May 31, 1955 W. R. CARTER 2,709,500

CENTRIFUGAL AIR SEPARATOR FOR REMOVAL OF PARTICLES

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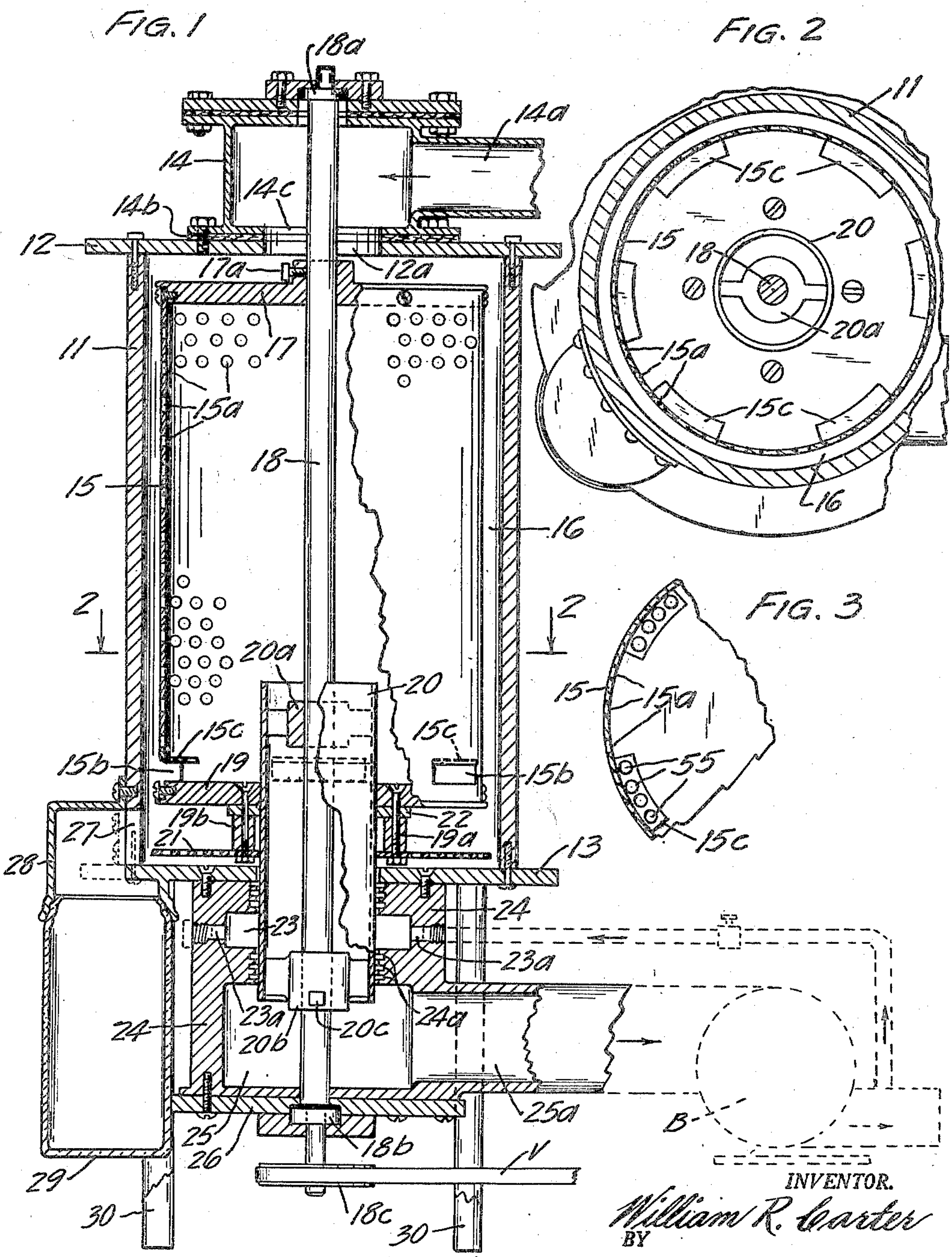

INVENTOR.

