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RING SLIT CONIFUGE

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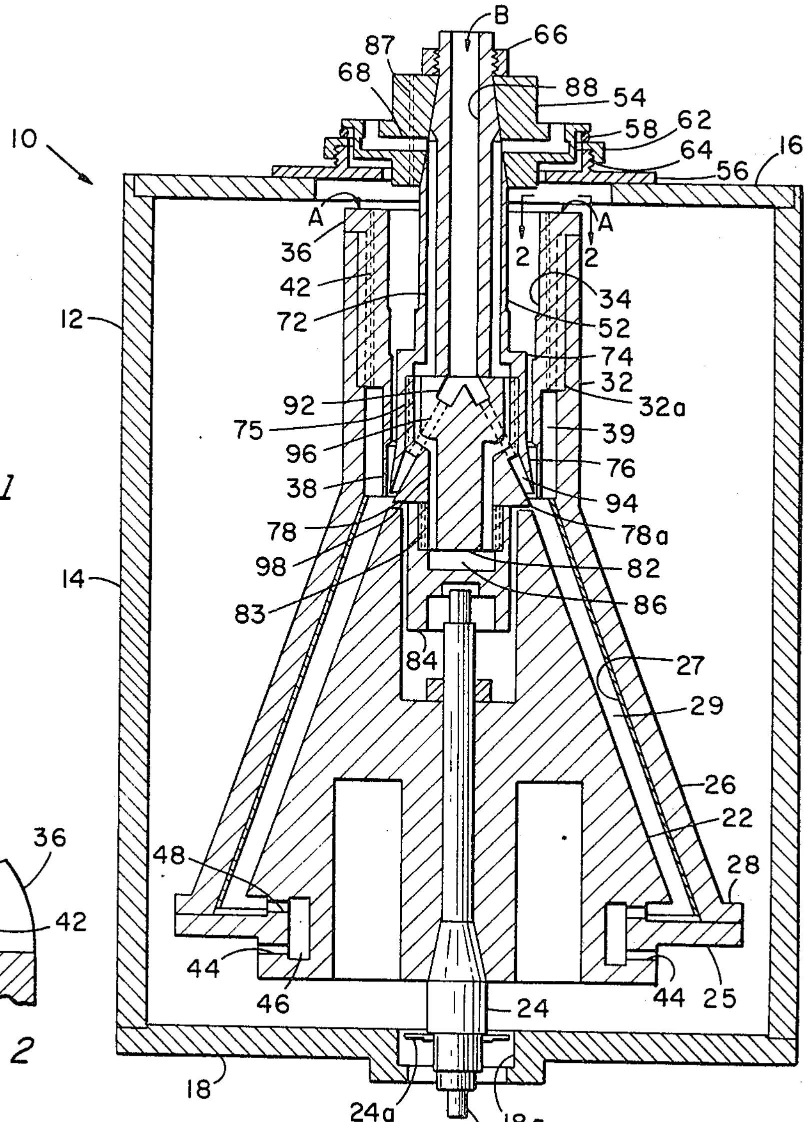

Fig. 1

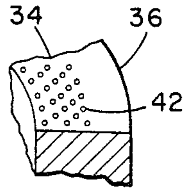

Fig. 2

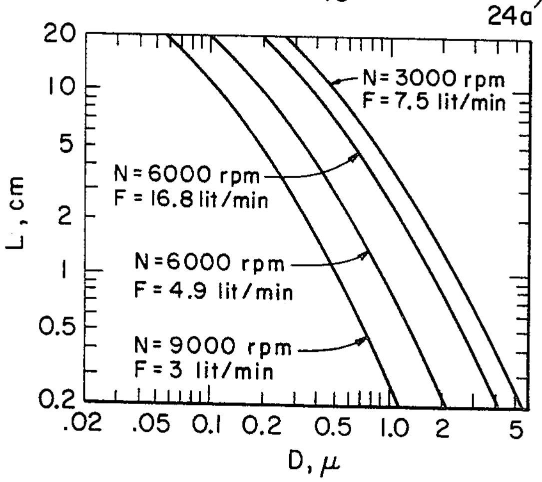

Fig. 3

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RING SLIT CONIFUGE

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Int. Cl. G01l *19/00*

ABSTRACT OF THE DISCLOSURE

A centrifugally operated device for producing a true particle size spectrum from an aerosol. The device continuously recirculates clean air along a conically shaped annular channel. At the entrance to the channel the aerosol is injected through an adjustable ring slit. High capacity of the device is obtained by using capillary tubes to accelerate the air and maintain laminar flow at the high rates of flow.

