SELF-DECONTAMINATING ELECTROSTATIC PRECIPITATOR STRUCTURES

Filed Sept. 7, 1962

4 Sheets-Sheet 1

Fig. 7.

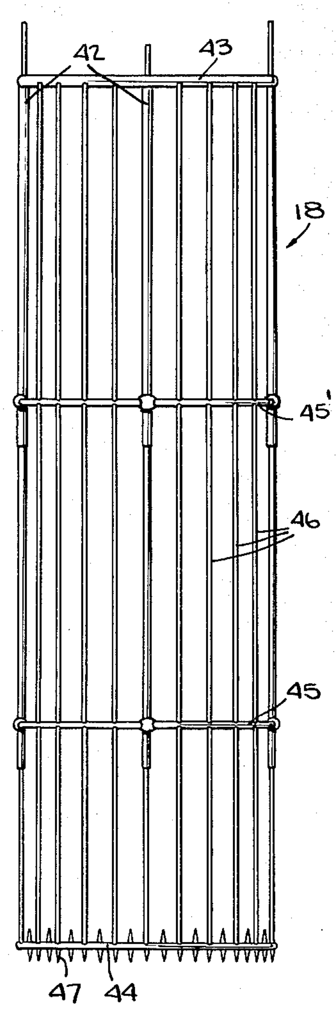
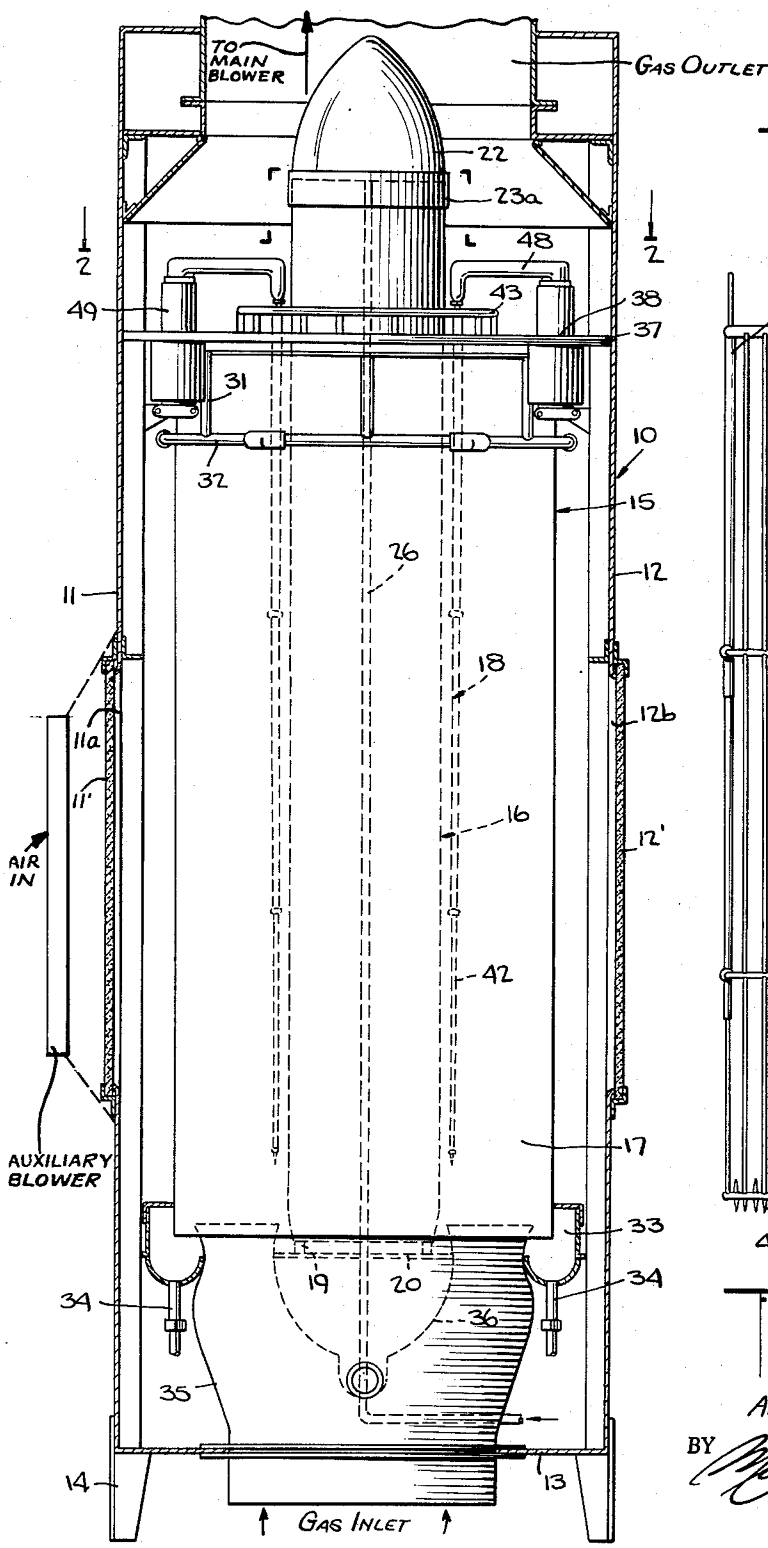


Fig. 1.



