United States Patent [19]

Davies et al.

[11] **3,845,386**

[45] **Oct. 29, 1974**

[54] **METHOD OF AND AN APPARATUS FOR COUNTING FIBERS**

[75] Inventors: **Reg Davies,** Bollingbrook; **Richard F. Karuhn,** Downers Grove, both of Ill.

[73] Assignee: **IIT Research Institute,** Chicago, Ill.

[22] Filed: **July 2, 1973**

[21] Appl. No.: **375,705**

[52] **U.S. Cl.** .... **324/71 CP**
[51] **Int. Cl.** **G01n 27/00**
[58] **Field of Search** .... 324/71 CP

[56] **References Cited**

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3,515,884	6/1970	Imadate	324/71 CP X
3,739,268	6/1973	Karuhn et al.	324/71 CP

Primary Examiner—Alfred E. Smith
Assistant Examiner—Rolf Hille
Attorney, Agent, or Firm—Fitch, Even, Tabin & Luedeka

[57] **ABSTRACT**

A method and apparatus are provided for distinguishing microscopic size, elongated fiber-like particles from cubically shaped, irregularly shaped, or spherically shaped particles in a mixture suspended in an electrically conducting liquid medium and for counting the fiber-like particles. In accordance with the method, an electrical zone sensing apparatus is provided with a screen means having microscopic openings therein of predetermined size to filter from the suspension particles having an effective area larger than the size of screen openings. Particles passing through the screen and through the sensing aperture of the zone sensing apparatus are separately sized by volume characteristics of electrical signals generated. The electrical signals having predetermined volume characteristics associated with the maximum spherical particles for passing through the screen openings are counted as non-fiber particles; whereas signals having larger volume characteristics are separately counted and designated as fibers. By the use of screens of successively smaller sizes, the larger particles including fibers having larger transverse cross sections may be successively filtered from the suspension and from reaching the sensing aperture. Therefore, smaller fibers having smaller cross-sectional area may be distinguished from particles having diameters approximating that of the smaller screen size openings.

