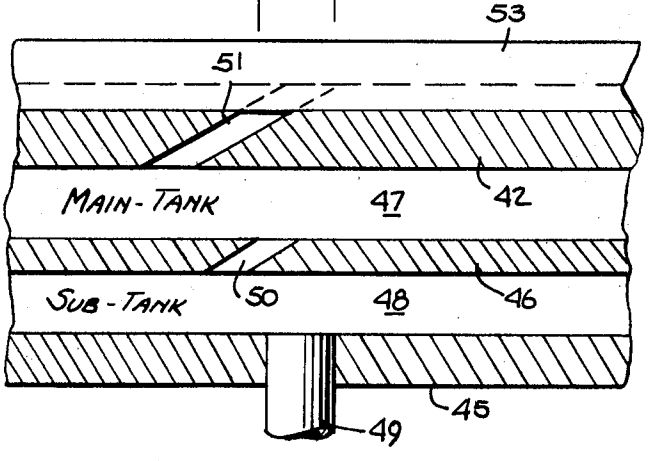



Fig. 5.



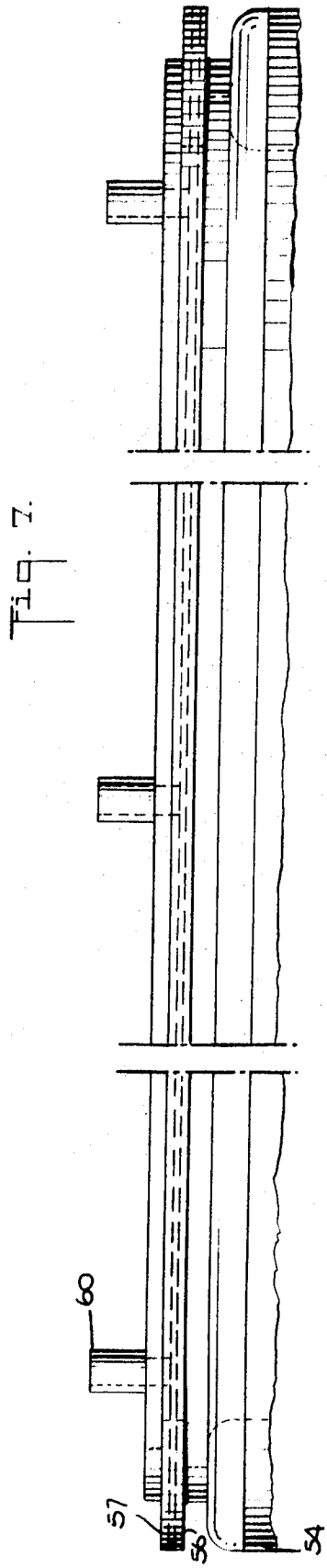



Fig. 7.

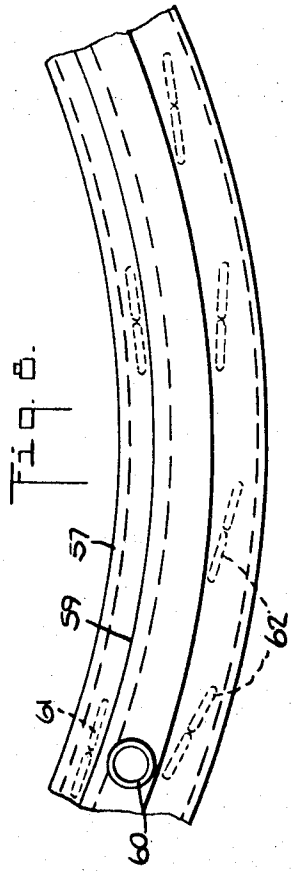



Fig. 8.