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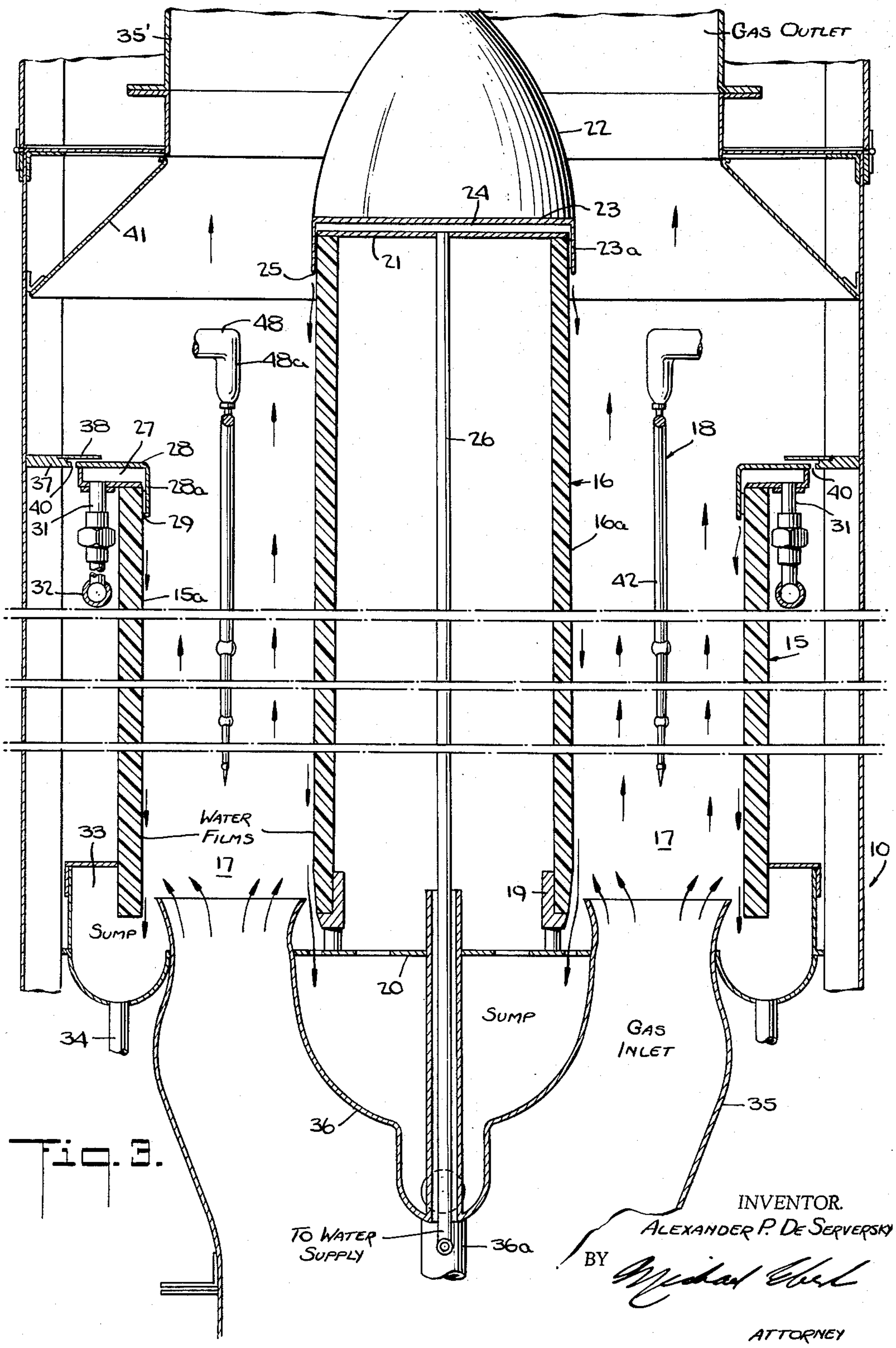

Fig. 3.

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Fig. 2.

