June 25, 1968 HIROSHI IMADATE 3,390,326

PARTICLE COUNTING DEVICE INCLUDING FLUID CONDUCTING MEANS BREAKING UP PARTICLE CLUSTERS

Original Filed Nov. 14, 1962

Fig. 1.

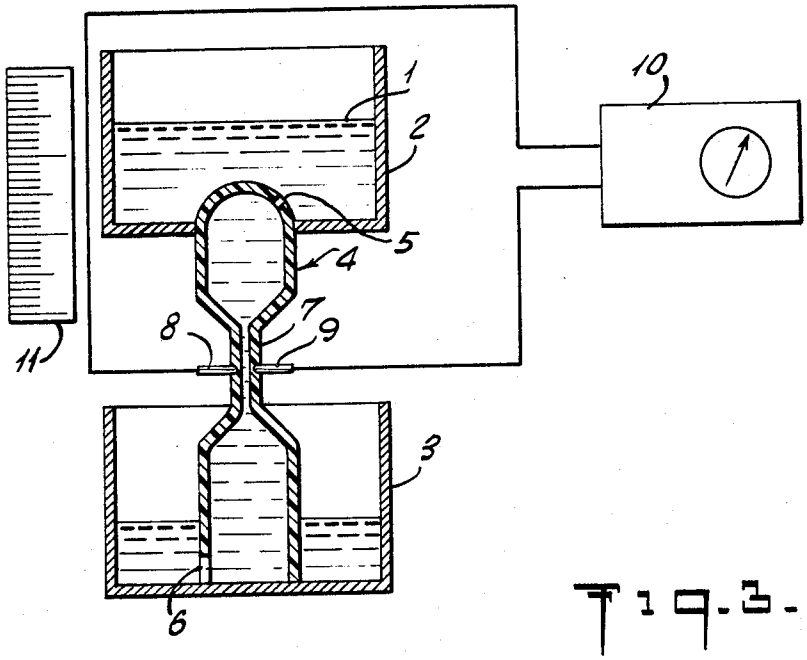


Fig. 3.

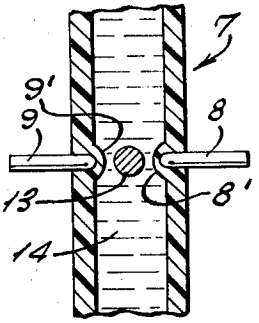
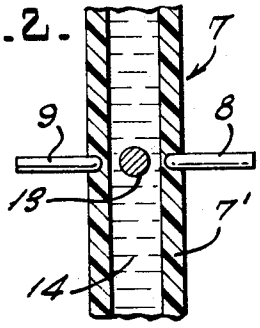


Fig. 2.



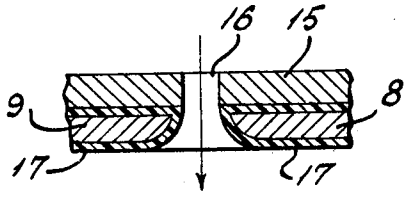


Fig. 4.

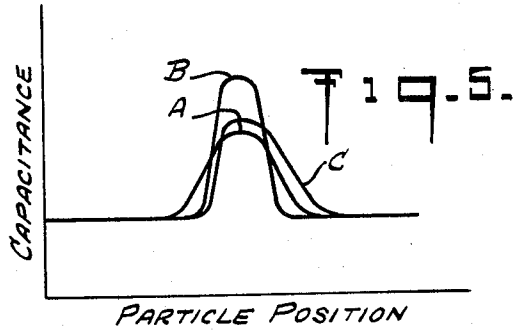


Fig. 5.

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PARTICLE COUNTING DEVICE INCLUDING FLUID CONDUCTING MEANS BREAKING UP PARTICLE CLUSTERS

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Continuation of application Ser. No. 237,463, Nov. 14, 1962. This application Apr. 11, 1967, Ser. No. 630,485
Claims priority, application Japan, Nov. 20, 1961, 36/42,477
4 Claims. (Cl. 324—61)

ABSTRACT OF THE DISCLOSURE

Apparatus for counting particles in a flowing medium by breaking up clusters of particles in the solution, agitating the solution to produce a uniform dispersion of particles and then conducting the fluid with the dispersed particles through a narrow tubular member and counting the particles flowing through said tubular member.

This invention relates to the detection of fine particles suspended in a flowing medium and for counting the number of particles.