William R. Carter

BY

Williamson & Williamson

ATTORNEYS

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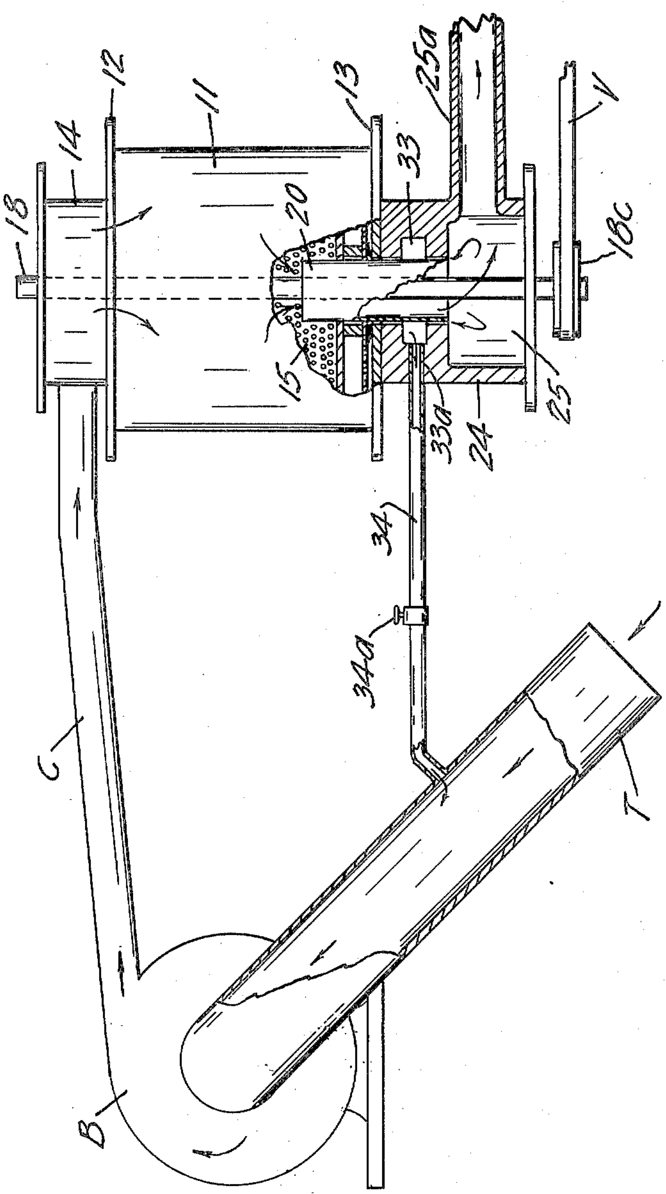

FIG. 4

INVENTOR.
William R. Carter
BY
Williamson & Williamson
ATTORNEYS

United States Patent Office

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CENTRIFUGAL AIR SEPARATOR FOR REMOVAL OF PARTICLES

William R. Carter, Minneapolis, Minn.

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6 Claims. (Cl. 183—77)

This invention relates to machines and apparatus for removing fine particles from air or other gaseous mediums and for, if desired, classifying particle-removal through the principle of centrifugal separation.

It is an object of my present invention to provide an extremely efficient gas separating machine or apparatus which will remove the finest particles of dust or other material entrained in a moving gaseous medium through the close cooperation of a high speed centrifuge rotor with a surrounding casing and with a gas withdrawal tube mounted at one end of said casing and extending through one end of said rotor and communicating with the axial portion within such end of the rotor.

A further object is the provision of a centrifugal, rotor-type air separator which eliminates the undesirable features of filtering elements, cyclone dust collector systems and which while creating a main, high speed separation vortex, eliminates disturbing turbulence throughout the separation vortex.

A further object is the provision of a centrifugal dust collector having some features in common with my co-pending application, Serial Number 167,465, filed June 10, 1950, now Patent No. 2,633,930, but attaining an extremely high dust removal efficiency through the employment of a high speed, hollow, densely apertured rotor body, working in close cooperation with an axial gas-withdrawal tube and spaced rotor casing.

A further object is the provision of a centrifugal air separator or particle remover which will produce a desired vortex and angular velocity of air without employment of any vanes or blades; which will maintain a substantially constant efficiency of separation although the capacity and flow is varied materially and which at a given air capacity, causes substantially no change in pressure drop across the apparatus even though there is a wide variation in the amount, type and particle size of the material to be separated.