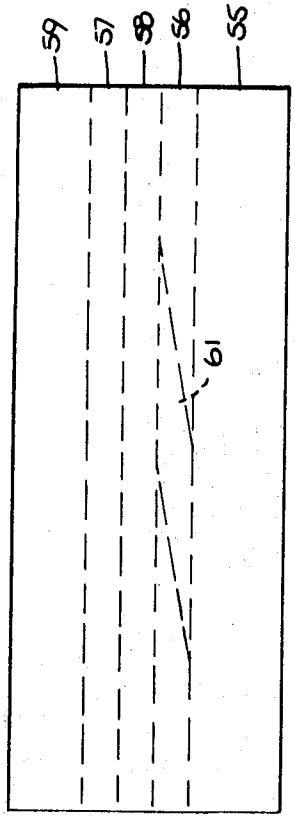



Fig. 9.

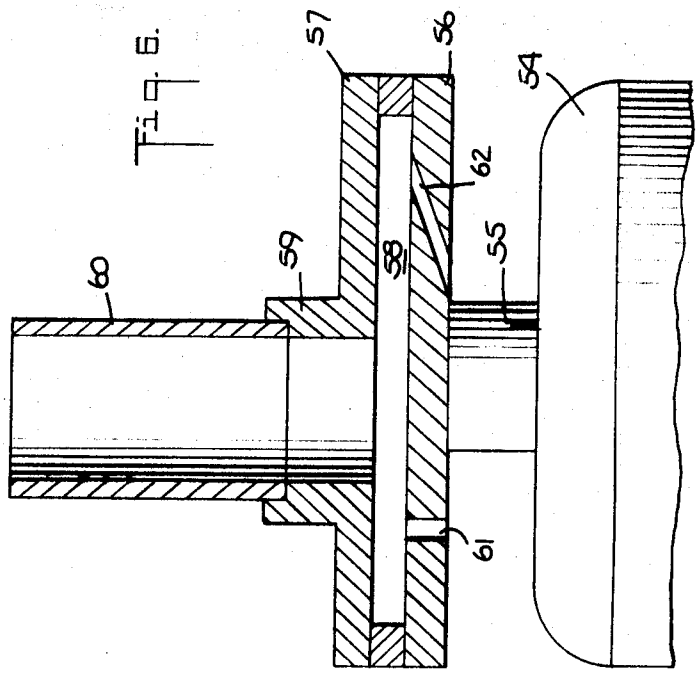



Fig. 6.

