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(54) **Title**: PARTICLE PRECIPITATOR

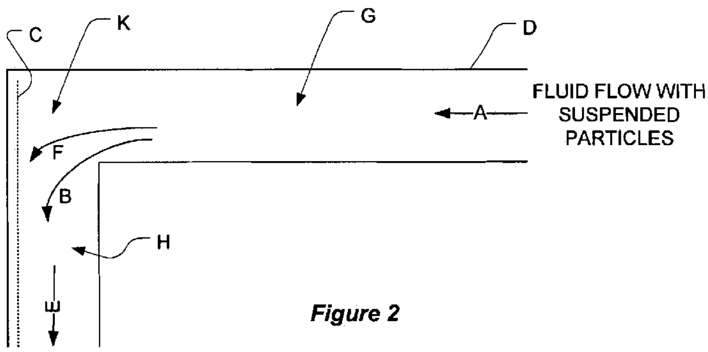

Figure 2

(57) **Abstract**: A particle separation system for separating particles (B, F) in an airflow (A) upstream of a detection chamber in an aspirating smoke detector is disclosed. The particle separation system includes an airflow path (D) for directing the airflow from an inlet to an outlet. The airflow path (D) includes a first airflow path section (G) in a first direction and a second airflow path section (H) in a second direction, the first and second directions being different relative to each other. The airflow path also includes at least one electrically charged surface (C) such that the airflow (A) undergoes electrostatic precipitation as it traverses the airflow path (D). A method of separating particles in an airflow upstream of a detection chamber in an aspirating smoke detector is also disclosed.

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Particle precipitator

Field of the invention

The present invention relates to a particle precipitator employed in a sensing system for detecting particles in an airflow. More particularly, although not exclusively, the invention relates to an aspirating smoke detector, however the invention is not limited to this particular application and other types of sensing systems for detecting particles in an airflow are included within the scope of the present invention.

Background of the invention

Smoke detection systems can be falsely triggered by exposure to dust. In aspirating smoke detection systems, various analytical solutions have been implemented in order to detect the dust and thereby avoid a false alarm. In light-scatter-based smoke detection systems, dust discrimination or rejection may be implemented by using time-amplitude analysis (dust tends to produce a spike in the scatter signal) or by using multiple light wavelengths, multiple polarisations, multiple viewing angles, inertial separation, or combinations of the above. These analytical tools can unnecessarily complicate the smoke detection systems.

In order to avoid or reduce the problems associated with dust it is advantageous to limit the introduction of dust into the analysis site. This is typically performed by use of a foam, HEPA, or other mechanical filter. However, over time such filters may block, increasing resistance to air flow and extreme cases may even prevent smoke particles reaching the detection chamber.

It is therefore an object of the present invention to provide an improved particle separation system.

Reference to any prior art in the specification is not, and should not be taken as, an acknowledgment or any form of suggestion that this prior art forms part of the common general knowledge in Australia or any other jurisdiction or that this prior art could reasonably be expected to be ascertained, understood and regarded as relevant by a person skilled in the art.

Summary of the invention

In accordance with a first aspect of the present invention, there is provided a particle separation system for separating particles in an airflow upstream of a detection chamber in an aspirating smoke detector, the particle separation system including an airflow path for directing the airflow from an inlet to an outlet, the airflow path including:

a first airflow path section in a first direction and a second airflow path section in a second direction, the first and second directions being different relative to each other; and

at least one electrically charged surface such that the airflow undergoes electrostatic precipitation as it traverses the airflow path.

Advantageously, the first and second airflow path sections are arranged relative to each other such that a bend or curve is formed in the airflow path where the two sections meet, and the airflow is caused to travel around the bend or curve as it moves from the inlet to the outlet. The intersection between the first airflow path section and the second airflow path section may include a transition region between the first and second directions.

In a preferred embodiment, the first and second airflow path sections are arranged at substantially 90° to each other in order to introduce a sharp bend into the airflow path. Other forms of bends or curves are envisaged by the invention.

Preferably the electrically charged surface is located downstream and adjacent the transition region between the first and second directions. Advantageously the electrically charged surface is located on the outside of the bend or curve such that larger particles are carried closer to the charged surface by their momentum as they traverse the bend or curve.

The electrically charged surface preferably takes the form of a substantially smooth surface and may form a wall of the airflow path. Alternatively, the electrically charged surface is folded, corrugated, textured, or similar in order to present a greater surface area to the airflow so as to attract more particles.

The first aspect of the invention also provides a method for separating particles in an airflow upstream of a detection chamber in an aspirating smoke detector, the method including:

directing the airflow along a first airflow path section in a first direction and then along a second airflow path section in a second direction, wherein the first direction and second direction are different relative to each other; and

providing at least one electrically charged surface within the airflow path such that the airflow undergoes electrostatic precipitation as it traverses the airflow path.

Advantageously, the method includes locating the electrically charged surface downstream and adjacent a transition region between the first and second directions.

In a second aspect of the invention there is provided a particle separation system for separating particles in an airflow upstream of a detection chamber in an aspirating smoke detector, the particle separation system including:

a particle separation chamber having a first volume;

an inlet airflow path for introducing the airflow into the particle separation chamber; and

an outlet airflow path for exiting the airflow from the particle separation chamber;

wherein the inlet and outlet airflow paths have volumes smaller than the first volume such that the airflow introduced into the particle separation chamber is caused to rapidly expand in a first region; and wherein the particle separation chamber includes one or more electrically charged surfaces adjacent the first region.

