BACTERIAL AEROSOL ANALYZER
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Filed Mar. 5, 1956, Ser. No. 569,661
6 Claims. (Cl. 195—163.5)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment to me of any royalty thereon.

This invention relates to an apparatus and method for counting and classifying viable particles in a gas. More particularly, the invention relates to an apparatus for counting bacteria or other microorganisms found in air, water, soil, or any substance that is capable of being suspended in air.

Specifically, the invention relates to a mechanism which serves to count and classify microorganisms in air and which will give a rapid and correct evaluation of these microorganisms.

The problem of determining contamination of the atmosphere by bacteria or other microorganisms is one of considerable difficulty since the time required for exposing and growing bacteria is considerable. Also, it is necessary to know the kind and relative size of such bacterial particles in order that remedial measures may be quickly taken.

It is the object of this invention to secure not only an accurate count, but an accurate classification of any microbial particles in the air and to separate such microbial particles according to size or mass and to grow them into colonies which can be analyzed.

In the drawings, FIG. 1 shows a top view of the apparatus. FIG. 2 shows a longitudinal section through the apparatus at 2, 2 of FIG. 1. FIG. 3 shows a corresponding section through two adjacent stages including the top stage. FIG. 4 shows diagrammatically the relative sizes of the perforations in the bottom of the respective stages.

More particularly, in the drawings, the cover 10 is shown applied to the top unit 12. This is followed by subsequent units 16, 18, 20, 22, 24, and bottom unit 26. These cylindrical units are nested together under compression by means of spring tie rods 28. The units are held in air tight relation by means of plastic washers 30. Each unit has a transverse perforated wall 32, 34, 36, 38, 40, 42 with perforations progressively diminishing in size.

The following table gives a series of sizes of perforations used and the range of particles which were collected under each size:

<table>
<thead>
<tr>
<th>Sampler Stage No.</th>
<th>Diameter of holes in inches</th>
<th>Size range of particles in microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.052</td>
<td>2.8 to 10.6</td>
</tr>
<tr>
<td>2</td>
<td>0.039</td>
<td>2.7 to 7.2</td>
</tr>
<tr>
<td>3</td>
<td>0.023</td>
<td>2.0 to 5.3</td>
</tr>
<tr>
<td>4</td>
<td>0.014</td>
<td>1.4 to 2.6</td>
</tr>
<tr>
<td>5</td>
<td>0.013</td>
<td>0 to 1.9</td>
</tr>
<tr>
<td>6</td>
<td>0.010</td>
<td>0 to 0.8</td>
</tr>
</tbody>
</table>

Below the perforated walls, Petri dishes 44, 46, 48, 50, 52, 54 are positioned. These dishes are partly filled with a nutrient medium which will serve to grow any viable particles which strike its surface. The dishes are centered by means of angular spacing bars 56 and they are separated from the underlying units by means of projections 58. By this means a continuous air channel is formed from the surface of each dish, around the sides and under the same, to the perforated cover in the next lower stage. By this means a continuous air passage is created through the apparatus.

When suction is applied at the exit of bottom unit 36, air will enter through unit 16, pass through perforations 32 and around dish 44 through perforations 34 and so on, through all the stages of the analyzer. As the air passes through the perforations 32 its velocity is increased depending upon the size of the perforations and the rate at which the air is aspirated through the instrument. The viable particles in the air will reach a velocity corresponding to that of the air and the largest particles will be projected down to the surface of the nutrient medium in the first dish 44. Smaller particles, whose mass is less, do not reach the surface of the medium but are carried around dish 44 to pass through the smaller perforations 34 of the second stage 16. Due to the smaller perforations, the air velocity will be increased with the result that another group of particles will strike the nutrient medium in the second stage. This process continues with progressively diminishing perforations and progressively increasing air velocity at each stage, with the result that more and more of the particles are removed as the air approaches the exit of the apparatus. By choosing the proper sizes of perforations and the proper air rate, it is possible to remove all particles on the various stages. If it is desired to leave an amount of the smallest particulate matter in the exit air, these may be filtered out with a millipore filter at the exit of the apparatus. This filter is not necessary, however, and the apparatus may be terminated as shown in FIG. 2 with a simple bottom exit plate 26.

When the desired air sample has been aspirated, the analyzer is disassembled and the respective Petri dishes are removed for culturing the viable organisms gathered thereon.

