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APPARATUS FOR GAS FILTRATION

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Fig. 1.

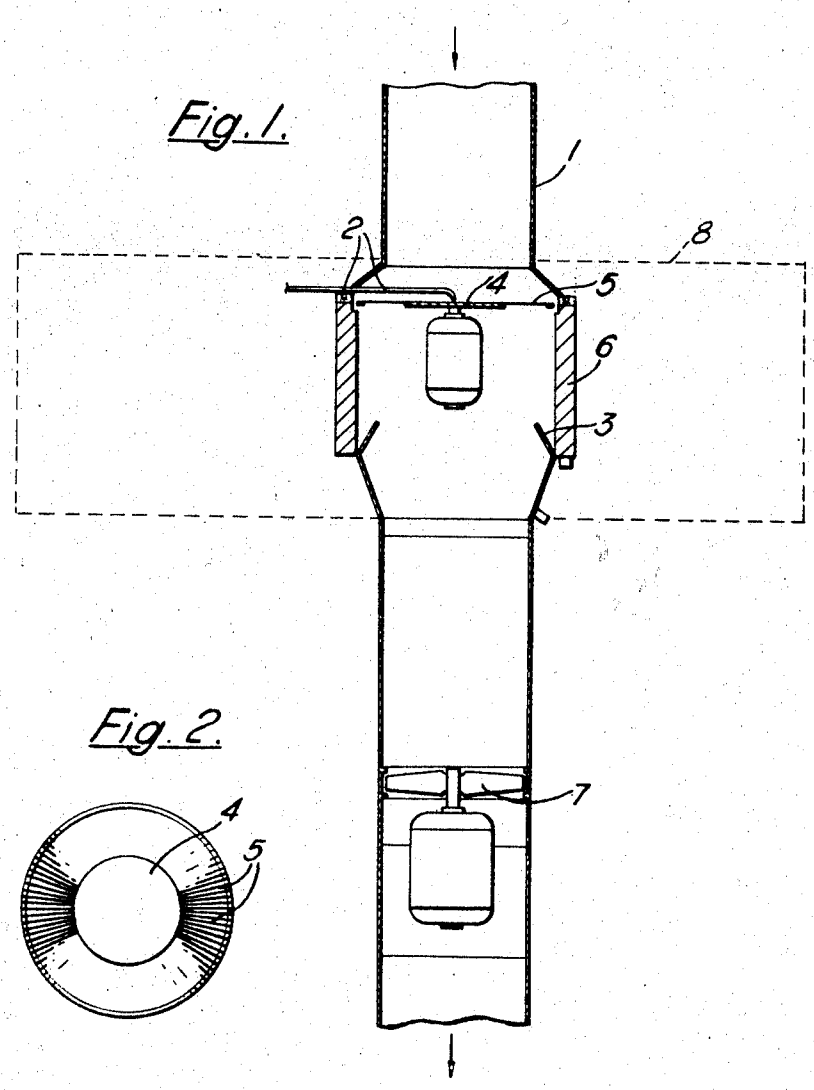


Fig. 2.

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APPARATUS FOR GAS FILTRATION

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6 Claims

ABSTRACT OF THE DISCLOSURE

A gas filter comprising a number of rigidly held filaments spaced apart and arranged for rotation in a common plane transverse to the general direction of gas flow at a sufficient speed to ensure that each cross-sectional element of gas is swept out by at least one filament in one revolution, the arrangement being designed to operate with wet gas or with the addition of liquid to the filaments if necessary so that particles striking the filaments adhere thereto, are directed centrifugally outwardly along the filaments, and are ejected from their ends into a collecting zone.

This application is a continuation of application Ser. No. 616,627, filed Feb. 16, 1967 and now abandoned.

The present invention relates to apparatus for gas filtration by means of moving filaments for the continuous removal of suspended particles or droplets from a flow of gas.

The principle of the invention is that a number of filaments are rotated by means of a motor across the area of flow of the gas entering the system. As a consequence of the relative velocity between the filaments and the gas, the particles or droplets suspended in the gas stream are impacted onto the filaments. That is, because of the inertia of the particles, they do not follow exactly the paths of the gas molecules around the filaments and, consequently, they collide with or impact onto the filaments.

The particles so collected by each filament may (1) be reentrained into the gas stream, (2) remain fixed to the filament at or near the impaction point, or (3) travel along the filament. Which of these situations obtained in practice will depend on the shape, size, density, surface tension and viscosity of the particles or droplets, and on the size and shape of the filaments, their speed and the degree of turbulence of the gas around them.