Preferably, the one or more electrically charged surfaces are in the form of plates that may also form one or more walls of the chamber. Alternatively, the electrically charged surfaces may be folded, corrugated, textured, or similar in order to present a greater surface area to the airflow so as to attract more particles.

Advantageously, the particle separation chamber is an electrostatic precipitation chamber.

In a further embodiment of the second aspect of the invention, the particle separation chamber further includes a barrier or wall means located in front of and near the inlet airflow path such that as the airflow is introduced into the chamber it is caused to diverge around the barrier or wall means. Advantageously, the barrier is located in such a position to cause eddies to develop in the airflow. In this manner the airflow cycles in the chamber bringing it into contact with the one or more electrically charged surfaces several times.

The second aspect of the invention also provides a method for separating particles in an airflow upstream of a detection chamber in an aspirating smoke detector, the method including:

introducing the airflow into a particle separation chamber;

causing the airflow to undergo a rapid expansion within the particle separation chamber in a first region;

providing one or more electrically charged surfaces adjacent the first region for attracting larger particles out of the airflow; and

exiting the airflow from the particle separation chamber.

Advantageously, the method further includes providing a barrier within the particle separation chamber to create eddies in the airflow and increase contact of the airflow with the one or more electrically charged surfaces.

In aspects of the invention described above, the electrically charged surface may be an electret material (polarised polymer), an actively charged surface relying on a high-voltage source to maintain the surface potential, or the charge may be intrinsic in the surface itself. For example, the charge may be intrinsic in the manufacture of the pipe or duct through which the airflow flows. In particular, electrically charged regions can develop during the plastics moulding process and the desired electrostatic field may be obtained without the need for a separate charged surface.

The applicant has further observed that the efficiency of particle removal from the airflow can diminish over time, generally due to the accumulation of particulate material on the electrically charged surfaces.

In a third aspect the invention accordingly provides a detection system for detecting particle accumulation in a particle separation system, the particle separation system including one or more electrically charged surfaces, the one or more electrically charged surfaces being at least partially transparent, the detection system including:

a light source for directing light towards at least one of the electrically charged surfaces; and

a receiver for detecting the intensity of the light transmitted through or reflected from the at least one electrically charged surface.

The third aspect of the invention also extends to a method of detecting particle accumulation in a particle separation system, the particle separation system including one or more electrically charged surfaces, the one or more electrically charged surfaces being at least partially transparent, the method including

providing a light source and directing light towards at least one of the electrically charged surfaces;

providing a receiver and detecting the intensity of the light transmitted though the at least one electrically charged surface;

obtaining two or more measurements of the intensity of light transmitted over time;

comparing the two or measurements of the intensity of light transmitted and determining from the comparison if the intensity of light transmitted has reduced over time.

The invention further provides a method of detecting particle accumulation in a particle separation system, the particle separation system including one or more electrically charged surfaces, the one or more electrically charged surfaces being at least partially transparent, the method including

providing a light source and directing light towards at least one of the electrically charged surfaces;

providing a receiver and detecting the intensity of the light reflected from the at least one electrically charged surface;

obtaining two or more measurements of the intensity of light reflected over time;

comparing the two or measurements of the intensity of light reflected and determining from the comparison if the intensity of light reflected has increased over time.

In a further aspect of the invention there is provided a detection system for detecting particle accumulation in a particle separation system, the particle separation system including one or more electrically charged surfaces, the detection system including:

an acoustic transducer to mechanically excite vibration in at least one of the electrically charged surfaces; and a detector for measuring the intensity of damping or resonance of the at least one electrically charged surface.

There is also provided a method of detecting particle accumulation in a particle separation system, the particle separation system including one or more electrically charged surfaces, the method including

providing an acoustic transducer and mechanically exciting vibration in at least one of the electrically charged surfaces;

providing a detector and measuring the intensity of damping of the at least one electrically charged surface;

obtaining two or more measurements of the intensity of damping over time;

comparing the two or measurements of the intensity of damping and determining from the comparison if the damping has increased over time.

There is also provided a method of detecting particle accumulation in a particle separation system, the particle separation system including one or more electrically charged surfaces, the method including

providing an acoustic transducer and mechanically exciting vibration in at least one of the electrically charged surfaces;

providing a detector and measuring the intensity of resonance of the at least one electrically charged surface;

obtaining two or more measurements of the intensity of resonance over time;

comparing the two or measurements of the intensity of resonance and determining from the comparison if the resonance has reduced over time.

In a preferred embodiment, the acoustic transducer may be the electrically charged surface itself. Alternatively, the electrically charged surface may consist of a piezoelectric material, such as PVDF, which allows for both the provision of a charged surface and for exciting the surface acoustically.

In all aspects of the invention, the particle separation systems and detection systems described above may form part of a sensing system for detecting particles in an airflow. The sensing system may include a detector to which the airflow flows for testing. The detector may be in the form of a particle detector such as a light-scatter particle detector. Preferably, the particle detector is a smoke detector. Suitably, the detector is connected to the fire alarm loop and optionally, to an appropriate suppressant system. A fan may be included in the particle separation system to induce air flow through the system.