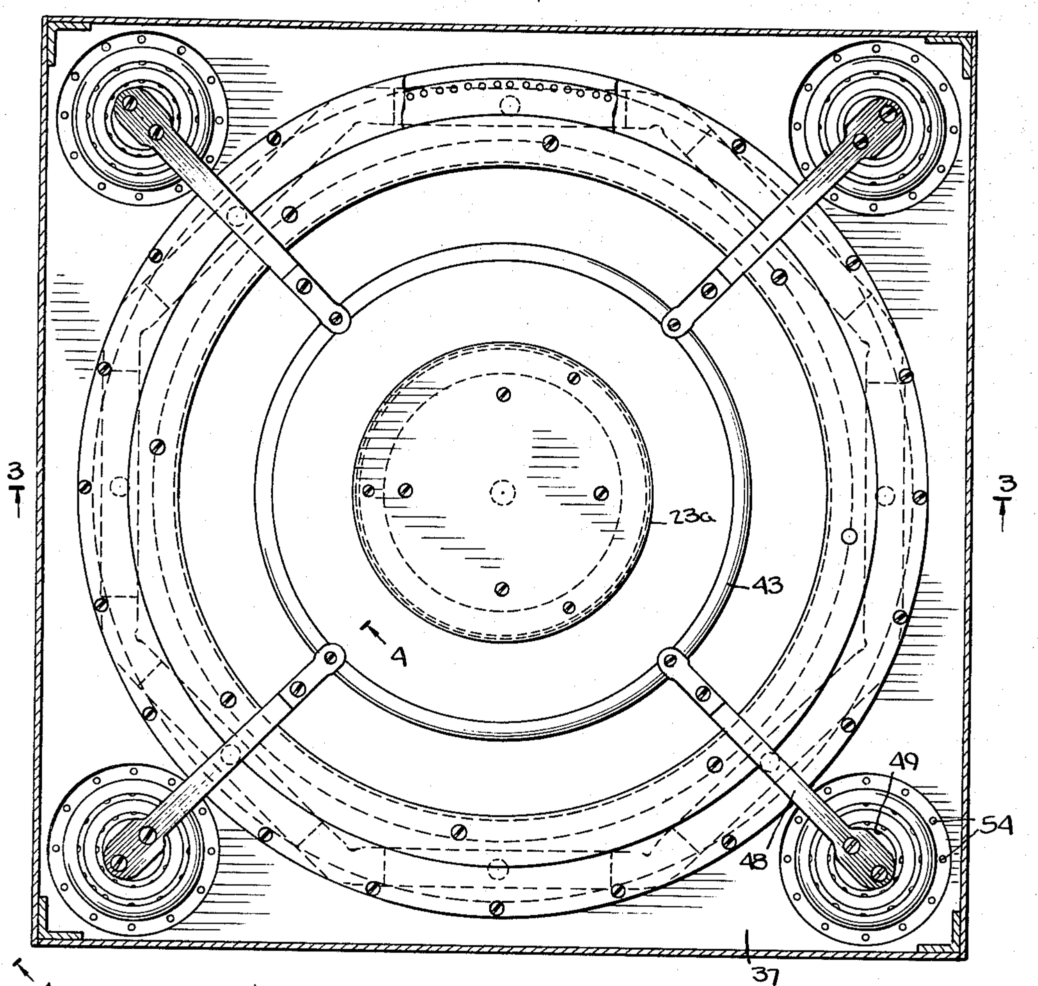
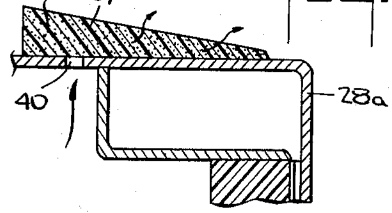


Fig. 9.



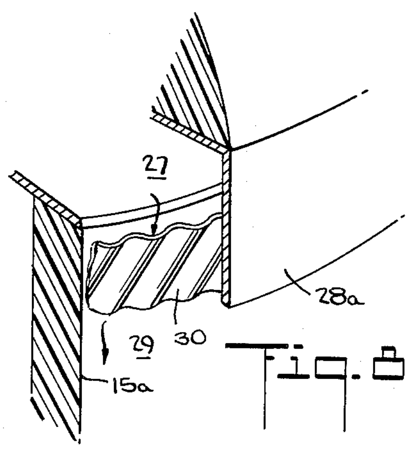


Fig. 8.

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March 8, 1966 A. P. DE SEVERSKY 3,238,702

SELF-DECONTAMINATING ELECTROSTATIC PRECIPITATOR STRUCTURES

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Fig. 4.

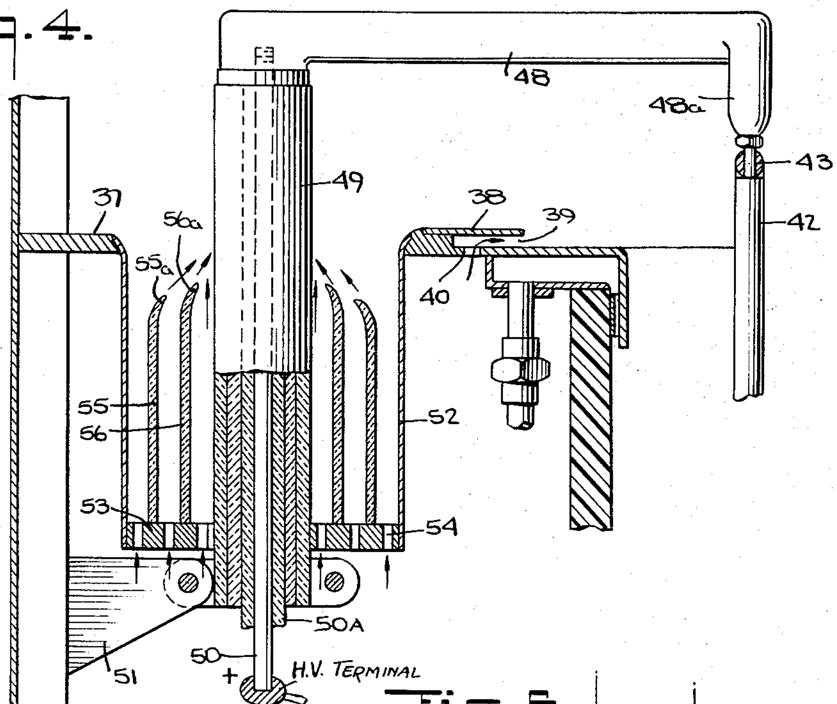


Fig. 5.