Background of the invention

The investigation of aerosols and the evaluation of particulates contributing to radiation hazards frequently requires the separation of particles according to their size. A common instrument suitable to some degree for this purpose is the cascade impactor. The different impaction stages of this device produce deposits of defined size ranges which can be analyzed separately. As the need for a more detailed analysis grows, however, increases in the number of stages in this type of device to meet this requirement raises the cost as well as mechanical problems to the level where other approaches to the problem become of interest.

One such alternative approach is that of obtaining a continuous size spectrum of the particulate present in an aerosol. The most convenient way of providing this is a dynamical arrangement wherein a laminar flow of air passes through a transverse mechanical force field which elutriates the air-borne particles according to their kinetic diameter. If these diameters do not fall below 1 micron, as in case of coarse aerosols and dusts, particle separation can easily be effected by the gravitational field acting on a laminar flow of air passing through a horizontal duct. For smaller particles, however, the Brownian motion limits the applicability of gravitational devices. In this case, it is necessary to apply more powerful force fields, as can be produced in centrifuges.

In size-separating centrifugal devices the air ducts participate in the rotation of the centrifuge rotor in such a way that the air flow is almost perpendicular to the centrifugal force field. Thus, the same principle of size separation as in gravitational devices is maintained. Correspondingly, a laminar air flow is required and, as with gravitational instrument, there are two methods of aerosol deposition, both of which have been realized in actual centrifuge designs. In one case, the aerosol enters the duct over the whole cross section, while in the other case the aerosol is released from an inlet nozzle into a laminar flow of clean air.

In the former arrangement, the centrifuge has the advantage of a relatively high sampling capacity, but suffers from the drawback that particle separation remains incomplete and only tedious mathematical evaluation procedures give approximate results for the actual particle size distribution of an aerosol deposit.

In the latter arrangement, which is sometimes referred to as a "conifuge," a true particle size spectrum is obtained. Basically, a typical construction for carrying out this operation consists of a funnel-shaped lid and an inner rotating cone between which a lminar flow of clean air

is forced down from the top to the bottom by centrifugal forces. The flow rate is controlled by outlet jets in the rotor base. The aerosol is fed into the duct by a non-rotating inlet nozzle at the tip of the cone. Here the particles are entrained in the laminar flow of clean air and become subject to the centrifugal field. Thus, the trajectories of all particles of like size end up at the same annular ring on the inner wall of the funnel-shaped lid where they can be investigated. For a polydisperse aerosol the deposition pattern results in a true particle size spectrum between the top and the base of the cone.

A major drawback, however, of the above-described device is the relatively low sampling rate. In case of non-gaseous atmosphere pollutants, which usually occur in rather low concentrations, the conifuge requires very long sampling times. For this reason, the conifuge has been utilized only in studies of high concentrations of air-borne particles as they are found in mining operations and in cigarette smoke.

Summary of the invention

The invention described herein was made in the course of, or under, a contract with the U.S. Atomic Energy Commission.

The present invention makes it possible for the first time to utilize the conifuge effectively and efficiently for the sampling of non-gaseous atmospheric pollutants under relatively low concentrations of air-borne particles at sampling rates heretofore considered to be unattainable.

In accordance with this invention higher rates of laminar flow are accomplished by utilizing capillary openings to accelerate the clean air. In addition, the ratio of clean air flow to aerosol flow can be modified for optimum conditions under all flow rates without affecting the rate of clean gas flow.

It is thus a principal object of this invention to produce a continuous sampling spectrum of particles from low concentration aerosols such as is found in atmospheric conditions.

Other objects and advantages of this invention will hereinafter become readily apparent from the following description of a preferred embodiment of this invention taken with reference to the accompanying drawing.

Brief description of the figures

FIG. 1 is an elevation view in cross section of a preferred embodiment of this invention;

FIG. 2 is a view along 2—2 of FIG. 1; and

FIG. 3 is a graph showing typical calibration curves for the preferred embodiment.