In particularly preferred embodiments, the particle separation systems and detection systems described above are located upstream of a detection chamber of an aspirating smoke detector.

Brief description of the drawings

Exemplary embodiments of the present invention will now be described by way of non-limiting example only, with reference to the accompanying drawings, in which:

Figure 1 illustrates an electrostatic precipitation chamber of an aspirating smoke detector according to a first preferred embodiment of the invention;

Figure 2 illustrates a particle separation system according to second preferred embodiment of the present invention;

Figure 3 illustrates an alternative embodiment of the particle separation system of Figure 2;

Figure 4 illustrates a particle separation system according to a third preferred embodiment of the present invention;

Figure 5 illustrates an alternative embodiment of the particle separation system of Figure 4;

Figure 6 illustrates a further alternative embodiment of the particle separation system of Figure 4;

Figure 7 illustrates a detection system according to a fourth preferred embodiment of the present invention;

Figure 8 illustrates an alternative embodiment of the detection system of Figure 7; and

Figure 9 illustrates a detection system according to a further embodiment of the present invention.

Description of preferred embodiments

Figure 1 illustrates the operation of an electrostatic precipitation chamber located upstream of a detection chamber (not shown) of an aspirating smoke detector (not shown). The airflow entering the electrostatic precipitation chamber generally contains a range of particles - larger particles, generally associated with dust rather than smoke, and smaller particles which are generally associated with smoke. In an aspirating smoke detector, the object of the electrostatic precipitation chamber is to preferentially attract the larger particles out of the airflow leaving the smaller particles unaffected so that they can travel to the detection chamber of the smoke detector.

Referring to Figure 1, the air flow A containing suspended particles enters a pipe region D. Electrically charged surfaces C attract particulates B out of the flow resulting in an outflow E with a reduced particle content. The electrostatic field may be passively or actively generated and may be adjusted such that larger particles are preferentially drawn out of the airflow leaving relatively smaller particles to continue in outflow E.

In alternative, more complex embodiments the inventors have realised that inertial separation techniques can be combined with electrostatic filtration techniques to enhance performance of the system. In this regard, the airflow changed or path can be shaped, disturbed in such a way that heavy and light particles take different paths. In combination with this the electrostatic precipitator can be placed such that the heavy particles are more likely to be located closer to it, thus increasing the relative capture of the heavy particles. Figure 2 illustrates a particle separation system according to a second embodiment of the invention. The particle separation system includes an airflow path defined by pipe D which further includes a first airflow section G and second airflow section H that are arranged at 90° to each other, thereby introducing a sharp bend K in the pipe D. The bend K forms a transition region between the first airflow section G and second airflow section H.

An electrically charged surface C is provided downstream and adjacent the transition region, and on the outside of the bend as illustrated. The electrically charged surface is a smooth surface and may form a wall of the pipe D.

Air flow with suspended particles A enters the pipe D at the inlet end, travels through pipe D and around the bend K. As indicated in Figure 2, as the fluid flow A passes around the bend, the larger, heavier particles F tend to take a wider path around the bend as they are carried by their momentum and approach the electrically charged surface C and adhere to it while the lighter, smaller particles B follow the air stream more closely and exit the pipe D as part of the remaining flow E.

It will be appreciated that other forms of bends or curves may be utilised to alter the direction of travel of the airflow such that larger particles within the airflow come into close proximity to the electrically charged surface by virtue of their own momentum as the airflow travels around the bend or curve.

Figure 3 illustrates an alternate form of electrically charged surface C. In this embodiment the electrically charged surface C is folded in order to present a larger surface area to the air flow A. By increasing the surface area of the electrically charged surface C by folding, corrugating, or similarly texturing the surface, the number of particles intercepted by the charged surface C is increased.

A further embodiment of a particle separation system is illustrated in Figure 4. Air flow with suspended particles A enters via a relatively small dimension inlet into chamber J where the air flow undergoes a rapid expansion in region H before contracting again to leave the chamber via an outlet which is also of relatively small dimension. Electrically charged surfaces C are located within the chamber and preferably line the perimeter walls. Most preferably the electrically charged surfaces C are located adjacent the region of rapid expansion and towards the outlet.

Smaller particles B follow the streamlines more readily and leave the chamber J as part of the exit stream E. Larger, heavier particles F lag the air stream motion and as a result are more likely to approach the electrically charged surfaces C to which they will adhere.

Further variations to the system of Figure 4 are illustrated in Figures 5 and 6. In Figure 5 a barrier G is placed in front of the entering air flow A. The air stream diverges to move around the barrier causing eddies to develop. This brings the air stream, and consequently the particles suspended therein, to cycle into close contact with the electrically charged surfaces C several times, thus increasing the likelihood of suspended particles adhering to the charged surfaces C. The larger heavier particles are more likely to be at the periphery of the eddies due to centrifugal acceleration and are therefore preferentially removed from the air stream.

Referring to Figure 6, the capture of larger, heavier particles is enhanced by increasing the area of the charged surface C that is exposed to the air stream. In the illustrated configuration, the electrically charged surface C is constructed as a folded arrangement. Eddies in the air stream cycle while in close proximity to the extended surface area of C and the charged surface is therefore more effective in removing suspended particles. Due to the cyclic nature of the eddies and the centrifugal acceleration arising therefrom, larger, heavier particles are preferentially removed during the traversal of the electrically charged surface C.