In sensitivity tests on this sampler it has been found that the instrument is capable of detecting a bacterial cloud generated from 200 ml of slurry at a distance of 38 miles. The device is sensitive to one viable particle in the total volume of air sampled.

The ability of the sampler to separate different size particles has been accurately determined by making tests on non-viable materials. It has been determined that the sample is capable of collecting particles on each stage within a very narrow range of sizes. Tests have been made on particles of carnauba wax, Krylon and egg slurry. The particles from these materials are all spherical and their sizes are therefore easily determined by microscopic analysis.

The following table shows the percent of the total particles found on each stage in six runs using Krylon and emphasizes the ability of the sampler to separate airborne particles in sizes.
From the distribution of pathogenic particles collected in the sampler, infection in animals or man may be predicted since it has been shown that respiratory infection by pathogenic particles is largely dependent upon the size of the particles inhaled.

This sampler has shown itself not only accurate but extremely convenient in making quick analysis of air samples where the presence of pathogenic particles is suspected. Results are obtained in about one-third the time compared with all glass impingers and at one-half the cost in laboratory work per sample processed.

I claim:

1. A method for classifying and culturing viable particles suspended in a gas which comprises passing a volume of gas through a number of stages in series, each stage including means to impart a fixed velocity to the gas stream and to utilize said velocity to deposit suspended particles above a given mass on to a nutrient surface by impaction, each succeeding stage serving to impart a gas velocity in excess of that obtaining in the preceding stage thereby to deposit particles of lesser and lesser mass in each succeeding stage and incubating the viable particles on the respective nutrient media whereby the viable particles become visible as colonies.

2. Apparatus for classifying and culturing viable particles in a gas comprising a series of stages, each stage including a transverse, uniformly perforated member positioned above and spaced from a layer of nutrient medium, each succeeding stage containing uniform perforations of gradually diminishing size per stage from the inlet to outlet of the apparatus and including means for passing the particle containing gas through the several stages in series.

3. A method of classifying according to size and identifying viable microscopic particles suspended in air, which comprises passing a volume of air through a series of stages, each stage containing a Petri dish of solid nutrient medium below a perforated plate having a fixed number of holes, the size of which is constant in each stage but which decreases in size in each succeeding stage, whereby jets of air, produced by drawing air through the device, increase in velocity with each succeeding stage and wherein said velocity increase in each succeeding stage is utilized to separate the microscopic particles into groups of decreasing size and mass, such that the groups of particles are collected by impaction on the nutrient medium of each succeeding stage and particles of less size and mass to be impacted on a given stage follow the air stream around the dish into the next stage where the velocity is increased so that by the time the last stage is reached, all viable particles will have attained a velocity sufficient for impaction on one stage or another with the particles having the smallest mass being collected on the last stage, thereafter incubating the Petri dishes whereby viable microscopic particles will grow into visible colonies, the number of which represent the number of viable particles collected on that stage.

4. An apparatus for classifying according to size and identifying viable microscopic airborne particles comprising a series of stages connected together with air tight seals, each of said stages comprising a Petri dish of solid nutrient medium positioned a fixed distance below a perforated plate, the number of perforations in said plates being constant for all of the stages and the size of said perforations being constant for each stage, said perforations being of decreasing size for each succeeding stage, said perforations serving to produce air jets which impinge on the nutrient medium as air is drawn through the apparatus, the velocity of said air jets increasing with each succeeding stage thereby causing particulate matter in the air drawn through the apparatus to be deposited on the nutrient medium of the respective stages, the smallest particles being collected on the last stage.

5. Apparatus for classifying and culturing viable particles in a gas, comprising a series of stages, each stage including a transverse uniformly perforated member positioned above and spaced from a layer of nutrient medium, each succeeding stage containing uniform perforations of gradually diminishing size per stage from the inlet to outlet of the apparatus and wherein each stage includes an integral flanged section that serves to nest with the flanged sections of adjacent stages, whereby the assembled stages create a cylindrical casing for the apparatus and including means for passing the particle containing gas through the several stages in series.

6. Apparatus in accordance with claim 5 wherein a Petri dish containing the nutrient medium is supported on the next succeeding stage in a manner to permit the gas to pass around said dish and to pass through the perforations of the succeeding stage.

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