16 Claims, 12 Drawing Figures

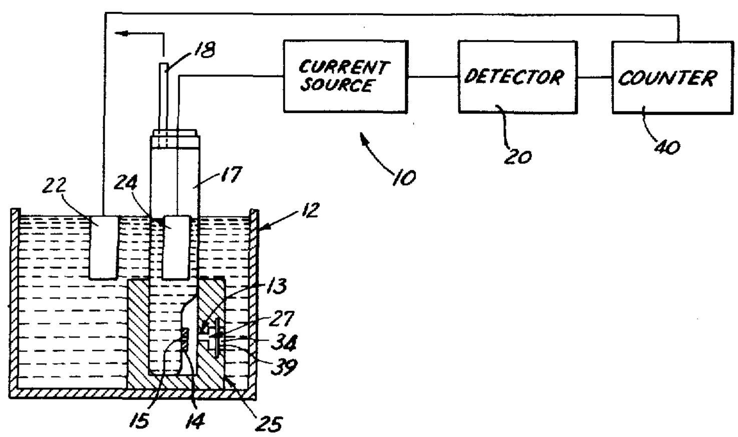

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FIG. 1

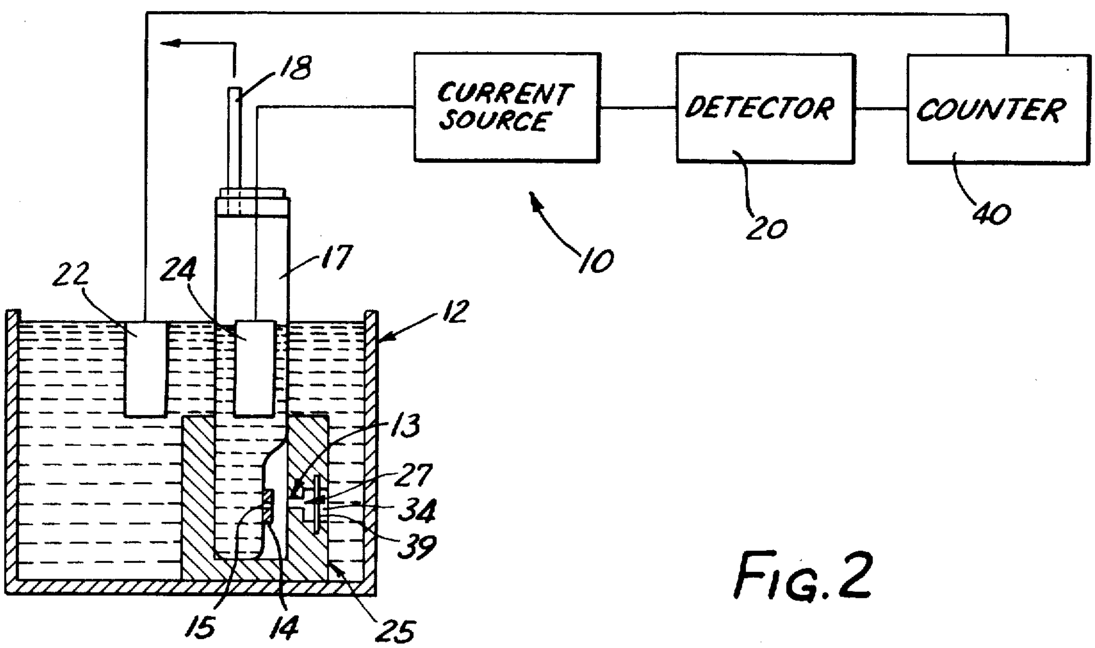


FIG. 2

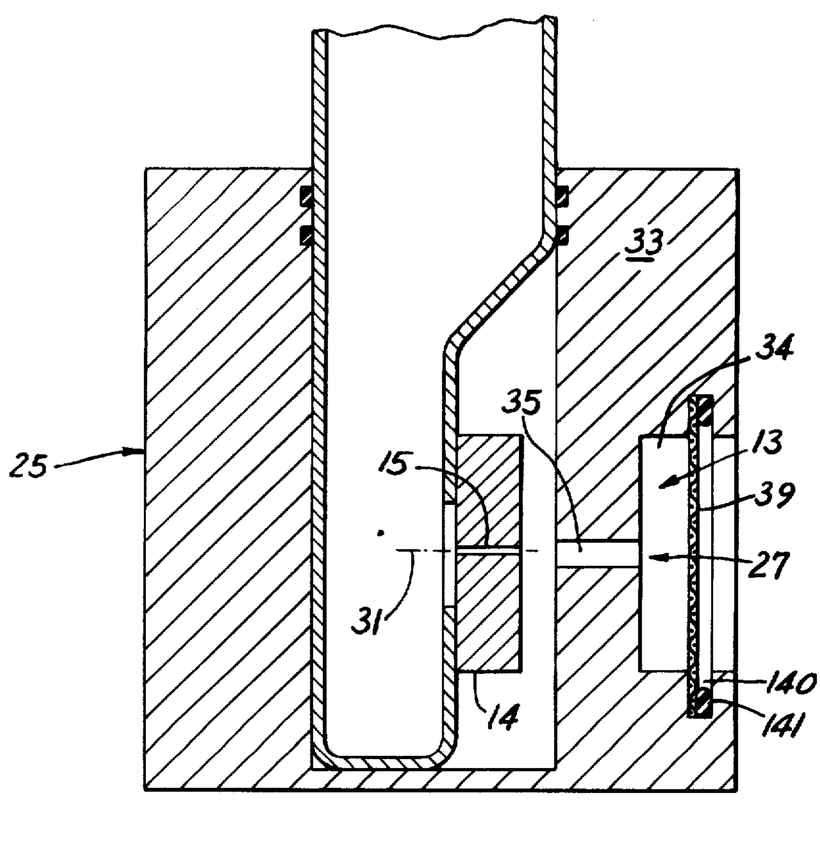
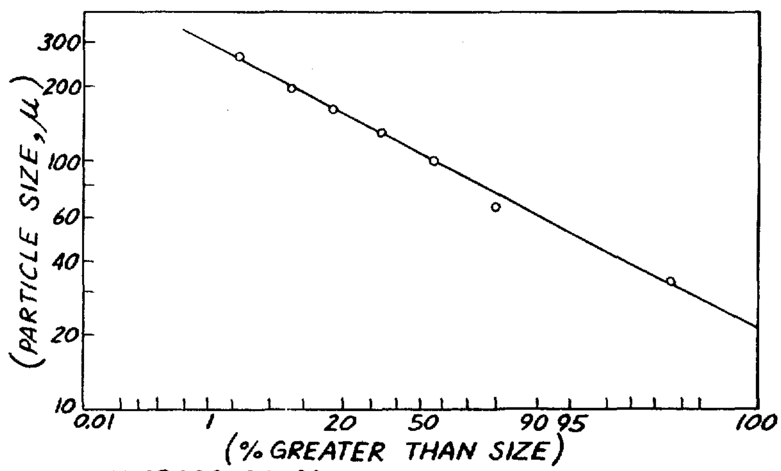
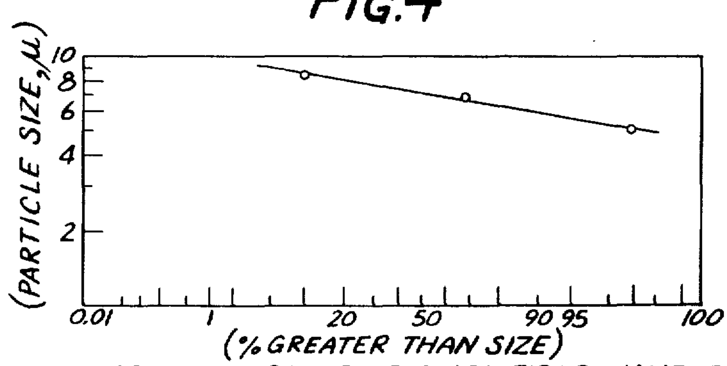


FIG. 3



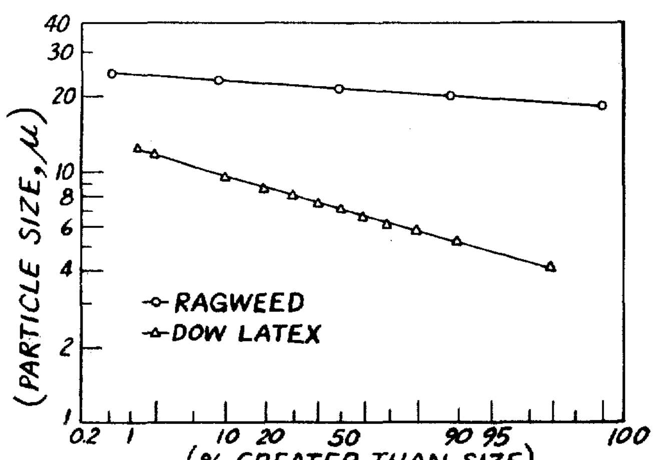
MICROSCOPE COUNT OF GLASS FIBER LENGTH

FIG. 4



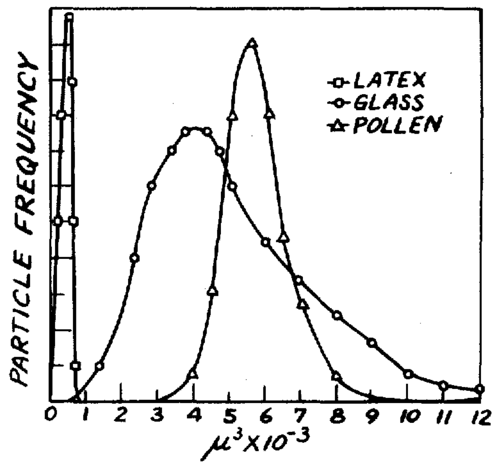
MICROSCOPE COUNT OF GLASS FIBER DIAMETER