It will be appreciated that there are variations on the configurations illustrated, involving more elaborate structures designed to direct the heavier, larger particles onto or near the electrically charged surface.

In a further preferred embodiment the electrically charged surface is an electret material (polarised polymer), or an actively charged surface relying on a high-voltage source to maintain the surface potential. Alternatively, the electric charge may be intrinsic in the manufacture of the pipe or duct through which the air flows. Electrically charged regions can develop during the plastic moulding process and the appropriate choice of material and moulding technique may be sufficient to produce the desired electrostatic field avoiding the need for a separate charged surface.

It has been observed, as is expected, that the efficiency of removal of particles from the air flow diminishes over time as the charged surface accumulates particulate material. It is therefore advantageous to incorporate a detection system that can determine the amount of material accumulated in order to signal the need for replacement or cleaning of the charged surface.

In a further embodiment of the invention, the charged surfaces are made of a transparent or partially transparent material, and the detection system employs parameters such as the reflection of light from or transmission of light through the charged surface. Such parameters vary over time and are used to indicate the need for replacement or other maintenance.

A detection system as envisaged above is shown in Figures 7 and 8. In Figure 7 a light source K transmits light M though a transparent charged surface C to receiver L. As the surface C becomes contaminated the received light intensity at receiver L is reduced.

Similarly in Figure 8. A light source K transmits light onto the transparent charged surface C. Some of the light M is received by the receiver L. The amount of light so reflected depends on the amount of particulate on the surface C and so this can be used to indicate that maintenance is required.

A similar method of detecting accumulated material on the charged surfaces involves using an acoustic transducer to excite the charged surface acoustically and measure parameters such as resonance and damping.

As shown in Figure 9, acoustic transducer N is used to mechanically excite vibration in the charged surface C. Measurement of damping or resonance indicate the extent to which mass is adhering to the charged surface C.

In some embodiments the transducer used may be the charged surface itself. For example, an electrostatic loudspeaker may be made by placing a charged surface between electrodes and varying the voltage between the parts of the surface or electrode structure. In another variation, the charged material may be made of a piezoelectric material, such as PVDF which will allow for both maintaining a charged surface and for exciting the surface acoustically.

It will be understood that any of the optical or acoustic parameters described above, either singly or in combination may be useful in determining the extent of material adhering to the charged surface and therefore the need for maintenance.

It will be appreciated that the preferred embodiments of the present invention provide improved particle separation systems resulting in improved particle separation and therefore dust rejection. Particle separation systems as described incorporated in smoke detection systems reduce the likelihood of false alarms triggered by exposure to dust for a given alarm level setting.

Figure 10 illustrates an exemplary aspirated particle detection system made in accordance with an embodiment of the present invention. Particle detection system 1000 includes a inlet 1002 into which air is drawn from the volume being monitored. The airflow 1004 is drawn up the upper sample inlet 1006 to an electrostatic precipitation chamber 1008. The electrostatic precipitation chamber may be of any of the types described in the specification. After traversing the electrostatic precipitation chamber 1008 the air sample passes into a detection chamber 1010. The detection chamber 1010 can, for example, be an optical particle detection chamber such as the one used in a "Vesda" air sampling smoke detector as produced by Xtralis Proprietary Limited. In such systems a beam of light 1012 is shone across the air sample and scattered light is monitored by a light receiver 1014 to detect light scattered from particles in the airflow. The output of this detector is then processed by a smoke detection controller and alarm logic applied to determine if particles exist and whether an action needs to be taken in response to their detection. The system 1000 also includes an aspirator in the form of fan 1016 which is used to drawer air through the system 1000. After traversing the system the air is passed back to the atmosphere via exhaust 1018.

Figure 11 illustrates a further embodiment of such a system which has a different configuration to that of Figure 10. A system of this type is typically referred to as a sub-sampling particle detection system. In this regard, the system 1100 includes primary airflow path 1102 in which an aspirator 1104 drawers air from inlet 1106 and out to an outlet 1108. The airflow will typically be an air sample from a volume being monitored for the presence of particles. From this main airflow 1102 a sub-sample is drawn via sub-sampling path 1110. Here the sub-sampling path is passed through an electrostatic precipitation chamber 1112 and then to a particle detection chamber 1114. The particle detection chamber and electrostatic precipitation chamber can be the same as that described in the previous embodiment. Air from the sub-sampling path then rejoins the main path 1102.

Either of the detection systems 1000 or 1100 of Figures 10 or 11 can be implemented in aspirated smoke detection systems such as that shown in Figure 12. In the system 1200 there is provided a particle detection system 1000/1100. The system is coupled to a sampling pipe network 1202 which includes a plurality of sampling pipes 1204,1206 and 1208 arranged in a branched configuration. In each of the branches 1104,1106 and 1108 there are a plurality of sample inlets or sampling holes e.g. 1210 in branch 1204. Air is drawn into the sampling holes through the pipe network 1202 to the particle detection 1000/1100 where the air samples are analysed to determine whether particles exist. As will be appreciated by those skilled in the art the various branches of the particle detection network may be used to monitor different air volumes (such as rooms 1212 and 1214) within a premises.

