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[54] **DILUTION SYSTEM FOR PARTICLE ANALYZER**

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[52] **U.S. Cl.** **73/28**

[51] **Int. Cl.** **G01n 31/00**

[58] **Field of Search** ..... 73/28, 432 PS, 23, 23.1

[56] **References Cited**

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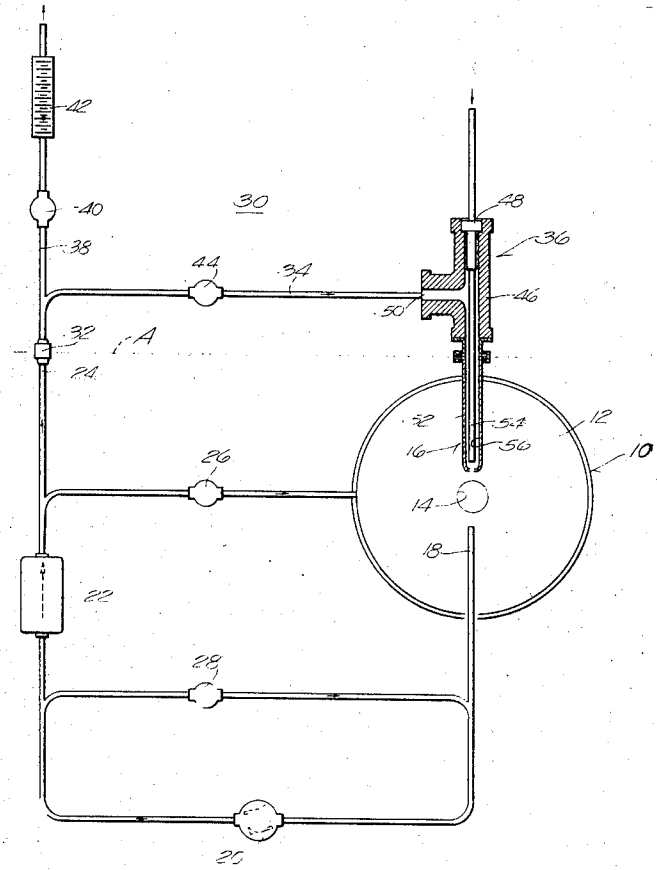
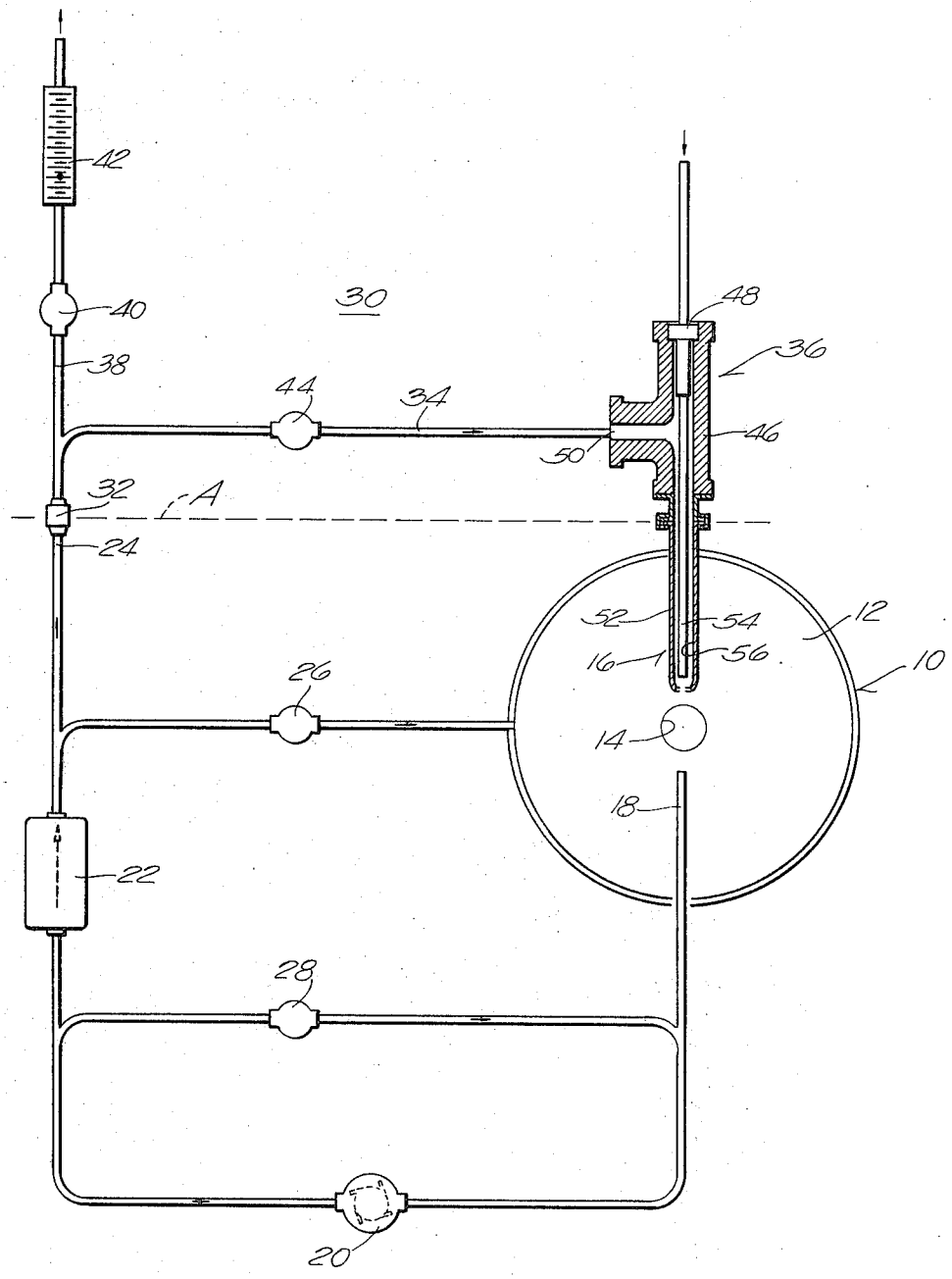
Primary Examiner—Jerry W. Myracle