The basis of the invention is to obtain a high degree of impaction efficiency and to induce the collected particles to run along the filaments so that they may be thrown off by centrifugal force onto a suitable collection area. The process may be facilitated by the injection of a liquid spray into the gas as it enters the system to act as a "lubricant." Alternatively, the liquid may be injected directly onto the filaments. As an example, if the filaments were mounted radially from a disk which is rotating in a plane at right angles to the incoming gas stream, the collected particles would run outward along the filaments

and be thrown off from their ends into the inside periphery of the surrounding casing. The casing would be cylindrical and the filaments would be arranged to almost touch the collection surface lining the inside periphery. Those particles which remain fixed on the filaments will eventually grow by collision with other particles which are impacted, or with droplets introduced into the system and impacted onto the filaments. The particles may then move along the filaments and be thrown off as required.

The smaller the width of the leading edge of a filament and the greater its velocity relative to the gas, the greater is its efficiency of impaction for removing smaller particles. A filter element for removing the smaller particles or droplets would, therefore, have a greater number of smaller filaments moving at high speed. Having determined the relative filament—gas velocity required for a suitable collection efficiency E for a given size range of particles on a given size of filament, the number of filaments n required is given by the formula:

$$n = \frac{\text{gas flow per unit time}}{E \times \text{volume swept out by a filament in unit time}}$$

Corrections may be necessary for irregularities in the gas flow, for turbulence and for irregular motion of the filaments. The rotary motion of the filaments will cause the gas, as it passes between them, to revolve at some fraction of the filament speed. A centrifuging action of the gas is thus produced which can be used to remove some of the particles which have not been removed by the filaments themselves.

In order that the present invention may be more fully understood reference will now be made by way of example to the drawings accompanying the provisional specification in which:

FIG. 1 is a vertical section through the filtration apparatus, and

FIG. 2 is a plan view of the filter element shown in FIG. 1.

The apparatus comprises a cylindrical casing **1** through the upper end of which the gas enters. Inside the casing **1** are upper sprays **2**, one of which is disposed near the disk **4** and the other disposed near the collection material **6**, and a lower baffle **3** inbetween which is a motor-driven filter element consisting of a central disk **4** which carries the filaments **5** extending radially outwards from the disk in a common plane and is arranged to rotate in a horizontal plane at right angles to the axis of the casing with the tips of the filaments close to the collection material **6** consisting of expanded polyurethane foam lining the inside periphery of the casing. A collection casing is generally indicated at **8**, the dashed lines. A motor-driven fan **7** inside the casing draws the gas through the apparatus. The spray disposed near the collection material **6** may be used to wash the material clean.

The gas to be filtered is drawn into the casing by the fan and passes through the motor-driven filter element carrying the filaments which is "lubricated" by the sprays **2**. Three mechanisms operate in removing droplets from the gas stream: (a) the rapid turn of the gas as it passes over the upper surface of the filter element which throws the larger droplets onto its surface, (b) impaction onto

the filaments, and (c) centrifuging action of the air rotating underneath the filter element.

One design of filter element used in experimental tests comprised 500 stainless filaments each 10 cm. long and 460 μm. in diameter, the filter element being rotated at 1900 rev./min. Steel was preferred to plastic, which was also tried, as owing to its higher density the filaments maintained a radial position when in motion and did not stick together.

Assuming that droplets of all sizes enter the system the following is an estimate based on theoretical considerations of the behaviour of the droplets. 60% of droplets above 50 μm. diameter and 100% above 75 μm. diameter are thrown off onto the upper surface of the central disk of the radial filter element and run off along the filaments. Of the remaining droplets a high proportion above 4 μm. diameter, about 50% of those of 1.5 μm. diameter and none less than 0.4 μm., are collected onto the filaments by impaction. Of these, some above 22 μm. may move round the filaments to the trailing edges. When the droplets have grown by coalescence with other impacted droplets to above 76 μm. centrifugal force will cause them to move down to the outer ends of the filaments where it is unlikely that air drag will detach them. On reaching the ends of the filaments, their high velocity in relation to the surrounding air will cause them to break up on leaving the filaments to produce droplets in the range 20 to 100 μm. with a mean of about 40 μm. diameter. Of these, those droplets above 30 μm. diameter will have sufficient kinetic energy to reach the collection surface lining the inside periphery of the casing about 1 cm. away from the ends of the filaments. Those above 10 μm. will be removed by the centrifuging action of the air produced by the drag of the rotating filter element. The droplets which fail to be removed by the filter element are (a) those thrown off the filaments and not collected, i.e. those less than 10 μm. diameter; (b) those down to submicron diameters produced by sheltering of the larger droplets on the filaments; and (c) those missed by the filaments due to their not being coplanar with the filaments or due to irregularities in the air velocity. Of these, those above 30 μm. diameter will be removed by the centrifuging action of the air below the filter element.