The foregoing describes preferred embodiments of the present invention and modifications may be made thereto without departing from the scope of the invention. It will be understood that the invention disclosed and defined in this specification extends to all alternative combinations of two or more of the individual features mentioned or evident from the text or drawings. All of these different combinations constitute various alternative aspects of the invention.

CLAIMS:

1. A particle separation system for separating particles in an airflow upstream of a detection chamber in an aspirating smoke detector, the particle separation system including an airflow path for directing the airflow from an inlet to an outlet, the airflow path including:

a first airflow path section in a first direction and a second airflow path section in a second direction, the first and second directions being different relative to each other; and

at least one electrically charged surface such that the airflow undergoes electrostatic precipitation as it traverses the airflow path.

2. A particle separation system according to claim 1, wherein the first and second airflow path sections are arranged relative to each other such that a bend or curve is formed in the airflow path where the two sections meet, and the airflow is caused to travel around the bend or curve as it moves from the inlet to the outlet.

3. A particle separation system according to claim 2, wherein the intersection between the first airflow path section and the second airflow path section includes a transition region between the first and second directions.

4. A particle separation system according to claim 3, wherein the electrically charged surface is located downstream and adjacent the transition region between the first and second directions.

5. A particle separation system according to claim 4, wherein the electrically charged surface is located on the outside of the bend or curve such that larger particles are carried closer to the charged surface by their momentum as they traverse the bend or curve.

6. A method for separating particles in an airflow upstream of a detection chamber in an aspirating smoke detector, the method including:

directing the airflow along a first airflow path section in a first direction and then along a second airflow path section in a second direction, wherein the first direction and second direction are different relative to each other; and

providing at least one electrically charged surface within the airflow path such that the airflow undergoes electrostatic precipitation as it traverses the airflow path.

7. A method according to claim 6, further including locating the electrically charged surface downstream and adjacent a transition region between the first and second directions.

8. A particle separation system for separating particles in an airflow upstream of a detection chamber in an aspirating smoke detector, the particle separation system including:

a particle separation chamber having a first volume;

an inlet airflow path for introducing the airflow into the particle separation chamber; and

an outlet airflow path for exiting the airflow from the particle separation chamber;

wherein the inlet and outlet airflow paths have volumes smaller than the first volume such that the airflow introduced into the particle separation chamber is caused to rapidly expand in a first region; and

wherein the particle separation chamber includes one or more electrically charged surfaces adjacent the first region.

9. A particle separation system according to claim 8, wherein the particle separation chamber further includes a barrier or wall means located in front of and near the inlet airflow path such that as the airflow is introduced into the chamber it is caused to diverge around the barrier or wall means.

10. A method for separating particles in an airflow upstream of a detection chamber in an aspirating smoke detector, the method including:

introducing the airflow into a particle separation chamber;

causing the airflow to undergo a rapid expansion within the particle separation chamber in a first region;

providing one or more electrically charged surfaces adjacent the first region for attracting larger particles out of the airflow; and

exiting the airflow from the particle separation chamber.

11. A particle separation system according to claim 1 or 8, wherein the electrically charged surface takes the form of a substantially smooth surface and may form a wall of the airflow path.

12. A particle separation system according to claim 1 or 8, wherein the electrically charged surface is folded, corrugated, textured, or similar in order to present a greater surface area to the airflow so as to attract more particles.

13. A particle separation system according to claim 1 or 8, wherein the electrically charged surface may be an electret material (polarised polymer), an actively charged surface relying on a high-voltage source to maintain the surface potential, or the charge may be intrinsic in the surface itself.

14. A detection system for detecting particle accumulation in a particle separation system, the particle separation system including one or more electrically charged surfaces, the one or more electrically charged surfaces being at least partially transparent, the detection system including:

a light source for directing light towards at least one of the electrically charged surfaces; and a receiver for detecting the intensity of the light transmitted through or reflected from the at least one electrically charged surface.

15. A method of detecting particle accumulation in a particle separation system, the particle separation system including one or more electrically charged surfaces, the one or more electrically charged surfaces being at least partially transparent, the method including

providing a light source and directing light towards at least one of the electrically charged surfaces;

providing a receiver and detecting the intensity of the light transmitted through or reflected from the at least one electrically charged surface;

obtaining two or more measurements of the intensity of light transmitted or reflected over time;

comparing the two or measurements of the intensity of light transmitted or reflected and determining from the comparison if the intensity of light transmitted has reduced over time or if the intensity of light reflected has increased over time.

16. A detection system for detecting particle accumulation in a particle separation system, the particle separation system including one or more electrically charged surfaces, the detection system including:

an acoustic transducer to mechanically excite vibration in at least one of the electrically charged surfaces; and

a detector for measuring the intensity of damping or resonance of the at least one electrically charged surface.

17. A detection system according to claim 16, wherein the acoustic transducer is the electrically charged surface itself.

18. A detection system according to claim 16, wherein the electrically charged surface consists of a piezoelectric material, such as PVDF, which allows for both the provision of a charged surface and for exciting the surface acoustically.

19. A particle separation system according to any one of claims 1 to 5, 8, 9 or 11 to 13, wherein the particle separation system forms part of a sensing system for detecting particles in an airflow in a smoke detector.