With my improved construction, air or other gaseous medium containing fine particles or globules is given substantially the positive angular velocity of the rotor without employment of any vanes or blades, thereby reducing turbulence and the otherwise attendant reduction of particle size through impaction and attrition which in prior art devices, lessens the speed and efficiency in separation.

The foregoing and other objectives will be more apparent from the following description made in connection with the accompanying drawings, wherein like reference characters refer to similar parts throughout the several views and in which:

Fig. 1 is a vertical section taken axially through an embodiment of my invention, the dotted lines indicating connection of the gas or air discharge passage with a blower casing and also, indicating an elective alternative connection of the air sealing passage with the discharge end of the blower;

Fig. 2 is a cross section taken on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary detail view showing the lower end and deflector flanges of an alternative rotor body; and

Fig. 4 is a somewhat diagrammatical view partly in side elevation and partly in vertical section showing an embodiment of my invention where a pressure air flow is created through the centrifugal air separator and where air sealing mechanism is employed between the air withdrawal tube of the rotor and the base of the casing, to exclude passage of air from the bottom of the casing into the air discharge passage.

Referring now to Figures 1 to 3 of the drawings, a cylindrical rotor casing **11** is employed, being as shown vertically disposed and having a smooth internal cylindrical wall, a closed top plate or disc **12** provided with a central and axial air intake passage **12*a*** and a bottom closure plate **13** suitably and removably affixed to the lower end of the cylinder **11**. A relatively small, cylindrical cap or intake casing **14** is secured to the top **12** of the rotor casing having a tangentially communicating air intake conduit **14*a*** connected therewith and this cap casing is affixed with the inner position of a sealing gasket **14*b*** to the central portion of the top plate **12**, and has communication through a central aperture **14*c*** with the upper end of the rotor casing **11**.

I provide a hollow centrifuge-rotor comprising a densely perforated, cylindrical shell **15** of a diameter somewhat less than the cylindrical casing **11** and axially mounted within the casing **11** with substantially wide clearance relative thereto, to leave an annular particle-collecting passage **16** between the rotor and the casing. The perforations **15*a*** formed in the cylinder shell **15** are of a dimension or dimensions to permit the largest size particles to be removed, to very freely pass therethrough without any restriction and such perforations are preferably circular, ranging in diameter according to the particular use of the machine, from one eighth of an inch to one half of an inch. Both external and internal surfaces of the cylindrical shell **15** are smooth and unobstructed by ribs, corrugations or detents in my preferred form. The cylinder **15** is affixed at its upper end to an imperforate end disc **17** which is disposed in spaced relation to the top plate **12** of the casing and which axially embraces and is affixed by set screw or the like **17*a*** to a vertical rotor shaft **18** having its ends journaled in suitable bearings **18*a*** and **18*b*** provided in the upper and lower ends of my apparatus or machine. The lower end of the cylinder shell **15** as shown, surrounds and is affixed to a bottom, imperforate end disc **19** which is provided with a relatively large circular aperture surrounding and closely fitting an air-withdrawal tube **20** which in the form illustrated, is affixed to and comprises a part of the rotor.

The air withdrawal tube **20** is open at both of its ends and as shown, is affixed to the lower portion of rotor shaft **18** by suitable means such as upper and lower spiders **20*a*** and **20*b*** respectively provided with radial set screws **20*c***. The inner end of the air withdrawal tube, therefore extends inwardly a short distance beyond the adjacent end closure **19** of the hollow rotor and is disposed axially thereof. The lower end disc **19** as shown is suitably affixed by bolts **19*a*** and a spacer collar **19*b*** to a perforated distributor disc **21** which is disposed near the lower end plate **13** of the casing and a sealing gasket **22** is preferably interposed between collar **19*b*** and disc **19**, compressed against the periphery of the withdrawal tube **20**.

The lower end of air withdrawal tube **20** extends through a so-called "sealing chamber" **23** formed in the upper portion of a cap cylinder **24** affixed to the bottom closure disc **13** of the casing and then enters and communicates with the clean air withdrawal passage **25** formed by the lower portion of cap cylinder **24**. Passage **25** is cylindrical and as shown, has a tangential discharge passage **25a** which may be connected with the eye or intake of a blower B.