[57] **ABSTRACT**

An airborne particle analyzer is provided with an adapter which affords dilution of the aerosol sample introduced into the analyzer. The adapter receives the clean exhaust air, which would otherwise be discharged into the ambient, and directs the clean air to the injector through which the aerosol sample is directed into the sensing area of the analyzer. The adapter has an adjustable exhaust to permit discharge to the ambient of a measured portion of the clean air so that a corresponding volume of new sample is drawn into the unit. The sample aerosol is injected into the center of the continuously circulating air in the unit directly at the sensing area. Regulation of the amount of fluid discharged into the ambient provides control over the amount of sample introduced into the unit for entrainment with the clean circulating air and, correspondingly, the degree of dilution of the sample.

10 Claims, 1 Drawing Figure

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DILUTION SYSTEM FOR PARTICLE ANALYZER

BACKGROUND OF THE INVENTION

This invention relates to airborne particle analyzers and, more particularly, to an arrangement for increasing the range of densities of aerosols which can be handled by a particle analyzer.

In the aerosol particle analyzer, or counter, art it is recognized that the probability of more than a single aerosol particle being present in the sensing area at any given time should be reduced. As the density of aerosols being monitored increases, the probability of more than a single aerosol particle being present in the sensing area increases accordingly. This places a practical limit on the upper range of densities that can be handled by an analyzer.

Attempts have been made to dilute the higher density fluids but these have generally involved mixing and proportioning the sample aerosol with a clean medium or a medium having a predictable or prescribed characteristic. Mixing and proportioning has not been satisfactory in that it creates turbulence and pressure and temperature changes in the sample. These adverse effects can cause vapor transfer and a change in size in the aerosol being monitored and, thus, do not produce accurate or reliable results. In this connection it might be noted that, for example, most natural aerosols with which these types of particle analyzers are concerned are made up of approximately 50% liquid droplets while smoke, which is another example of an aerosol monitored, is virtually all liquid; thus, turbulence and pressure and temperature changes can effect the condition of the liquid droplets present from the standpoint of size.