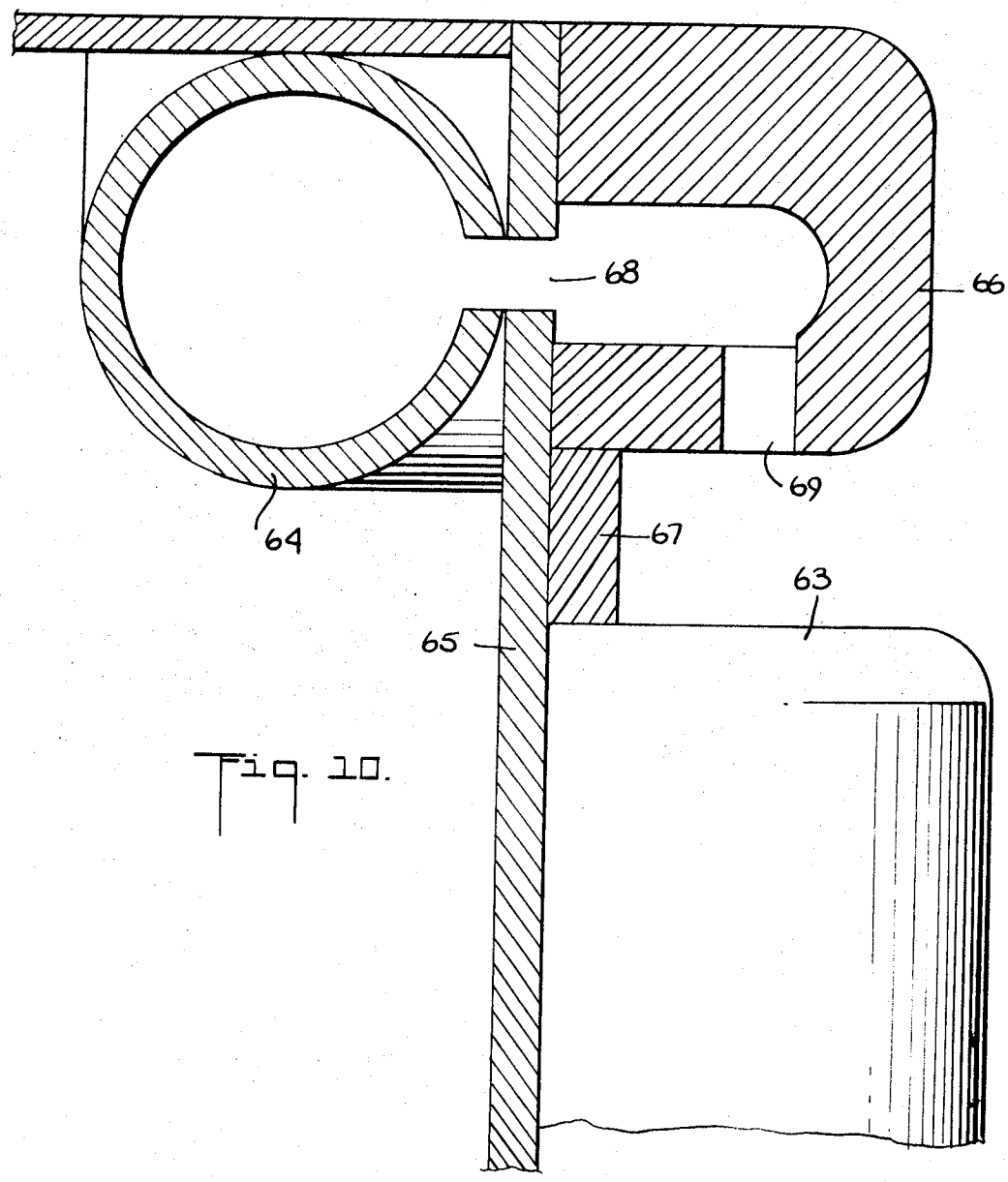



Fig. 10.

# LIQUID DISTRIBUTORS FOR WET ELECTROSTATIC PRECIPITATORS

## RELATED APPLICATION

This application is related to the co-pending applications of Alexander P. deSeversky, Ser. No. 723,810, filed Apr. 24, 1968 and Ser. No. 222,227 filed Jan. 31, 1972.

## BACKGROUND OF THE INVENTION

My invention relates generally to wet electrostatic precipitators for extracting particles of a solid or semi-solid nature, as well as toxic gaseous components, from air or other contaminated gaseous media, and more particularly to liquid distributors for use in conjunction with such wet precipitators for the purpose of forming uniform liquid films on the collector surfaces thereof.

For purposes of reducing atmospheric pollution, it is known to use electrostatic precipitators wherein impurity-laden gases, such as those issuing from a heating furnace, incinerator or an industrial outlet, are conveyed through a charged enclosure where they are subjected to an electrostatic field ionizing the particles and causing their migration from a discharge electrode to a collecting electrode which may be flat or tubular, thereby extracting the particles from the gas stream.

In the prior deSeversky U.S. Pat. Nos. 2,937,709, 3,053,029, 3,238,702 and 3,315,444, there are disclosed wet electrostatic precipitators wherein the collecting surfaces are constituted by uniform films of water which carry away the particles. Precipitators of the type disclosed in said patents are to be large extent inherently self-cleaning in contradistinction to dry precipitators which must be shut down to permit scraping agglomerated particles from the dry collector walls. Being maintenance-free, these wet precipitators are particularly suited for precipitating complex particulate matter of the type encountered in some chemical and industrial plants as well as in apartment houses and municipal incinerators.