An efficient and novel mechanism or sealing medium is provided between the periphery of the rotary air withdrawal tube **20** and the air discharge passage 25 to positively prevent flow of air and fine particles or dust from the bottom of the interior of the rotor casing **11** to the clean air discharge passage **25**. To this end, the annular sealing chamber **23** is provided surrounding the intermediate lower portion of the withdrawal tube **20** and communicating as shown in full lines, through one or more radial ports **23a** with the atmospheric air surrounding my machine or apparatus. The rotary tube **20** works in a clearance relation to apertured portions of the cap member **24** disposed above and below the sealing chamber **23** and to this end, if desired, a series of vertically spaced annular grooves **24a** may be supplied in such apertured portions.

In the form of the invention of Fig. 1, since the air discharge passage is connected with the intake of a blower B or some other source of partial vacuum, a slight partial vacuum is set up within casing **16** and within the lower portion thereof. Therefore, since sealing chamber 23 is connected with the atmosphere or a source of gaseous medium under pressure above or at atmospheric pressure, any flow of air or gaseous medium around the air-withdrawal tube **20** will be in an upward direction into the bottom of the casing **11** from the sealing chamber 23. Thus, downward or outward flow of air or any minute particles from the bottom of the rotor casing is excluded and positively prevented.

The bearing **18b** for the lower end of the rotor shaft as shown, is supported within a removable heavy plate or disc **26** secured to the bottom of the cap cylinder 24. The lower end of rotor shaft **18** as shown, is provided with a V-pulley **18c** which may be driven from a motor or other source of power by an endless V-belt V.

As shown, the lower end of the cylindrical rotor shell **15** is provided with a plurality of circumferentially spaced, particle-discharge passages or slots **15b**, the lower edges of which are preferably defined by the inner surface of the closure disc **19**. Deflector louvres or flanges **15c** are preferably formed just above the ports or slots **15b** and may be integrally constructed with the shell **15** by cutting the stock of the shell in U-fashion and bending the flaps so cut into positions perpendicular to the axis of the cylindrical shell. In handling certain types of particles it is desirable, as shown in Fig. 3 to aperture or perforate the deflectors or flanges **15c** by the drilling or other provision of closely spaced apertures **55** formed therein.

At the lower portion or bottom of the rotor casing **11** and preferably below the bottom closure disc **19** of the rotor, a particle-discharge chamber is formed, having as shown, a lateral discharge passage **27** communicating with a short, depending spout **28** which as shown, is internally threaded at its lower open end to engage and support a particle-collecting container **29**.

My apparatus may be supported or mounted in any suitable manner and in the form shown, is supported on four vertical legs **30** which are rigidly affixed to the bottom closure disc **13** of the rotor casing.

Operation

In operation, the centrifuge rotor is driven at relatively high speed, the speed varying within a range depending on the nature of the use. The linear foot travel of the periphery of rotor cylinder **15** may vary from 5000 feet per minute up to 15,000 feet per minute, depending upon the conditions, size and specific gravity of the prevalent particles to be centrifugally extracted from their entrainment with air or some other gaseous medium. Air flow is produced in the form shown in Figures 1 to 3, by connection of the air discharge passage **25a** with a source of suction or negative pressure such as the inlet of a power blower B. The air intake passage **14a** of my machine is connected with a room, chamber or the interior of a machine or apparatus from which particle-laden air is to be withdrawn. The general movement of the air or gaseous medium and the particles entrained thereby in the machine of Figure 1, is downwardly. The general movement of the pure air or gaseous medium is inwardly and downwardly while the movement of the heavier particles is centrifugally outward and downwardly in the operation of the apparatus of Figure 1.

The high speed revolution of the hollow rotor including the densely perforated cylindrical shell **15** and its imperforate top and bottom closure discs **17** and **19**, sets up a high speed vortex with an angular velocity of the air equaling or substantially equaling the speed of the rotor.

