(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
24 April 2014 (24.04.2014)

WIPO | PCT

(10) **International Publication Number**
WO 2014/059479 A1

(51) **International Patent Classification**:
G01F 1/66 (2006.01) *G01N 35/08* (2006.01)
G08B 17/00 (2006.01) *G01N 1/00* (2006.01)
G01N 1/26 (2006.01)

(21) **International Application Number**:
PCT/AU2013/001201

(22) **International Filing Date**:
16 October 2013 (16.10.2013)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:

2012904516	16 October 2012 (16.10.2012)	AU
2012904854	2 November 2012 (02.11.2012)	AU
2013200353	21 January 2013 (21.01.2013)	AU
2013902076	7 June 2013 (07.06.2013)	AU
2013902570	11 July 2013 (11.07.2013)	AU

(71) **Applicant**: **XTRALIS TECHNOLOGIES LTD** [BS/BS]; 2nd Floor, One Montague Place, Nassau, N-3933 (BS).

(72) **Inventors; and**
(71) **Applicants** *(for AU only)*: **AJAY, Kemal** [AU/AU]; 7 Greenham Crescent, Mount Waverley, Victoria 3149 (AU). **KNOX, Ron** [AU/AU]; 90 Allison Road, Mount Eliza, Victoria 3930 (AU). **ALEXANDER, Brian** [AU/AU]; 30 Harold Street, Wantirna, Victoria 3152 (AU). **BOETTGER, Karl** [AU/AU]; 5 Ralph Court, Mount Waverley, Victoria 3150 (AU). **SINGH, Rajiv Kumar** [AU/AU]; 7 Gareth Court, Glen Waverley, Victoria 3150 (AU). **NORTH, Thor** [AU/AU]; c/- Level 43, 101 Collins Street, Melbourne, Victoria 3000 (AU). **PATTINSON, Stephen James** [AU/AU]; 7 Weybridge Street, Surrey Hills, Victoria 3127 (AU). **MASSINGBERD-MUNDY, Peter** [AU/—]; 13 Albany Road, Leighton Buzzard LU7 1NS (GB).

(74) **Agent**: **FREEHILLS PATENT ATTORNEYS**; Level 43, 101 Collins Street, Melbourne, Victoria 3000 (AU).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) **Title**: ADDRESSABILITY IN PARTICLE DETECTION

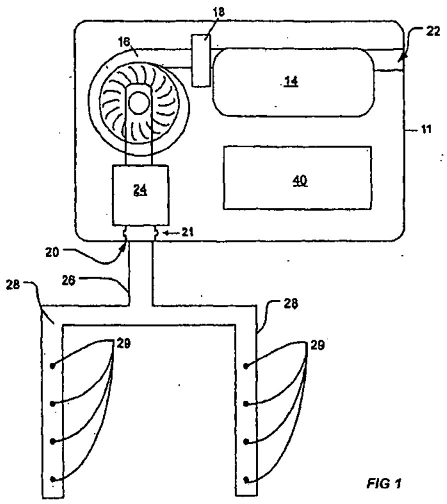


FIG 1

(57) **Abstract**: A method of determining at least one point of entry of smoke into a smoke detection system, the system having a sampling pipe network including at least one sampling pipe and a plurality of sampling inlets through which an air sample can enter the at least one sampling pipe of the smoke detection system for analysis by a particle detector, said method including: determining a volume of sample air that has passed through at least part of the smoke detection system since a predetermined event or a value corresponding to said volume; and determining through which sampling inlet of the plurality of sampling inlets the smoke entered the smoke detection system based, at least in part, on the determined volume or value. Systems for implementing such a method and related methods are also described.

WO 2014/059479 A1

Published:

— *with international search report (Art. 21(3))*

Addressability in particle detection

Field of the invention

The present invention relates to particle detection. For illustrative purposes only, the preferred embodiment of the present invention will be described in relation to a smoke detection system, but the invention should not be considered to be limited to that exemplary use.

Background of the invention

Air sampling or aspirated smoke detection systems operate by drawing air samples through a sampling network, to a central high sensitivity particle detector. The sampling network typically includes one or more sample pipes with a number of air sample inlets in the form of sampling holes or sampling points located along the length of the pipe(s). In such an arrangement, a single detector may be fed with air originating from many distinct geographical locations at which the air sample inlets are located. Thus a single such detector can monitor for the presence of smoke at many distinct locations simultaneously.

One recognised difficulty with air sampling systems as described above is that they do not identify through which air inlet smoke enters the system. If the air inlet is known, the geographical location of the source of the smoke may be inferred. This allows investigation of the likely site of the fire including allowing a person to be directed to the location of the smoke, so that they may investigate and possibly intervene and prevent further growth of the fire, or shut down equipment in the area. Alternatively, an appropriate fire suppression system may be deployed in a localised way, limiting damage caused by the system, as well as expense.

There have been attempts to provide air sampling particle detection systems capable of determining the geographical location at which smoke is detected, for example Jax, 'Method and Device for locating accumulations of pollutants', U.S. 5,708,218 and Hekatron Vertriebs GmbH, 'Verfahren und Vorrichtung zur Erkennung eines Brandes', EP 1811478.

Each of these systems measures the elapsed time between two instants at which measurements are made to infer where along sampling pipe (i.e. through which sample inlet) the detected smoke entered the system. However, this inferential process is often unreliable.

The Jax system measures the elapsed time between detection of a first smoke level, and a second smoke level. The time between detection of a first, lower level of smoke, and a second, higher level of smoke indicates the distance along the collection line at which smoke entered the system. However, this process may be inaccurate. For example, systems employing this approach rely upon the actual level of smoke detected at the first point of entry remaining approximately constant for the period of time beginning from the point at which smoke is first detected until the contribution from the second point of entry can be reliably detected. More specifically, an increase in smoke level, such as that caused by a fire of growing size, may result in an inaccurate estimate of the geographical location from which air has been drawn.

In Hekatron, a first air-sampling detection unit detects the presence of smoke. Responsive to detection of smoke, a second air-sampling detection unit is engaged, the air sampling unit drawing air along the pipe network. The time elapsed between initial detection by the first air-sampling unit and detection by the second air-sampling unit is measured. Ideally, the time elapsed indicates the location from which smoke filled air has been drawn. To ensure accuracy, such a system requires the aspiration system to operate in a highly consistent manner, each time it is operated. However, this is difficult to achieve as various features influence the operation of the fall, e.g. degradation of the aspiration system over time and variations in operational and environmental conditions e.g. air density, or the constriction of sampling points by dirt over time, will change the airflow characteristics within the system, and make the inference of the smoke address based on elapsed time potentially unreliable.

In some schemes, airflow may be temporarily reversed, introducing clean air to the sampling network, before redrawing air for detection. The idea in such schemes is to flush substantially all smoke particles from the system, before redrawing air through the sampling network and measuring the delay before detecting smoke. In theory, a longer delay indicates that the particles entered the sampling network at a point farther from the detector. However, these schemes suffer a drawback in that during the phase that clean air is introduced to the sampling network, smoke particles within the monitored environment may be displaced in the area surrounding the air inlets, since clean air is being expelled from the inlets. When air is subsequently drawn through the system, there may be an additional delay before smoke particles are once again drawn into the inlet.

It is therefore an object of the present invention to provide a particle detection system that addresses at least some of the aforementioned disadvantages. An alternative object of the invention is to provide the public with a useful choice over known products.

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 a first aspect of the present invention there is provided a method of determining at least one point of entry of smoke into a smoke detection system, the system having a sampling pipe network including at least one sampling pipe and a plurality of sampling inlets through which an air sample can enter the at least one sampling pipe of the smoke detection system for analysis by a particle detector. The method includes: determining a volume of sample air that has passed through at least part of the smoke detection system since a predetermined event or a value corresponding to said volume; and determining through which sampling inlet of the plurality of sampling inlets the smoke entered the smoke detection system based, at least in part, on the determined volume or value.

The predetermined event could be, for example, a smoke detection event; or a change in an air sample flow characteristic in the smoke detection system.

In some embodiments the method includes continuously determining a flow rate of the air sample passing through at least part of smoke detection system. Alternatively the method includes commencing determination of the volume of sample air or a related value upon the occurrence of the predetermined event.

The volume of the air sample that has passed through at least part of smoke detection network or a related value can be determined by accumulating a flow rate measurement over time. The rate of flow measurement is preferably a volumetric flow rate measurement. Most preferably the he flow rate measurement is determined using an ultrasonic flow sensor.

The step of determining a volume of sample air that has passed through at least part of the smoke detection system since a predetermined event or a value corresponding to said volume, can include determining any one of more of: a mass; a length; a pressure; a temperature, a second volume; or an accumulated count of volume-related events, or other parameter that that relates to a volume of sample air that has passed through at least part of the smoke detection system since the predetermined event.

The method can include collecting all or a proportion of the sample air that has passed through at least part of the smoke detection system since the predetermined event.

The method can further include changing an air sample flow characteristic in response to a first smoke detection event. For example, changing an air sample flow characteristic in the smoke detection system can include one or more of the following:

- opening a valve;
- closing a valve;
- changing a direction of an air sample flow in at least part of the smoke detection system;
- changing a rate of air sample flow in at least part of the smoke detection system;
- starting an aspiration system; and
- stopping an aspiration system.

In a second aspect of the present invention, there is provided an apparatus for determining at least one point of entry of smoke into a smoke detection system of the type having a particle detector in fluid communication with an air sampling network, the air sampling network having at least one sampling pipe and a plurality of sampling inlets through which an air sample can enter the at least one sampling pipe of the smoke detection system for analysis by the particle detector, and an aspirator for drawing the air sample through the air sampling network to the detector. The apparatus includes: means for determining a volume of sample air that has passed through at least part of the smoke detection system since a predetermined event or a value corresponding to said volume; and means for identifying at least one point of entry of particles into the sampling network based on the detected volume or value.

The apparatus preferably identifies one or more of said points of entry by reference to one or more corresponding sampling inlets through which smoke determined to have entered the system.

The means for determining a volume of sample that has passed through at least part of the particle detection system, or value related to said volume, preferably includes a flow sensor. Most preferably the flow sensor comprises an ultrasonic flow sensor.

The apparatus is preferably configured to perform a method in accordance with the first aspect of the present invention.

In a third aspect of the present invention, there is provided a smoke detector including a particle detection chamber to detect particles in an air sample, an inlet to receive an air sample from an air sampling network, said the sampling network having at least one sampling pipe and a plurality of sampling inlets through which a sample can enter the at least one sampling pipe for analysis by the particle detection chamber, and an aspirator for drawing the sample through the air sampling network to the detector, the detector further including a processor configured to: identify at least one point of entry of smoke into the sampling network based, at least in part, on a volume of sample air that has passed through at least part of the smoke detector or sampling network since a predetermined event, or a value corresponding to said volume.