In the above-identified prior patents, the wet precipitator is constituted by concentrically-arranged inner and outer tubes which define a vertically-disposed gaseous passage, downwardly-flowing liquid films being produced on those surfaces of the tubes which line the passage. A high voltage is applied between a discharge-electrode structure mounted in the passage and the liquid films which function effectively as collectors, whereby contaminants in solid or semi-solid particulate form in a gaseous stream conveyed through the passage, are ionized and caused to migrate toward the collector films to be carried downwardly thereby for disposal. Thus the gas emerging from the upper end of the passage is clean and may safely be discharged into the atmosphere.

In a wet precipitator of the above-described type, the efficiency of its operation depends to a large extent on the uniformity of the water films formed in the walls of the collector tubes, for if the water distributors mounted on the top of the collector tubes do not provide a water film evenly dispersed on the walls, splashing may occur at some points and dry spots may be formed at other points, and the precipitator action will be impaired.

## SUMMARY OF THE INVENTION

The main purpose of the present invention is to provide an improved liquid distributor for a wet electrostatic precipitator having at least one annular passage defined by concentrically-arranged inner and outer collector tubes.

More specifically, it is an object of this invention to provide improved liquid distributors adapted to operate in conjunction with cylindrical collector tubes and to produce uniform liquid films on either the inner or outer surfaces of the tubes or on both surfaces.

A significant feature of a liquid distributor, in accordance with the invention, is that the centrifugal forces which tend to cause the liquid emitted by the distributor to peel off the collector surface, are compensated for to maintain the liquid on the collector surfaces.

Yet another object of the invention is to provide improved water distributors for the collector tubes of a wet precipitator adapted to produce uniform, splash-free water films on the active walls of the tubes.

These objects are attained in a liquid distributor adapted to operate in conjunction with a wet electrostatic precipitator having concentrically-arranged collector tubes defining annular passages through which pass a contaminated gaseous stream, the distributor producing a downwardly flowing liquid film on the inner and outer walls of the collector tube associated therewith.

The liquid distributor includes an annular ring secured to the upper end of the collector tube, the interior of the ring being hollow to define a main tank for holding liquid fed thereto from a supply. The ring is provided with inclined openings to discharge liquid from the tank onto said inner and outer walls so as to impart a swirling motion thereto, and means effecting compensation for the centrifugal forces created by the swirling motion to prevent liquid from peeling off the outer wall.

## OUTLINE OF THE DRAWINGS

For a better understanding of the invention, as well as other objects and further features thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawings, wherein:

FIG. 1 is an elevational view of one preferred embodiment of a wet electrostatic precipitator in accordance with the invention, the view being in section and being partially schematic in form;

FIG. 2 is a perspective view of a first embodiment of a water distributor in accordance with the invention;

FIG. 3 is a transverse section taken through a first embodiment of a water distributor in accordance with the invention;

FIG. 4 is a plan view of a portion of the distributor shown in FIG. 3;

FIG. 5 is a longitudinal section taken through the first embodiment of the distributor;

FIG. 6 is a transverse section taken through a second embodiment of a water distributor in accordance with the invention;

FIG. 7 is an elevational view of the second embodiment of the water distributor;

FIG. 8 is a plan view of a portion of the second embodiment of the distributor;

FIG. 9 is a longitudinal section of the second embodiment of the distributor; and

FIG. 10 is a transverse section of a third embodiment of a water distributor in accordance with the invention.

## GENERAL DESCRIPTION OF THE INVENTION

Referring to the drawings and more particularly to FIG. 1, there is shown one preferred embodiment of a wet precipitator of multi-concentric construction comprising five concentrically disposed tubes **10, 11, 12, 13** and **14**, of progressively increasing diameter, which define four concentric annular gas channels or passages A, B, C and D having the same radial dimensions or cross-sectional widths.