Since the densely perforated or highly foraminous hollow rotor shell **15** is substantially unobstructed in its interior, neglecting losses due to friction the resulting angular velocity of the air vortex created increases from the peripheral portion of the revolving air within the shell **15** to the axial portion of the shell. The increase of the R. P. M. or angular velocity of air ignoring friction losses is inversely proportional to the diameter of the vortex. Centrifugal force exerted on a particle varies proportional to the square of the R. P. M. Thus, in the operation of my structure, the angular velocity or R. P. M. of the swirling air adjacent the center or axis of the vortex at the area where air or other gaseous medium is withdrawn through the withdrawal tube **20** is at a relatively very high speed, which speed of course is most effective in its centrifugal action in excluding and causing heavier particles to be excluded from the withdrawal tube. The result of the highly efficient centrifuging vortex produced by my apparatus is that an extremely high efficiency of separation is obtained. The vortex is substantially free from turbulence and eddy currents since the rotor is unencumbered with arms, vanes, or obstructing parts and since the rotor is smooth and symmetrical in shape. The imperforate upper closure disc **17** acts as a distributor upon the entering air or gaseous medium laden with particles of dust or other material, producing a substantially uniform radial and whirling distribution of the material to be separated, towards the inner peripheral wall of the rotor casing **11**.

The vortex created by my rotor of course extends to the annular passage **16** between the rotor shell **15** and the casing **11** and here again, the swirling action is substantially free of any turbulence or eddy currents because of my improved structure. The particles of foreign material such as dust, are centrifugally carried and worked by my apparatus to the annular passage **16** and then to the discharge end of the casing, passing through the lateral passage **27** into the top of the collector container. Gravity assists in the collection of particles.

The perforated disc **21** agitates particles collecting upon the bottom **13** of the casing and in its rotation, assists in the delivery of these partices to the lateral particle outlet **27** which communicates with the top of the collection container **29**.

The particle discharge slots **15b** at the lower end of the rotor shell in the centrifuge action, keeps the bottom of the rotor clear and in this connection, the inturned flanges **15c** restrict turbulence and recirculation currents.

In use, an embodiment of my invention utilizing a rotor of approximately six inch diameter and densely perforated at its cylindrical shell with apertures or passages approximating $\frac{3}{16}$ of an inch in diameter, demonstrated an efficiency in excess of 99.99% in the separation of air from dust particles entrained thereby.

In Fig. 4, a somewhat different embodiment of my improved sealing medium is employed in a system or apparatus wherein air circulation through the rotor and casing is set up by forced circulation rather than by partial vacuum.

In Fig. 4, the apparatus is diagrammatically illustrated, the parts of the rotor, the rotor housing, the intake passage and air withdrawal tube being substantially identical in structure with the form first described and therefore, being identified by like numerals in Fig. 4.

Air or other gaseous medium containing dust or entrained particles of other foreign material is drawn as shown, through a relatively large tube T into the intake of a power blower B′ and is discharged by that blower tangentially of the casing through a somewhat smaller conduit C into the top cap **14** constituting the intake for the housing **11** of my air separating machine. The rotor **15** of the general structure shown in Fig. 1 and mounted on rotor shaft **18** is axially mounted within housing **11** and has affixed thereto the open ended air withdrawal tube **20** which passes through a sealing chamber **33** generally similar in construction to the sealing chamber **23** of Fig. 1 and as shown, formed in a cylindrical base member **24** which is secured to the bottom closure **13** of housing **11**.

In this form of the invention, a pressure is set up within housing **11** and the interior of the rotor **15** slightly in excess of the atmospheric pressure surrounding the housing or casing. The annular sealing passage **33** is closed as shown with the exception of a radial port or passage *33a* which is threadedly or otherwise connected with a relatively small conduit **34** having a valve *34a* therein, such conduit **34** communicating with the interior of the tube T to cause induction of a flow in the direction illustrated by the arrows under the effect of partial vacuum set up by the axial portion of the blower rotor.

The centrifugal, vortex separation of the gaseous medium or air from the particles entrained thereby in the apparatus of Fig. 4 is similar to the operation previously disclosed herein. An efficient seal between the periphery of the air withdrawal tube **20** and the air discharge passage **25** is accomplished by the structure described and illustrated in Fig. 4 since any leakage of air from the lower portion of housing **11** between the periphery of withdrawal tube **20** and the bottom of the casing or the upper portion of the cylindrical member **24** together with fine particles entrained thereby, collects in the annular sealing passage **33** and is withdrawn therefrom through the partial vacuum impressed upon the communicating tube 34. Likewise any leakage of air from the air discharge passage **25** communicating with the lower open end of tube **20** is directed upwardly as indicated by the arrows in Fig. 4, excluding passage of particle-laden air from the air discharge passage, since upward escape of very small amounts of air is also effected by the partial vacuum impressed upon the withdrawal tube **34**. The air or other gaseous medium which may contain a small percentage of fine particles is transmitted into the entering air stream of the apparatus which passes into the inlet of blower B′ from the enlarged tube T.