The smoke detector can include a flow sensor, e.g. an ultrasonic flow sensor, configured to detect rate of flow of sample air passing through at least a part of the smoke detector.

The processor is preferably configured to cause the smoke detector to perform a method in accordance with the first aspect of the present invention.

Also disclosed herein is a method of determining the point of entry of particles into a particle detection system, said particle detection system including a particle detector and a sampling network in fluid communication with the particle detector, the sampling network including a plurality of inlets through which a fluid is drawn, the particle detection system further including means for drawing fluid through the sampling network to the detector. The method includes: comparing a first particle detection profile to a second particle detection profile; determining an offset between the particle detection profiles at which the profiles match to a predetermined degree; and, determining a location of entry of particles into the detection system on the basis of that offset.

In some embodiments, the offset is a time offset. In other embodiments, the offset is a volume offset.

In some embodiments, the comparison involves calculation of a cross-correlation between particle detection profiles.

In some embodiments, a maximum value of the calculated cross correlation is determined, and an offset between particle detection profiles corresponding to the maximum value is determined.

In some embodiments, the calculated cross correlation function is determined and compared to a predetermined value.

Preferably, the fluid is air, and the means for drawing fluid through the sampling network to the detector is an aspirator.

One embodiment includes determining that at least a first predetermined particle detection criteria has been met on the basis of a first particle detection profile being a comparison of the first and second particle detection particles.

The method can include continuously storing a first and/or second particle detection profile. Alternatively one of the profiles may be stored only after at least one predetermined criteria has been fulfilled.

The method can include changing an air flow characteristic in at least part of the particle detection system prior to beginning a comparison of the first and second particle detection profiles.

In one form the step of changing an air flow characteristic in the particle detection system includes one or more of the following:

- opening a valve;
- closing a valve;
- changing a direction of an air flow in at least part of the particle detection system;
- changing a rate of air flow in at least part of the particle detection system;
- starting an aspiration system; and

- stopping an aspiration system.

Further disclosed herein is an apparatus for determining the point of entry of particles into a particle detection system of the type having a particle detector in fluid communication with an air sampling network, the air sampling network having a plurality of inlets through which air may enter the air sampling network, and an aspirator for drawing air through the air sampling network to the detector, the apparatus including means for determining a volume of air passing through at least a part of the particle detection system, said apparatus including: means for receiving a signal representative of the volume of air passing through at least a part of the particle detection system; means for determining a location in the air sampling network at which air carrying particles entered the network on the basis of the determined volume.

Also disclosed herein is a device for determining the point of entry of particles into a particle detection system through one or more of a plurality of air inlets. The device includes means for determining a volume of air flowing through at least part of the particle detection system and means for determining a point of entry of the particles based upon the measured volume.

Preferably, the apparatus for determining the point of entry of particles into the particle detection system identifies the source of particles by reference to at least one inlet through which particles are likely to have entered.

Further preferably, the apparatus for determining the point of entry of particles into the detection system identifies the source of particles by providing an indication of the distance of along the sampling network at which particles entered the air sampling network.

Further disclosed herein is a method of determining the point of entry of particles into a particle detection system having a sampling pipe network with a plurality of sampling points through which particles can enter the particle detection system. The method includes, determining the volume of air passing through at least part of particle detection system and determining through which sampling hole of the plurality of sampling points the particles entered the particle detection system.

The method can include, detecting a first particle detection event and a second particle detection event, and measuring the volume of air passing through at least part of particle detection network between the particle detection events.

The method can include continuously measuring the volume of air passing through at least part of particle detection network. Alternatively the method can include activating the volume measurement upon the occurrence of a predetermined condition.

The volume of air passing through at least part of particle detection network is preferably measured by summing a rate of flow measurement over time. Preferably the rate of flow measurement is a volumetric flow rate measurement. Most preferably it is determined using an ultrasonic flow sensor.

Further disclosed herein is a particle detection system including a particle detector, a sampling network in fluid communication with the particle detector, and means for drawing fluid through the sampling network to the detector. The sampling network includes a plurality of inlets, the inlets being arranged into a plurality of location groups. Each location group has an address defined by the presence or absence of an inlet connected to each of a plurality of sampling pipes. The particle detector is configured to draw air along each sampling pipe and in the event that smoke is detected, determine the address of the location group through which particles entered the detector based upon both the presence and absence of particles in each of the sampling pipes.

Also disclosed herein is a method of determining a single point of entry of particles into a particle detection system. The particle detection system includes at least one particle detector, a sampling network in fluid communication with a or the particle detector, and means for drawing fluid through the sampling network to a or the detector. The sampling network includes a plurality of sample communication paths along which a sample can be drawn and in which the presence of particles can be independently detected by at least one of the detectors, wherein each sample communication path includes at least one sample inlet. Each of said inlets further belongs to one of a plurality of location groups defined by the physical location of the inlet. The particle detection system being configured to determine whether particles are been detected on an air sample from each sample communication path. The method includes:

determining a location group of inlets at which particles entered into the particle detection system uniquely on the basis of whether particles have or have not been detected on each sample communication path.

In one embodiment, the sampling network comprises a plurality of pipes that respectively correspond to a sample communication path, and the step of determining that particles have been detected at a location group comprises determining that particles have or have not been detected in fluid drawn through each of the plurality of pipes..

Further disclosed herein is an apparatus for determining the point of entry of particles into a particle detection system of the type having at least one particle detector in fluid communication with a sampling network, and aspiration means for drawing fluid through the sampling network to the or a particle detector, the sampling network including a plurality of sample communication paths in which particles can be separately detected. The sampling network includes a plurality of sample inlets, each inlet being a member of a location group at one of a plurality of physical locations; the apparatus further including means for determining a location at which particles are present on the basis of whether particles have or have not been detected on each sample communication path.

Also disclosed herein is a method in a particle detection system having:

at least one particle detector; and

a sampling system including a sampling pipe with a plurality of sampling inlets, said sampling system being arranged to convey a sample to be analysed from an environment surrounding the sampling inlet via the sampling pipe to the at least one particle detector;

a flow inducer arranged to cause an air sample to flow in the sampling system to the at least one particle detector;

the method including:

measuring a first particle concentration in a sample arriving form the sampling system;

varying a sampling parameter at a subset of the sampling inlets;

measuring a second particle concentration in a sample arriving form the sampling system;

measuring a particle concentration in a sample arriving form the sampling system; on the basis of the first and second particle concentrations and the varied sampling parameter.

The sampling parameter that is varied can be flow rate through the first subset of sampling inlets. The variation can be triggered by opening or closing valves or using a fan or other flow inducer to increase (or decrease) flow through the subset of sampling inlets. In this case the varied sampling parameter used to determine the measuring a particle concentration in a sample arriving form the sampling system can be a flow rate through the subset of sampling inlets.

In some embodiments the sampling parameter that is varied is the particle concentration drawn through the first subset of sampling inlets. The variation can be triggered by adjusting a filtering parameter applied to the first subset of sampling inlets, e.g. by interposing or removing a filter in the flow path of air entering through the sampling inlets. In this case the varied sampling parameter used to determine the measuring a particle concentration in a sample arriving form the sampling system can be a sample concentration the subset of sampling inlets.

In some embodiments the first subset of sampling inlets is the same as the second subset of sampling inlets. The first or second subsets if sampling inlets may include a plurality of inlets, or may be a single inlet.

Also disclosed herein is a method for detecting contaminant(s) in air samples from a plurality of air intake paths, the method including:

varying the flow balance between the multiple paths by increasing or partially reducing the flow in one or more of the plurality of air intake paths to create a plurality of different flow patterns;

measuring the contaminant level of the combined air intake paths for each of the plurality of different flow patterns; and

determining the contaminant level of each air intake path by using known, predetermined or measured values of flow rate in each air intake path for each of the plurality of different flow patterns,

wherein the number of different flow patterns created and the number of contaminant level measurements taken are sufficient to determine the contaminant level in each air intake path.

Varying the flow balance is preferably achieved over the plurality of different flow patterns by partial flow reduction in each of the air intake paths, in turn. In other words, if there are four air intake paths, a first subset of the air intake paths (e.g. three paths) are partially closed while the remaining intake path(s) remain open while the contaminant level is measured. Next, that first subset air intake path is reopened and a second different subset of air intake paths is partially closed while the remaining air intake path(s) remain open and a second measure of the contaminant level is made. This is continued until four different flow patterns are created while four measurements of the contaminant level are taken.

The partial reduction in flow is preferably achieved by partially closing valves in the air intake paths. So, each valve is partially closed in turn while the other valves remain open. In this arrangement, the flow rate through each air intake path may not be known. Therefore, it may be necessary to measure the flow rate in each air intake path, for each of the plurality of different flow patterns.

In an alternative form, the step of varying the flow balance may be achieved by having moveable baffles within the air intake paths. For example, the moveable baffles may be in the form of rotatable discs movable to a number of selectable positions. The discs have openings which, depending upon the selected position, create a predetermined flow rate. Thus, in this arrangement, flow rate measurements may not be required.

In a third alternative method of varying the flow balance, each air intake path may be vented in turn while the other pipes remain unvented. Compared to the other two methods described above, this will result in an increase in air flow through each vented air intake path in turn and may also affect the flow rate in the other air intake paths.

In a preferred form, there are as many flow patterns created as there are air intake paths. Given that there are as many measurements of contaminant level as there are flow patterns, this means the number of measurements of contaminant level equal the number of flow paths too. This will provide enough information to determine the contaminant level in each air intake path, provided the flow rate in each air intake path is also known/predetermined or measured for each flow pattern.

In some arrangements, the flow rate is measured in each air intake path. This is preferably achieved by a flow rate sensor having a reasonably high degree of accuracy. In a most preferred form, flow rate is measured by ultrasonic flow rate sensors, one in each air intake path.