The tubes are vertically arranged, the inlet for the gaseous stream to be purified being at the lower end, and the gas outlet being at the top end of the tubes. While a system with four concentric channels is shown, it will be appreciated that the system may be enlarged to include any number of concentric channels.

In practice, the arrangement may be made such as to provide concentric channels all having the same radial dimensions, in which event, the operating voltage is made the same for all channels; or the system may be arranged with concentric channels, some of which have one radial dimension, and the others another radial dimension, in which event those channels having a first radial dimension all have the same operating voltage appropriate to the channel dimension, and those channels having a second radial dimension also all have another operating voltage, but at a level appropriate thereto; thus channels having a larger radial dimension will be operated at a higher voltage.

The concentric arrangement enormously increases the operating capacity of the system without waste of space. It therefore becomes possible, as compared to a conventional precipitator of the same capacity, to provide a far more compact unit, requiring a smaller installation area. The compact unit, which performs the same function as the conventional unit, is also considerably less expensive.

Tubes **10, 11, 12, 13** and **14** are preferably of double-walled or hollow construction to provide space for plumbing in order to supply liquid to the tubes. A set of conduits FE feeds fresh water or whatever other liquid is used in the system through the interior of the tubes to the upper end thereof to distributors **10A, 11A, 12A, 13A** and **14A**, which are mounted slightly above the upper ends of the collector tubes and are adapted to cause the liquid fed thereto to flow down the walls of the tubes, whereby the annular passages are lined with liquid films.

In practice, the liquid distributors may be fed by supply lines which do not go through the interior of the collector tubes, but which come from above the water distributors, in which event the collector tubes need not be of hollow construction.

The downwardly-flowing liquid on these collector surfaces runs into a conduit DW which carries contaminated liquid into a drain through pipe **15** or suitable vessel if it contains valuable by-products. Thus, the tube surfaces which line passages A, B, C, and D, have fluid films produced thereon which act as collector electrodes.

It is to be noted that fresh-liquid conduits FW run into conduit DW for the contaminated liquid. Also extending through conduit DW is a conduit FA which supplies filtered air to the input terminal **16** of scavenging assembly **17** of the discharge electrode support **18**, to prevent its contamination by dirt or other foreign matter. This scavenging assembly may make use of aerodynamic vanes of the type disclosed in prior U.S. Pat. No. 3,238,702, and in particular, FIGS. **4, 5** and **6** in said patent. The arrangement is such that air is cyclonically directed and forced against all scale and dirt therefrom to maintain the insulating qualities thereof.

On top of electrode support **18**, there is attached a conductive spider **19** formed by three horizontal cantilever arms from which are suspended two cylindrical cages or discharge-electrode structures. Discharge-electrode structure **20** is disposed in channel A, and discharge-electrode structure **21** is disposed in channel B.

A high voltage of suitable magnitude is supplied by a D-C power supply $PS_1$. One side of the supply is connected through a cable to input terminal **16**, which is electrically coupled to the conductive spider **19** and hence to the discharge-electrode structures. The other side of power supply $PS_1$ is grounded, as is the liquid supply fed to the collector tubes. Hence an electrostatic field is established between the liquid films which line the annular passages A and B and the associated discharge-electrode structures **20** and **21**. Passages C and D are provided with discharge electrode cages **24** and **25** supported by radial arms **26A** and **26B** connected by a line **27** to a high-voltage supply $PS_2$.

Contaminated gas is introduced through the bottom end of passages A, B, C and D through radial Venturi slots **29A, 29B, 29C** and **29D**, respectively, the gas being subjected to the high-voltage electrostatic field which causes solid and semi-solid particles in the gaseous stream to become ionized and to migrate to the liquid-collecting films on the surfaces of the tubes lining the passages. These liquid films carry the extracted matter down conduit DW into a drain or vessel.