This invention is based in part on the recognition that if dilution of the aerosol sample can be achieved without disrupting the characteristics of the sample and while still maintaining a representative sample, the high end density capacity of a particle analyzer could be greatly increased. This invention is concerned with that problem and has as one of its general objects the effective dilution of the aerosol sample while maintaining a representative sampling and with virtually no disruption of the physical characteristics of the sample.

For the achievement of these and other objects, this invention proposes an arrangement wherein the outlet discharge of a particle analyzer, which would otherwise be discharged into the ambient, is received by an adapter fitted onto a conventional particle analyzer. The adapter recirculates the thus received discharge to the unit inlet, where it is directed with the sample into the sensing area of the analyzer. The medium flowing in the unit is cleaned by passage through a filter after it has passed through the sensing area and thus the medium which is directed back into the sensing area is clean and will not affect the sample. The adapter forms a virtually closed system for circulating clean media through the particle analyzer. The adapter is also provided with mechanism for discharging a regulated amount of the medium to the ambient and thereby reduce the volume of the medium flowing through the analyzer and the adapter. A volume of sample fluid will be drawn in through the inlet to replace that volume discharged to the ambient and thereby maintain a relatively constant average volume of flow through the circulating system of the particle analyzer. This sample

medium is drawn through the inlet of the analyzer and discharged into the clean medium circulating from the adapter and with that clean medium is directed to the sensing area of the analyzer.

Accordingly, the normal flow rate of the particle analyzer is maintained at a constant value with a virtually continuous closed circulation of clean medium being achieved. The amount of discharge to the ambient of the flowing fluid is precisely controlled to thereby control the amount of sample drawn into the circulation system and in this manner any desired degree of dilution can be achieved. For example, if the circulating system of the particle analyzer is set to circulate one cubic foot per minute, the exhaust discharge can be regulated to discharge 0.01 cubic feet per minute to the ambient which will result in a corresponding introduction of a sample aerosol at the rate of 0.01 cubic feet per minute. The dilutions can be varied in accordance with the expected density of the aerosol to be monitored. Utilizing the normal flow rate of the unit minimizes, if not virtually eliminates, any turbulence which might otherwise result from the introduction of the sample aerosol into the clean media.

Also, it is preferred that the sample be introduced into the unit through an injector mechanism positioned at the sensing area and so that the sample drawn in is directed into the center of the circulating flow. The sample will approach a laminar type flow and therefore the sample will be introduced with a minimum of disruption and turbulence and will pass undisturbed through the sensing area for more reliable and accurate monitoring.

Other objects and advantages will be pointed out in, or be apparent from, the specification and claims, as will obvious modifications of the single embodiment shown in the drawings in which:

FIG. 1 is a generally schematic view illustrating the particle analyzer with the adapter connected thereto.

DESCRIPTION OF THE PREFERRED EMBODIMENT

This invention will perhaps find its greatest application in connection with particle counting instruments, which are more generally referred to as particle analyzers. The particle analyzer can take any generally conventional form and thus is illustrated in a schematic manner in the drawings, the particle counting unit being that portion of the unit below line A.

The construction and operation of such particle analyzers is generally well known and therefore has not been described in detail and it is believed that a general showing and description of the particle analyzer will be sufficient for the purpose of understanding the present invention.

With reference to the FIGURE and below line A, a sensing area **10** includes a mirror **12** having a central portion **14** which defines the view volume sensing area. An inlet tube **16** extends into the sensing area and is positioned opposite to but in concentric alignment with an outlet tube **18.** Inlet tube **16** is part of an injector assembly which will be described more completely hereinafter but at this point it should be noted that the injector assembly is effective to introduce a sample aerosol into the sensing area. Passage of particles contained in the aerosol sample past the view volume area **14** is monitored by a conventional light-optical system and it is on the basis of this monitoring that the particle

counter operates. The light-optical system and its operation is well known to those skilled in the art and will not be described.

The internal circulation system for the particle counter includes pump **20,** which is generally a constant volume pump, for drawing the sample into the sensing area and circulates the sample through the internal unit system. Filter **22** is positioned downstream of the pump and will clean the sample after having passed through the pump and sensing area. The flow, in a conventional analyzer, would then proceed through outlet **24** to the ambient.