FIG. 5



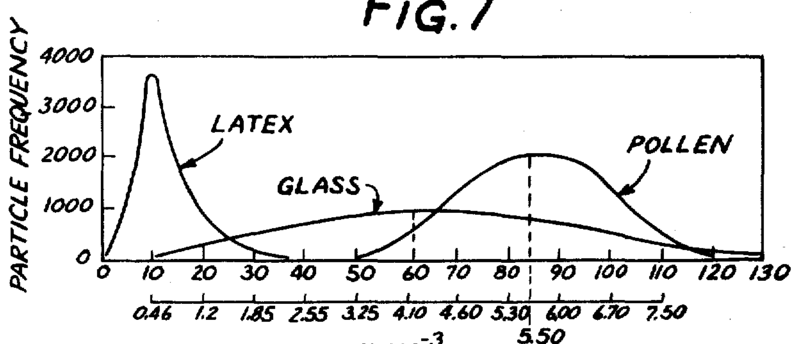
MICROSCOPE COUNT OF RAGWEED POLLEN AND DOW LATEX

FIG.6



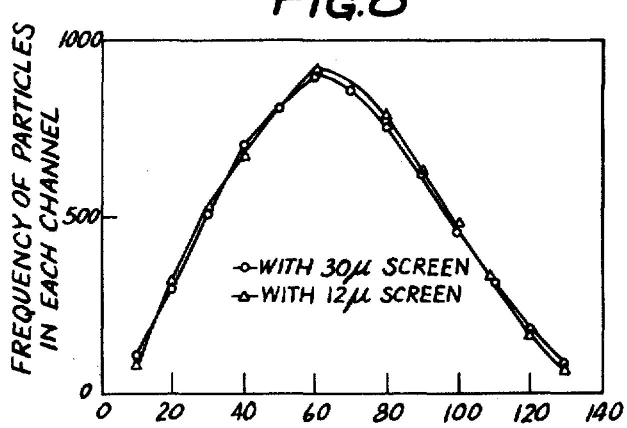
RELATIVE VOLUME DISTRIBUTION OF LATEX, GLASS AND POLLEN

FIG.7



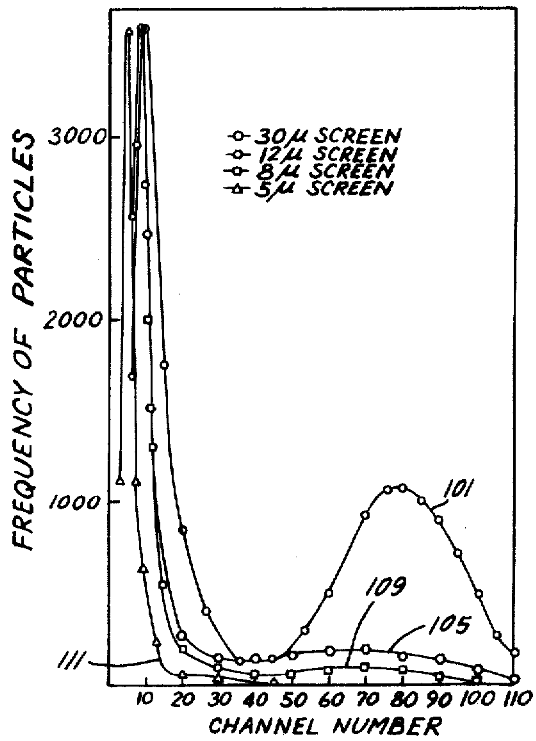
COULTER COUNTER ANALYSES OF GLASS, LATEX AND POLLEN DETERMINED INDEPENDENTLY

FIG.8



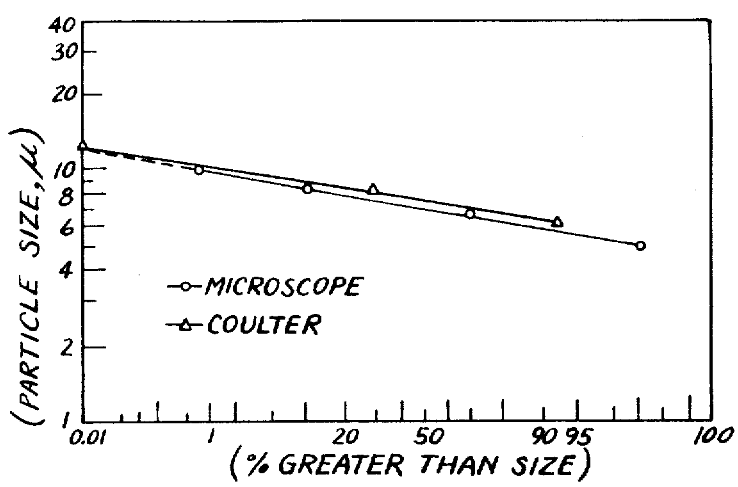
GLASS FIBER DISTRIBUTIONS MEASURED ON 72,000 PARTICLES

FIG. 9



COULTER COUNTER ANALYSIS OF THE THREE COMPONENT MIXTURE

FIG. 10



COMPARISON OF THE FIBER DIAMETER DISTRIBUTIONS BY MICROSCOPE AND MODIFIED COULTER COUNTER.

