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(54) Title of the Invention: **A low cost apparatus and method for the detection of a fluid-borne particle**  
Abstract Title: **Detection of fluid-bourne particles**

(57) An apparatus for the detection of a fluid-borne particle in an optically defined detection zone, comprises a scattering chamber 3, a fan 1 for providing a sample of fluid, containing the fluid-borne particle, in the form of a flow through the optically defined detection zone and a laser beam generator 5 for generating a beam of radiation through the optically defined detection zone 5. There is also a first reflector or refractor means 8a, a second reflector or refractor means 8b; a first detector means 11; a second detector means 12 and a means for deriving data from the radiation detected by the first and second detection means.

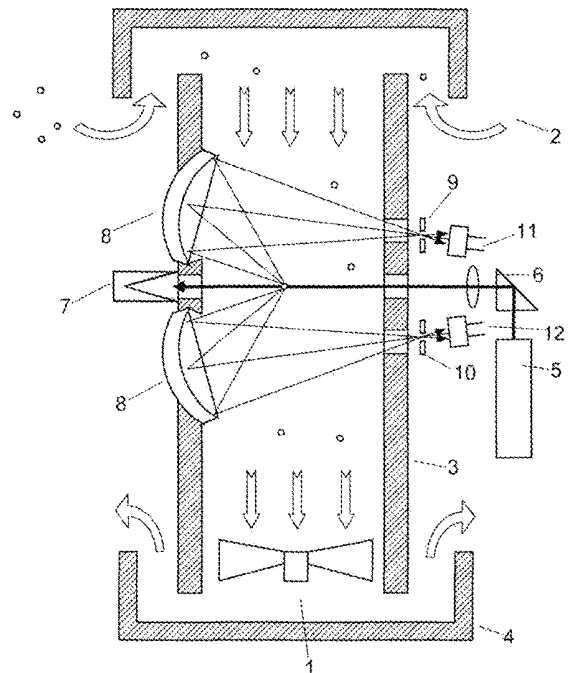


Figure 1

The claims were filed later than the filing date but within the period prescribed by Rule 22(1) of the Patents Rules 2007.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

## **A Low Cost Apparatus and Method for the Detection of a Fluid-Borne Particle**

### **Field of the Invention**

5 The present invention relates to a low cost apparatus and method for the detection of a fluid-borne particle. It is particularly applicable for the detection of a fluid-borne particle in an optical detection zone.

### **Background**

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In many fields of environmental monitoring, workplace monitoring, pollution control, and occupational health monitoring, it is necessary to continuously measure the aerosol content of a local environment. Where real-time high-sensitivity measurements are desired, instruments are used that are capable of measuring the sizes of individual particles at high rates (thousands of particles per second) so that an accurate assessment of both the concentration of particles and their size distribution can be achieved.

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The instruments that are commonly used for this purpose are 'optical particle counters' (OPC). These use an intense light source (usually a laser) to illuminate a narrow column of sample air drawn through a sensing chamber by an electrical air-pump. The air column is sufficiently narrow that the volume of air illuminated by the laser beam – often referred to as the sensing zone - rarely contains more than a single particle, and the pulse of light scattered by this particle as it crosses the laser beam is recorded as a particle count, the magnitude of the pulse being indicative of the particle size according to a calibration function, the calibration function depends on factors such as the laser wavelength and beam power and the solid angular range over which the scattered light from the particle is recorded.

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30 There are many excellent commercial varieties of OPC manufactured by companies such as Met One Instruments (USA), Grimm Aerosol Technik GmbH (Germany), and Casella Measurement Ltd., (UK). In all these instruments, the air-pump provides the necessary suction to draw the ambient air through a narrow sample tube and deliver the resulting column of air through the laser beam. The pump itself must be powerful enough to generate the required pressure drop inside the sensing chamber to draw the external air in through the sample tube. Furthermore, since the pumps are normally

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required to be protected from particulate contamination in the air, they are generally preceded in the air-flow by a high efficiency particle filter and this too will present a flow impedance which the pump must overcome. These features of conventional OPC's result in several drawbacks; firstly, the pumps used must overcome the pressure drops  
5 in the sample tube and particle filter, and this has implications for pump size and current consumption (and, by extension, for battery-life in standalone of hand-held units); secondly, the particle filters need to be periodically replaced (incurring further cost to user); and thirdly, the air sample handling system comprising sample inlet tube, vent tube, interconnecting tubing and filter, etc.), can be relatively complex to  
10 manufacture and assemble, with implications for final unit cost.

WO2008140816 (UNGER) describes a compact low cost particle sensor wherein the flow of fluid is directed to a detection zone via a series of baffles. The detection zone is basically a detector located directly under the laser beam which collects radiation  
15 scattered by particles passing through the beam. The problem with this device is that the detector is not able to distinguish the number or size of particles passing through the, rather large, detection zone. This device is only able to detect that at least one particle has passed through the detection zone, and in this regard it is little more than a portable smoke detector. This device cannot be used to accurately count the number  
20 of particles passing through the detection zone

There is a need for an apparatus and method of aerosol monitoring, having single particle sensitivity, which requires no air-pump or particle filter, and which is mechanically very simple, thus offering the prospect of manufacture using a small  
25 number of parts.

### **Summary of the Invention**

According to a first aspect of the present invention there is provided a detector  
30 assembly for the detection of fluid-borne particles comprising  
a tube through which fluid to be analysed flows in use;  
means for generating a radiation beam, the radiation beam being directed towards the tube in use, such that fluid to be analysed passes through the radiation beam in use, said tube being transparent to the radiation beam;  
35 a detector adapted to detect radiation scattered by a particle passing through the radiation beam.