This is a continuation of my copending application, Ser. No. 237,463, filed Nov. 14, 1962, now abandoned.

Devices have been suggested for the detection of particles by measuring the varition of resistance of a conductive fluid as the particles pass between the electrode. Such procedures, however, have not been found to be satisfactory, since the particles in many cases are carried by an electrically insulating material as, for instance, when they are suspended in oil or gas.

This invention overcomes the difficulties of prior known devices and provides a novel and improved method and apparatus for the detection and counting of particles carried by a medium which may be liquid or gaseous, conductive or insulating.

Another object of the invention resides in the provision of a novel and improved method and apparatus for the detection of particles in a flowing medium which affords a high degree of accuracy of particle count.

Still another object of the invention resides in the provision of a novel and improved device for the detection and counting of particles in a flowing medium which is characterized by its simplicity, accuracy and relatively low cost.

The above and other objects and advantages of the invention will become more apparent from the following description and accompanying drawings forming part of this application.

In the drawings:

FIGURE 1 is an elevational view in section of apparatus in accordance with the invention.

FIGURE 2 is a greatly enlarged cross-sectional view of a fragmentary portion of the apparatus shown in FIG. 1.

FIGURE 3 is a cross-sectional view similar to FIG. 2 showing a modified embodiment of the invention.

FIGURE 4 illustrates still another embodiment of the invention for detection and counting particles in a flowing medium.

FIGURE 5 shows the response of apparatus in accordance with the invention when utilized with different types of electrodes.

Referring now to FIG. 1, the illustrated embodiment of the invention includes upper and lower fluid tanks 2 and 3 with the tank 2 containing the fluid suspended particles to be detected and counted. A detecting cylinder 4 having a very narrow central portion 7 is sealed in the bottom of the container 2. The enlarged upper portion of the detecting cylinder 4 extends into the container 2 and has a fine orifice 5 through which the liquid or other medium 1 flows into the tube 4. The bottom end of the detecting tube 4 is disposed within the container 3 and includes an opening 6 through which liquid may pass through the tube 4 into the container 3.

The detecting tube 4 is preferably made of an insulating material and carries a pair of electrodes 8 and 9 diametrally opposed one to the other. The electrodes 8 and 9 are preferably isolated so that the conductivity of the medium carrying the particles will not affect the operation of the device. The electrodes are connected to a capacity measuring device 10 responsive to changes in capacity between the electrodes 8 and 9 as the particles to be counted pass therethrough. Inasmuch as capacity measuring devices are well-known in the art, as well as means for counting electric pulses, it is felt that a detailed description of such apparatus is not necessary and would unduly complicate the application.

In order to attain a high degree of accuracy of the device as described in FIG. 1, the entrance orifice 5 should be made slightly larger than the diameter of the particles to be counted so that two or more particles will not pass through the orifice simultaneously. For instance, in the case of measuring a quantity of blood corpuscles in a blood sample, the diameter of the orifice 5 may be of the order of thirty to one hundred microns. Similarly, the diameter of the restricted portion 7 of the detecting tube 4 should be of the order of the particle diameter, though in the case of blood cell measurements, it has been found that diameters of fifty to five hundred microns produce excellent results. By limiting the diameter of both the orifice and the tubular portion 7 of the detecting tube, the particles will move individually between the electrodes in order to give an accurate count.

FIGURE 2 shows an enlarged view of the restricted portion 7 of FIG. 1. It will be observed that the electrodes 8 and 9 are imbedded in the wall 7' in a manner that will cause the particles 13 carried by the fluid medium 14 to pass between the electrodes. In this way, the capacity between the electrodes is varied each time a particle passes therebetween. The response of the indicator 10 to the passage of the particle 13 between the electrodes as shown in FIG. 2 is generally represented by the curve A of FIG. 5. In the preparation of the medium, it is desirable that the sample to be tested be diluted with a proper liquid medium, it being preferable that the medium have a dielectric constant that is materially different from the particles being detected. In the case of liquid mediums, it is also desirable that the specific gravity and viscosity be such that the particles will neither settle nor float in order to maintain a uniform particle dispersion. By properly diluting the medium and by utilizing the proper size of orifice 5, the particles will flow singly into the upper portion of the detecting cylinder 4. Moreover, since the particles enter through the side of the cylinder 4 (note the position of the orifice 5), the medium in the upper portion of the cylinder 4 will be constantly agitated to maintain uniform particle dispersion. In this way, the particles will flow singly down through the restricted portion 7 of the tube 4.