FIG. 11

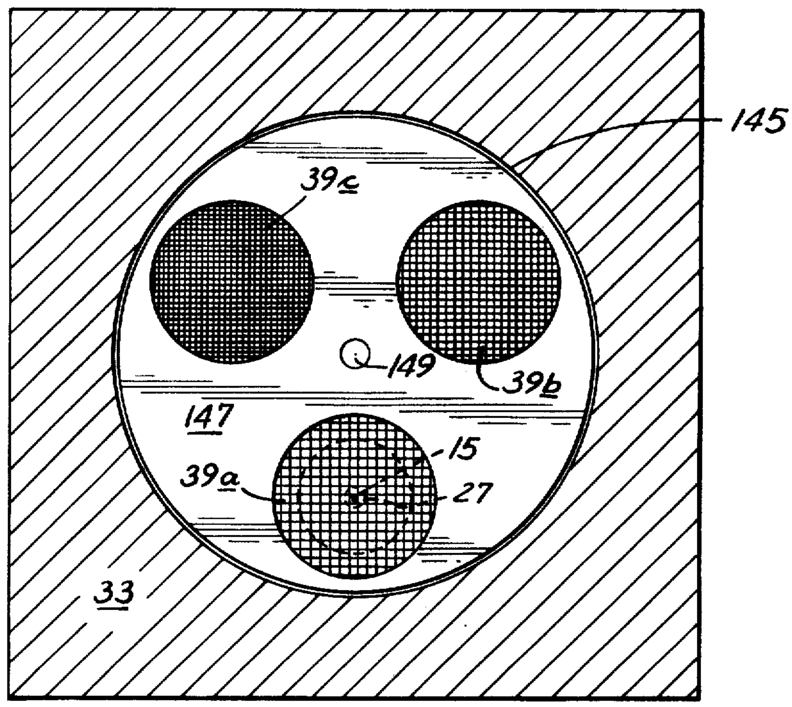
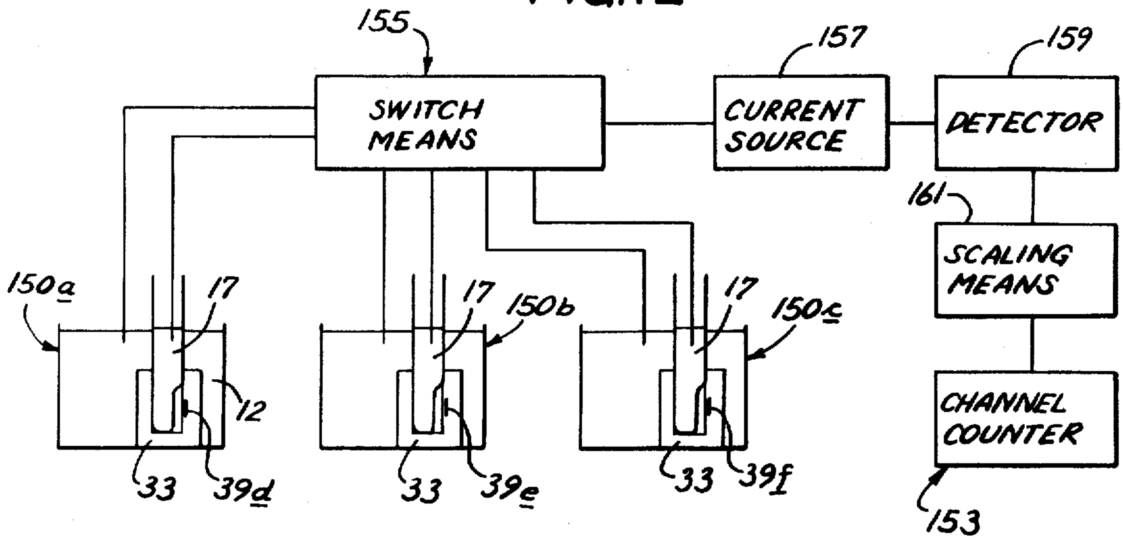

145
39c
149
39b
147
15
39a
27
33

FIG. 12


155
SWITCH MEANS
157
CURRENT SOURCE
159
DETECTOR
161
SCALING MEANS
CHANNEL COUNTER
153
150a
17
12
33
39d
150b
39e
150c
39f

METHOD OF AND AN APPARATUS FOR COUNTING FIBERS

This invention relates to a method of and an apparatus for distinguishing elongated fiber-like microscopic size particles from other shapes and kinds of particles and for counting and sizing the elongated particles suspended in a liquid conducting medium with an electrical zone-sensing apparatus.

The present invention is directed to and in particular to sensing microscopic size particles; for example, particles having a cross sectional diameter or area in the order of about 0.000005 to 0.000030 meter, i.e., 5 to 30 microns. Heretofore, particles having a transverse cross sectional area in this general range have been as disclosed in copending applications No. 173,372, now U.S. Pat. No. 3,739,258 and Ser. No. 173,575, now U.S. Pat. No. 3,739,268, but no attempt was made to distinguish between rounded and elongated fiber shaped particles. These copending applications disclose improvements to commercially available Coulter counters; and apparatus of the general kind shown in the latter one of these applications may be used to practice the method, as described herein, to discriminate between the rounded and fiber particles and to count and to size them. Other apparatus is described herein to provide a more automatic sizing and counting of fiber shaped particles.

A particular need exists in the fields of occupational health and safety for a fast and efficient method of detecting and size measuring microscopic particles particularly to analyze a suspension for the size and number of fibers of a given kind and to distinguish fibers from other types of particulate foreign matter, either natural or man-made, which may be present in the sample which is being counted. For example, it may be desired to size and count asbestos fibers, glass fibers, or other man-made fibers in a sample and to distinguish these fibers from more circular foreign matter in the samples, such as small grains of dirt or sand or pollen. With the present invention, it is possible to size the fibers as to their approximate diameter and/or length so that a more precise understanding of the count of the fibers of a given size and length may be understood relative to other particles being counted within the liquid.

Heretofore, the most commonly used method for counting such fibers was by a microscopic sampling technique with an actual manual counting of the approximate diameter and length of the particles in the sample. From this, the approximate statistical analysis of fibers in the sample could be made. This manual counting with a microscope is an inefficient, time-consuming, and costly process as compared to the use of automatic electrical zone sensing and counting apparatus using a flowing liquid stream to convey the particles through an electrical zone sensing aperture.