Preferably, with the measured contaminant levels for each flow pattern and the known/predetermined or measured flow rates in each path for each flow pattern, a series of equations may be solved as follows:

$$C_1 = X_1 F_{11}/(F_{11} + F_{12} + \ldots F_{1n}) + X_2F_{12}/(F_{11} + F_{12} + \ldots F_{1n}) \ldots + X_n F_{1n}/(F_{11} + F_{12} + \ldots F_{1n})$$

$$C_2 = X_1 F_{21}/(F_{21} + F_{22} + \ldots F_{2n}) + X_2F_{22}/(F_{21} + F_{22} + \ldots F_{2n}) + \ldots X_n F_{2n}/(F_{21} + F_{22} + \ldots F_{2n})$$

$$\vdots$$

$$C_n = X_1 F_{n1}/(F_{n1} + F_{n2} + \ldots F_{nn}) + X_2F_{n2}/(F_{n1} + F_{n2} + \ldots F_{nn}) + \ldots X_nF_{nn}/(F_{n1} + F_{n2} + \ldots F_{nn})$$

where

$X_1 \ldots X_n$ = concentration in air intake paths 1 to n

$C_1 \ldots C_n$ = measured contaminant level of the combined air intake paths

$F_{11} \ldots F_{n1}$ = flow rate in pipe 1 for flow patterns 1 to n

$F_{12} \ldots F_{n2}$ = flow rate in pipe 2 for flow patterns 1 to n

$F_{1n} \ldots F_{nn}$ = flow rate in pipe n for flow patterns 1 to n

In a preferred form, the air intake paths may be in the form of air sampling pipes. Each air sampling pipe may feed into a respective intake port on a detector unit. The flows may be merged in a manifold, in the detector unit prior to being fed to the detector.

The step of measuring, whether for the contaminant level or the flow rate may involve multiple readings from which an average is taken. Alternatively, any other statistical calculation may be made to determine the central tendency of the multiple readings.

Also disclosed herein is a sensing system for detecting contaminants in air samples from a plurality of air intake paths, the system including:

a control system for controlling flow control means in each of the air intake paths to increase or partially reduce the flow in one or more of the air intake paths to create a plurality of different flow patterns;

a detector to measure the contaminant level of the combined air intake paths, the control system controlling the detector to measure the contaminant level for each of the plurality of different flow patterns;

the control system being further operable to determine the contaminant level of each air intake path using known, predetermined or measured values of flow rate in each air intake path for each of the plurality of different flow patterns; and

the control system being operable to create a sufficient number of different flow patterns and to control the detector to take a sufficient number of measurements to determine the contaminant level of each air intake path.

The sensing system may be in the form of a sensing unit which includes air intake ports corresponding to the number of air intake paths. Each air intake port may be coupled to a respective sampling pipe. Each of the flow control means may be disposed within the sensing unit or alternatively may be disposed in a respective sampling pipe.

Preferably, the control system is able to control the measurement of flow rate.

Also disclosed herein is a sampling point for an environmental sampling system of the type having a at least one elongate sampling duct defined by a peripheral wall and having plurality of sampling inlets located along the duct's length and extending through the wall to allow the ingress of a sample, said environmental sampling system being configured to draw a sample from the environment through the sampling inlets into the duct and to convey the samples through the duct to an analysis device, the sampling point including a sample injection inlet extending into an interior of the duct inward of the peripheral wall thereof.

The sample injection inlet can include a pipe extending through the peripheral wall of the duct. Most preferably the pipe has an outlet at or near the centre of the duct, away from the peripheral wall of the duct.

The sample injection inlet can have its outlet facing in a downstream direction of flow in the duct. In a preferred form the sample injection inlet is an L-shaped pipe, with a first inlet end for drawing a sample from the environment and a second, outlet end located within the duct and having an outlet facing in a downstream direction of flow in the duct. Also disclosed is a method in an environmental sampling system of the type having a at least one elongate sampling duct defined by a peripheral wall and having plurality of sampling inlets located along the duct's length and extending through the wall to allow the ingress of a sample, said environmental sampling system being configured to draw a sample from the environment through the sampling inlets into the duct and to convey the samples through the duct to an analysis device, the method including:

providing a structure to ameliorate diffusion of at least a front of a discrete sample portion, along the duct, as the sample portion travels down the duct.

The structure can be a sampling point including a sample injection inlet extending into an interior of the duct as described above. The structure could also be a structure that creates turbulence within the duct configured to prevent laminar flow within the duct in use. For example, the structure could be a contoured or textured wall of the duct; a turbulator; a passive or active rotating element or the like.

Also disclosed herein is a sampling system for an environmental analysis system, said sample system including at least one elongate sampling duct defined by a peripheral wall and having plurality of sampling inlets located along the duct's length and extending through the wall to allow the ingress of a sample into the duct, said environmental sampling system being configured to draw a sample from the environment through the sampling inlets into the duct and to convey the samples through the duct to environmental analysis system, the sampling system further including means to ameliorate diffusion of at least a front of a discrete sample portion, along the duct, as the sample portion travels down the duct. The structure can be a sampling point including a sample injection inlet extending into an interior of the duct as described above. The structure could also be a structure that creates turbulence within the duct configured to prevent laminar flow within the duct in use. For example, the structure could be a contoured or textured wall of the duct; a turbulator; a passive or active rotating element or the like.

The structure could extend substantially the whole length of the duct, or be localised, e.g. at or near, one or all, of the sampling inlets.

Further disclosed herein is a method in an environmental sampling system of the type having at least one elongate sampling duct having plurality of sampling inlets located in series along the duct's length to allow the ingress of a sample from the environment, said environmental sampling system being configured to draw a sample from the environment through the sampling inlets into the duct and to convey the samples through the duct to an analysis device, the method including: changing the airflow characteristic in the duct to alter a local sample concentration at or near at least one particular sampling inlet to increase the local sample concentration towards the sample concentration in the atmosphere surrounding the particular sampling inlet.

Changing the airflow characteristic can include stopping or reversing a direction of flow in the duct to so that a portion of a sample adjacent the particular sampling inlet is expelled from the sample inlet. The method then includes drawing an additional sample from the environment via the particular sample inlet. The steps of stopping or reversing a direction of flow in the duct to so that a portion of a sample adjacent the particular sampling inlet is expelled from the sample inlet, and drawing an additional sample from the environment via the particular sample inlet can be repeated one or more times.

The method can include oscillating the direction of flow in the duct such that a repeated process of expulsion and re-sampling the environment occurs.

The method can then include transporting the contents of the duct to the analysis device. This transportation is preferably performed with minimal dilution of the sample within the duct, or mixing between longitudinally positioned portions of the sample of the duct. For example the method can include; one or more of the following:

closing one or more of the sampling inlets prior to transportation,

opening duct at an upstream position to provide a low flow impedance;

blowing the sample along the duct from an upstream position.

An environmental sampling system of the type having at least one elongate sampling duct having at least one sampling inlet located along the duct's length to allow the ingress of a sample from the environment, said environmental sampling system being configured to draw a sample from the environment through the or each sampling inlet into the duct and to convey the samples through the duct to an analysis device, The system further including sample amplification arrangement to ameliorate dilution of the sample by air flow in the duct.

The sample amplification arrangement could include a device to reverse flow direction in at least a portion of the duct. The device to reverse flow direction is preferably arranged to cause multiple reversals of flow direction to promote mixing of an air sample at or adjacent a sampling inlet. The device to reverse flow could be, for example, a reversible fan, bellows, reciprocating piston, vibrating membrane, or the like.

Also disclosed herein is an environmental sampling system of the type having at least one elongate sampling duct having plurality of sampling inlets located in series along the duct's length to allow the ingress of a sample from the environment that is configured to perform the above method. The environmental sampling system can include one or more of the following:

One or more valves to control flow along the duct and/or through one or more of the sampling inlets;

fans, blowers or other flow inducing means to control flow along the duct and/or through one or more of the sampling inlets.

A particle detection system, and preferably a smoke detection system, is also provided that includes an environmental sampling system of the above type to deliver air samples for analysis from a plurality of locations.

In a preferred form the particle detection system comprises a detection system according to the following aspects of the present invention. In this case, the accessory can comprise any one or more of: a sampling inlet or a sampling point; a valve; a filter; a duct or portion of a duct; a flow-inducing device such as a fan, piston, bellows, pump, vibrating membrane or the like; and a localisation module.

In accordance with an further aspect of the present invention there is provided a detection system, such as a particle detection system of any of the types described herein, for detecting an abnormal condition in an air volume, the detection system including a detector for detecting an abnormal condition of the air volume and an accessory, wherein the detector and the accessory are in fluid communication with each other and the air volume by an air flow path,

wherein the detector is operable to communicate, at least unidirectionally, with the accessory through the air flow path.

The detector may be in the form of a particle detector which is used to detect an abnormal level of particles within the sampled air volume. Preferably, the type of particle detector is an aspirating smoke detector i.e. includes a fan or other type of fluid drive. Accordingly, in this preferred embodiment, the detector is able to send signals to the accessory through the air flow path by changing the air flow characteristics in the air flow path. In this preferred embodiment, that can be achieved by adjusting flow speed or direction. Suitably, the changes in the air flow characteristics may be detected by the accessory, with the accessory being responsive to the detected change. Thus the change in air flow characteristics functions as a signal from the detector to the accessory.

Preferably the air flow path comprises an air sampling system or environmental sampling system as described in any one of the aspects of the present invention or embodiments described herein.

The accessory could comprise a detector for detecting an abnormal condition of the air volume. The accessory detector may be any one of the following types: particle detector, gas detector, temperature/heat detector, humidity detector. Alternatively, the accessory may comprise a filter, For example, the filter may be a pre-filter which is used before particle detection. The accessory can be in the form of a valve or fan incorporated into the air flow path.

The air flow path suitably includes a sampling pipe network including pipe and inlet ports. In the embodiment which utilises a particle detector, the air flow path may also include the flow path through the detector including the aspirator i.e. the fan and the detection chamber. The exhaust from the detector also forms part of the air flow path. The flow path through the accessory is also understood to be part of the air flow path.

The detector and the accessory may subsist as separate units along the air flow path. The accessory may be retrofittable into an existing detection system such as a smoke detection system already having a smoke detector unit with a sampling pipe network.

Preferably the detector sends operational information to the accessory. For example, the detector may send information about the operation of the detector such its current mode of operation. The accessory's response to the sensed information may be to adjust its settings or perform a calibration or recalibration or change its operating state.

As discussed above, one mode of communicating through the air flow path is for the detector to cause a change in air flow characteristics which may be detected by the accessory. The change in air flow characteristics may include any aberration in the air flow which is detectable by the accessory. This may include a change in the air flow rate or direction; or a pressure surge or wave in the air flow path. This may be created by an air flow apparatus within or within the control of the detector such as the aspirator fan within the detector. The aspirator is preferably controlled by a programmable controller within the detector. Thus, suitable programming will cause the detector to send the required signal(s).

The change in flow characteristics of the air flow path may vary so that different signals mean different things to the accessory. For example, rather than a single change in flow rate, there may be a plurality of changes such as pulses of increased flow, the number of pulses corresponding to particular information. Alternatively, the degree of change in the flow rate or the actual measured flow could also be used to denote different information.

Preferably, the accessory has a sensing system comprising one or more sensors to detect the changes in flow characteristics.