According to a second aspect of the present invention there is provided an apparatus for the detection of a fluid-borne particle in an optically defined detection zone, the apparatus comprising:

- 5           i)       a scattering chamber;
- ii)       a means for providing a sample of fluid, containing the fluid-borne particle, in the form of a flow through the optically defined detection zone;
- iii)       a means for generating a beam of radiation through the optically defined  
10           detection zone;
- iv)       a first reflector or refractor means;
- v)       a second reflector or refractor means;
- vi)       a first detector means;
- vii)       a second detector means; and
- 15           viii)       a means for deriving data from the radiation detected by the first and second detection means

          wherein the first reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the  
20           optically defined detection zone into the first detector means and wherein the second reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone in to the second detector means.

25           Preferably the optically defined detection zone comprises a first zone and a second zone wherein the second zone is smaller than the first zone and wherein the second zone is located wholly inside the first zone.

          This is particularly advantageous as it provides for the a low cost apparatus for  
30           counting and sizing particles which operates by providing an optical rather than physical detection zone in which particles are detected. The optical detection zone allowing not only for particles to be detected but also to be counted and sized accurately. The apparatus being able to operated without the need of a pump to draw a sample through a narrow chamber. Given that there is no pump and that the parts  
35           are simple, light and cheap to construct this apparatus provides a low cost hand held device with single particle sensitivity, for the first time.

Preferably the first zone is defined by a first aperture located between the first reflector or refractor means and the first detector means and wherein the second zone is defined by a second aperture located between the second reflector or refractor means and the second detector means.

Preferably the second aperture is smaller than the first aperture.

Preferably the apparatus further comprises focussing means adapted to focus the beam of radiation such that the beam of radiation has an elliptical cross-section. More preferably the major axis of the elliptical cross-section is orthogonal/perpendicular to the direction of fluid flow.

Preferably the beam of radiation is generated using a diode laser.

Preferably the means for providing a sample of fluid in the form of a flow through the optically defined detection zone comprises an open ended tube of a diameter large compared to the optically defined detection zone in the scattering chamber through which fluid can freely flow. By selecting a scattering chamber diameter which is larger than the diameter of the optical sensing zone, the air, or other fluid sample, can freely flow through the scattering chamber. There is therefore no need for the air, or other fluid sample, to be sucked through the scattering chamber as in prior art devices, but whilst still retaining the desired single particle sensitivity without a pump.

Preferably the means for providing a sample of fluid in the form of a flow through the optically defined detection zone comprises a fan. This is advantageous as a flow of air can be provided cheaply and with low weight and low power usage to help draw air, or other fluid sample, through the device when there is no natural air or fluid flow in the environment. Alternatively the apparatus could be "waved" (i.e. moved through the air, for example manually by the user or attached to a moving vehicle) through the air to generate a flow of air or other fluid. Alternatively the apparatus can be placed in an environment wherein the fluid sample will flow through the optically defined detection zone, such as an environment of sample air moving relative to the apparatus by convection.

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Preferably the first and second reflector or refractor means comprise mirrors. More preferably the mirrors comprise concave mirrors. This allows the mirrors to be used to not only reflect the scattered radiation towards the detector, but also to focus the radiation so that a greater sample of scattered radiation is detected from the particle.

5 This is also advantageous as mirrors are much cheaper than lenses to produce, again resulting in a lower cost apparatus. Preferably the mirrors are of the same size and the same curvature.

10 Preferably the first and second reflector or refractor means are arranged above and below the beam of radiation; more preferably the first and second reflector or refractor means are arranged above and below the plane containing the major axis of the cross-section of the beam of radiation. This is advantageous since the reflector or refractor means being above and below the plane containing the major axis of the cross-section of the beam of radiation means that they can be used to define an optical detection  
15 zone that lies entirely within the beam of radiation.

Preferably the first and second reflector means are integrally formed in the scattering chamber. This is advantageous as there are less parts to produce and producing less parts is cheaper resulting in a lower cost apparatus.

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Preferably the scattering chamber is formed from an injection moulded plastics material. This is advantageous as injection moulding of plastics is a cheap process to run to mass produce identical items, resulting in a lower cost apparatus.

25 Preferably a first and second concave surface are formed integrally within the scattering chamber.

30 Preferably the first and second concave surfaces are provided with a reflective material to form the first and second reflector or refractor means. This is advantageous as the mirrors are formed internally to the scattering chamber, in the correct positions, in a single step and coated with a reflective material. This results in a lower cost apparatus due to reduced parts and also because the mirrors are automatically positioned correctly.

According to a third aspect of the present invention there is provided a method for the detection of a fluid-borne particle in an optically defined detection zone, the method comprising:

- 5 i) providing a sample of fluid, containing the fluid-borne particle, in the form of a flow through the optically defined detection zone;
- ii) directing a beam of radiation that illuminates the optically defined detection zone and with uniform intensity of radiation;
- iii) detecting radiation scattered by the fluid-borne particle as it passes through the beam of radiation in the optically defined detection zone.

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Preferably the method employs an apparatus for the detection of a fluid-borne particle in an optically defined detection zone, the apparatus comprising:

- i) a scattering chamber;
- 15 ii) a means for providing a sample of fluid, comprising the fluid-borne particle, in the form of a flow through the optically defined detection zone;
- iii) a means for generating a beam of radiation through the optically defined detection zone;
- iv) a first reflector or refractor means;
- 20 v) a second reflector or refractor means;
- vi) a first detector means;
- vii) a second detector means; and
- viii) a means for deriving data from the radiation detected by the first and second detection means.

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wherein the first reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone into the first detector means and wherein the second reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone in to the second detector means.

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According to a fourth aspect of the present invention there is provided a method for the for the detection of a fluid-borne particle in an optically defined detection zone, the method comprising:

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- i) providing an apparatus having; a scattering chamber, a first reflector or refractor means, a second reflector or refractor means, a first detector means, and a second detector means;
- 5 ii) providing a sample of fluid in the form of a flow through the optically defined detection zone;
- iii) directing a beam of radiation that illuminates the optically defined detection zone with uniform intensity of radiation; and
- iv) deriving data from the radiation detected by the first and second detection means;

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wherein the first reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone into the first detector means and wherein the second reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone in to the second detector means.