Description of the preferred embodiment

Referring to the drawing, conifuge **10** for use in sampling atomspheric air is seen to consist of a closed vessel **12** formed from a hollow cylindrical body **14** and a pair of upper and lower end walls **16** and **18**. Within vessel **12** is a conically shaped rotor **22** mounted on a vertically suspended shaft **24** which extends out through opening **18***a* of end wall **18**. Shaft **24** is provided with a dust shield **24***a* and a key fitting extension **24***b* to which would be connected as understood in the art a motor or other drive source (not shown) to rotate shaft **24** and hence operate conifuge **10**.

Rotor **22** has a flange **25** on which is mounted a funnel shaped lid **26** which has a flange **28** which may be bolted or otherwise attached to flange **25**. Lid **26** which is lined with a removable foil **27** forms with rotor **22** a conical, annular space or channel **29** whose function is to be further described below. Lid **26** has an upper cylindrical section **32** which is internally threaded at **32***a* as illustrated to receive a cylindrical laminator **34** which is externally threaded. A flange **36** at the top of laminator **34** overlaps the end of lid **26**. Laminator **34** is provided with a downwardly extending extension **38** annularly spaced inwardly from the inside wall of cylindrical extension **32** of lid **26** forming an annular channel **39**. In addition, as best shown in FIG. 2, laminator **34** is provided with several annularly arranged rows of spaced openings, described as capillaries **42**. Typically each ring of capillaries would contain about 100 holes of 0.06″ diameter. Hence, as indicated by arrows A, gas entering channel **39** would do so by way of capillaries **42**, as will be further explained below.

The lower end of rotor **22** is provided with a number (such as six) of radially directed outlet jets **44** which are connected by way of chambers **46** and passageways **48** to channel **29**. The diameters of jets **44** may, if desired, and for reasons explained further below, be reduced by inserting sleeves for that purpose or by making the bottom portion of rotor **22** containing the jets removable so that another section with different sized jets may be substituted.

Extending down through and supported by end wall **16** of vessel **12** is a stationary duct member **52** which is held in place by a cap **54** which is in turn supported by an annular plate **56** resting on wall **16**, a rubber O-ring **58** and a ring **62** which is threaded on a vertical lip **64** extending from plate **56**. A threaded nut **66** engaging a threaded portion of member **52** holds the assembly in place. The function of O-ring **58** is to make up for slight differences in dimensions between the described rotor mounting and housing **12**.

Cap **54** is provided with coolant passageways **68** which are aligned with coolant passageways **72** extending down through member **52**. The bottom portion of the latter is provided with cylindrical extension **74** with a flared portion **76**. The inside of extension **74** is threaded at **75** to support a port member **78** which has a bottom solid cylindrical extension **82** which is threaded at **83** to receive a closure **84**. A cavity **86** is formed between closure **84** and extension **82** for a purpose to be later described. Cap **54** is also provided with one or more holes **87** for a purpose to be later described.

Duct member **52** also has an axial aerosol duct **88** extending its length and which is aligned with a V-shaped opening **92** in port member **78**. Opening **92** is connected to an annular space **94** between flared extension **76** and port member **78** by way of a plurality of passageways **96**. Port member **78** is also provided with coolant passageways **98** which cooperate with coolant passageways **72** in duct member **52**. As will be more particularly described later, aerosol enters duct **88** as indicated by arrow B, passes into V-shaped opening **92**, flows through passageways **96**, and enters annular space **94**. The aerosol flows out into channel **29** by passing through the annular jet formed by the lower tip of extension **38** and annular tip **78*a*** of port member **78** as illustrated. Flared extension **76** does not form a jet but functions to prevent particulate in the aerosol from depositing on the inside of extension **38** by reducing or eliminating sharp changes in direction of flow of the aerosol leading up to the jet opening.

In the operation of the apparatus just described, removable foil **27** is placed along the outer wall of channel **29** (lining the inner wall of lid **26**). Shaft **24** and rotor **22** are then rotated externally through extension **24*b*** by suitable drive means such as a motor (not shown). The rotation of rotor **22** establishes as is understood in the art a centrifugal force field in channel **29** and acts to pump gas through the system.