It is significant in the detection and counting of particles that the quantity of liquid or other medium flowing through the tubular portion 7 be measured. For this purpose, an appropriate scale, such as the scale 11, may be associated with the container 2 so that the change in level of the liquid 1 in the container 2 can be related to the particle count.

In the form of the invention illustrated in FIGS. 1 and 2, the electrodes 8 and 9 may be exposed to the

medium if both the medium and the particles have an electrical insulating property. If they do not have the desired insulating property, then the tip ends of the electrodes 8 and 9 are imbedded in the wall 7' as shown in FIG. 2.

FIGURE 3 is a modification of the structure shown in FIG. 2, and it will be observed that the inner surface of the wall 7 includes inwardly extending bosses 8' and 9' which receive the electrodes 8 and 9. This produces a restricted passage for the particles 13 with the result that a detection curve, such as the curve B of FIG. 5, will be produced.

FIG. 4 illustrates still another modification of the invention which includes a wall 15 having opening 16 extending therethrough. The medium together with the suspended particles are arranged to pass through the opening 16. The trailing edge of the opening 16 is tapered, and the electrodes 8 and 9 are set in the trailing edge of the wall with the wall portion 17 overlying the electrodes to insulate them. Inasmuch as the electrodes 8 and 9 are also curved, a response curve, such as curve C of FIG. 5, is obtained.

The particular form of electrode structure, such as those shown in FIGS. 1 through 4, would generally be selected in accordance with the particular characteristics of the medium and particles being counted and the nature of the output signal required for operating the counting device.

From the foregoing, it is evident that the number of particles as well as the particle density of the sample can be measured since the quantity of the liquid passing through the detecting unit, as well as its dilution, is known. It is also evident that the output of the measuring circuit 10 can be used to control automatic devices that may be required, for instance, to maintain a given particle concentration in a selected medium. Furthermore, in the case of mediums carrying particles of different types, it is possible with this invention to count the particles of different types by detecting the different capacitive effects of the different types of particles. Thus, the different types of particles can be classified, and the concentration of individual particles in a solution can be determined.

While only certain embodiments of the invention have been illustrated and described, it is apparent that other modifications, changes and alterations may be made without departing from the true scope and spirit thereof as defined in the appended claims.

I claim:

1. A device for the counting of individual particles suspended in a flowing fluid medium comprising tubular fluid conducting means having an opening extending therethrough, said opening having a diameter of the order of but greater than the diameter of the individual particles to be measured, a hollow fluid cylinder of substantial volume compared with the size of the particles being measured and of a greater diameter than the diameter of said opening connected with and communicating with one end of said fluid conducting means, said cylinder having at least one fluid entrance orifice of constant size, said orifice being at least slightly larger than the size of the particles being measured and not greater than said opening, said fluid flowing through said orifice and thereby producing substantial agitation in the fluid entering said cylinder, fluid retaining and supplying means connected with and communicating with the entrance end of said cylinder, a fluid pressure differential between said retaining means and said fluid conducting means causing said fluid then to flow through said fluid conducting means, and electrical impedance means for sensing each particle as it moves through said fluid conducting means, said orifice breaking up particle clusters and said agitation causing said particles to move individually through said fluid conducting means thereby minimizing coincidental errors caused by the simultaneous movement of two or more particles through said fluid conducting means and said orifice minimizing clogging of said opening.

2. A device for detecting particles according to claim 1 wherein said cylinder is funnel shaped.

3. A device for detecting particles according to claim 1 wherein said sensing means comprise a pair of electrodes carried by said fluid conducting means and forming a capacitor and means connected with said electrodes to sense the change in capacitance as the particles move therebetween.

4. A device for detecting particles according to claim 3 wherein said electrodes are in insulated relationship to said fluid medium.

References Cited

UNITED STATES PATENTS

2,071,607	2/1937	Bjorndal	324—61
2,369,577	2/1945	Kielland	235—92
2,779,232	1/1957	Small	88—14
2,807,416	9/1957	Parker et al.	235—92
2,985,830	5/1961	Coulter et al.	324—71
3,123,541	3/1964	Donnell	324—71 XR
3,238,452	3/1966	Schmitt et al.	324—61

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