Communication through the air flow path could be by way of sound transmission detectable by the accessory. For example a change in fan noise , might be used for signalling purposes. Otherwise, sound signals e.g. acoustic, ultrasound or infrasound could be created by the detector or other component of the system and sensed by the accessory. Suitably, the accessory has a microphone or other transducer to detect such noises as part of its sensing system.

In an alternative form of the invention, vibrations may be created by the detector e.g. tapping of the pipe with a suitable vibration sensor provided in the accessory.

The detector could alternatively transmit light signals with a light sensor on the accessory, although such a system may require a line of sight through the air flow path.

While the above discussion has focused on unidirectional communication between the detector and the accessory, bidirectional communication is also possible. Communication from the accessory to the detector may be created by the presence of a valve in the accessory with the consequential effect on the air flow characteristics being detected by a flow sensor in the detector. Some accessories also incorporate a fan. This fan may also be used to have an influence in the air flow characteristics which may be sensed by the detector.

In accordance with another aspect of the present invention there is provided an accessory for a detection system, the detection system for detecting an abnormal condition in an air volume, the accessory being fluidly connectable to the detection system and the air volume by an air flow path, wherein the accessory is operable to receive communication transmitted by the detection system through the air flow path. The accessory may include any of the features discussed above in accordance with the first aspect of the invention.

In accordance with another aspect of the present invention there is provided a detection system for detecting an abnormal condition in an air volume, the detection system including a detector for detecting an abnormal condition of the air volume and an accessory, wherein the detector and the accessory are in fluid communication with each other and the air volume, wherein the detector is operable to communicate, at least unidirectionally with the accessory by effecting changes in air flow characteristics of the fluid communication, said changes being detectable by the accessory.

In accordance with another aspect of the present invention there is provided an accessory for a detection system, the detection system for sensing an abnormal condition in an air volume, the accessory being fluidly connectable to the detection system and the air volume, wherein the accessory is operable to detect changes in air flow characteristics generated by the detection system. Preferably, the accessory is operationally responsive to said changes. However, the accessory may also be operationally responsive to a lack of any changes.

The detection system and the accessory in the preceding two aspects above may incorporate any of the preferred features discussed above.

In accordance with another aspect of the present invention there is provided a method of operating a detection system which detects an abnormal condition in an air volume, the detection system including a detector for detecting an abnormal condition of the air volume and an accessory, the detector and the accessory being in fluid communication with each other and the air volume by an air flow path, the method including: sending a signal from the detector to the accessory through the air flow path, wherein the accessory is responsive to the signal or a lack of signal.

The detector may send a signal to the accessory through the air flow path by effecting a change in the air flow characteristics. Alternatively, the signal may be sent according to any of the alternative methods discussed above in connection with the above aspects of the invention.

The accessory response to the signal or to the lack of signal may be to shut down, go into a fault mode or adjust its operating characteristics.

In accordance with another aspect of the present invention there is provided a method of operating a detection system which detects an abnormal condition in an air volume, the detection system including a detector for detecting an abnormal condition of the air volume and an accessory, the detector and the accessory being in fluid communication with each other and the air volume by an air flow path, the method including: receiving, at an accessory, a signal via the air flow path; controlling the accessory on the basis of the received signal.

The step of receiving a signal can include detecting a change in a flow parameter, such as flow rate, direction or pressure or the like, in part of the airflow path at the accessory.

Controlling the accessory can include changing at least one operational parameter or state of the accessory in response to the received signal. Preferably the change of the operational parameter changes a flow condition in the airflow path.

In accordance with another aspect of the present invention there is provided a method of operating a detection system which detects an abnormal condition in an air volume, the detection system including a detector for detecting an abnormal condition of the air volume and an accessory, the detector and the accessory being in fluid communication with each other and the air volume by an air flow path, the method including: sensing at an accessory, a change in air flow in the air flow path; controlling the accessory on the basis of the sensed change.

The step of receiving a signal can include detecting a change in a flow parameter, such as flow rate, direction or pressure or the like, in part of the airflow path at the accessory.

Controlling the accessory can include changing at least one operational parameter or state of the accessory in response to the received signal. Preferably the change of the operational parameter changes a flow condition in the airflow path.

In the above embodiments the accessory can include any one or more of: a valve, fan, flow control device, detector, filter.

As will be appreciated a system, detector and or accessory can advantageously be used in any one of the embodiments described herein. In particular using such an accessory and method minimises the complexity of installation of the accessory since additional communication lines need to be connected between the accessory and other system components.

Also disclosed herein is a method in an environmental sampling system of the type having at least one elongate sampling duct having plurality of sampling inlets located along the or each duct's length to allow the ingress of a sample from the environment, said environmental sampling system being configured to draw a sample from the environment through the sampling inlets into the duct and to convey the samples through the duct to an analysis device to detect the presence of a threat substance in the sample, the method including:

operating in a detection mode in which the presence and or concentration of the threat substance is being monitored, and in the event at least one criterion is met, the system performs the step of:

operating in a localisation mode to determine which of the sampling inlets the threat substance entered the system.

The method can include operating in a training mode to characterise a sample flow through the at least one sampling duct to the analysis device so as to enable determination of which of the sampling inlets the threat substance entered the system in the localisation mode.

The localisation mode can include a sample amplification phase and transportation phase.

The localisation mode can include a purge phase.

In a further aspect there is provided a particle detection system configured to monitor a series of physical locations for the presence of particles, the particle detection system including a particle detector and a sampling pipe network for delivering air samples from the series of physical locations to the particle detector for analysis, said sampling pipe network being arranged such that: each of said physical locations has a sample inlet arrangement through which an air sample is drawn into the sampling pipe network, each of said sample inlet arrangements being connected to a sampling pipe at a respective sampling connection location, wherein the average distance between the sample inlet arrangements of neighbouring physical locations is less than the average distance between the sampling connection locations of neighbouring physical locations when measured along a flow path within the sampling pipe network.

In the event that a sample inlet arrangement includes multiple sample inlets the centroid of the sample inlets can be used to determine the distance to its neighbouring arrangement(s). Similarly if the sampling connection location of a physical location includes multiple points of connection to the sampling pipe the centre of the multiple points of connection can be used to determine the distance to its neighbour(s) along the flow path.

In some embodiments the sampling pipe passes through the regions being monitored to service the regions, in other embodiments the sampling pipe runs near, but not through the regions (such as might be the case where the sampling pipe runs above a ceiling of a room, or outside an equipment cabinet which is being monitored, in order to service the region.

In preferred embodiments the sampling pipe includes a first portion extending past or through regions being serviced by the sampling pipe and a second portion connected to the sampling pipe network upstream of the first portion which extends past or through at least one region being serviced by the first portion. Preferably the second portion extends past or though a plurality of regions that the first portion extends past or through. Most preferably the second portions extend past or through a majority of the regions that the first portion extends past or through.

In some forms the first and second portions extend substantially side by side, most preferably they run parallel to each other.

In a preferred form the second portion services a location positioned between locations serviced by the first portion. Most preferably locations positioned adjacent one another are alternately serviced by the first and second portions of the pipe network. Such an arrangement acts to spread out the points of connection along flow path of the sampling pipe network, which aids in reducing ambiguity in particle localisation

A region should be considered to be serviced by either a given (e.g. the first or second) portion of the common portion of the sampling pipe network if a point of connection of the region's sample inlet arrangement is made to the given portion of the common portion of the sampling pipe network. In another aspect there is provided a particle detection system arranged to monitor particles in a plurality of regions, said particle detection system including a particle detector and a sampling pipe network including a plurality of sample inlets into which particles are drawn for transport to the detector for analysis. Said sampling inlets being arranged to draw samples from a specific region, wherein the sampling pipe network includes a plurality of side by side pipes interconnected in series, wherein the sampling inlets corresponding to at least two regions that are located sequentially adjacent each other along the length of the plurality of side-by-side pipes are connected to different members of the plurality of pipes. Most preferably when the plurality of pipes has two pipes the sampling inlets of sequentially adjacent regions are alternately connected to the first or second pipe.

In another aspect of the present invention there is provided an apparatus comprising: a delivery system for delivering a test substance to a particle detector arranged to protect a location; an activation means to activate the delivery system to deliver the test substance;

a indicator signalling the activation of the delivery system, such that the activation can be automatically detected by an image capture system arranged to capture images of the location.

The apparatus can further include an interface enabling data regarding the activation to be entered into the apparatus for storage or transmission thereby. The delivery system can comprise at least one of: a test substance generator; a duct for delivering a test substance to a the particle detector from a test substance generator; a fan, pump or the like to move the test substance through the apparatus to the particle detector. The indicator preferably comprises one or more radiation emitters configured to emit radiation for capture in an image. The apparatus can include a synchronisation port, to enable data transfer to and/or from the apparatus to an external device, such as the particle detection system or video capture system.

In another aspect the present invention provides a method for correlating an address in a particle detection system, said address corresponding to a physical location, with a location being monitored in a video capture system that monitors a plurality of locations; the method comprising; causing the detection of particles in the particle detection system at the address;

indicating visually a physical location corresponding to the address; identifying the visual indication of the physical location in at least one image captured by the video capture system;

correlating address with a location of the plurality of locations monitored by the video capture system.

The method preferably includes correlating the address with one or more of: a camera that captured the at least one image in which the visual indication was identified; One or more of a pan, tilt or zoom parameter of a camera that captured the at least one image in which the visual indication was identified.

The method can include providing the correlation data to the video capture system to enable selective capture, storage or display of images relating to corresponding to an address in the particle detection system in the event that particles are detected by the particle detection system at the address. Described herein this allows video verification of the particle detection event.

The step of indicating visually a physical location corresponding to the address can include, emitting radiation that can be captured and identified in an image captured by the video capture system. This can includes selectively activating a radiation source in a detectable pattern. For example on-off modulating a light source.

The step of causing the detection of particles in the particle detection system preferably includes emitting particles at, or near, the physical location so as to be detected by the particle detection system at the address.

The step of causing the detection of particles in the particle detection system at the address; and indicating visually a physical location corresponding to the address are preferably performed simultaneously to enable temporal correlation between images captured by the video capture system with a particle detection event in the particle detection system.

Most preferably the method is performed using an apparatus of the previous aspect of the present invention.