Clean air within vessel **12** is circulated in a closed cycle through the apparatus in the following manner. Air enters capillaries **42** as shown by arrows A where it is accelerated in velocity and is then discharged into channel **39**. The air, under high velocity, is then carried into channel **29** and ultimately is discharged through nole **44** back into the space surrounding lid **26**. With conifuge **10** located in the aerosol environment to be sampled, aerosol enters duct member **52** as indicated by arrow B and as previously described is fed through the adjustable annular slit formed by the lower tip of extension **38** and tip **78*a*** of member **78** into the clean air flowing from channel **39** into channel **29**. As already noted, rotor **22** acts as a centrifugal pump which causes the air and aerosol flow as described.

As the aerosol air mixture travels down channel **29** the particulate present is deposited as a result of the centrifugal force field established on removable foil **27** in a true particle size spectrum between the top and base of lid **26**. Excess air accumulating within vessel **12** leaks out through opening hole **87** in cap **54** and also the space around shield **24*a***.

The apparatus just described is capable of sampling rates which are unattainable by devices of this type previously in use. It can be operated at a variety of rotational speeds up to at least 12,000 r.p.m. with appropriate adjustment in size of outlet jets **44** being made for the selected speed. As already noted, this can be accomplished by providing a removable annular section (not shown) for changing jet size or using inserts in over sized outlet jets **44** for reduced sie at slower speeds.

At speeds above 6,000 r.p.m. cooling may be necessary. In such a case, cooling water is fed into and through some of the coolant passageways **68**, **72** and **98** into chamber **86**, from whence the coolant returns by way of the remaining passageways.

Capillaries **42**, consisting of a large number of parallel holes of relatively small diameter, permit the clean air to accelerate without turbulence to the rate dictated by the rotational speed of rotor **22**. This maintains conditions of laminar flow in annular channel **39**, which is required before a meaningful impaction spectrum can be obtained. In addition, capillaries **42** tend to precipitate residual aerosol particles which may have escaped prior precipitation in channel **29** because of a size smaller than the critical size defined by the operating conditions.

The annular jet formed by the lower tip of extension **38** and annular tip **78*a*** of port member may be adjusted in size by rotating laminator **34** which is threaded into cylindrical section **32**. In this way it is possible to obtain by theoretical considerations and/or by trial and error the most advantageous relationship of aerosol to clean air from the point of view of maximum capacity and/or particulate distribution along foil **27**.

An example of calibration curves prepared for a device built in accordance with this invention is shown in FIG. 3, where L refers to the location of the precipitation on the foil, D is particle size, and F refers to the total flow rate.

It is thus seen there has been provided an improved size-separating centrifugal particle sampler in which higher sampling rates than heretofore obtainable are made possible. While only a preferred embodiment of the invention has been described it is understood that many variations thereof may be made without departing from the principles of this invention. Thus the invention is not to be limited thereby but is to be defined only by the scope of the appended claims.

I claim:

1. Particle size separating apparatus comprising:

(a) gas pumping means for establishing an annular channel subject to a transverse force field of continuously increasing effect along its length;

(b) means for delivering particulate carrying gas into said channel;

(c) means extending through said channel for collecting particulate impacted out of said gas as a result of said force field and distributed continuously according to size; and

(d) containment means for receiving the clean gas discharging from said gas pumping means and containing said clean air in a closed system surrounding said gas pumping means;

(e) said delivering means including inlet means for accelerating said clean gas and delivering the latter to said channel while simultaneously maintaining laminar flow conditions, and

(f) adjustable means for injecting into said clean air at the entrance to said channel an aerosol containing particulate to be collected.

2. The device of claim **1** in which said gas pumping means is a conically shaped rotor surrounded by a spaced, stationary lid forming said channel therebetween.

3. The device of claim **2** in which said inlet means forms and includes a plurality of parallel arranged capillaries for maintaining laminar flow as the clean gas is accelerated up to the velocity reached at the entrance to said channel.

4. The device of claim **3** in which said injecting means includes a ring slit formed by an annular stationary wall surrounded by an outer spaced, slidable cylindrical extension to permit selective adjustment of rate of aerosol flow into said clean gas.

5. The device of claim **4** having means to prevent precipitation of particulate along the inner face of said adjustable extension.

References Cited

UNITED STATES PATENTS

1,945,786	2/1934	Peltzer et al.	233—28
3,074,627	1/1963	Goetz	73—432
3,092,583	6/1963	Wolff et al.	73—28 X
3,141,337	7/1964	Hoffstrom	73—432

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U.S. Cl. X.R.

209—473; 233—28