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According to a fifth aspect of the present invention there is provided a method for the for the detection of a fluid-borne particle in an optically defined detection zone, the method comprising:

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- i) providing an apparatus as claimed in any of claims 1 to 15
- ii) providing a sample of fluid in the form of a flow through the optically defined detection zone;
- iii) directing a beam of radiation that illuminates the optically defined detection zone with uniform intensity of radiation; and
- 25 iv) deriving data from the radiation detected by the first and second detection means.

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The present invention seeks to provide a method of aerosol monitoring (having single particle sensitivity) which requires no air-pump or particle filter, and which is mechanically very simple, thus offering the prospect of manufacture using a small number of injection-moulded plastic parts. The air-movement may be achieved using a small electrical fan (far lower current consumption than a rotary-vane or diaphragm air-pump), by exploiting the natural movement of the ambient air (e.g.: wind, convection flow, etc.), or by simply moving the sensor unit itself through the air by hand or by attaching to a moving vehicle (car, train, aircraft, etc).

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The present invention is based on the principle of optically defining a detection zone rather than mechanically defining the zone as in conventional OPCs. As mentioned above, OPCs confine the sample airflow to a narrow column, typically ~1mm in diameter, which is directed through a narrow ribbon-shaped laser beam such that the intersection between the beam and the airflow – the detection zone – is sufficiently small that it very rarely contains more than a single particle even when measuring high-concentration aerosols. Avoiding ‘particle coincidences’ where two or more particles occupy the detection zone at any instant is crucial to obtaining unbiased aerosol size and concentration data.

In the present Invention, the sample air does not pass through a narrow inlet tube as in conventional OPCs, but instead passes through a far wider space that may or may not have cylindrical tube-like geometry. The particles carried by the air moving through this space are not constrained to move in single file by any mechanical tube or other device. The single-particle detection zone is instead defined by suitable optical components.

#### **Brief Description of the Drawings**

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A preferred embodiment of the present invention will now be more particularly described, by way of example only, with reference to the accompanying drawings, wherein:

25 Figure 1 shows a cross-sectional view of the particle detection apparatus according to a first embodiment;

Figure 2 shows a side perspective view of the particle detection apparatus inside the scattering chamber;

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Figure 3 shows a graphical display of the first and second detector responses of a particle passing through the first and second zones of the optical detection zone; and

35 Figure 4 shows a cross-sectional view of the particle detection apparatus according to a second embodiment.

### **Description of the Preferred Embodiments**

5 A preferred embodiment of the present invention is shown in Figure 1. In this embodiment, a small low-power electrical fan 1 causes particle-laden ambient air 2 to move through a scattering chamber 3 at a desired rate. The fan, in one alternative, is of a type commonly used to cool computer microprocessors, requiring a current of only a few milliamps; far less than the tens-of-milliamp currents required by conventional OPC air-pumps. The scattering chamber 3 has end-caps 4 that do not restrict the airflow but act as light baffles to prevent entry of ambient daylight or room-light. An alternative arrangement can be seen in Figure 4.

15 A beam of radiation from a continuous-wave laser 5 traverses the inside of the scattering chamber. The beam of radiation is configured using lenses and other optical components 6 to have a narrow elliptical cross-section with the major axis of the beam of radiation lying perpendicular to the direction of the air flow in the scattering chamber. Depending on the particulate concentration in the air, the beam of radiation may illuminate many particles simultaneously that all happen to be traversing at different points along the beam path. Finally, the beam of radiation exits the scattering chamber 3 and is absorbed in some form of beam-dump 7.

20 Above and below the beam of radiation on the opposite side of the scattering chamber 3 to the beam entry point are positioned first and second optical mirrors 8a, 8b having concave spherical surfaces. The first and second optical mirrors 8a, 8b are of the same size and are of the same curvature. Light scattered by a particle passing through a small region of the beam of radiation will be reflected by the first mirror 8a back across the scattering chamber and through apertures 9, and reflected by mirror 8b across to aperture 10, finally to fall onto respective first and second optical detectors 11, 12. The apertures 9, 10 are critical to the operation in one embodiment of the invention as they optically define the required detection zone as shown in Figure 2.

30 The first aperture 9 has a diameter such that when projected back via the mirror and onto the beam of radiation forms an elliptical field-of-view 14. This field-of-view is smaller than the width of the beam of radiation so as to minimise the effects of intensity variations across the beam of radiation resulting from the Gaussian beam intensity profile common in such laser beams. Any particle passing through this field-of-view will cause light to fall onto the detector 11. In itself, the resulting detector signal can be

used to register the presence of a particle. However, it cannot be used to size the particle because of so-called 'edge effects', i.e: light scattered by a particle passing through the edge of the field-of-view will suffer some vignetting of the rays collected by the mirror, resulting in a lower signal on the detector 11 and the under-sizing of the particle. The second mirror-aperture assembly overcomes this.

The second aperture 10 is smaller than the first so as to project a field-of-view 16 that lies entirely within the first field-of-view 14, as in Figure 2. This field-of-view is sufficiently small that the maximum intensity variation across it resulting from the, normally, Gaussian beam intensity profile is acceptable, typically <5%. It is only particles passing through this well-defined region of space of the smaller field-of-view 16 that will be deemed 'valid' particles in particle counting and sizing determination. Typically for normal ground level applications (i.e. in the vicinity of the ground at low altitudes rather than at high altitudes) the first aperture 9 is around 400 $\mu\text{m}$  and the second aperture 10 is between 200 and 250 $\mu\text{m}$ .

In operation, therefore, a particle traversing the beam along trajectory A will not be 'seen' by either optical detector 11 or 12. A particle on trajectory B will be detected by detector 11 but not by detector 12, and will therefore be ignored. A particle on trajectory C, however, will be detected simultaneously by both detector 11 and detector 12, and will be recorded as a single valid particle, as illustrated in Figure 3. Edge effects caused by a particle traversing the edge of field-of-view 16 are unimportant as the signal used to infer particle size is not that from detector 12, which will suffer edge effects, but instead that from detector 11, which since the particle is well away from its boundary, will not suffer edge effects. Typically for normal ground level applications the particles being detected are in the size range of around 0.5 to 10 $\mu\text{m}$  in diameter.