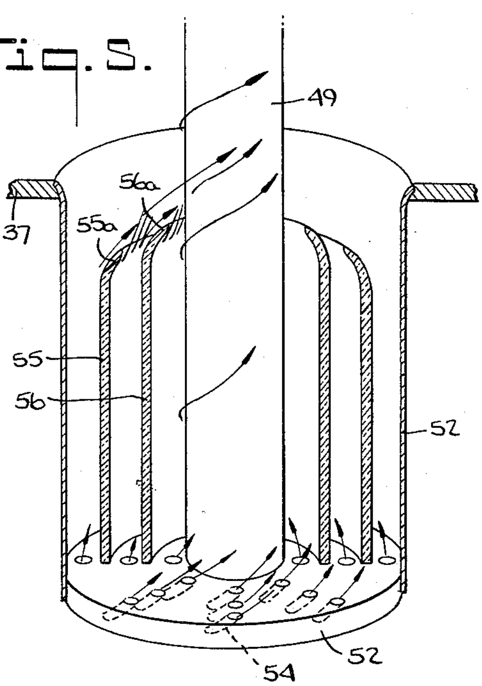
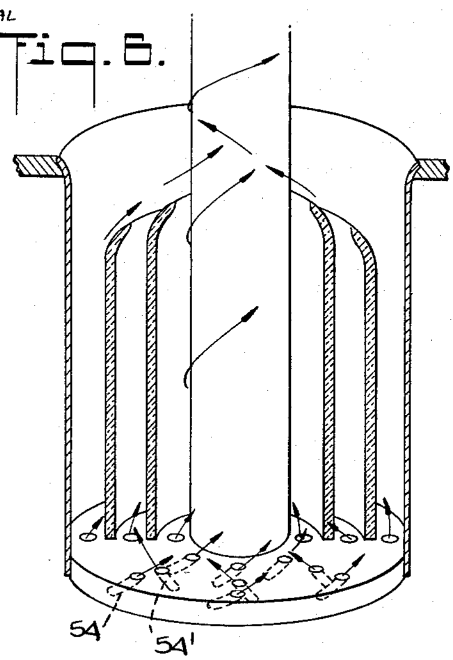


Fig. 6.



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United States Patent Office

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3,238,702
SELF-DECONTAMINATING ELECTROSTATIC PRECIPITATOR STRUCTURES

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Filed Sept. 7, 1962, Ser. No. 222,009
6 Claims. (Cl. 55—119)

This invention relates generally to electrostatic precipitators for separating particles or droplets of a semi-solid or solid nature from the atmosphere, and more particularly to a precipitator structure which is self-decontaminating and is adapted to function efficiently for prolonged periods without servicing or maintenance.

An analysis of the atmosphere pervading large metropolitan areas, such as Los Angeles and New York, reveals a high density of dust, soot, colloidal mists, and other deleterious and corrosive contaminants. Atmospheric pollution has become increasingly serious with the rise in the use of apartment house and hotel incinerators to burn waste. Also discharging into the city atmosphere are not only pollutants from such incinerators, but the combustion products from heating systems as well as those emanating from various industrial operations.

The spread of atmospheric pollution and smog has reached such hazardous proportions as to constitute a health issue of national concern. While various expedients have been proposed to reduce the main causes of such pollution, the fact remains that existing precipitators are so expensive both in initial cost and in maintenance as to preclude their use except in large-scale industrial operations. Moreover, conventional precipitators are of cumbersome design and cannot readily be installed in the limited spaces encountered, for example, in apartment houses.

In electrostatic precipitators of conventional design, the gases to be purified, such as those issuing from a heating furnace, are conveyed through a collector tube where they are subjected to an electrostatic field which causes the particles to deposit on the tube surface, thereby separating the particles from the gas. With continued use, the particles accumulate on the walls of the collector tube and on other exposed surfaces. It is therefore necessary at frequent intervals to decontaminate the structure. Thus requires a shut-down of precipitator operation in order to permit scraping of the agglomerated particles from the surfaces, or the use of vibratory cleaning, rapping or flushing. Thus the conventional installation cannot function uninterruptedly and must be serviced at frequent intervals. These requirements add materially to the cost of operation.

In my co-pending application entitled Wet Electrostatic Precipitator, Ser. No. 53,255, filed Aug. 31, 1960, there is disclosed an apparatus wherein the collecting surfaces are constituted by uniform films of water which carry away the particles. A precipitator of this type is to a large extent inherently self-cleaning and being therefore maintenance-free it is particularly suited to non-industrial applications, such as as in apartment houses. It also may be advantageously used for extracting radioactive particles from the atmosphere in the case of fall-out, for these particles are carried away by the collecting liquid which may be stored or decontaminated.

While a wet precipitator of the type described and claimed in my co-pending application is capable of operating without attention for reasonably long periods, certain critical surfaces which are not washed by the collector

water flow become fouled, and it is necessary, therefore, on occasion to remove the scale formed on such surfaces in order to maintain efficient operation.