Accordingly, a general object of the present invention is to provide a new and improved method of distinguishing and counting fibers, particularly microscopic size particles of the kind above-described.

These and other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a schematic representation of an apparatus for detecting and sizing microscopic particles and for use with a method of the present invention;

FIG. 2 is an enlarged, sectional, elevational view of a portion of the apparatus shown in FIG. 1;

FIG. 3 is a graphic representation of the length of glass fibers as made with a microscope;

FIG. 4 is a graphic representation of the diameter of the glass fibers as made with a microscope;

FIG. 5 is a graphic representation of the size of ragweed pollen and Dow latex particles as made by a microscope;

FIG. 6 is a graphic representation of the volume distribution of a sample of latex, glass and pollen particles;

FIG. 7 is a graphic representation of the volume distribution of the glass, latex and pollen particles each made independently with the electrical zone sensing apparatus of FIG. 1 prior to combining the same into a sample for analysis;

FIG. 8 is a graphic representation of glass fiber distribution measured with a 12 micron screen and with a 30 micron screen using the electrical zone sensing apparatus of FIG. 1;

FIG. 9 is a graphic representation of the size distribution of the respective pollen, latex particles and glass fibers in a sample made with the results of the method of the present invention and the apparatus shown in FIG. 1;

FIG. 10 is a comparison of the results of the fiber distributions found with the prior art microscopic analysis method and with the method and apparatus of the present invention;

FIG. 11 is a diagrammatic view of a carrier carrying a plurality of filter screens for selectively positioning each screen at an operative filtering position; and

FIG. 12 is a diagrammatic view of a series of electrical zoning sensing devices each having a screen of a different size for sizing and counting fibers in accordance with the invention.

As shown in the drawings for purposes of illustration, the invention is embodied in an apparatus 10 for detecting and measuring the size and frequency distribution of microscopic particles and particularly elongated particles, i.e., fibers suspended in a fluid medium such as a liquid electrolyte. Very generaly, the illustrated apparatus comprises a vessel 12 such as a beaker containing the electrolyte and the mixture of suspended particles and fibers which are to be analyzed. The electrolyte containing the particles in the vessel is drawn through a flow straightening means 13 into a small aperture 15 in a scanner element 14 and through the latter into a receiving means or tube 17. The liquid flow through the scanner element is caused by a fluid head, i.e., a pressure differential, such as by applying reduced pressure from a vacuum line 18 to the upper surface of the liquid in the tube. To measure the change in conductivity caused by a particle passing through the aperture 15 in the scanner element, an electrical circuit means is provided including a detector circuit 20 which is connected to an electrode 22 projecting into the electrolyte in a vessel and electrode 24 projecting into the electrolyte in the tube.

As described more specifically in the aforementioned patent application Ser. No. 173,575, now U.S. Pat. No. 3,739,268, which is hereby incorporated by reference as if fully reproduced herein, each particle passing through the aperture 15 displaces its own volume of the electrically conductive liquid within the aperture. Because the liquid electrolyte and particles have different conductivites and resistances, the displacement of one by the other results in momentary change in the detected resistance between the electrodes **22** and **24** on either side of the aperture **15.** This resistance change produces a voltage pulse of short duration having a magnitude proportional to particle volume if the current is kept constant. On the other hand, the method may also comprise maintaining the voltage constant while detecting a change in the measured current. The pulses are amplified, scaled and counted. It has also been found that the particle passing through the aperture will have a response which is substantially linear with particle size if the particle has less than about 40 percent the diameter of the aperture **15.** Also, to insure that the change in current or voltage induced by the passage of particles through the aperture **15** is dependent substantially on particle size, the electrolyte is chosen so that the particle resistivity is effectively several orders of magnitude greater than the liquid resistivity.

Aforementioned co-pending application Ser. No. 173,575, now U.S. Pat. No. 3,739,268 discloses a method and apparatus for improving the accuracy of size measurement and size distribution of particles by the addition of the flow straightener means **13** in the form of a flow direction collar **25** which is attached to the tube **17** with an elongated flow directing bore **27** in the collar **25** disposed in substantial alignment with the axis of the aperture **15** to cause a directional flow of electrolyte into the aperture thereby reducing particle induced turbulence in the electrolyte flowing from the vessel **12** into the detection tube **17** particularly at the entrance edge of the wafer scanner element **14.** The flow direction collar also serves to direct the particles to flow along paths substantially parallel to an axis **31** (FIG. **2**) through the circular cross section aperture **15** in the scanner element **14.** The illustrated flow directing collar **25** includes an outer housing **33** for telescoping on the bottom of the detection tube; and in this instance the flow directing bore **27** comprises a larger outer diameter section **34** and an inner restricting diameter section or bore **35.** In the aforementioned application Ser. No. 173,575, now U.S. Pat. No. 3,739,268, a micro-mesh screen or filter **39** was provided upstream of the flow straightening means for filtering oversized particles and debris from the electrolyte flowing through the bore **27** and into and through the aperture **15.** This filtering reduces the possibility of orifice blockage.

In accordance with the present invention, fiber shaped particles are sized and counted and may be distinguished from other shapes of particles by calibrating a counter means **40** with the size of the openings in the screen **39** such that electrical signals generated by particles indicating volumes larger than maximum size of spherical particles passing through the screen openings are counted as fibers. More specifically, the screen openings each have a largest known dimension; for example, a diameter or a length of one of the sizes of a square opening; and will pass spherical particles having diameters equal to or less than the largest dimension for the screen opening. However, as will be explained, fibers having a transverse area close to the maximum dimension of the screen opening will have much larger volumes than the maximum size spheres passed through the screen. Therefore, by classifying and segregating the electrical pulses associated with particle volumes larger than the maximum spherical volume, the fiber volumes may be separately counted and sized.