The concentration of particles in the aerosol may be computed using the product of the air velocity through the laser beam and the cross-sectional area of field-of-view 16. This velocity may be determined from a knowledge of the beam-depth, being the minor axis of its elliptical beam cross-section, and the time-of-flight of the particle through the beam, as measured from the duration of the electrical signal from detector 11. Typically for normal ground level applications the minor axis of the elliptical cross-section of the beam of radiation is around 100 $\mu\text{m}$  and the major axis is around 2mm.

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The maximum measurable particulate concentration will be reached when the probability of more than one particle being within field-of-view 16 reaches an unacceptable level, typically ~2% maximum, or when there is a particle within field-of-view 16 at the same instant as a particle outside of field-of-view 16 but within field-of-view 14. The beam depth and detector fields-of-view are selected such that this would not occur for concentrations less than typically several thousand particles per millilitre of air.

The apparatus as described offers several advantages over conventional OPCs;

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- Mechanical simplicity. The absence of internal pipework, filters, and tubing common in conventional OPC units means that the invention could be fabricated at a low manufacturing cost, especially if specialist plastic injection moulded parts (including mirrored surfaces) were employed. In such a case, the scattering chamber 3 comprises two semi-cylindrical parts, the first part with integral first and second mirrored surfaces 8a, 8b and the second part with first and second precision apertures 9 and 10. The integral first and second mirrored surfaces 8a, 8b are formed by injection moulding the scattering chamber 3 with integral first and second concave surfaces which are then provided with a coating of a reflective material.

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- The air fan 1 would be capable of moving large volumes of air, required in efficient ambient monitoring, with very low power consumption, since it would be operating against minimal pressure drop. This could significantly extend the battery life of a standalone or hand-held unit compared to that in a conventional OPC with comparable sample air flow-rate. Indeed, the fan would not be necessary at all in some cases. For example, where the airflow through the sensor unit was generated by movement of the unit itself through the air, such as 'waving' a hand-held unit at arm's length, in which case, the end-caps 3 would be replaced by a low flow impedance light block such as counter-aligned opaque louvers 17, as in the embodiment shown in Figure 4. Such a 'no moving parts' implementation of the invention would be not only be even cheaper to manufacture than the fan-assisted version of the invention but would also offer improved reliability, it having no moving parts to wear out.

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- In addition as no pump is required, the scattering chamber 3 does not need to be air-tight. In conventional OPC devices where a pump is required to suck the air through the narrow mechanically defined detection zone, the scattering chamber 3 needs to be air-tight. The scattering chamber needs to be air-tight, because the air pressure or vacuum drop required to cause the air to flow through the narrow mechanically defined detection zone is significant. In the present invention there is no air pressure or vacuum drop needed as the scattering chamber 3 is large and the detection zone is defined optically rather than mechanically the air-tightness is not critical. This means that the scattering chamber 3 can be formed from a plastics material rather than a metal material. This allows for a cheaper and lighter apparatus to be constructed.
- Further in addition, if a fan is employed the fan is located below the detection zone such that any particles depositing on the fan blades have already been detected.
- The apparatus would require no periodic replacement of internal filter units, making it more suitable than conventional OPCs in remote or hostile monitoring environments where manual filter replacement is undesirable on grounds of inaccessibility or safety hazard.

In an alternative embodiment of the present invention instead of the radiation scattered by a particle being reflected by the first and second mirrors through respective first and second apertures and into the respective first and second detectors, the scattering chamber 3 is provided with first and second apertures through which radiation exits the scattering chamber 3 which is then focussed into respective first and second detectors by the use of respective first and second lenses. In this embodiment, again, the first and second apertures are of different sizes and correlate to form inner and outer zones of an optical detection zone.

**CLAIMS:**

1. An apparatus for the detection of a fluid-borne particle in an optically defined detection zone, the apparatus comprising:
- 5 i) a scattering chamber;
  - ii) a means for providing a sample of fluid, containing the fluid-borne particle, in the form of a flow through the optically defined detection zone;
  - 10 iii) a means for generating a beam of radiation through the optically defined detection zone;
  - iv) a first reflector or refractor means;
  - v) a second reflector or refractor means;
  - vi) a first detector means;
  - vii) a second detector means; and
  - 15 viii) a means for deriving data from the radiation detected by the first and second detection means

wherein the first reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone into the first detector means and wherein the second reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone in to the second detector means.

- 25 2. An apparatus as claimed in claim 1 wherein the optically defined detection zone comprises a first zone and a second zone wherein the second zone is smaller than the first zone and wherein the second zone is located wholly inside the first zone.

3. An apparatus as claimed in claim 2 wherein the first zone is defined by a first aperture located between the first reflector or refractor means and the first detector means and wherein the second zone is defined by a second aperture located between the second reflector or refractor means and the second detector means.

- 35 4. An apparatus as claimed in claim 3 wherein the second aperture is smaller than the first aperture.

5. An apparatus as claimed in any preceding claim, wherein the apparatus further comprises focussing means adapted to focus the beam of radiation such that the beam of radiation has an elliptical cross-section.

5 6. An apparatus as claimed in Claim 5, wherein the major axis of the elliptical cross-section is orthogonal/perpendicular to the direction of fluid flow.

7. An apparatus as claimed in any preceding claim wherein the beam of radiation is generated using a diode laser.

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8. An apparatus as claimed in any preceding claim wherein the means for providing a sample of fluid in the form of a flow through the optically defined detection zone comprises an open ended tube of a diameter larger than the optically defined detection zone in the scattering chamber through which fluid can freely flow.

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9. An apparatus as claimed in any preceding claim wherein the means for providing a sample of fluid in the form of a flow through the optically defined detection zone comprises a fan.