From the foregoing description, it will be seen that in both forms of the invention illustrated, a very highly efficient centrifuge-separation is obtained between the air or other gaseous medium and any particles, globules or foreign material entrained therein. This highly efficient separation produces unexpected results and is thought to be due to the close cooperation between a generally cylindrical high speed rotor unobstructed radially or transversely and of smooth wall construction densely perforated with a distribution of the entering air around one end of the periphery of the rotor and with an air withdrawal tube or the equivalent of very small diameter relative to the rotor with its air admitting end extending axially for some distance into the confines of the rotor at the end opposite its entrance end. With such cooperative structure, a positive and substantially perfect seal is required between the air withdrawal tube at its periphery and the bottom of the rotor and stationary bottom of the rotor housing so that no air containing fine particles may become mixed with the pure air or gaseous medium withdrawn through the interior of the tube. My novel and improved sealing mechanism therefore closely cooperates with other essential parts of my structure to produce an unexpected and highly efficient unitary result.

It will of course be understood that various changes may be made in the form, details, arrangement and proportions of the parts without departing from the scope of my invention.

What I claim is:

1. A centrifugal separating machine for removing particles from a particle-laden gaseous stream comprising, a separating chamber through which the moving gaseous stream is passed, a rotor of hollow, symmetrical construction mounted within said chamber in spaced relation to the walls thereof to provide an annularly arranged particle-collecting chamber, means for driving said rotor at high speed on its longitudinal axis, said rotor having an imperforate end portion, said chamber having a gaseous stream inlet at one end thereof adjacent the said imperforate end portion and arranged to direct the incoming flow of said gas stream against said imperforate end portion whereby the incoming flow of said gaseous stream will be deflected radially outward about the periphery of said rotor, said rotor having a densely foraminated peripheral wall of circular cross section defining interiorly an unobstructed passage for substantially the full length of said rotor to permit simultaneous radial and axial movement of the gaseous stream through the rotor, and with the foraminations of such size as to freely permit passing of particles radially in either direction therethrough during rotor revolution, a "clean" gas withdrawal tube of substantially smaller diameter than said rotor connected at its outer end with a source of partial vacuum and having an inner open end extending axially within the interior of said rotor through one end thereof so that upon rotation of the rotor the passage of the stream within the rotor to the "clean" gas withdrawal tube is along an unobstructed spiral vortex-like path decreasing in diameter from one end of said rotor to the said withdrawal tube, said extended inner end of said tube functioning to concentrate the apex of said vortex-like path at a location inwardly from said one end of the rotor whereby the angular velocity of the stream while traveling in said spiral vortex-like path increases with the decrease in diameter of the path to subject the remaining particles carried by the stream to an increasing centrifugal force thereby separating the particles from the gas and directing the particles radially through said foraminations to the space peripherally of the rotor for discharge.

2. The structure set forth in claim 1, wherein said rotor and said "clean" gas withdrawal tube are axially mounted upon a common shaft, said shaft extending through said rotor and being connected with said driving means.

3. The structure set forth in claim 1, wherein said rotor has also a second imperforate end portion, one of said imperforate end portions surrounding said "clean" gas withdrawal tube in concentric relation and having sealed connection therewith.

4. The invention according to claim 1, wherein the said end of the rotor is spaced from an end of the chamber, and a particle outlet opening in a side of the chamber in a plane lying between the said end of the rotor and the adjacent end of the chamber.

5. The invention according to claim 1, with a distributor disk encircling the tube in a plane between and spaced from the said one end of the rotor end wall and an adjacent end wall of the chamber and coupled to the rotor to turn therewith.

6. The invention according to claim 1 wherein said rotor peripheral wall has a plurality of horizontal slots therethrough in close proximity to the said one end wall thereof, and an inwardly extending flange carried by said

peripheral wall along the edge of each slot remote from the said one end wall.

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