Brief description of the drawings

Illustrative embodiments of the invention will now be described by way of a non-limiting example with reference to the accompanying figures. In the figures:

Figure 1 shows a particle detection system including an air sampling network;

Figure 2 shows a particle detection system employing two particle detectors to enable determination of the location at which smoke enters an air sampling network;

Figure 3 shows a particle detection system employing a single particle detector coupled to an air sampling network having two branches separated by a valve;

Figure 4 shows a particle detection system employing two particle detectors coupled to a single air sampling pipeline;

Figures 5 and 6 graphically illustrate a timing of events as measured at respective detectors (or branches) of a particle detection system;

Figure 7 illustrates another embodiment of a particle detection system that is used to determine a location particles entering the system;

Figure 8 illustrates a particle detection system including a sampling system including a plurality of valves, for altering a sampling parameter of the sampling system [to implement an embodiment of one aspect of the invention];

Figure 9A illustrates a particle detection system including a sampling system including a plurality of filters which are configured to alter a sampling parameter the sampling system [to implement an embodiment of one aspect of the invention];

Figure 9B illustrates a filter and valve arrangement used in the system of figure 9A;

Figure 10A is a schematic diagram of a particle detection system according to a preferred embodiment of the present invention;

Figure 10B is a schematic diagram of a portion of the particle detection system of Figure 10A;

Figure 10C is a schematic view of the portion of the particle detection system as per Figure 10B, except with one of the valves in a partially closed position; and

Figure 10D is a schematic view of the portion as per Figure 10C, except that one of the other valves is partially closed;

Figure 11A illustrates a particle detection system;

Figure 11B is a graph illustrating diffusion of a front of a sample portion as the sample portion travels down a duct;

Figure 11C illustrates a flow speed profile within the sample duct of figure 11A;

Figure 12 illustrates 3 sampling points according to different embodiments of the present invention, that may ameliorate the affect of the diffusion illustrated in figure 11B;

Figures 13A to 13D are examples of turbulators that may ameliorate the affect of the diffusion illustrated in figure 11B;

Figure 14 illustrates a particle detection system including an air sampling network that is connected to bellows that can be used to oscillate the direction of sample flow within the air sampling duct to counteract sample dilution by other sampling inlets within the particle detection system;

Figures 14A to 14E illustrate an exemplary system that uses a vibrating membrane to perform sample amplification in a manner analogous to that of Figure 14;

Figure 15 illustrates a particle detection system including an air sampling system that has an upstream fan that can be used to counteract sample dilution by other sampling inlets within the particle detection system.

Figure 15B illustrates a particle detection system similar to that of figure 15, which has been augmented with an sample flushing system.

Figure 16 illustrates a particle detection system having an air sampling system including a valve upstream of the sampling inlets that can be used to open the end of the sampling duct to enhance transport of sample in the duct to the particle detector for analysis;

Figure 17 illustrates a variant of the system of figures 14A to 14E;

Figure 18 illustrates a particle detection system including an air sampling network that has a sample amplification arrangement comprising a plurality vibrating membranes; and

Figure 19 illustrates another particle detection system including an air sampling network with branched sampling pipes and which has a sample amplification arrangement comprising a plurality vibrating membranes.

Figures 20A and 20B illustrate a variation on the systems of figures 14 and 15 respectively, which include a dedicated localisation module.

Figure 21 illustrates a particle detection system according to an embodiment of the present invention, which is arranged to detect particles in a series of regions.

Figures 22 and 23 illustrate further two embodiments of a system according to the invention that are arranged to detect particles in a series of regions.

Figure 24 illustrates a particle detection system incorporating video verification using a video security system.

Figures 25 and 26 illustrate exemplary user interfaces used for video verification in the system of Figure 24.

Figure 27 is a schematic diagram of an apparatus used for commissioning and/or testing of a system of the type illustrated in figure 24.

Figure 28 is an exemplary accessory, in this case a valve, which is arranged to sense a change or condition in flow in the air flow path from another system component and control its operation in response to the sensed change or condition.

Figure 29 illustrates a particle detection system incorporating an accessory as described in connection with figure 28.

Figure 30 illustrates an embodiment of a localisation module.

Figure 31 illustrates another embodiment of a localisation module to which multiple sampling pipes can be connected.

Figures 32 and 33 illustrate additional embodiments of accessories similar to that of figure 28.

Detailed description of the embodiments

Figure 1 shows a particle detection system including a particle detector 11 in fluid communication with a sampling network 28. The sampling network includes a plurality of inlets 29 through which air is drawn. An aspirator 16 draws air into the sampling network 28 through inlet 21 and along into a particle detection chamber 14. Air sample exits the detection system through outlet 22.

The detector includes a flow sensor 24. In a preferred embodiment of the present invention, an ultrasonic flow sensor as described in WO 2004/102499 is employed. This sensor enables volumetric flow measurements to be made. The flow sensor 24 provides an indication of the volume of air flowing into the particle detector 10 from the sampling network 28 per unit time. The output of the flow sensor 24 may be used to infer, for example, when flow faults e.g. a blockage of the sampling network 28 or reduced aspirator performance, has occurred.

The system 10 also includes a controller 40 for determining the level of particles in the air sample based on the detector's 14 output and apply alarm and fault logic to the detector output alert a user to the presence of particles and the operating state of the system. A typical installation of a Vesda or ICAM smoke detector, from Xtralis Pty Ltd. would be an example of a system of this type.

Such a detection system can be applied in an embodiment of the present invention to additionally determine the point of entry of particles into the air sampling network 28.

Figure 2 shows two particle detectors 202 and 204, each particle detector being of the type illustrated in Figure 1. Each detector is connected to a respective pipe of sampling network 203 and 205 respectively. The sampling networks 203 and 205 are effectively parallel and configured to monitor the same area. Each detector is also connected to a control unit 207, containing a microcontroller 209. Pipe 203 has a plurality of air inlets 206-216. Similarly, pipe 205 has a plurality of air inlets 218-230. Each air inlet from pipe 203 can be paired with an inlet from its parallel air pipe 205. At the time of installation, each inlet from pipe 203 is positioned to be close to a corresponding inlet from pipe 205. The inlets are therefore arranged in pairs. For example, air inlet 206 of pipe 203 and air inlet 218 of pipe 205 are together labelled air sampling inlet pair 232, because air inlet 206 and air inlet 218 are placed in close physical proximity. For example each pair of inlets may be located in the same room of a row of offices, or even be attached to a common sampling point.

In normal operation, the aspirator of particle detector 202 draws air pipe 203. The aspirator of particle detector 204 draws air through pipe 205. As each particle detector draws air, the scattered light or "smoke level" is measured, and reported to the control unit 207. The microcontroller 209 of the control unit 207 stores the reported smoke levels in its internal memory.

In the event that smoke enters the air sampling network at air sampling inlet pair 232, the distance that smoke must travel to reach particle detector 202 from air inlet 206 is much smaller than the distance that smoke must travel to reach particle detector 204 from air inlet 218. Accordingly, particle detector 202 will register an increased smoke level due to smoke entering air sampling inlet pair 232 before particle detector 204.

When the detected smoke level of one of the detectors 202,204, say particle detector 202, surpasses a predetermined threshold (which may also be an alarm threshold or not) , the microcontroller begins to monitor the volume of air that has been drawn through one or both of the detectors. Because the smoke introduced at air inlet 218 must travel along the length of sampling pipe 205 before it can be detected at detector 204. After the particle detector 204 has drawn some volume of air, particle detector 204 will record an increased smoke level similar to that seen by particle detector 202. When this increased smoke level is recorded, the microcontroller 209 finishes monitoring the volume of air that has been drawn through detector 204. This final volume can be used to determine the sampling hole through which the smoke entered the air sampling pipe.

Because the flow sensor e.g. 24, outputs volumetric rate of flow, the volume of air passing through the detector is determined by integrating the output of the flow sensor over time. For example, the flow rate may be output one or more times per second by the sensor. These volumes can be accumulated either in the detector itself or at the microcontroller 209 to determine the total volume of sample air that has flowed.

The microcontroller 209 then uses the determined volume of air drawn by detector 204 to infer the sampling inlet pair through which the smoke particles were introduced. In one embodiment, the microcontroller achieves this by consulting a lookup table such as the one below:

Volume	Air Inlet Pair
-5L	Pair 1
-3L	Pair 2
-1L	Pair 3
1L	Pair 4
3L	Pair 5
5L	Pair 6

The lookup table contains measured volumes mapped back to a corresponding sampling hole pair. Each volume corresponds to the volume of air that is drawn through the second detector before particles are detected by it. The negative and positive values indicate which detector of the pair 202 or 204 measure the volume. In this case a negative value indicates that the detector 202 measures volume.

For example, the microcontroller 209 may measure a volume of 112 mL of air drawn through detector 204 in the time between a smoke detection event by detector 202 and a subsequent detection event by detector 204. The row of the table that has a volume most closely corresponding to the volume is the fourth row, and corresponds to Pair 4. Pair 4, in turn, corresponds to air inlet pair 238. Had the measured volume instead been -112mL, the closest table row would have been the entry for -100mL, and Pair 3 (air inlet pair 236) would have been determined as the point at which smoke entered the system.

As will be appreciated, instead of measuring volume directly a value that corresponds to volume could be used in other embodiments of the present invention. For example the amount of air sample that has passed through the system can be determined by measuring a parameter other than volumetric flow rate, for example, if a mass flow sensor is present in the detector the output of such a sensor is able to be used in an embodiment of the present invention as it is related to volume by a correction factor that corrects for the temperature or density of the fluid.

Other physical parameters may also be used, including but not limited to as length, pressure or temperature or a count of volume-related events. For example, the time variable speed of the sample flow can be measured (e.g. in ms^{-1}) at location and accumulated (eg. summing or integration etc.) to determine an amount of air that has passed through the system in the form of a "length". Volume could also be represent as a "length" by using the air sample (or known proportion of it) to displace a piston. The total displacement of the piston by the collected sample (or fixed proportion thereof) will represent a measure of the amount of air that has passed through the system, alternatively for a small cylinder size the a number of cycles of the piston could be counted to yield an numerical value corresponding to the volume of air sample that has passed through the system.

To give an example in which the physical parameter being used to determine an amount of air passing through the system is pressure or temperature, consider a system in which the air sample (or a known proportion of the air sample volume) is captured in a first chamber of a closed system, the actual volume V_1 (or pressure if volume if fixed) of this amount of air may never be known. However if the temperature T_1 and pressure P_1 (or volume if pressure is fixed) of the captured sample is measured. The captured sample is then moved to a second camber of known, volume V_2 and the new temperature T_2 and pressure P_2 are related to the initial volume by Boyle's law. By controlling one the either pressure or temperature to be held constant during the transfer of the sample (or sample portion) to the second chamber a temperature or pressure can be used as an amount that relates to volume of sample air that has passed through the system.

If a measurement of a value , such as mass, pressure, temperature and length, or other physical parameter that might be measured and which is tolerant to variable flow rate, is used in place of volume, the look-up table may alternatively map those other physical parameters directly to the air inlet pair number, without having to undertake the intermediate step of calculating the volume.