20. A detection system according to any one of claims 14 or 16 to 18, wherein the particle separation system forms part of a sensing system for detecting particles in an airflow in a smoke detector.

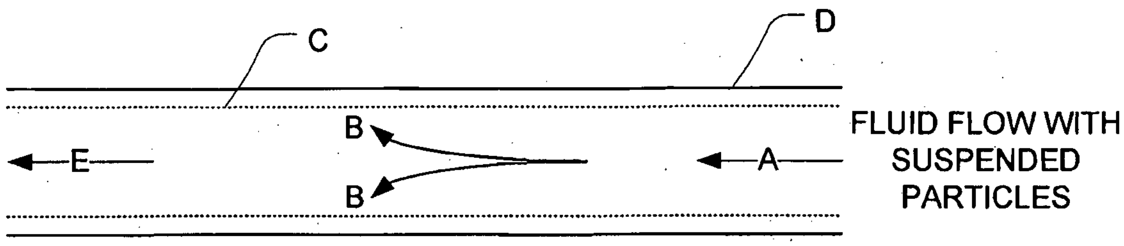

Figure 1

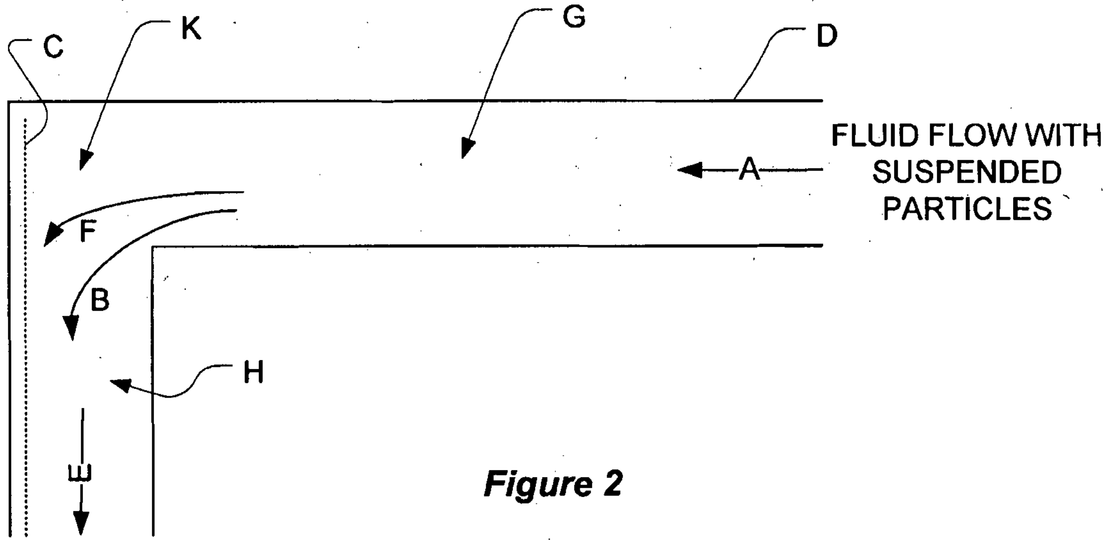

Figure 2

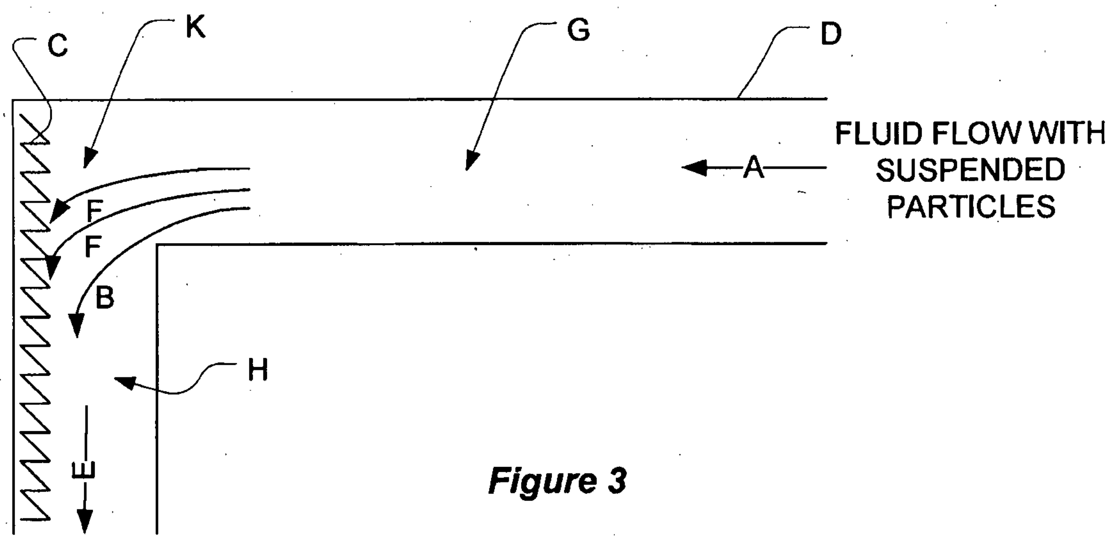

Figure 3

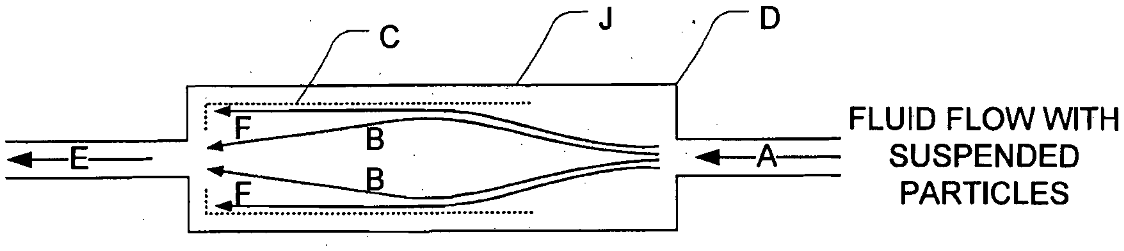

Figure 4

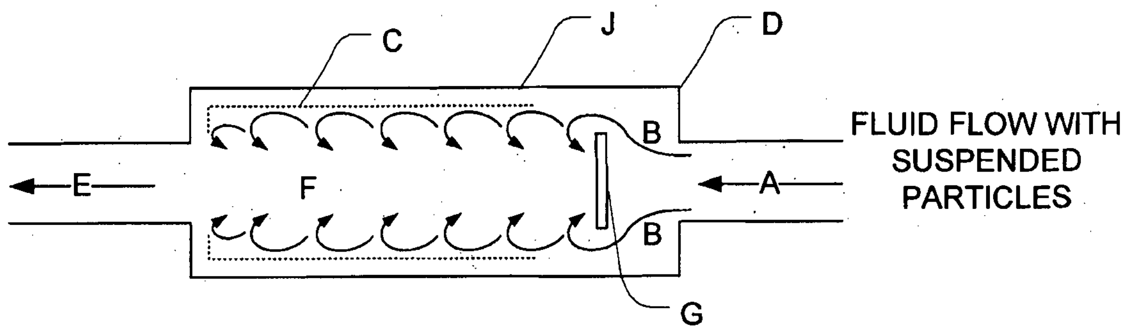

Figure 5

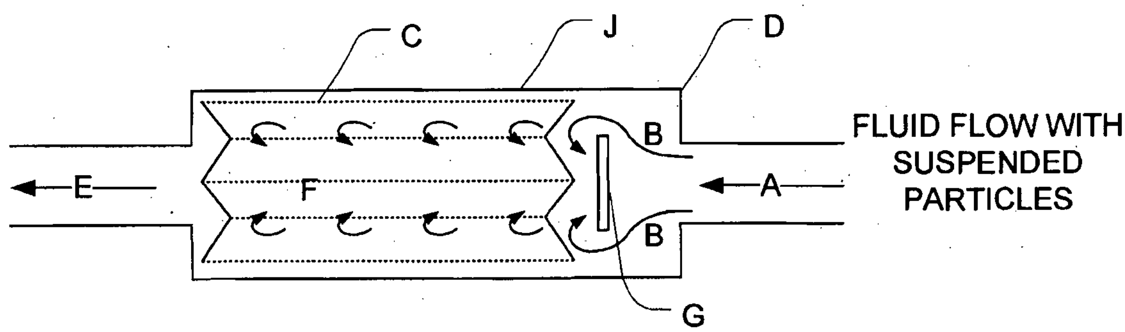

Figure 6

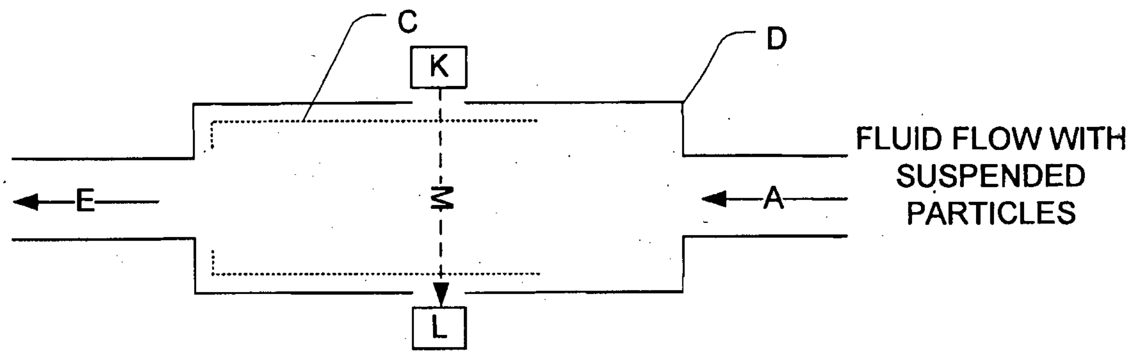

Figure 7

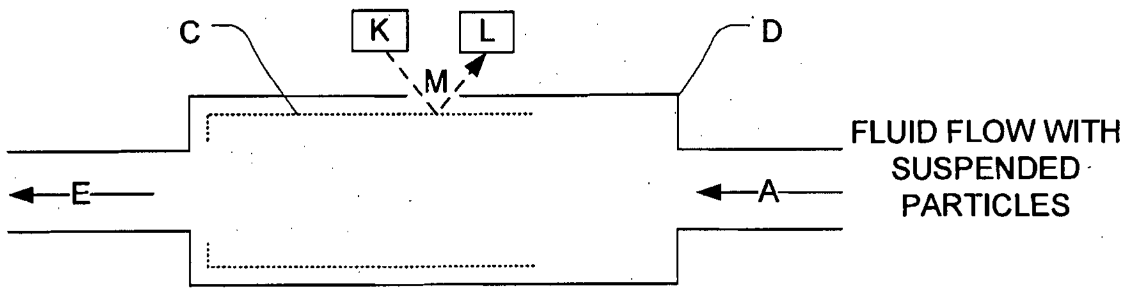

Figure 8

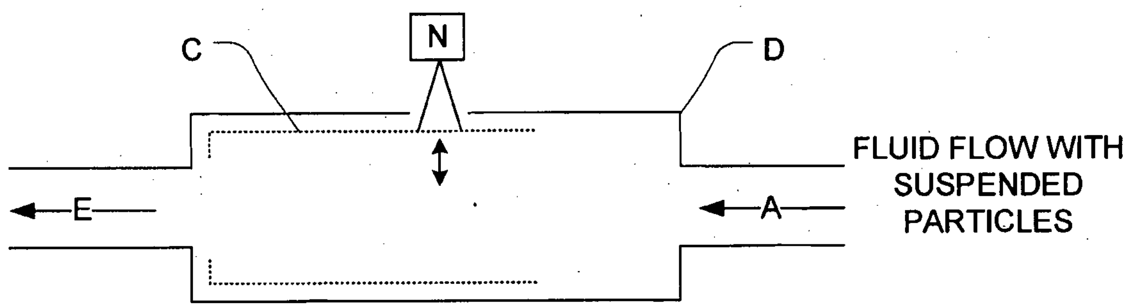

Figure 9

INTERNATIONAL SEARCH REPORT	International application No. PCT/AU2011/000237

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

B03C 3/00 (2006.01) ***B01D 53/32*** (2006.01) ***G08B 17/10*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI, EPODOC; IPC Marks - B03C3/00, B03C3/017, B03C3/04/LOW, B03C3/34, B03C3/36, B03C3/38, B01D53/32, G08B17/10/LOW; Key Words - smok+, fire, detect+, dust+, dirt+, separat+, remov+, elect+ and similar words; Google Patents, Esp@ace with above key words;

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7669457 B2 (GRIFFITH et al.) 02 March 2010 Refer Col. 3 line 12 to Col. 4 line 67 and Fig. 1 & 2	1 – 13 & 19
Y	US 5610592 A (OKAZAKI) 11 March 1997 See Col. 2 line 55 to Col. 4 line 57, and Fig. 1 & 2	1 – 13 & 19
Y	US 6285291 B1 (KNOX et al.) 4 September 2001 See Col. 3 line 41 to Col. 8 line 30, Figs 1 – 4	8 – 13 & 19

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 16 May 2011	Date of mailing of the international search report 25 MAY 2011