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10. An apparatus as claimed in any preceding claim wherein the first and second reflector or refractor means comprise mirrors.

11. An apparatus as claimed in claim 10, wherein the mirrors comprise concave mirrors.

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12. An apparatus as claimed in any preceding claim wherein the first and second reflector or refractor means are arranged above and below the beam of radiation.

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13. An apparatus as claimed in Claim 12 when dependent on Claim 5, wherein the first and second reflector or refractor means are arranged above and below the plane containing the major axis of the cross-section of the beam of radiation.

14. An apparatus as claimed in any preceding claim wherein the first and second reflector means are integrally formed in the scattering chamber.

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15. An apparatus as claimed in any preceding claim wherein the scattering chamber is formed from an injection moulded plastics material.

16. An apparatus as claimed in any preceding claim wherein a first and second concave surface are formed integrally within the scattering chamber.

17. An apparatus as claimed in claim 16, wherein the first and second concave surfaces are provided with a reflective material to form the first and second reflector or refractor means.

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18. A method for the for the detection of a fluid-borne particle in an optically defined detection zone, the method comprising:

- i) providing a sample of fluid, containing the fluid-borne particle, in the form of a flow through the optically defined detection zone;
- ii) directing a beam of radiation that illuminates the optically defined detection zone with uniform intensity of radiation; and
- iii) detecting radiation scattered by the fluid-borne particle as it passes through the beam of radiation in the optically defined detection zone.

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19. A method for the for the detection of a fluid-borne particle in an optically defined detection zone, the method comprising:

- i) providing an apparatus having; a scattering chamber, a first reflector or refractor means, a second reflector or refractor means, a first detector means, and a second detector means;
- ii) providing a sample of fluid in the form of a flow through the optically defined detection zone;
- iii) directing a beam of radiation that illuminates the optically defined detection zone with uniform intensity of radiation; and
- iv) deriving data from the radiation detected by the first and second detection means;

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wherein the first reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone into the first detector means and wherein the second reflector or refractor means is adapted to direct radiation scattered from the fluid borne particle

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passing through the beam of radiation in the optically defined detection zone in to the second detector means.

20. A method for the for the detection of a fluid-borne particle in an optically defined  
5 detection zone, the method comprising:

- i) providing an apparatus as claimed in any of claims 1 to 15
- ii) providing a sample of fluid in the form of a flow through the optically defined detection zone;
- iii) directing a beam of radiation that illuminates the optically defined  
10 detection zone with uniform intensity of radiation; and
- iv) deriving data from the radiation detected by the first and second detection means.

21. An apparatus or method substantially as hereinbefore described with reference  
15 to any suitable combination of the accompanying figures.

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**CLAIMS:**

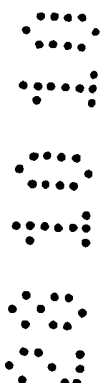
1. An apparatus for the detection of a fluid-borne particle in an optically defined detection zone, the apparatus comprising:

- 5 i) a scattering chamber;
- ii) a means for providing a sample of fluid, containing the fluid-borne particle, in the form of a flow through the optically defined detection zone;
- 10 iii) a means for generating a beam of radiation through the optically defined detection zone;
- iv) a first reflector means;
- v) a second reflector means;
- vi) a first detector means;
- vii) a second detector means; and
- 15 viii) a means for deriving data from the radiation detected by the first and second detection means

wherein the first reflector means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined  
20 detection zone into the first detector means and wherein the second reflector means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone in to the second detector means and wherein the optically defined detection zone comprises a first zone and a second zone wherein the second zone is smaller than the first zone and wherein the  
25 second zone is located wholly inside the first zone.

2. An apparatus as claimed in claim 1 wherein the first zone is defined by a first aperture located between the first reflector means and the first detector means and wherein the second zone is defined by a second aperture located between the second  
30 reflector means and the second detector means.

3. An apparatus as claimed in claim 2 wherein the second aperture is smaller than the first aperture.



4. An apparatus as claimed in any preceding claim, wherein the apparatus further comprises focussing means adapted to focus the beam of radiation such that the beam of radiation has an elliptical cross-section.

5 5. An apparatus as claimed in Claim 4, wherein the major axis of the elliptical cross-section is orthogonal/perpendicular to the direction of fluid flow.

6. An apparatus as claimed in any preceding claim wherein the beam of radiation is generated using a diode laser.

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7. An apparatus as claimed in any preceding claim wherein the means for providing a sample of fluid in the form of a flow through the optically defined detection zone comprises an open ended tube of a diameter larger than the optically defined detection zone in the scattering chamber through which fluid can freely flow.

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8. An apparatus as claimed in any preceding claim wherein the means for providing a sample of fluid in the form of a flow through the optically defined detection zone comprises a fan.

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9. An apparatus as claimed in any preceding claim wherein the first and second reflector means comprise mirrors.

10. An apparatus as claimed in claim 9, wherein the mirrors comprise concave mirrors.

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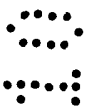
11. An apparatus as claimed in any preceding claim wherein the first and second reflector means are arranged above and below the beam of radiation.

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12. An apparatus as claimed in Claim 11 when dependent on Claim 4, wherein the first and second reflector means are arranged above and below the plane containing the major axis of the cross-section of the beam of radiation.

13. An apparatus as claimed in any preceding claim wherein the first and second reflector means are integrally formed in the scattering chamber.

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14. An apparatus as claimed in any preceding claim wherein the scattering chamber is formed from an injection moulded plastics material.

15. An apparatus as claimed in any preceding claim wherein a first and second concave surface are formed integrally within the scattering chamber.

16. An apparatus as claimed in claim 15, wherein the first and second concave surfaces are provided with a reflective material to form the first and second reflector means.