More specifically, spherical particles wil have a maximum aspect ratio of 1 and a maximum volume of $\pi d^3/6$ where d is the diameter of the largest screen opening. An aspect ratio as used herein is defined as the ratio of the length to breadth dimensions of a particle in a flat, two dimensional plane. Typical needle or fiber particles have an aspect ratio of about 5 to 1 with the length being five times the breadth. For spheres, the length and breadth in a two dimensional plane are equal and hence the aspect ratio is one. The volume of the fibers will therefore be at least an order of magnitude greater than that of the volume measurement of a rounded or spherical particle just passing through the same screen opening. In this instance the counter means is provided with a scaling or segregating means which scales, that is, classifies the signals as to the size of the pulse generated as related to the volume of the particles and all particle volumes of a given size range are counted separately by a separate counter, herein a separate counter is provided for each of a plurality of volume ranges, i.e., channels. In the embodiment of the invention illustrated herein there may be as many as **128** separate channels provided in the counting means which is adapted to be used with each of a series of successive screens **39.**

The pulses may thus be classified by **128** different ranges with a separate count of particles for each of the volume ranges.

While it is possible to use the counting means provided with the usual Coulter counter, which is commercially available, the apparatus **10** shown in FIG. **1** and described herein below employed a commercially available multichannel analyzer of the pulse amplitude distribution kind made by Nuclear Data of Chicago, Illinois and identified as ND 130AT. The counter means **40** includes a scaling or sizing apparatus for measuring the heights of pulses. The pulse heights are related to particle volume with the larger height associated with the larger volume particles. Thus, the pulses are separated by the height of the pulse generated and sent to each one of the series of channels each associated with pulses of a given height range and hence a given volume range. By way of illustration, FIG. **7** shows the correlation between channels **10** and **110** and the volumes of the particles being analyzed in terms of $0.46u^3 \times 10^{-3}$ to $7.5\ u^3 \times 10^{-3}$, where u^3 equals micron^3.

In accordance with a specific example of the invention, an admixture was formed including generally rounded ragweed pollen particles and mono-size, spherical latex particles obtained from Dow Chemical Corporation, Midland, Michigan. To these rounded particles were added glass fiber particles formed from a sample of pyrex wool Cat. No. 3950 manufactured by Corning Glass Company, which sample was ball milled in water for three hours to break up the fibers to microscopic size. After classification, decantation, and centrifugation, the residual glass fibers were placed in chromic acid and allowed to stand overnight, washed in distilled water, and then photographed. The glass fibers were then sized under a microscope and photographed. Using the photographs, a count distribution by length was made as shown in FIG. **4,** and by diameter as shown in FIG. **5.** Generally speaking, the glass fibers had diameters in the range of 5 to 10 microns and lengths of about 10 to 98 microns. The mean fiber length was 7.3 microns, the volume of the particles having the values of mean length and mean breadth were equal to about 4,200 cubic microns. The pollen particles and Dow latex particles were suspended in water to which a drop of isopropyl alcohol had been added. The particles were sized using the microscope. The sizes of the latex diameters were about 7.2 microns, and the pollen particles were about 21.8 microns. Using this data, the relative volume distribution of the latex, glass, and pollen particles was calculated; and, as shown in FIG. **6**, the modes of distributions for the latex particles was about 4.1 $u^3 \times 10^{-3}$; and for the pollen particles was about 5.5 $u^3 \times 10^{-3}$.

This admixture was then analyzed with the zoning sensing apparatus (FIG. **1**) using a screen **39** having a nominal mean screen size of 30 microns, and results are shown in FIG. **9**. The screens used had generally square openings or apertures with each side of the opening having a 30 micron length for the 30 micron screen. Each of the other screens had similarly shaped square openings with the screen size. The curve **101** shown in FIG. **9** made with the 30 microns screen shows a distribution mode for pollen particles at about channel **80.** The glass fiber particles remain hidden in the curve **101** which was prepared with the use of the 30 micron screen. A micromesh screen **39** having a nominal screen opening size of 12 microns was then fitted into place and substituted for the 30 micron screen, and the same analysis was performed again and results plotted to form curve **105,** FIG. **9**. The 12 micron screen having the smaller diameter openings filtered the ragweed pollen, which have a minimum diameter of about 20 microns from the suspension passing through the screen **39**, bore **27**, and sensing aperture **15**. As a result, the curve **105** is generally flat in the area of channel **80** at which the pollen particles were previously found, but the curve **105** clearly shows the glass fiber population at channel **28**. Next, the 8 microns screen **39** was positioned in place, and the results obtained were plotted to provide curve **109** which is generally flat from channel **30** on and including the area of the pollen count previously found in channel **80.** The use of the 5 micron screen **39** detected only the latex particle population and this is clearly shown at channel **10** as shown by curve **111**. The size distribution of the latex passing through the 5 micron screen is however finer than that of the original lates as particles in excess of 5 microns have been removed by the screen. During the tests above described, it was discovered that channels **28**, **10** and **5** counted some spherical particles having diameters greater than the nominal mesh diameters for the screens being used. A microscopic analysis of the 30, 12, 8, and 5 micron screens indicated a number of holes in each screen of a size larger than the nominal mesh size opening for that screen. One of the problems with these screens was that they were not new, and some mesh distortion had taken place during previous usage. Despite the slight increase in the screen size, openings for several of the openings in each screen **39** beyond the nominal mesh size, the data obtained with the present invention correlated quite well with the data obtained with the microscope as shown in FIG. **10.**

More specifically, the results obtained during the manual count with the microscope and the method of the present invention are shown in FIG. **10** with the curve **120** being developed with the method and apparatus of the present invention, whereas the curve **121** is developed from the microscopic analyzed data. Thus, it can be seen that the results are quite close, but they could possibly be improved by using more precise screens.