Valve **28** shunts pump **20** to allow flow control with a constant displacement type of pump. Valve **26** proportions the amount of clean air used to constantly purge area **10.** Convergence of purge air as it joins the sample air exiting through tube **18** constrains and stabilizes the sample jet as it passes from nozzle **16** to exit tube **18.**

It has generally been recognized that the accuracy and reliability of the particle counter can be enhanced if the probability of having not more than one particle present in the sensing area at any given time is reduced. With lower density media this generally is not a problem but it becomes a problem when higher density aerosols are encountered. This invention proposes to increase the upper range of densities which can be accommodated by the particle counter with the addition of an adapter which is effective to produce a controlled dilution of the sample without disrupting the physical characteristics of the aerosols. Moreover, it accomplishes this while still maintaining a representative sample of the aerosol.

Again with reference to the drawing, but to the arrangement above line A, adapter **30** includes a coupling **32** which communicates with outlet **24** and a conduit **34** which provides a by-pass between the coupling **32,** or the outlet of the unit, and injector **36** which is part of the inlet to the particle counter. The adapter also includes a branch **38** which communicates with both by-pass **34** and outlet coupling **32.** Branch **38** opens to the ambient through a sample rate valve **40** and a flow meter **42.** By-pass **34** includes a valve **44** which along with valve **40** is used to balance the flow in the by-pass and through flow meter **42** to the ambient.

With particular reference to injector **36,** it will be noted that the injector includes a fitting **46** which is generally in the form of a "T-connection" having an inlet **48** open to the ambient, an inlet **50** connected to by-pass **34,** and an outlet **52** in which is positioned a tubular member **54.** Tubular member **54** extends around inlet tube **16,** the inlet tubes extending from the sensing area through a suitable coupling to inlet **48** of the injector where it is open to the ambient. Inlet **16** is concentrically arranged with tube **54** and the two together form an annular passage **56** surrounding inlet tube **16.**

In operation, adapter **30** receives the clean air passing through unit outlet **24.** This clean air, depending on the relative settings of valve **40** and **44,** splits into conduits **38** and by-pass **34.** That portion which passes into conduit **34** is introduced into injector **36** and flows through passage **56** for discharge into the sensing area. The sample aerosol which is drawn into the particle counter is discharged through inlet **16** into the center of the clean air passing through passage **56** and passes with the clean air through the sensing area.

The flow of both the clean air through passage **56** and the inlet sample through tube **16** will be generally laminar and thus the two flows will comingle in the sensing area with a minimum of turbulence allowing the aerosol particles in the sample to flow undistrubed through the sensing area for monitoring.

The sample rate valve **40** can be adjusted to achieve a preselected volume of clean air to be exhausted into the ambient, in the preferred embodiment valve **44** can also be adjusted to assist in control. The amount of clean air exhausted into the ambient determines the amount of sample air drawn in through inlet **48** by pump **20** to maintain a relatively constant volume of fluid flowing in the system. For example, if pump **20** is designed to produce one cubic foot per minute of flow, in the higher density ranges the adapter will be adjusted to discharge 0.01 cubic feet per minute into the ambient which will result in that same amount of sample media being drawn into the injector thus achieving a 100-1 dilution of the sample passing through the sensing area. Thus, the higher density aerosols can be sampled with accuracy and reliability.

It will also be noted that the adapter utilizes the normal flow rate present in the unit and thus reduces the amount of turbulence which would otherwise be achieved through a mixing or proportioning system. Also, the sample is introduced directly into the center of the clean air again minimizing the amount of turbulence which is produced. Thus the dilution is achieved with a representative sample and yet without effecting the physical characteristics of the aerosols.

Flow meter **42** contributes in overall control by giving an indication of the amount of exhaust media which is being emitted.

It will be appreciated that valve **44** could be eliminated and only valve **40** used to balance the exhaust and recirculation volume.