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18. A method for the for the detection of a fluid-borne particle in an optically defined detection zone, the method comprising:

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i) providing an apparatus having; a scattering chamber, a first reflector means, a second reflector means, a first detector means, and a second detector means;

ii) providing a sample of fluid in the form of a flow through the optically defined detection zone;

iii) directing a beam of radiation that illuminates the optically defined detection zone with uniform intensity of radiation; and

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iv) deriving data from the radiation detected by the first and second detection means;

wherein the first reflector means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone into the first detector means and wherein the second reflector means is adapted to direct radiation scattered from the fluid borne particle passing through the beam of radiation in the optically defined detection zone in to the second detector means and wherein the optically defined detection zone comprises a first zone and a second zone wherein the second zone is smaller than the first zone and wherein the second zone is located wholly inside the first zone.

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20. A method for the for the detection of a fluid-borne particle in an optically defined detection zone, the method comprising:

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i) providing an apparatus as claimed in any of claims 1 to 15

ii) providing a sample of fluid in the form of a flow through the optically defined detection zone;

iii) directing a beam of radiation that illuminates the optically defined detection zone with uniform intensity of radiation; and

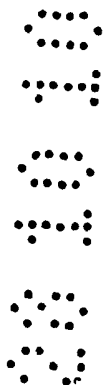
iv) deriving data from the radiation detected by the first and second detection means.

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21. An apparatus or method substantially as hereinbefore described with reference to any suitable combination of the accompanying figures.

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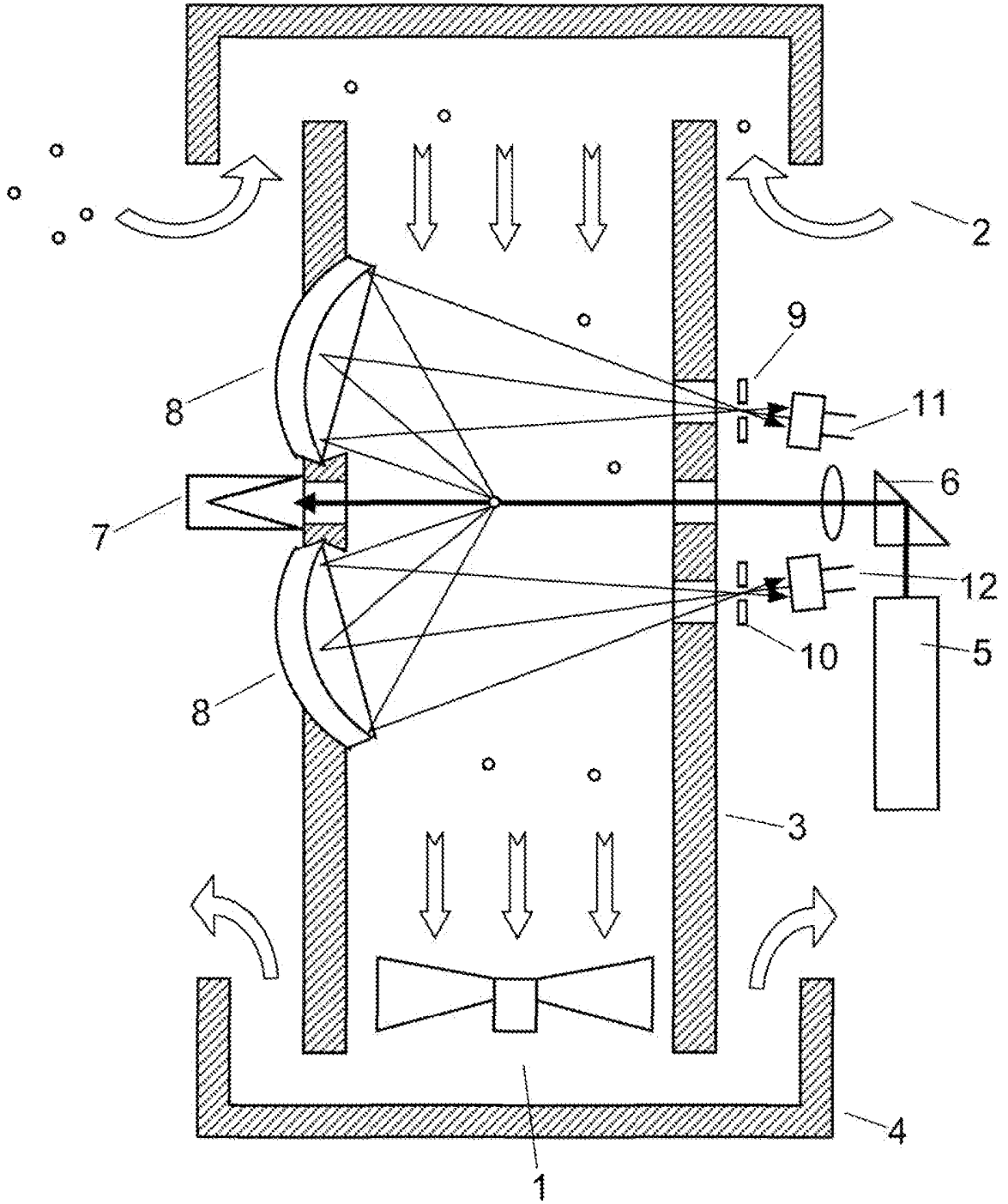