It has been found that the glass fibers will pass readily through a screen **39** having a mesh size closely approximating that of the fiber diameter. It was feared that the glass fibers might turn sideways or lay against the outer side of the 12 micron screen and block the flow of other glass fibers through the screen. However, a comparison of the results obtained using both a 30 micron screen **39** and a 12 micron screen **39** failed to reveal any significant variation, the results being graphically illustrated in FIG. **8.** More specifically, the data obtained when using the 12 micron screen, as shown by curve **130,** is quite close to the data developed with the **30** micron screen, as shown by curve **131.** For both the **12** and **30** micron screens, the fiber modes occurred in channel **60** which was equivalent to a volume of 4.1 $u^3 \times 10^{-3}$. However, if blockage of the screen by fibers should become a problem, then a pressure pulse in the reverse direction can be generated to back flush the screen of crosswise laying fibers on its outer facing surface.

From the foregoing, it will be seen that the present invention provides a fast and economical method of calculating the frequency and volume of very small size fibers. The apparatus is particularly useful in distinguishing microscopic fiber-shaped particles from generally rounded or spherical particles having a projected area or diameter generally similar to the minimum projected area or diameter of the elongated fibers.

In the above described embodiment of the invention, each of the screens **39** was laboriously inserted into a receiving ring shaped pocket **140,** FIG. **2,** in the housing **33** and sealed around the ends of the screen **39** by a sealing means including a resilient ring gasket **141.** In some instances additional sealing material was applied around the edges of the ring gasket to assure that all particles flowing into the bore **35** had in fact passed through a screen opening.

To provide a faster analysis and technique of changing the sizes of the screens **39** at an operative screen position, i.e., upstream of the aperture **15** for filtering, a carrier means **145** (FIG. **11**) may be provided on the collar housing **33** for carrying a plurality of screens **39*a*, 39*b*,** and **39*c*** for movement into and from the operative position before the aperture **15.** While the carrier **145** may take various forms, the illustrated carrier is in the form of a rotatable disc **147** mounted in an opening in the collar housing **33** for turning about a horizontally disposed shaft **149.** By turning the shaft **149,** the disc **147** may be rotated to shift one of the screens such as **39*a*** from the operative position while another screen **39*b*** is shifted into the operative filtering position. In like manner, the screen **39*c*** may also be shifted into the operative position. Appropriate seals cooperate with each of the screens when it is in the operative position to prevent leakage of particles about the screen. Thus, it will be seen that means may be provided for shifting different sizes of screens into operative position without the manual replacement above described in connection with the apparatus shown in FIGS. **1** and **2**.

Another alternative to the individual and manual replacement of the screens **39** will be described in connection with FIG. 12. In the embodiment shown in FIG. 12, a plurality of zone sensing devices **150a**, **150b**, and **150c** are each provided with a portion of the substantially homogeneous suspension to be analyzed. Each of these three zone sensing devices is identical to the zone sensing device shown in FIG. 1 including a suspension containing vessel **12**, a receiving tube **17**, a zone sensing aperture **15**, and a screen **39d**, **39e**, or **39f**. However, each of the screens **39d**, **39e**, and **39f** has predetermined and different sizes of screen openings therein with its size of opening being calibrated with a particular channel of the counter **153**. Preferably, the electric zone sensing devices are connected to a common switch means **155** for a selective and individual connection to a current source **157**, detector **159**, scaling means **161**, and the counter **153**. In operation, the switching means **155** will be operated to connect the sensing device **150a** with fibers being counted in channels calibrated for volumes larger than an aspect ratio of 1 or 2 for its screen openings. Preferably, the screen **39d** has openings larger than the openings in the screen **39e**, and the openings in the screen **39e** will be larger than the openings in the screen **39f**.

After sizing and counting the larger cross section fibers in channels above the channel associated with the volume of a maximum size spherical particle capable of passing the screen and/or particles with smaller volumes in other channels of the channel counter **153**, the switching means **155** may be operated to connect the zone sensing device **150b** to the electrical and counting means to test for the intermediate size fiber particles which had volumes that could not have been distinguished from volumes of the largest spherical particles passing through the screen **39d**. Fiber particles in the second vessel **12** of the same population counted by the electrical sensing device **150a** will be filtered by the screen **39e** so that it will be smaller fibers which are next counted by the channel counters **153** in channels above that calibrated for a spherical volume equal to that capable of passing through the screen **39e**. In a similar manner, the zone sensing apparatus **150c** may be operated to distinguish another and smaller size of fibers from other shape particles which passed through the filter **39e**, by using the filter screen **39f** and counting again as fibers the pulses associated with particle volume greater than the volume of the largest sphere capable of flowing through the screen **39f**. Also, by having previous calibrations and knowledge of fiber sizes and volume characteristics, it should be possible to not only count the different populations of fibers in a sample but also to identify the particular kind of fiber being counted in a given channel. Microscopic viewing of the fibers or other tests of the various populations may also be made to confirm the identity of the fiber population being electrically and automatically counted by the respective devices **150a**, **150b**, and **150c**.

While a preferred embodiment has been shown and described, it will be understood that there is no intent to limit the invention by such disclosure but, rather, it is intended to cover all modifications and alternate constructions falling within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A method for electrically sensing and sizing small elongated fiber particles suspended in an electrolyte to form a suspension within a vessel comprising the steps of: passing the particles and electrolyte through a screen means having openings of a predetermined size therein, passing the particles having been screened through an electrical zoning sensing aperture along with the electrolyte, electrically sensing the particles passing through said aperture and generating electrical signals having a characteristic indicative of the volume of the particle passing through said aperture, classifying the signals according to the volume characteristics thereof, counting the classified signals having volume characteristics equal to or less than the predetermined volume associated with the maximum size of spherical particles capable of passing through said screen openings,

and separately counting as fibers those classified signals having volume characteristics greater than said volume characteristics for said maximum size of spherical particles capable of passing through said screen means.