The Venturi slots **29A** to D cause the gas entering the passages to expand, the expanding gas flowing upwardly in countercurrent relationship to the downwardly flowing liquid, and forcing the liquid against the surfaces of the tubes to produce a smooth uniform film thereon, thereby avoiding dry patches on the surfaces and preventing re-entrainment of liquid droplets into the gas-flow passages, which droplets give rise to arcing and other deleterious effects. The clean gas emerging at the upper end of the wet precipitator is exhausted through a hood H on whose surface moisture is condensed, the resultant liquid being discharged

## WATER DISTRIBUTORS

We shall now consider several preferred embodiments of water distributors which are adapted to fit on top of collector tubes in a wet electrostatic precipitator for producing uniform films of water on both walls of the collector tube or a film on one wall thereof, depending on the position and function of the collector tube in the precipitator assembly. While the term "water distributor" is used herein, it is to be understood that the distributor is useable with any liquid. In some precipitators wherein the liquid is intended to interact with the collected particles, the liquid may be a chemical solvent or reagent, rather than water.

Thus in the multi-concentric precipitator shown in FIG. 1, the collector tubes **10** and **14** are so positioned in the assembly that in the case of collector tube **10**, a water film is formed only on the outer surface of the tube, whereas in the case of tube **14**, it must be formed only on the inner surface thereof. However, collector tube **13**, which cooperates both with collector tube **14**

and collector tube 12 to define concentric annular passages, must have water films on both walls thereof. The present invention deals with water distributors adapted to operate in conjunction with wet precipitators of the type shown in FIG. 1, or of any other type in which liquid films are to be formed on the inner or outer surfaces of collector tubes.

Referring now to FIGS. 2, 3, 4 and 5, there is shown one preferred form of water distributor adapted to create water films on both walls of a hollow collector tube formed by concentric cylinders 40 and 41, having a hollow space therebetween. Received on the collector tube and seated on top of cylinders 40 and 41 is a water distributor including a hollow ring 42 having a semi-circular cross-section and provided with feet 43 and 44 which extend into the space between cylinders 40 and 41 and lie thereagainst.

The interior of water distributor ring 42 is divided by partitions 45 and 46 into an annular main tank 47 and a sub-tank 48 therebelow. The sub-tank 48 is coupled by way of pipe 49 passing between the cylinders 40 and 41 of the collector tube to a suitable water supply or liquid source. The sub-tank communicates with main tank 47 through a circular series of inclined openings 50 whereby the main tank is filled by inclined water sprays which cause the water in the main tank to swirl.

Water from main tank 47 is fed to the exterior of the distributor ring by way of a circular series of inclined jet openings 51 which are registered with a circular groove 52 adapted to receive a divider collar 53. The position of the collar is such as to divide the water flow from jet openings 51 into two streams, one flowing over the curved left surface 42A of ring 42 to produce a water film on the wall of the inner cylinder 40, and the other flowing over the curved right surface 42B of ring 42 to produce a water film on the wall of the outer cylinder 41.

Because of the circular motion of the water in the upper tank and the inclination of jets 51 emitting the water, the resultant water streams on the inner and outer cylinders are caused to rotate in overlapping patterns to produce a uniform film on the wall of outer cylinder 41. The centrifugal force created by the water on the wall of the inner cylinder 40 tends to force the water film against the wall, whereas the force on outer cylinder 41 tends to peel the water from the wall.

To avoid this peeling effect, the division of the water effected by the divider collar 53 is made uneven to compensate for the different effects of centrifugal force, and for this purpose the lower end 53A of collar 53 is chamfered. The embodiment of the distributor shown in FIGS. 2 to 5 is adapted to operate with a hollow collector tube in which the water or liquid supplied to the distributor is conducted through the hollow tube.

In the embodiment shown in FIGS. 7 to 10, the water distributor is also adapted to produce water films on both the inner and outer walls of a collector tube, but in this instance, the collector tube 54 is not hollow, so that water is supplied to the distributor not upwardly through the collector tube, as in the previous embodiment, but downwardly from pipes above the distributor.