For example, the discharge electrodes are supported between the wet collector surfaces by means of conductive arms extending from insulating posts, high voltage being applied to the discharge electrodes through one or more of these arms. With continued operation, particles which may be moist or oily accumulate on the surface of the insulating posts, and as these particles are relatively conductive, electrical shorts are developed which cause high-voltage leakage and breakdown of the equipment.

It must be borne in mind that electrostatic precipitators require ionizing and collecting voltages which run as high as 15,000 to 50,000 volts and much higher in some applications in order to develop the necessary electrostatic energies. The presence, therefore, of semi-conductive contaminants on the exposed surfaces of the structure, interferes with its proper functioning.

In view of the foregoing, it is the primary object of this invention to provide an electrostatic precipitator which is self-decontaminating, whereby uninterrupted, reliable and efficient operation may be maintained for prolonged periods without the need for servicing.

While this invention will be described herein connection with wet precipitators, it will be appreciated that certain features thereof are fully applicable to dry electrostatic precipitators.

More specifically, it is an object of this invention to provide a precipitator structure whose critical surfaces are maintained dirt-free and dry by a cyclonic scavenging action.

A further object of the invention is to provide an arrangement wherein a scavenging air flow arises from the pressurized flow of gas through the precipitator, but in the event of pressure failure, by auxiliary blower means, thereby maintaining the precipitator clean under all circumstances.

Yet another object of the invention is to provide a precipitator structure which may be used for any industrial or non-industrial purpose, and is of particular advantage for the precipitation of corrosive effluents and is adapted to recover useful waste products from such effluents by chemical reaction combined with electrostatic separation. A significant feature of the invention resides in the use of porous discharge electrodes and supports therefor which may be purged and which serves to introduce chemical fluids into the gas stream to react with constituents thereof.

Also an object of the invention is to provide an efficient, reliable and compact wet precipitator which is of economical design, and which may be readily installed in apartment houses and in industrial establishments to prevent pollution of the atmosphere and to function as a filter for air conditioning systems.

Briefly stated, these objects are accomplished in a precipitator structure wherein the gases to be cleaned are blown through a precipitator channel, and wherein the flow of gases blown through said channel and the pressure differentials developed thereby, are utilized to produce cyclonic drafts which are directed onto critical surfaces of the structure to effect a scavenging action maintaining the surfaces free of dirt. Means are also provided to maintain the scavening air drafts in the event of a blower failure.

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 like components in the several views are identified by like reference numerals.

In the drawings:

FIG. 1 is an elevational view showing a preferred embodiment of a self-decontaminating wet precipitator in accordance with the invention;

FIG. 2 is a tranverse section taken along the planes indicated by lines **2—2** of FIG. 1;

FIG. 3 is a longitudinal section taken through the precipitator structure in the central plane indicated by the lines **3—3** in FIG. 2;

FIG. 4 is a longitudinal section taken through one of the insulating post wells in the plane indicated by lines **4—4** in FIG. 2;

FIG. 5 is a perspective view, partially cut away, of the insulator post well in FIG. 4, showing the flow of cyclonic currents;

FIG. 6 is a modification of the well shown in FIG. 5;

FIG. 7 is a perspective view of the discharge electrode cage;

FIG. 8 is a perspective view, partially cut way, showing the water flow distributor for the outer collector tube; and

FIG. 9 is a sectional view showing a modified form of flow distributor.

Referring now to FIGS. 1, 2 and 3, there is shown a wet precipitator in accordance with the invention, housed in a suitable metal cabinet generally designated by the numeral **10**. While the cabinet is shown as rectangular, in practice any other form is suitable. The cabinet includes side panels **11** and **12** having openings **11***a* and **12***a*, respectively, to admit ambient air into the cabinet, and a base **13**. The cabinet is mounted on legs **14**. Brackets are mounted adjacent the openings **11***a* and **12***a* to support suitable filters **11′** and **12′** for filtering the air drawn into the interior of the cabinet.

Vertically supported within the cabinet is a collector assembly including an outer collector tube **15** and an inner collector tube **16**, disposed coaxially therein to define an annular gas channel **17** between the interior wall **15***a* of the outer tube and the exterior wall **16***a* of the inner tube. The inner and outer tubes are preferably formed of a suitable wettable material such as transite, porous alumina or a porous metal. Concentrically mounted within the gas channel **17** is a circular discharge electrode cage generally designated by the numeral **18**.

The precipitated particles are continuously washed from the surfaces of the inner and outer collector tubes by forming on the cylindrical surfaces thereof a film of water or any other suitable liquid or liquid suspension which is caused to flow uniformly down the surfaces so that an unbroken cylindrical curtain of liquid is provided.

The inner tube **16** is seated on a collar **19** supported on a lower deck **20**, secured at its edges to the walls of the cabinet and spaced above the base thereof. The upper end of the inner tube **16** is enclosed by a disc **21**, and mounted above the disc by means of spacer elements (not shown) is a nose cone **22** having an inverted cylindrical cup **23** attached to the base thereof, which cup in combination with disc **21** forms a water distributor **24** for the inner tube. The flange **23***a* of the cup encircles the upper end of the inner tube and is concentric therewith to define an annular channel **25** for flowing liquid over the outer surface **16***a* of the inner tube. Water is supplied to distributor **24** by means of a pipe **26** passing through the inner tube and terminating in disc **21**, the pipe being connected to a suitable water source (not shown).