No account has been taken of the evaporation of droplets. Small water droplets may evaporate very rapidly, particularly under the conditions of high air speeds which exist around the filaments.

Experimental measurements have confirmed the use of fast moving small diameter filaments in the form of a rotating radial filter elements as an efficient method of filtering droplets down to micron diameters from an air stream, the removal of dry particulate matter being improved by wetting the filaments with water or some other liquid in order to retain the particles and prevent their being reentrained into the air. Experience has shown the necessity to reduce the vibration of the filaments to the minimum since such vibration encourages the reentrainment into the gas stream of particles collected by the filaments and also increases the drag of the rotating filter elements. Vibration is reduced by making the filaments rigid or, preferably, by supporting the filaments with a rim at their outer extremities.

A particular example of a filter element designed to remove all particulate greater than 10 μm. in an air volume of 2,500 c.f.m. had the following parameters:

Outer radius of filter element	in.	30
Length of filaments	in.	6.15
Diameter of filaments	in.	[1]0.08
No. of filaments		66
Rotational speed of filter element	r.p.m.	1700

[1] 14 S.W.G.

Using a glycerol-water mixture to wet the filaments the filter was found to have the efficiency shown in the table below for the various sizes of particles:

Particulate size in micrometres:	Removal efficiency, percent
50	99.9
20	99.3
10	97.6
5	92.0
2	68.5

The calculation of the number of filaments required for the filter element, discussed above, has in practice been superseded by a more advanced design formulation, which, with the aid of a computer, relates the parameters of filament length, filament number, filament diameter, rotation speed of the filter element, the air volume to be filtered, the diameter of the trunking passing the air and the particulate sign down to which it is desired to filter. The operation of the program gives an optimised filter element design.

It must be emphasized that the principal action of a filter element according to the present invention is the collection of the particles or droplets suspended in the gas by impact of the particles or droplets on to the filaments and, for most applications, a single plane of filaments of comparatively open structure will be sufficient. Such a filter element has a low pressure drop and does not produce excessive drag which would require considerable motive power to rotate the filter element in the gas stream and is to be contrasted with known rotary filters having a large number of unsupported filaments several layers thick, which perform their filter action by means of a mat effect and present considerable resistance to the gas flow. The fact that the filaments in these known brushes are flexible and are free at their outer extremities means that the filaments can vibrate and encourage reentrainment into the gas stream of filtered particles and also increases the drag of the rotating filter element whilst presenting a very high pressure drop across the filter.

We claim:

1. A gas filter comprising a cylindrical casing, conduit means to admit gas at one end of said casing and to discharge gas at the other thereof, means for drawing said gas through said filter, a filter element comprising a central disk to which are attached a number of rigid filaments extending radially outwards from said disk in a common plane, said filaments being supported by a rim at their outer extremities and said disk being rotatably mounted within said casing in a plane transverse to the axis of said casing with the outer extremities of said filaments disposed near the inside periphery of said casing, means for rotating said disk at a speed sufficient to ensure that each portion of said gas is traversed by at least one of the said filaments in one revolution thereof, means for supplying liquids to said filter element, and collection means lining the inside periphery of said casing to collect particles ejected by centrifugal force from said filter element.

2. A gas filter according to claim **1** wherein said collection means lining the inside periphery of said casing comprises a lining of expanded polyurethane foam.

3. A gas filter comprising a cylindrical casing, conduit means to admit wet gas at one end of said casing and to discharge said gas at the other thereof, means for drawing said gas through said filter, a filter element comprising a central disk to which are attached a number of rigid filaments extending radially outwards from said disk in a common plane, said filaments being supported by a rim at their outer extremities and said disk being rotatably

mounted within said casing in a plane transverse to the axis of said casing with the outer extremities of said filaments disposed near the inside periphery of said casing, means for rotating said disk at a speed sufficient to ensure that each portion of said gas is traversed by at least one of the said filaments in one revolution thereof, and collection means lining the inside periphery of said casing to collect particles ejected by centrifugal force from said filter element.

4. A gas filter according to claim 3 wherein said collecting means lining the inside periphery of said casing comprises a lining of expanded polyurethane foam.

5. A gas filter according to claim 3 wherein the gas is substantially dry and there is provided a means for supplying liquids to said filter element.

6. A gas filter according to claim 5 wherein said collection means lining the inside periphery of said casing comprises a lining of expanded polyurethane foam.

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