A releasable connection can be provided between the adapter and basic analyzer unit at the outlet and inlet so that the basic unit can be operated with or without the adapter. Also, a basic unit can be readily set up for higher densities by connection of the adapter to the unit.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

I claim:

1. In apparatus of the type described the combination with means defining a sensing area, means for circulating a sample fluid through said sensing area, and means for filtering said fluid after it has passed through said sensing area of means defining a generally closed circulation flow path for said fluid from and back to said sensing area and comprising, in combination,

means defining a flow passage downstream of said filter means for directing the fluid after it has passed through said filter means to said sensing area,

means defining a sample inlet open to the ambient for introducing a sample volume of fluid into said closed circulation and into said sensing area,

and means defining a restricted, variable exhaust from said closed circulation path whereby an adjustable volume of flowing fluid can be discharged into the ambient and corresponding fresh sample of

fluid will be drawn from the ambient into the sensing area.

2. In apparatus of the type described, the combination with means defining a sensing area, means including an inlet open to the ambient and operative to draw a sample amount of fluid from the ambient and direct it into said sensing area, means for circulating a predetermined volume of fluid through said sensing area, and filter means for cleaning said flowing fluid after it has passed through said sensing area of means for diluting the sample drawn in through said inlet means and comprising, in combination,

conduit means connecting the flow from said filter means to said inlet means so that fluid passed through said filter means can be redirected to said sensing area,

and means defining an adjustable, restricted outlet from said conduit means whereby a measured volume of flowing fluid can be discharged into the ambient with the remainder of said flowing fluid being directed to said inlet means and a fresh sample of fluid corresponding to the discharged measured volume will be drawn through said inlet means into said recirculated fluid for passage through said sensing area.

3. The combination of claim 2 wherein said means defining said adjustable, restricted outlet includes a conduit open to the ambient and a valve member in said conduit adjustable to regulate the amount of discharge flow through that conduit to the ambient.

4. The combination of claim 2

wherein said inlet means includes an inlet tubular member open to the ambient to be sampled and extending into said sensing area,

and including a second tubular member concentric with said inlet tubular member and communicating with said conduit means so that the recirculated flowing fluid is directed to the annular space between said inlet tubular member and said second tubular member,

said second tubular member also being directed into said sensing area and said fresh sample volume is injected directly into the center of said flowing fluid.

5. The combination of claim 3 wherein said conduit and said adjustable outlet to said ambient are positioned downstream of said filter means.

6. The combination of claim 5 wherein said conduit means and said adjustable outlet mechanism comprises an adapter connectable to said apparatus including said sensing area, said fluid circulating means, and said filter means.

7. The combination with a particle analyzer having an inlet open to the ambient, a sensing area into which said inlet opens to direct a sample volume, pump means for circulating fluid medium through said sensing area from said inlet and through an outlet to said ambient, and filter means downstream of said sensing area for cleaning said sample volume before passage through said outlet, of an adapter assembly comprising in combination,

means communicating with said outlet to receive the flowing fluid after it leaves said filter medium,

an injector assembly including said inlet means,

conduit means connecting said means communicating with said outlet to said injector assembly for directing said flowing fluid back through said injector assembly to thereby define a generally closed recirculating system,

and means associated with said conduit means and defining an adjustable outlet to said ambient whereby a measured portion of said circulating fluid medium can be discharged into said ambient and a corresponding amount of fresh sample fluid medium will be drawn into said sensing area and mixed with said recirculated clean fluid medium.

8. The combination of claim 7 including a flow meter upstream of said adjustable valve to measure the amount of discharge into said ambient.

9. The combination of claim 7 wherein said injector assembly includes

an inlet tubular member open to the ambient to be sampled and extending into said sensing area whereby a sample volume can be drawn into the apparatus and discharged into the sensing area,

a second tubular member concentric with said inlet tubular member and communicating with said conduit means whereby the recirculated flowing fluid medium is directed to the annular space between said inlet tubular member and said second tubular member,

said second tubular member also being directed into said sensing area so that said recirculated fluid medium is directed into said sensing area and said fresh sample volume is injected directly into the center of said flowing fluid medium.

10. The combination of claim 7 wherein said pump means circulates a predetermined volume of fluid medium.

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