Once the air inlet pair number has been determined, the air inlet pair number can then be communicated to a secondary device, such as a Fire Alarm Control Panel (FACP) or displayed to the user, to enable the localisation of the fire.

The lookup table can be created during the commissioning of the system, for example, by introducing smoke to each sample inlet pair and measuring the volume of air drawn before detection. As will be appreciated, if smoke has entered at sampling pair 232, there will be a very large volume of air drawn by detector 204 in the period after detection by detector 202 while detector 204 waits to detect the increased smoke level. Conversely, if smoke entered the system through sampling pair 242, detector 204 would detect an increased smoke level before detector 202, detector 202 drawing a very large volume of air while waiting to detect the increased smoke level. If smoke were to enter the sampling network toward the middle, for example at sample pair 236, although detector 202 would detect an increased smoke level first, the volume of air drawn before detection by detector 204 would be relatively smaller than in either of the first cases, since by the time of detection by detector 202, smoke will have already been drawn a substantial distance toward detector 204.

A person skilled in the art will appreciate that in the present configuration, where the sampling pipe network length is large, and transport time of particles through the sampling network is large, it will be possible to detect the presence of smoke before determining the location of smoke. For example, in the event that smoke is introduced at sampling inlet pair 232 of Figure 2, smoke entering sampling hole 206 will quickly proceed to detector 202, and be detected. Detector 202 can immediately raise an alarm, despite the fact that smoke has not yet been detected by detector 204. Accordingly, where regulations prescribe the time by which smoke introduced to a sampling hole must be detected, this particular configuration is capable of detecting and reporting upon the presence of fire upon detection of smoke particles. Determination of the geographic location of the fire can then proceed in the manner previously described using a threshold level that is not an alarm level.

Accordingly, in a preferred form, the threshold used for determining an addressing event for each detector is higher than the lowest alarm (eg: a pre-alarm) threshold. A preferred embodiment waits until a higher level of particles is detected before attempting addressing.

In one embodiment, instead of employing a lookup table, the volume offset is multiplied by a constant to determine the distance along the sampling network at which smoke particles entered the system. In another embodiment, the volume offset is used as a variable in a function, which when evaluated, yields an estimate of the distance along the sampling network at which particles entered. In yet another embodiment, the volume offset is used as an index into a lookup table, the resulting lookup value being an estimate of the distance along the pipe. In preferred embodiments, the multiplicative constant, function, or lookup table described immediately above is determined at the time of commissioning by introducing smoke to each sampling hole pair and measuring the resulting volume offset to generate calibration data. As a person skilled in the art will appreciate, it may be possible to infer results for a subset of sampling holes by introducing smoke to another subset of holes, and relying upon the known distribution of sampling pairs in the sampling network.

As a person skilled in the art will appreciate, modifications of the invention can be adapted to determine, for example, the spread of a fire. The information reported by the system may be a distance along the sampling network at which particles appear to have entered, although this distance may not correspond to a sampling inlet pair.

The calculated distance or air inlet may be presented directly to an end user. The calculated distance or air inlet may also be communicated to another system, such as a fire alarm control panel (FACP). Where a fire alarm control panel has been designed to receive data from a system of addressable point detectors rather than a single aspirated smoke detector having multiple sampling points, the present system may communicate the calculated distance or inlet to the fire alarm control panel in a way which mimics a system of addressable point detectors, thereby utilising the FACPs understanding of geographic location of fires without actually utilising individual addressable point detectors.

Figure 3 illustrates an alternative embodiment of the invention that employs a single particle detector attached to an air sampling network comprising two pipes 303 and 305 and a valve 304. In normal operation, air is drawn through pipe 303. When smoke detector 202 detects smoke above a predetermined threshold, valve 304 is moved to obstruct pipe303, and to allow air to flow through pipe 305, and the microcontroller 309 begins to record the volume of air drawn through detector 302. When smoke particles are detected by detector 302, microcontroller 309 finishes recording the volume of air drawn though detector 302. The volume of air passing through air sampling network 305 and into particle detector 302 prior to again detecting particles is then used to infer the point at which smoke particles enter pipe 305, using any of the methods herein described.

Figure 4 shows yet another approach which employs two particle detectors attached to a single air sampling network. Initially, smoke detector 402 operates and smoke detector 404 is inoperative. Smoke enters the system through air inlet 408. The smoke is drawn through the air sampling network, and detected by smoke detector 402. The determination of a smoke detection event triggers smoke detector 402 to become inoperative, smoke detector 404 to become operative, and microcontroller 409 to begin recording the volume of air drawn through detector 404. The aspirator of smoke detector 404 draws air along air sampling network 403 in a direction opposite to the initial flow direction caused by the aspirator of smoke detector 402. If smoke enters only through a single air inlet 408, smoke detector 404 cannot detect smoke until smoke from air inlet 408 reaches it. According to the present invention, the volume of air drawn by detector 404 after the initial detection by smoke detector 402 and up until subsequent detection of smoke by detector 404 is used to determine the air inlet through which smoke particles enter air sampling network 403, using any of the methods herein described.

The inventors have realised that it can be advantageous to use the volume of air drawn through the system or corresponding values to determine the point of entry of particles into the air sampling system. Moreover, by measuring volume rather than time, certain disadvantages or problems associated with reliance on measurement of time may be ameliorated. For example, it is known that with usage the sampling inlets gather dirt and get constricted, resulting in greater pressure drop and less flow of air. This means changing transport time for air samples over the life of the system. However the volume of air displaced to get a sample to the detector is relatively constant over time which makes the correlation between displacement volume and address more stable than transport time. Moreover if there are delays in opening a valve or beginning an aspirator, or the fan starts more slowly than expected the volume of air drawn through the system before particles are detected a second time is likely to be relatively unchanged, as compared to time based systems. Advantageously volume-based addressing systems may be able to be operated independent of the flow rate or over a range of variable flow speeds, enabling techniques such as those described below, in which the system opens up an end cap to speed up the flow of a sample to the detector.

Other types of flow sensor can be used in embodiments of the invention, for example a mass flow sensor, which provides an indication of the mass of air moving past the sensor over time. However, because mass flow sensors are insensitive to the density of the air they measure, other information such as the temperature of the air is required in order to determine the volume of the air moving past them.

A further difficulty that can arise in implementing embodiments of the above invention and that of the prior art is the potential difficulty in reliably determining that two equivalent smoke detection events has occurred, for example noise introduced prior to conversion of a signal from analogue to digital form may frustrate the process of determining when smoke is detected by detector 202, or detector 204. The inventors have devised an improved process that avoids or ameliorates this drawback.

A smoke detection system such as that of Figure 2 produces two distinct data sets or "particle detection profiles". One data set is drawn from particle detector 202. The second data set is drawn from particle detector 204. Each data set contains a series of measured smoke levels. The data set may also contain information regarding the volume of air flowing through the detector, or a time at which a particle smoke level was measured.

In the following example, we will describe a system that monitors smoke levels over time. A person skilled in the art would appreciate that the method can be adapted to measuring smoke levels compared to the volume of air drawn by the system (as described above), however for illustrative purposes, we presently describe the system in relation to a series of measured smoke levels taken at various times.

Figure 5 illustrates a particle detection profile. Detected smoke level is represented along its vertical axis. Time is measured along the horizontal axis. The smoke levels are those measured by detector 202 of Figure 2. Figure 6 shows a second particle detection profile. It is similar to that of Figure 5, except that it relates to smoke levels measured by detector 204.

Comparing the figures, detector 202 detected a smoke level that reached a maximum at time 200, at which time it was deactivated and the particle detection output returned substantially to zero. Detector 204 detects a maximum smoke level at time 300. The different times are at least partially attributable to the additional distance along the sampling network 205 that smoke reaching detector 204 must travel. It would be possible to use the difference between the time of each maximum or the difference in time at which each profile crosses some predetermined threshold e.g. a smoke level of 150 on the vertical axis (which may be different to the alarm thresholds in use), to estimate the air inlet through which smoke entered the particle detection system. However, more preferably a cross correlation can be calculated using the data illustrated in Figures 5 and Figure 6.

For real and continuous functions *f* and *g*, the cross-correlation is calculated according to the formula:

$$(f * g)(t) = \int_{-\infty}^{\infty} f(\tau)g(t+\tau)d\tau$$

A person skilled in the art will appreciate that this equation can be adapted for use with discrete measurements, such as the smoke levels detected in the present systems. For example, such a system can be implemented in hardware by temporarily storing a particle detection profile of each detector data in a respective buffer, e.g. a ring buffer. The buffers may be chosen so as to store data such that the longest possible offset measurable by the system can be accurately calculated. The cross correlation at a point can then be calculated by multiplying each pair of data elements in turn, and adding them, as described by the equation above. This process can then repeated for each possible offset t, to determine the overall cross-correlation function. The cross correlation function can then be used to estimate of the time offset between two particle detection events. This can in turn be used to infer through which inlet pair the particles entered the sampling pipe network. In some embodiments, information from the cross-correlation function is used to locate further geographic locations at which smoke may have entered the system.

In one embodiment, multiple peaks of the cross-correlation function are identified. A list of time offsets is calculated based upon the location of each peak and its corresponding cross-correlation value. The time offsets are used to infer the geographic location of the source of smoke. This can be used to potentially infer multiple locations at which fire occurs.

Figure 7 illustrates a detector particle detection system 700 that includes a particle detector 702 in fluid communication with an air sampling network in the form of pipes 704, 706, 708 and 710. Each pipe includes a plurality of inlets, arranged into sampling inlet groups 712 to 740. Each sampling inlet group corresponds to a physical address, eg: a room or location that is serviced by the detector. Each sample inlet group includes between one and four air inlets.

The particle detector is connected to each pipe, and configured to provide an indication to a controller whether particles have been detected in fluid drawn through each pipe. The detector 702 could for example be four VESDA smoke detectors (from Xtralis Pty Ltd) detectors coupled to a central controller or a detector capable of independently detecting smoke on up to 4 pipes.

Each of sampling inlet groups 712 to 740 comprises one, two, three or four individual sampling inlets. The inlets are arranged into groups such that the same pattern does not occur twice. For example, sampling inlet group 730 includes an inlet on each pipe but no other group includes an inlet on each pipe. Sampling inlet group 712 includes an inlet only on pipe 710, but no other sampling inlet group includes only a hole on pipe 710. In the example of Figure 7 the inlets are arranged in groups corresponding to a 4-bit Gray code.