The outer collector tube **15** is supplied with water by means of an annular distributor **27** secured to the upper end of the tube and including a ring **28** provided with a downwardly extending flange **28***a* spaced from the interior surface **15***a* of the outer tube to define a water channel **29** for flowing liquid over this surface.

In order to cause the water to strike the surface of the collector tangentially and thereby to impart a whirling or spiral motion to the water producing a uniform water film, a strip of metal **30** as shown in FIG. 8 is inserted in channel **29**. This strip is provided with transversely-inclined corrugations forming slanted water ducts which produce the desired water motion. The formation of the corrugations may also take the form shown for the water distributing channels disclosed in my above-noted co-pending application. A similar strip may be inserted in the channel **25** for the inner collector tube. Water is supplied to the distrtbuor **27** by means of a series of pipes **31** connected to a manifold **32**.

The water flowing down the outer collector **16** and containing the particles precipitated in the gas channel **17** spills into a circular sump **33** having a concave bottom mounted on lower deck **20**, the water being drained through outlet pipes **34**. To improve the flushing action as well as to prevent clogging, a jet of water may be introduced tangentially into the sump by means similar to those employed in flush toilets. This expedient is useful in removing particles washed into the sump, including those which otherwise would float on the surface.

The gases to be cleaned are introduced into the precipitator through the lower end of the gas channel **17** by means of an inlet pipe **35** which passes through openings in base **13** and lower deck **20**. Mounted concentrically within the upper section of the inlet pipe is an inverted bell **36** which acts as a sump for the water flowing down the inner collector tube **16**, this sump being drained by pipe **36***a*.

The mouth of bell **36** is curved inwardly and surrounds the lower end of the inner collector tube **16**. The upper section of the inlet pipe **35** is curved inwardly and then flared outwardly so that in combination with the mouth of the bell, there is formed a flared annular gas input to introduce gas into the channel **17** with a Venturi effect.

Hence when the gas is admitted into the precipitator channel **17**, the resultant gas expansion as the gas exits from the pipe generates forces tending to urge water flowing down the inner and outer collector tubes against the surfaces thereof, thereby maintaining a uniform water film. It is not essential that the annular Venturi inlet be disposed within the end of gas channel **17**, and in practice it may be disposed below the collector tubes which define this channel.

As indicated by the arrows, the gases admitted through inlet pipe **35** pass through the channel **17** and out of the precipitator through an outlet duct **35′** extending through the top of the cabinet. In actual practice, assuming that the precipitator is to be installed in the output of an incinerator, the combustion products from the incinerator would usually be conveyed first through a scrubber of standard design before being fed into the precipitator, and from the precipitator through a suitable blower into a chimney, the blower acting to draw the gases through the system.

It is also possible to avoid the use of a blower by installing the scrubber and precipitator at ground level adjacent the incinerator, the precipitator being coupled into the duct of the chimney, and depending on the draft developed in an extended chimney to produce the necessary suction.

It is to be understood that the precipitator in accordance with the invention may be used for any industrial or non-industrial purpose, and is particularly advantageous for the separation of corrosive effluents, since the collector tubes are protectively sheathed by the water film. The other exposed surfaces may be covered by or made of corrosion-resistant material. Thus, where conductive surfaces are required, stainless steel, Monel metal or other corrosion-resistant metals may be used, and in other instances where insulation is required the surfaces may be coated with or fabricated of such materials as Teflon, Kel-F and the like.

The upper end of the outer collector tube **15** and the water distributor therefor, are supported from an upper deck **37** secured at its edges to the walls of the cabinet, and as best seen in FIGS. 3 and 6, attached to this deck at a position slightly raised above the surface of the annular water distributor, is a flat ring **38** forming an air space **39**. A series of circumferentially arranged apertures **40** are formed in upper deck **37** below ring **38** to admit air from outside of the collector assembly into the air space.

The upper section of the inner collector tube **16** is surrounded by a truncated conical outlet hood or funnel **41** which is coupled to the outlet pipe **35'**. Hood **41** in combination with the nose cone defines an annular outlet free of drag. The hood acts also as a moisture-condensing surface, the droplets being diverted from the discharge electrode **18** and draining onto the upper surface of the water distributor **28** from which point they flow down the collector tube **15**.

The area in the cabinet surrounding the outer tube **15** of the collector assembly is isolated from the gas channel **17**, except through apertures **40** and other apertures to be later described. The cabinet itself is air-tight, the only air being admitted through filters **11'** and **12'**. Hence the pressure differential created by the flow of gas through the precipitator causes dirt-free air from the exterior of the cabinet drawn through filters **11'** and **12'** to be sucked into apertures **40** to produce a high-pressure air stream which is ejected through the annular air space **39**.

This air stream is projected along the upper surface of the water distributor **28** in a direction opposed to the flow of particles toward the distributor. It acts as a scavenger to prevent such particles from lodging themselves on the distributor, thereby maintaining this component clean and preventing the agglomeration of particles which would in time interfere with the distributor operation.