The upper end of collector tube 54, as shown in FIG. 6, is rounded on either edge thereof, and the water distributor is mounted on a pedestal 55 midway between the rounded edges. The water distributor in this instance is a flat ring defined by annular plates 56 and 57 which are spaced from each other to create a main tank 58, which is supplied with water through pipes 60 coupled to openings in a rim 59 projecting from upper plate 57. Main tank 58 communicates with the rounded inner edge of collector tube 54 through a circular series of spaced jet openings 61 which are inclined in the vertical plane to produce overlapping streams creating a rotating water film on the inner surface of the collector tube 54.

Main tank 58 communicates with the rounded outer edge of the collector tube through a circular series of spaced jet openings 62 which have the same inclination as jets 61, but in a plane displaced from the vertical so that the jets spray water in a direction toward pedestal 55. This is done to compensate for the centrifugal forces which otherwise would tend to cause the water to peel away from the outer wall of the collector tube.

Referring now to FIG. 10, there is shown a water distributor in accordance with the invention for producing a uniform water film on only one wall of a collector tube 63. For this purpose, the distributor includes a toroidal tank 64 mounted on a bracket 65 attached to the inner wall of collector tube 63 whose outer wall is to be made wet.

Water from tank 64 is supplied to a distributor ring 66 overlying the upper end of collector tube 61 and spaced therefrom by a spacer 67. Water is fed from tank 64 to ring 66 by openings 68 which pass through the mounting bracket on which both the tank and the ring are supported. Water from ring 66 is emitted onto the upper end of collector tube 61 through a circular series of inclined jet openings 69 in the same fashion as in the previous embodiments, to cause overlapping streams of water to form on the outer wall of the collector to create a uniform water film thereon.

While there have been shown and described preferred embodiments of water or liquid distributors for use in conjunction with a wet electrostatic precipitator for removing gaseous and particulate contaminants ,in accordance with the invention, it will be appreciated that many changes and modifications may be made therein without, however, departing from the essential spirit of the invention.

I claim:

1. A liquid distributor adapted to operate in conjunction with a wet electrostatic precipitator having concentrically-arranged collector tubes defining annular passages through which passes a contaminated gaseous stream, the distributor producing a downwardly-flowing liquid film on the inner and outer walls of the associated collector tube, said distributor comprising:

an annular ring secured to the upper end of the associated collector tube, the interior of said ring being hollow to define a main tank for holding liquid fed thereto from a supply thereof, said ring having inclined openings therein to discharge liquid from said tank onto said inner and outer walls, and to impart a swirling motion thereto, and means effecting compensation for the centrifugal forces created by said swirling motion to prevent liquid from peeling off said outer wall.

2. A distributor as set forth in claim 1, wherein said ring has a semi-circular profile which merges with the inner and outer walls of said associated collector tube and is provided at its top with a divider collar which separates the liquid passing through said openings into

two distinct streams, one passing over the inner wall and the other over the outer wall.

3. A distributor as set forth in claim 2, wherein said ring is provided with two partitions to define said main tank, and a sub-tank therebelow, said sub-tank being coupled to said main tank by inclined openings causing the liquid in the main tank to swirl.

4. A distributor as set forth in claim 2, wherein the lower end of said collar is chamfered to cause more liquid to flow to said inner wall.

5. A distributor as set forth in claim 1, wherein said collector tube is hollow, the liquid from said supply being fed through said hollow tube into said main tank.

6. A distributor as set forth in claim 1, wherein said collector tube is solid and the liquid from said supply is fed through the top of said ring into said tank.

7. A distributor as set forth in claim 6, wherein said ring is raised above said collector tube by a pedestal and is provided at its underside with a first series of openings on one side of said pedestal to discharge liquid to flow over the inner wall,and a second series of openings on the other side of said pedestal to discharge liquid to flow over the outer wall.

* * * * *