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **PRAVEEN JAIN** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6222 3653

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5160510 A (STEINBACHER et al.) 3 November 1992 See Abstract	1 – 13 & 19
A	WO 1997/035287 A1 (LEWINER JACQUES et al.) 25 September 1997 See whole document	
	Note: Document US 5160510 A can be combined with any of the following documents i.e. US 5610592 A, US 6285291 B1	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/000237

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Sheet No. 1

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1 – 13 and 19

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box No. 1
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art.

This International Searching Authority has found that there are different inventions as follows:

1. Claims 1 – 13 and 19 are directed towards a particle separation system and method for separating particles in an airflow, wherein the airflow path includes a first airflow path section and a second airflow path section. The first airflow path section and a second airflow path section are different from one another in a way that it facilitates separation of particles from air. Further the system and method comprises at least one electrically charged surface such that the airflow undergoes electrostatic precipitation as it traverses the airflow path. It is considered that the air flow path which facilitates particle separation due to inertia and at least one electrically charged surface such that the airflow undergoes electrostatic precipitation comprises a first distinguishing feature. It is considered that this group of claims define a first invention.

2. Claims 14 – 15 are directed towards a detection system comprised of a light source for directing light towards at least one or more electrically charged surfaces; and a receiver for detecting the intensity of the light transmitted through or reflected from the at least one electrically charged surface. It is considered that a detection system comprised of a light source for directing light towards at least one of the electrically charged surfaces; and a receiver for detecting the intensity of the light transmitted through or reflected from the at least one electrically charged surface comprises a second distinguishing feature. It is considered that this group of claims define a second invention.

3. Claims 16 – 18 are directed towards a detection system comprised of an acoustic transducer to mechanically excite vibration in at least one or more electrically charged surfaces; and a detector for measuring the intensity of damping or resonance of the at least one electrically charged surface. It is considered that a detection system comprised of an acoustic transducer to mechanically excite vibration in at least one of the electrically charged surfaces; and a detector for measuring the intensity of damping or resonance of the at least one electrically charged surface comprises a third distinguishing feature. It is considered that this group of claims define a third invention.

   Claim 20 can be related to either the second or third invention.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

None of the abovementioned groups of claims share any special technical feature. Because there is no common special technical feature it follows that there is no technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention *a priori*.