Figure 1

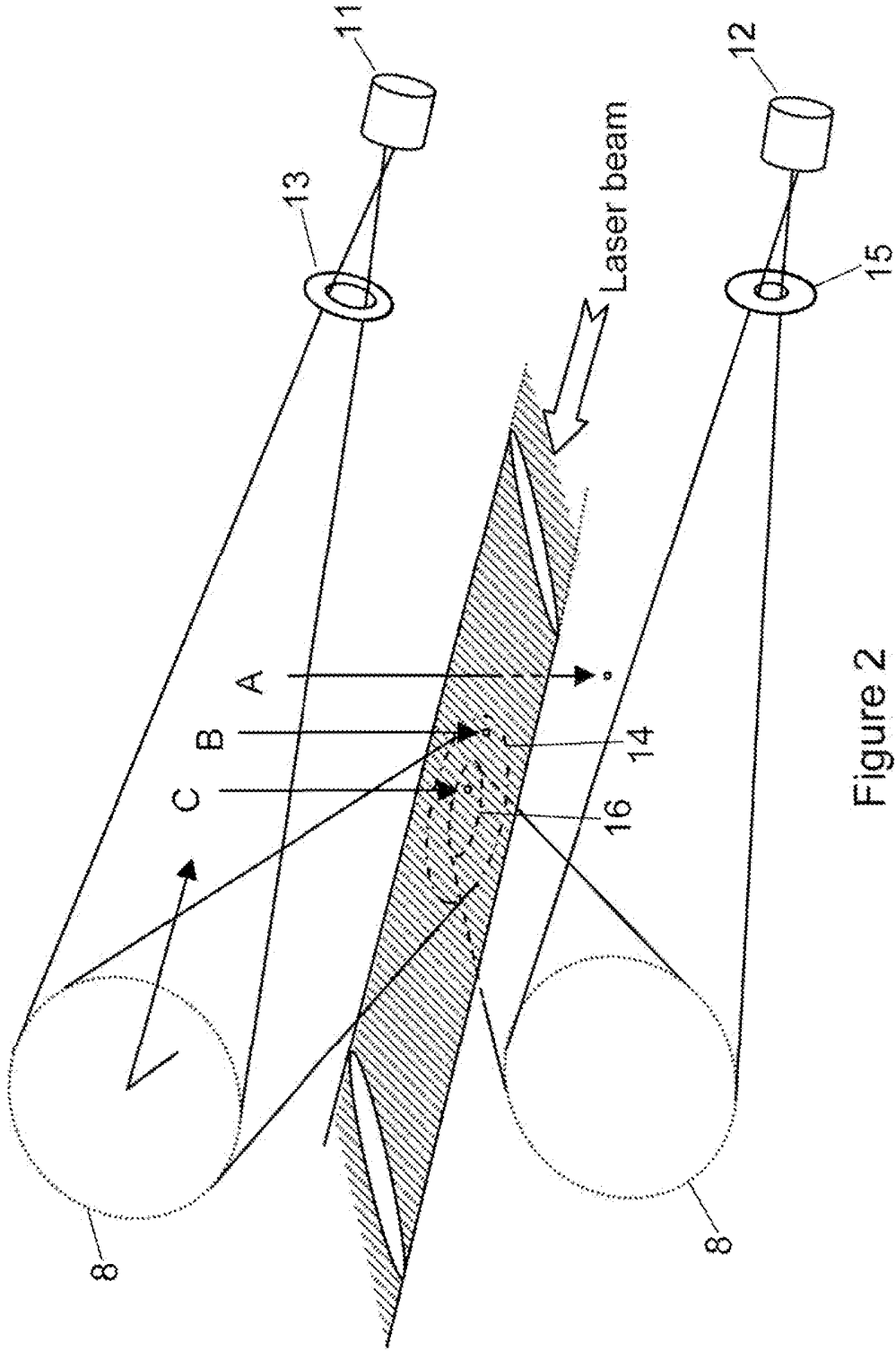


Figure 2

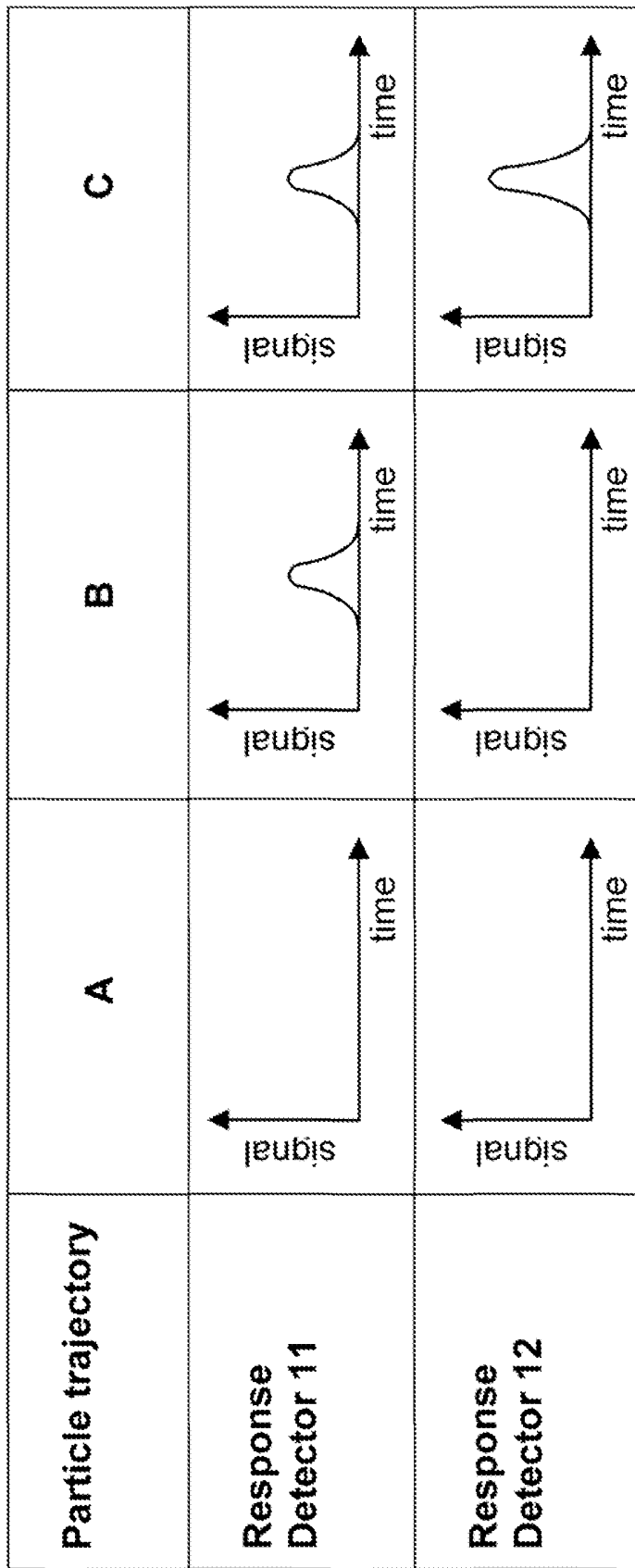


Figure 3



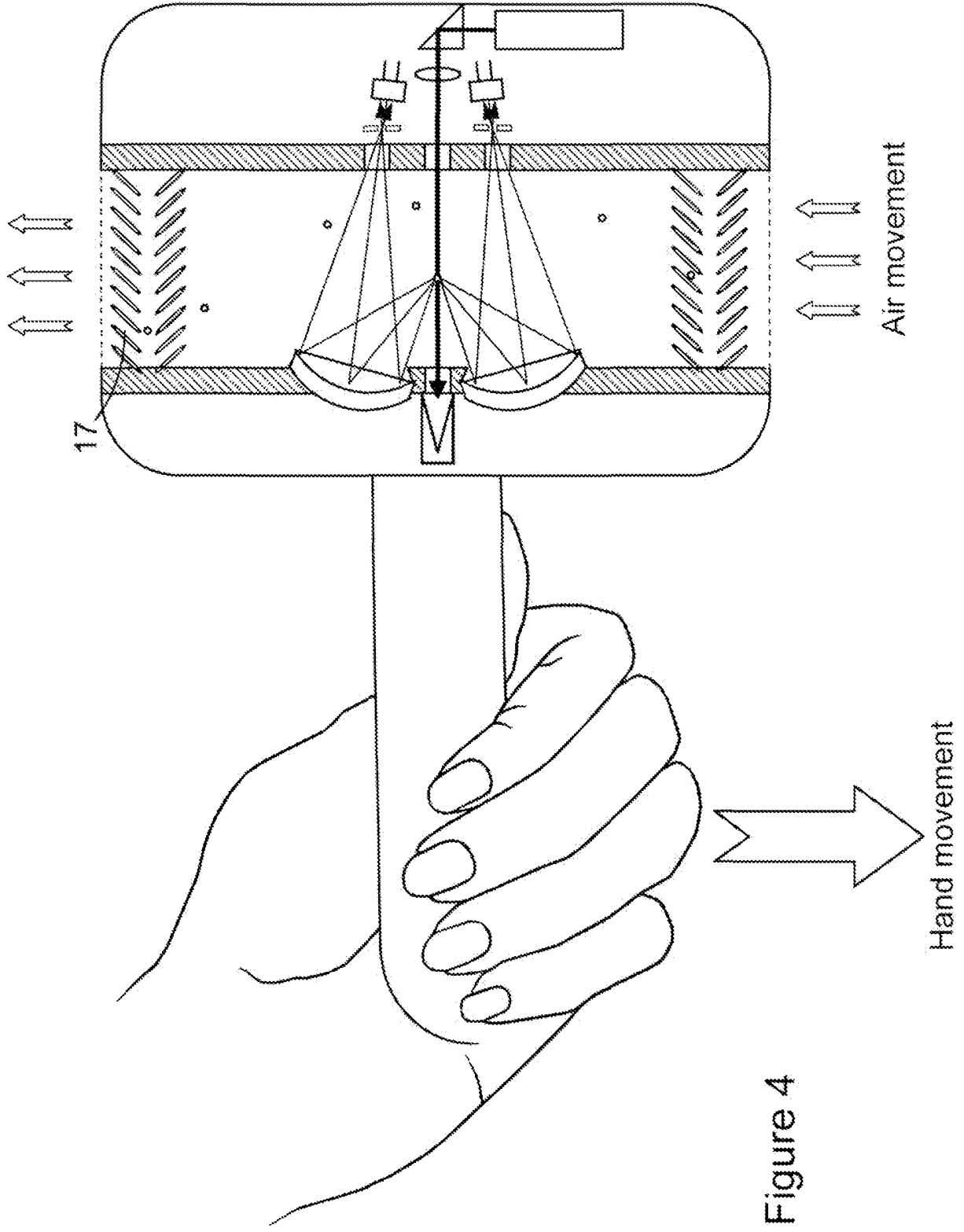


Figure 4



**Application No:** GB0917444.2

**Examiner:** Mr Mike Walker

**Claims searched:** ALL

**Date of search:** 27 January 2010

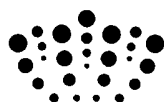
**Patents Act 1977: Search Report under Section 17**

**Documents considered to be relevant:**

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1,7,9-14,16-20	WO2005/001436 A1 (SECR OF DEFENCE) see figs 1-4; p.11, ll.14-36
X	1,7,10,11,14,16-20	US5467189 A (KREIKEBAUM) see abstract
X	1,3,7,10,11,14,16-20	GB2456671 A (SECR OF DEFENCE) whole document
X	1,7,8,18-20	US4662742 A (CHUPP) see whole document
X	1,10,18-20	US7113266 B1 (WELLS) col.6, line 20 onwards
X	1,10,18-20	EP0361503 A1 (TOA MEDICAL) col.8, l.48 to col.9, l.28
X	18	WO2008/140816 A1 (UNGER) see abstract
X	18	US2005/0021244 A1 (NICOLI) see especially figs 29,31 and 32A which shows a particle sizing system having twin detectors
X	18	US5870190 A (UNGER) see col.5, l.9 onwards

**Categories:**

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.



**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>X</sup> :

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Worldwide search of patent documents classified in the following areas of the IPC

G01N
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The following online and other databases have been used in the preparation of this search report

EPODOC, WPI
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**International Classification:**

Subclass	Subgroup	Valid From
G01N	0015/02	01/01/2006
G01N	0015/14	01/01/2006
G01N	0021/53	01/01/2006