2. A method in accordance with claim 1 including the steps of passing a portion of said suspension through a second screening means having openings of a second and predetermined size, electrically sensing said particles and generating and classifying said signals, said signals having characteristics equal to or less than a predetermined volume associated with a maximum spherical volume capable of flowing through said second screen openings being counted as non-fiber particles and larger volume signals being counted as fibers.

3. A method in accordance with claim 1 including the step of directing said liquid and fibers to flow along streamlined paths substantially parallel to the axis of the sensing aperture after passing through said screening means.

4. A method in accordance with claim 1 including the step of measuring the pulse height and pulse length and relating the pulse volume to a fiber size.

5. A method in accordance with claim 1 including the step of back flushing said screen to remove therefrom fibers in or about the screen means.

6. A method in accordance with claim 1 in which the step of providing screens having openings with a maximum dimension thereof being between 5 to 30 microns and calibrating said counting means to count fibers having an aspect ratio of two or less as non-fibers and particles having an aspect ratio greater than two as fibers.

7. An apparatus for electrically sensing and sizing small elongated fiber particles suspended in an electrolyte to form a suspension, said apparatus comprising means for containing the suspension, receiving means for receiving the suspension subsequent to a sensing and sizing of the particles, means defining at least one aperture interconnecting in fluid communication said containing means and said receiving means and through which said particles pass to be sensed and sized in the course of travel from said containing means to said receiving means, means for electrically sensing the particles passing through said aperture and for generating an electrical signal having a characteristic indicative of the volume of the particle passing through said aperture, a plurality of filter means each sequentially adapted to flow therethrough and each having a predetermined and different sizes of openings therein through which said electrolyte and said particles may flow, means to separate said electrical signals indicative of different volumes into categories which are related

to a predetermined particle volume for passing through each of said filter means, and means for counting as fibers said particles being filtered and sensed with signals associated with volumes larger than said predetermined particle volume for a given filter means.

8. An apparatus in accordance with claim **7** in which said filter means are micromesh screens, said screens having generally square shaped openings therein with sides of the openings measuring within the range of about 5 to 30 microns.

9. An apparatus in accordance with claim **8** in which each of said screens is selectively moved into an aperture filtering position and a preceding filter screen is selectively removed from the operative position.

10. An apparatus in accordance with claim **9** in which a carrier means is provided for carrying one of said filter screens into the operative position.

11. An apparatus in accordance with claim **7** in which a mounting means is provided for releasably holding a filter means in an operative position for filtering, each of said filter means being inserted and removed from said mounting means in a predetermined sequence to size fibers of different transverse cross sections.

12. An apparatus in accordance with claim **7** in which several containing means, receiving means, apertures, and filter means are connected to said electrical means and to said means to separate said signals and to said counting means for operation in sequence to size and count fibers of different volumes.

13. A method for electrically sensing and sizing microscopic fiber particles suspended in an electrolyte within a vessel comprising the steps of passing the particles and electrolyte through a first screen means having openings of a predetermined size therein, passing the particles having been screened through an electrical zone sensing aperture along with the electrolyte, electrically sensing the particles passing through said aperture and generating electrical pulses each having an amplitude indicative of a volume of the particle passing through the aperture, classifying the pulses by amplitude and counting the classified signals in separate channels of a pulse amplitude distribution analyzer, designating as fibers those particles counted in channels associated with volumes larger than the channel counting pulses for largest spheres capable of passing through said first screen means, analyzing a portion of the suspension with a second screen means having openings of a smaller size by passing the particles and electrolyte through an electrical zone sensing aperture along with the electrolyte to generate electrical pulses having amplitudes indicative of the volumes of the particles passing through the aperture and said second screen means, classifying these latter pulses by amplitude in channels with a pulse distribution analyzer, and counting as fibers with diameters between said sizes of said first and second screen openings, those said classified pulses in channels associated with particle volumes larger than the channel for counting the maximum size of spherical particles capable of passing through said second screen openings.

14. A method in accordance with claim **13** including the step of passing the particles through a third screen means having openings larger than the diameters of the spherical particles or the diameters of the fiber particles to obtain a total count of particles in said suspension.

15. A method for analyzing a fiber distribution in an electrolyte suspension by ranges of diameters and lengths with an electrical zone sensing apparatus and a volume distribution analyzer counter means comprising the steps of: analyzing the suspension by passing the electrolyte and particles through a first screen means having openings of a first predetermined size with particles of sizes larger than said openings not passing through said first screen means, generating electrical pulses with said electrical zoning sensing means for each particle passing through said first screen means, each pulse being indicative of the particle volume passing through said zone sensing means, classifying the pulses by volumes with said volume distribution analyzer counter means and separately counting the pulses for each of said classified volumes, designating as fibers those pulses counted and classified as having volumes larger than the volume of the largest spherical particle capable of passing through said opening in said first screen means, analyzing the suspension a second time with a second screen means having openings of a size smaller than said openings of said first screen means by passing through said second screen means particles having diameters less than the size of said second screen openings and generating electrical pulses with said electrical zone sensing means indicative of a particle volume, classifying the pulses by volumes with said volume distribution analyzer means and separately counting the pulses for said classified volumes, and designating as fibers having diameters between the sizes of the first and second screen openings those pulses having classified volumes larger than the pulse volume for the maximum size of spherical particles capable of passing through said second screen openings.

16. A method in accordance with claim **13** including the further steps of: selecting a third screen means having openings less than the diameter of the smallest fiber particles thought to be in said suspension and passing the particles and electrolyte through said third screen means and electrical zone sensing aperture to generate electrical pulses indicative of the volume of particles passing through said third screen means, classifying the latter pulses according to volume characteristics, and designating as fibers having diameters between the sizes of said second screen means and said third screen means those classified volumes larger than the volumes of the maximum spherical particles capable of passing through said third screen means.

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