The discharge electrode cage **18** is constituted by a circular array of four conductive rods **42** whose ends are attached to conductive upper and lower hoops **43** and **44**. Intermediate reinforcing hoops **45** and **45'** may also be provided. Strung between the upper and lower hoops are conductive wires **46** forming with the conductive rods a circular discharge grid. Supported on the bottom hoop **44** is a ring of double-ended conductive needles **47** acting as pre-ionization electrodes. These electrodes serve to ionize particles in the gases admitted to the gas channel, whereby the charged particles when entering the electrostatic field are attracted toward the liquid electrode.

The main rods **42** are each formed by a series of rods of progressively diminishing diameter to form a cantilever structure preventing vibration of the electrodes even when subjected to a gas stream of high velocity. These rods also serve an ionization function, for the smaller their diameter at the lower end of the gas channel, the greater the high-voltage gradient and the tendency toward corona effects producing ionization. Thus as the gases travel upwards in the channel **17**, they are first pre-ionized and then collected.

While the rods **42** have been described as being fabricated of conductive material, it is also possible to make use of electrically resistive rods, such as calbar or other heating elements, and to pass current through the discharge electrode to render it incandescent and thereby burn off any particles which might otherwise tend to adhere thereto.

The electrode grid or cage **18** is supported within the gas channel by means of conductive arms **48** extending radially from insulating posts **49** (note FIGS. 1, 4, 5 and 6) and having downwardly extending fingers **48a** connected to the uppermost ring **43** of the discharge electrode cage. As shown in FIG. 4, high voltage is applied to the discharge electrode by means of a rod **50** connected to one of the arms **48** and extending coaxially through insulating post **49**. The rod **50** is surrounded by an insulating tube **50a** which may be of Mycalex, or any other insulating material, the annular space between this tube and the post being filled with a potting epoxy or similar material. Such fillers will not, however, be used when, as disclosed hereinafter, the insulating posts are made of porous material and air or other fluids are to be conveyed therethrough.

The positive terminal of a suitable high-voltage supply is connected to the end of rod **50** leading to the discharge electrode **18**, whereas the negative terminal of the supply as well as the water system of the precipitator, are grounded.

The high voltage supply may be a constant D.C. high voltage source, or it may be of the pulsed type disclosed in my above-identified co-pending application. Thus an electrostatic field is established between the discharge electrode and the fluid curtains on the collector electrodes, the normal mineral content of the water being sufficient to render it effectively conductive for the applied voltages. As pointed out previously other liquids may also be used.

As best seen in FIGS. 4 and 5, the insulating posts **49** are supported by brackets **51** attached to the wall of the cabinet. The posts extend centrally through a circular well **52** depending from the upper deck **37**. This well is provided with a circular base **53** provided with slanting apertures **54** arranged in a series of concentric circles. Seated on base **53** and coaxially arranged with respect to insulating post **49**, are two tubular sleeves **55** and **56** whose upper ends are shaped to define cylindrical air foils **55a** and **56a**. The upper edge of air foil **55a** is at a position slightly above the bend in air foil **56a**.

As pointed out previously, the flow of gases through the channel **17** creates suction effects drawing air under pressure through apertures **40**. This suction effect also serves to draw air through the apertures **54** in the wells, and as the apertures are slanted, the resultant air currents, which are confined to the spaces between the coaxially arranged insulator post and sleeves **55** and **56**, flow tangentially relative thereto, as indicated by the arrows, to produce an upwardly-directed cyclonic flow. The interference in the currents produced by the air foils **55a** and **56a** is such as to collimate these currents, causing the air to flow cyclonically and with high pressure in a column surrounding the surface of the insulating post, and scavenging all particles therefrom. Air valve or louvre means may be attached to the wells below base **53** to control the amount of scavenging pressure. Such valves may be individual for each well or a common valve may be employed for the assembly of wells.

The suction which is produced to draw air into the apertures in the wells is generated by the blower or other means serving to draw the contaminated gases through the percipitator assembly. In the event of blower failure, there is a danger that contaminants will then deposit on the exposed surfaces of the precipitator, with resultant breakdown. To avoid this danger, an auxiliary air blower (not shown) may be attached externally to one or more of the air filters **11'** and **12'** on the cabinet, the auxiliary blowers being switched on by means of suitable switches only in the event the main blower fails. In this way air is forced into the cabinet and through the scavenging apertures to maintain the precipitator surfaces free of contaminants. The filters may also be provided with shutters of the Venetian blind or compur type, the shutters being electromagnetically actuated in response to a shut-off of the main blower to close the air openings, except those admitting air from the auxiliary blower.

Thus the particles which would otherwise tend to accumulate and agglomerate on the post to cause voltage breakdowns or leakage, are removed therefrom and the post is maintained clean and dry for uninterrupted, trouble-free operation. It is also possible to make the insulating post **49** and conductive arms **48** porous with a central passage therethrough into which pressurized air or steam may be introduced to purge these surfaces of all contaminants. The posts and supporting arms for the discharge electrodes may be made of the same porous insulating substance, thereby forming, in effect, a porous bracket which may be continuously purged. In this event, the discharge electrode can be electrified by a suitable conductor passing through the core of one of the arms.