Consistent with the discussion previously in relation to Figure 2, at the time of installation, the inlets from each group are positioned close to one another. In the event that smoke enters the sampling network at a particular inlet, smoke should enter each of the pipes for which there is an inlet present in that group. For example, if smoke enters the sampling network near the location of sampling inlet group 730, one would expect smoke to enter each of the four pipes 704, 706, 708 and 710 at that location. Conversely, if smoke enters the sampling network at sampling inlet group 712, one would expect smoke to only enter pipe 710, since at that location, no other pipe includes an inlet. Upon detection of particles in the samples drawn into the individual pipes 704, 706,708, 710, the particle detection system is able to determine the point of entry of smoke into the sampling network based upon the pattern of detection across the pipes 704, 706,708, 710.

The table of Figure 7 more completely illustrates the possible combinations of particle detection states across the four pipes and their corresponding particle detection locations. It is useful to begin by defining a nomenclature for expressing the indicated smoke levels. For present purposes, we will use a four binary bits to correspond to the detected smoke levels for each of pipes 704, 706, 708, and 710 respectively. For example, the indication '1111' corresponds to detection of smoke at some threshold level, in air drawn from each of pipes 704, 706, 708, and 710. The indication '1100' would refer to detection of smoke in air drawn from each of pipes 704 and 706. The indication '1010' would refer to detection of smoke in air drawn from each of pipes 704 and 708. Accordingly, each of these four bit indications can be treated as an address that corresponds to a location. There are fifteen non-zero four bit numbers. Accordingly, these fifteen numbers can be used to distinguish fifteen separate locations. The table of Figure 7 lists each of the possible fifteen non-zero binary numbers in the column 'Gray Code' address. Alongside each binary number is one of 15 locations in the 'Location' column. The 'Smoke Detected' column shows whether smoke had been detected at the assigned threshold level at pipe.

There is a large number of possible ways of allocating addresses to each location. For example, in some embodiments, each successive location from 1 to 15 may take a subsequent binary number, in a manner similar to ordinary counting. Accordingly to this scheme, location 1 would have the address '0001' (which is a binary representation for the decimal number '1') and location 2 would have the address '0010' (which is a binary representation for the decimal number '2'). In this scheme, location 15 is given the binary address '1111', which is a binary representation for the decimal number 15.

However, the illustrated embodiment uses a different method of allocating addresses, called a 'Gray code'. In the illustrated gray code of Figure 7, the location 1 is given the address '0001'. Location 2 is given the address '0011' (which corresponds to the binary for the decimal number '3'). Location 3 is given the address '0010' (which corresponds to the binary for the decimal number '2'). This sequence of numbering has a special property when each of the binary representations is considered. In particular, each pair of adjacent locations has a binary representation that differs by precisely one bit. For example, location 4 has the address '0110', whereas location 5 has the address '0111', and so only the <u>fourth</u> bit of each number differs. Similarly, location 11 has the address '1110' whereas location 12 has the address '1011', and so these also differ by their <u>second</u> bit only.

The way in which addresses are chosen may influence performance in the presence of detection errors. In particular use of a Gray code scheme may be, more robust to addressing errors than a straight "counting" address scheme in which successive locations are addressed by successive binary numbers. To illustrate this point, in a system that adopts the gray code numbering as described in figure 7, there is roughly a fifty percent chance that for a single bit error the determined location of the fire will be a location adjacent to the actual location of smoke, since the address of each adjacent location differs by a single bit only.

A person skilled in the art would appreciate that judicious selection of the sample inlet groups and increasing of the number of pipes feeding the detector can result in increased redundancy for the purpose of the localizing decision. In practical terms, the introduction of this redundancy may be such that, for example, simultaneous entry of smoke at multiple sample inlets can be distinguished, or alternatively, such a system may simply provide greater resilience to error.

Figures 8 and 9 show two embodiments of a further mechanism for providing addressability within an aspirated particle detection system of the type described in Figure 1.

Turning firstly to Figure 8, which shows a particle detection system 800, including a particle detector 11, coupled to an air sampling system 26. The air sampling system 26 includes a sampling pipe 28, including five sample points 29. As described in relation to Figure 1, the aspirator of the particle detector 11 draws air samples in through the sample inlets 29, which then travel along the pipe 28 and into the detector 11 for analysis. In this embodiment, each sampling hole 29 additionally includes a valve 802. Each valve 802 is independently able to adjust flow through its respective sampling hole 29. The valves are controlled by the central controller of the detector 11, and are configured to be opened and closed under the control of detector 11. In some embodiments the valves 802 can receive sense the need to change state by interpreting glow changes as signals from the detector 11 in a manner described in more detail in connection with figure 28.

The purpose of the valves 802 on each sampling inlet 29 is to enable the smoke detector 11 to vary one of its systems' sampling parameters in order to assist in determining which of the sampling inlets 29 particles of interest have entered the system 800 through. Upon an initial detection of particles of interest by the detector 11, at a predetermined threshold level, the detection system 800 goes into the localisation routine. In this routine, the detector 11 causes the valves 29 to vary a sampling parameter, in this case flow rate, of air entering the sampling inlets. This variation may be performed on an inlet by inlet basis, or in groups of multiple inlets. After each variation in flow rate, a new particle concentration measurement is made. The initial particle concentration measurement and the second particle concentration measurement along with a variation parameter can then be used to determine which of the sample inlets particles of interest entered through.

This works because the particle level detected at the detector 11 is a weighted sum of particle concentrations and flow rates of the sample flow at each individual inlet 29. By varying the smoke level or flow rate through the sampling inlets, it is therefore possible to solve the set of simultaneous equations to determine the particle level entering any one sample inlet or group of inlets.

To illustrate a simple example, consider a smoke detection system including a smoke detector and a sampling network having a pipe with two sample inlets.

In this example, the level of smoke detected when all valves are open is given by the following equation:

$$DetectorSmokeAllValvesOpen = \frac{Smoke1 * flow1 + Smoke2 * flow2}{flow1 + flow2}$$

Where, *DetectorSmokeAllValvesOpen* is the total smoke detected by the smoke detector;

Smoke1 is the smoke level in the sample entering sample inlet 1;

flow1 is the flow rate of the sample entering through sample inlet 1;

Smoke2 is the smoke level entering the sample inlet 2; and

flow2 is the flow rate through sample inlet 2.

Now, when the first sample inlet is closed by its valve, the weighted sum of smoke arriving at the detector becomes:

$$DetectorSmokeValves1Closed = \frac{Smoke1 * 0 + Smoke2 * flow2}{0 + flow2}$$

It will be noted that this weighted sum is identical to equation 1, except that *flow1* = 0, because the valve on sample inlet 1 has been closed fully.

We are now in a situation where we can solve these equations for *Smoke1*, to determine the amount of smoke that has entered through sample inlet 1, as follows:

$$Smoke1 = \frac{DetectorSmokeAllValvesOpen(flow1 + flow2) - DetectorSmokeValves1Closed(0 + flow2)}{flow1}$$

Thus, if we know *flow1*, *flow2* and the change in flow, we can solve the equation and determine what smoke level entered at sample inlet 1. This principle also works in the event that the valves 802 only partially restrict flow through their respective sampling hole when they are closed, so long as it is possible to determine the flow rate at each sampling inlet 29. In order to allow flow rate to be detected, the system 800 includes a flow sensor 804 at each sample inlet 29. The flow sensor 804 could be a high sensitivity flow sensor, such as an ultrasonic flow sensor or a lower cost thermal flow sensor of the type which will be known to those skilled in the art.

In some embodiments, the valves 802 will not reduce the flow rate through their respective sample inlet to 0, but will only reduce it by some fraction. The following equation demonstrates how in a two hole system, as described in relation to the last example, smoke level through sample inlet 1 (Smoke1) may be calculated if valves are used to reduce the flow rate through their respective sampling holes to half their previous flow rate.

$$Smoke1 = \frac{DetectorSmokeAllValvesOpen(flow1 + flow2) - DetectorSmokeValves1Closed(0.5\,flow1 + flow2)}{0.5\,flow1}$$

In a further embodiment of the present invention, instead of varying flow rate through the sample inlet to solve the simultaneous equations, it is possible to vary the level of smoke entering each of the inlets. This can be achieved by selectively interposing a filter into the flow path through each of the sample inlets 29. An example of such a system is shown in Figures 9A & 9B. The system of figure 9A 900, includes a detector 11 connected to a sampling network 26, which includes sampling pipe 28, into which air samples are drawn through plurality of sample inlets 29. Each sample inlet additionally includes a selectable filter arrangement 902, which is shown in more detail in Figure 9B. The selectable filter arrangement 902 presents an air sample inlet 904 (equivalent to inlet 29) at one end, and a sample outlet 906 at the other. The air sample inlet 904 is open to the environment, and allows an air sample from the environment to be drawn into the selectable filter arrangement 902. The sample outlet 906 is connected to the sampling pipe 28. Inside the selectable filter arrangement 902 are two flow paths, one path, 908, which is unfiltered, and another 910 which includes a filter 912. The selectable filter arrangement 902 additionally includes a valve 914. The valve 914 is moveable between the first position in which it blocks the filtered flow path 910, and a second position in which it blocks the unfiltered flow path 908. After smoke has initially been detected by the detector 11, at a threshold level, and the detector goes into its localisation mode, in which it attempts to determine which sample inlet 29 particles have entered the system from, the valve 914 is triggered to switch between the first position in which particles drawn in through the inlet 904 are allowed to pass through to the outlet 906, into a second position, in which any particles entering the inlet 904 are removed from the airflow passing out of the outlet 906 by the filter 912. In a preferred form, the filter 912 is a HEPA filter or other high efficiency filter which will remove substantially all particles from the airflow.

The sampling point 29, and in this case the selectable filter arrangement 902 includes a flow sensor 916 to measure flow rate entering the sampling point 29.

The selectable filter arrangement 902 can be configured to communicate with the detector 11 via the airflow path of the system 900. In an example such as this the communication protocol used by the detector 11 will need to signal such that each selectable filter arrangement 902 can be individually addressed or each selectable filter arrangement programmed to operate with a co-ordinated timing. More details of an example communication method are described in connection with figure 28.

As will be appreciated, a similar set of equations to that described in connection with the first example, can be applied to the system of the type illustrated in Figure 9A and 9B.

For a two hole system, as discussed above, the level of smoke arriving at the detector when all sample inlets have their input unfiltered can be expressed with the following equation:

$$DetectorSmokeAllUnfiltered = \frac{Smoke1 * flow1 + Smoke2 * flow2}{flow1 + flow2}$$

Where, *DetectorSmokeAllUnfiltered* is the level of smoke received at the detector when all flows are unfiltered, and all other terms are as described above in connection with equations 1 through 4.

After the selectable filter arrangement of the first sampling hole is moved into its filtered mode, the weighted sum expressing the level of smoke received at the detector is expressed as follows:

$$DetectorSmokeFiltered1 = \frac{0 * flow1 + Smoke2 * flow2}{flow1 + flow2}$$

Where, *DetectorSmokeFiltered1* is the level of smoke received at the detector when the flow-through sample inlet 1 is fully filtered.