With the use of porous or hollow arms 48 or porous discharge electrode rods one may also introduce liquids or gases of a chemical composition reacting with chemical effluents in the gas stream in the channel 17, and thereby recover useful waste products. For example, with ammonia vapor passing through the precipitator, one may transmit through the supporting arms to the porous discharge electrodes a vapor of hydrochloric acid to produce ammonia hydrochloride aerosols which are electrostatically precipitated and which may therefore be recovered in the water draining from the collector tubes. Obviously, a great number of chemical reactions may be carried out by this method. By properly apportioning the ratio of hydrochloride to the existing volume of ammonia, the resultant effluent discharged from the precipitator may be made odorless.

In FIG. 6, there is shown a modification of the cyclonic scavenging arrangement wherein the apertures 54 and 54′ are slanted in opposing directions to produce counter-cyclonic currents which enhance the scavenging action, and which produce shearing effects at the edges of the air foils to keep them free of contaminants which otherwise would cause spark-over.

In FIG. 9, a porous, annular wedge 57 is placed over the apertures 40, rather than the ring 38 (note FIG. 4), whereby the air sucked through the apertures serves to penetrate the wedge and to eject particles therefrom to maintain the surface clean and dry.

When a porous discharge electrode structure is to be used, in lieu of a structure constituted by an array of individual rods of the type shown in the figures, the discharge electrode may take the form of two concentrically disposed cylinders fabricated of porous conductive material, with a corrugated porous filler interposed therebetween the diffuse the flow of air or other gas therethrough.

This concentric discharge electrode structure (not shown) is mounted within the gas channel 17 of the precipitator assembly and is provided at the upper end with a manifold ring to supply air or gas thereto, which air or gas is emitted through the pores of both cylinders to keep them clean or to interact chemically with constituents in the gas flowing through the channel, or for both such purposes. The manifold ring in turn is coupled to hollow supporting brackets which function as gas feed lines.

In a concentric discharge electrode structure, as above described, the porosity of the cylinders may be varied throughout the length of the structure in such a way as to equalize the emission thereof (C.F.M. per sq. inch). Alternatively, the variations in porosity may be chosen to bring about increased emission of air or gas, say, toward the bottom of the structure, in order to take care of a greater tendency toward contamination in the chosen area or to increase chemical interaction in that area. Ionization points are attached to the lower end of the concentric structure.

Where air or gas is blown through a porous discharge electrode structure, this acts to intensify the migration of particles to the collecting electrodes, for such migration occurs not only by reason of ionization effects, but also because of the dynamic forces generated by the blown-out air or gas.

While there have been shown preferred embodiments of the apparatus according to 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. It is intended, therefore, to cover all such changes and modifications by the annexed claims.

What is claimed is:

1. An electrostatic precipitator for cleaning contaminated gas, said precipitator comprising:
   (a) a collector assembly including concentrically arranged inner and outer collector electrode tubes defining an annular gas channel,
   (b) means communicating with said assembly to draw said contaminated gas through said channel and to discharge the resulting clean gas into the atmosphere,
   (c) an annular fluid distributor mounted above and secured to said outer tube to flow a liquid film down the inside surface thereof,
   (d) means mounted above and secured to said inner tube to flow a liquid film down the outside surface thereof,
   (e) a discharge electrode structure disposed between said inner and outer tubes within said annular channel and connectable to a high-voltage source to establish an electrostatic field relative to said tubes to cause migration of particles in said gas toward said films thereon,
   (f) an enclosed casing surrounding said assembly and spaced from said outer tube,
   (g) a deck disposed perpendicularly to said casing and in parallel relation to the surface of said fluid distributor to divide said casing into an upper region communicating with said channel and a lower region which is defined by the annular air space between said casing and the outer tube, said deck having apertures therein providing air passages between said upper and lower regions,
   (h) a filter mounted on said casing to effect fluid communication between the atmosphere and said lower region, and
   (i) means mounted on said deck in said upper region to direct air currents emitted from said apertures and derived from air drawn from the atmosphere through said filter as a result of a pressure differential created when gas is drawn through said channel, onto the surface of said distributor to scavenge particles therefrom.

2. A precipitator, as set forth in claim 1, further including insulating posts mounted in wells depending from said deck to support said discharge electrode, said posts extending into said upper region, said wells extending into said lower region and being provided with openings producing air currents which are directed against said posts to scavenge particles therefrom.

3. A precipitator, as set forth in claim 2, wherein each well is provided with a base having slanted apertures forming said openings and producing cyclonic currents, and further including at least one sleeve mounted on said base and surrounding said posts, the upper end of said sleeve being shaped to constitute an air foil to collimate said air currents.

4. A precipitator, as set forth in claim 3, wherein said apertures in the base of each well are slanted in opposing directions to produce counter-cyclonic currents.

5. A precipitator as set forth in claim 1, wherein said discharge electrode structure is constituted by a circular array of rods concentrically disposed within said channel, each rod being formed by sections of diminishing diameter to constitute a cantilever structure of high rigidity.

6. A precipitator as set forth in claim 1, further including a blower mounted over said filter and rendered operative upon a pressure failure of said gas in said channel to maintain said scavenging air currents.

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