Solving these equations simultaneously yields the following equation, from which the level of smoke arriving at sample inlet 1 can be determined.

$$Smoke1 = \frac{DetectorSmokeAllUnfiltered(flow1 + flow2) - DetectorSmokeFiltered1(flow1 + flow2)}{flow1}$$

In order to handle increasing or decreasing smoke levels which may change reliability of this type of localisation process, the sequence of taking measurements in a first state and a second state can be repeated, and equivalent states averaged over a number of cycles. For example, the first measurement with all valves open can be taken followed by a smoke level measurement with the varied parameter, followed again by an equivalent initial reading with all valves open again. The two valve open measurements can then be averaged and used in subsequent calculations.

Further variation on the present systems can be implemented where instead of constricting or reducing the flow through each of the sampling points, the flow rate at the sampling points is increased, either by opening a valve, to increase the size of the sampling hole to decrease its flow impedance, and thereby increase the proportion of the total airflow from the system which is drawn through that sampling point, or by putting a fan at each sampling point and actuating or varying the speed of the fan to either increase or decrease the flow through the sampling point by a known amount.

The above embodiment has been described with a simple two inlet system. However, as will be appreciated, an as described in Figures 8 and 9A, systems are likely to have more than two sampling inlets. In such systems it is possible to scan through each of the inlets individually and vary the sampling parameter at only one inlet at a time. However, it may be beneficial to perform the variation in a grouped manner in which a subset of the total number of inlets have their sampling parameters adjusted in each measurement cycle. In some cases it may be possible to vary the sampling parameters of all sampling inlets by a differential amount in order to determine the contribution of each. As will be appreciated, the more inlets in the system that there are, the more times the process of varying sampling parameters and remeasuring particle concentration needs to be performed in order to collect sufficient data to solve the necessary set of equations.

The concept described in connection with figures 8, 9A and 9B can be extended more generally to a method for detecting contaminant(s) in air samples drawn from a plurality of air intake paths and determining the contaminant level in each. For example the methods could be applied to an aspirating particle detector that is coupled with a sampling network having a plurality of air sampling pipes feeding to the single detector, where the contribution from each pipe or branch of the sampling system is to be determined. Figure 7 describes a system in which this type of 'per pipe' localisation or addressing is used.

In the example of Figure 7 the multi-pipe air sampling system may feed into a single contaminant detector such that it requires sampling of one pipe at a time, in order to determine which of the pipes has the contaminant in the air stream. This can be achieved by sealing all but one of the pipes and allowing a sample to enter the detector from one pipe at a time while the detector measures the contaminant level. This is repeated for each of the pipes in the multi-pipe air sampling network. The sealed pipe must be fully sealed against air flow in order to obtain accurate measures of the contaminant level in the open pipe. However, complete sealing is very difficult to achieve in low or reasonable cost valves. However by using a method similar to that described in connection figures 8, 9A and 9B the requirement of complete sealing can be avoided.

Figure 10A schematically illustrates a sensing system 1010 having and a sampling pipe network 1011 comprised of a total of two sampling pipes 1012, 1014. Each sampling pipe 1012, 1014 defines an air intake path therethrough. The air intake paths are combined at manifold 1016. The manifold 1016 may include suitable baffles to assist with combining the air flows. Air is drawn through the sensing system 1010 through the use of the fan 1018. A subsample from the combined air flows is drawn through detector loop 1020 in which a filter 1022 and a particle detector 1024 are provided. Once the air flow has passed through detector loop 1020, it rejoins the main air flow path 1019. A flow sensor 1026 may optionally be provided prior to the outlet 1028 of the system 1010. As will be appreciated the sensing system 1010 is equivalent to the detector 11 of figure 1.

Each of the sampling pipes 1012, 1014 has a valve such as a butterfly valve or another type of flow modifier 1030, 1032. Additionally, each sampling pipe 1012, 1014 includes an ultrasonic flow sensor 1013 and 1015.

It should be noted that, although the valves 1030, 1032, flow sensors 1013, 1015 and manifold 1016 are illustrated as forming part of the sampling network 1011, they may equally be physically located within the housing of the sensing system 1010 and thus form part of the sensing system 1010 without changing operation of the present invention.

A method according to the present invention will now be described in connection with figures 10B to 10D. In normal operation, each valve 1030, 1032 is fully open as shown in Figure 10B. However, when the particle detector 1024 detects the presence of a contaminant in the sampled air flows at a predetermined level, the scanning method according to the present invention is undertaken. Firstly, the first sampling pipe 1012 is partially closed as shown in Figure 10C. In this condition, the particle detector 1024 takes a measure of the contaminant (C_1). Additionally, the flow rate is measured in the sampling pipes 1012, 1014 (F_{mp}, where F is the flow, m is the measurement number and p is the pipe number. Thus, the flow rate measurements will be F_{11} and F_{12}) with flow sensors 1013 and 1015 respectively.

In the next step, the other sampling pipe 14 is partially blocked by moving the butterfly valve to the position illustrated in Figure 10D. In this condition, the particle detector measures the contaminant level (C_2). Additionally, flow rate measurements are taken (F_{21}, F_{22}).

Assuming that the amount of contaminant (or relative amount of contaminant between pipes) is not changing significantly during the scanning period, the individual contaminant measurement for a pipe can be calculated from the following set of simultaneous equations:

$$C_1 = X_1F_{11}/(F_{11} + F_{12}) + X_2F_{12}/(F_{11} + F_{12})$$

$$C_2 = X_1F_{21}/(F_{21} + F_{22}) + X_2F_{22}/(F_{21} + F_{22})$$

where X_1 is the actual contamination in pipe 1 and X_2 is the actual contamination in pipe 2.

Advantageously, embodiments of the present invention enable cross-talk between the sample pipes, caused by imperfect sealing of the sample pipes, for a given species of contaminant to be eliminated without costly, precision valving. Instead, low-cost butterfly valves or other types of flow modifiers are sufficient to accurately eliminate the cross-talk, and allow pipe addressability to be achieved.

As noted above, the instead of using valves to partially close the pipes, a filter could be selectively interposed into the pipes to reduce the contaminant level in each pipe temporarily by a known amount (preferably to 0) and the method adjusted to solve for Contaminant level as described above for hole addressing.

In the various embodiments described herein, a common step which is performed, is an initial detection of particles at a detector and more particularly an attempt to accurately identify the receipt of the smoke from a particular sampling inlet of the sampling system. In particular, the event which is most commonly sought to be detected is an arrival of a smoke front that is propagating down sampling pipe, and which represents smoke which entered a particular sample inlet after a change in the operation in the sample network, e.g. opening or closing of valves or flushing the pipe network with clean fluid, or reversing flow direction or the like. Figures 11A and 11B illustrate this concept.

Figure 11A illustrates a particle detection system 1100, which includes the detector 1102, and a sampling pipe network 1104. Sampling network 1104 has three sample inlets, 1106, 1108 and 1110. A smoke plume 1112 is located adjacent to sampling inlet 1108. Take for example a situation in which the direction of flow in the sampling network 1104 is reversed and the detector 1102 is attempting to determine the time of arrival of smoke entering the system from sampling hole 1108. A graph of determined smoke concentration against time is illustrated in Figure 11B. Initially, for some period, 1020 low smoke level is detected as the sample fluid arriving at the detector only contains sample fluid from sample inlet 1106. At time T1, an increase in smoke is detected. Over the next time period 1022, when the sample from inlet 1108 begins arriving the detected smoke level ramps up until time T2, when approximate steady state level is detected. In the graph of Figure 11B, the ramp-up 1022 is not due to an increase in smoke level, but due to a smearing or diffusion of the smoke front of sample entering sampling hole 1108. If the entry of particles from the environment into the sampling network was even and instantaneous, there would be a step change in the smoke level detected by the detector 1102, at T1 when the sample from hole 1108 arrives at the detector 11.

The present inventors believe that there are a range of factors contributing to the diffusion of the smoke front, representing the arrival of the sample portion that includes an air sample drawn through a particular one of the sample inlets of the sampling system. Chief amongst these is suspected to be the existence of a flow speed gradient across the cross-section of the air sampling duct. Figure 11C illustrates a cross section through an air sampling duct 1130 such as pipe 1104. Arrows 1132 indicate that flow rate in the central portion of the duct 1130 is greater than the flow rate near the walls of the duct.

The belief is that it takes some amount of time for a sample being drawn in through a sample inlet, e.g. 1134 to break into the fast flowing central region of the flow in the duct 1130, and therefore the smoke front is smeared out when it arrives at the detector. This mechanism however has competing factors, namely initially a sample will be introduced into the slow flowing peripheral air within the duct which will delay its arrival at the detector. However over time part of the sample will find its way into the fast flowing central region which will minimise its transport time to the detector.

The inventors have proposed that a physical structure can be placed in the duct of the sampling network (i.e. in the pipe of the sampling network) to ameliorate this problem. In a first family of solutions, the inventors propose a sample injection inlet which extends inward from the wall 1131 of the pipe 1130, towards the centre 1133 of the pipe 1130, so as to deliver the sample in the faster flowing region of the sample flow. Three examples of such a sample injection inlet are shown in Figure 12.

In Figure 12, a duct forming part of an air sampling system in the form of pipe 1200 is illustrated. The pipe 1200 is defined by a wall 1202. Three sample injection inlets 1204, 1206 and 1208 are also illustrated. The first sample injection inlet 1204 is a short tube 1210, which extends from the side wall into the pipe 1200, towards its centre 12-12. Sample injection inlet 1206, is similar to inlet 1210 but terminates on its inside end 1214 with a Chamfered tip. The tip has the effect of functionally making the outlet 1216 point in a downstream direction with respect to the flow within the pipe.

Finally, sample injection inlet 1208 takes the form of an inverted L shaped tube 1220. Its inlet is external to the duct 1200, and its outlet 1222 faces in a downstream direction and is aligned with the centre of the duct 1200, thus injecting samples, drawn into the sample inlet 1208, at the centre of the pipe in the fastest flowing fluid flow. These three examples take advantage of the faster flowing central region of flow within the pipe to minimise smearing of samples drawn in through the sample inlet.

An alternative to this injection method is illustrated in 13A to 13D. This series of examples uses a structure which creates turbulence within the duct of the sampling system to prevent or disrupt laminar airflow within the sampling duct, to thereby minimise flow gradient of the type illustrated in Figure 11C. Figures 13A to 13D each illustrate a segment of duct 1300, 1310, 13,20 and 1330 respectively.

In Figure 13A, the inside wall 1302 of the duct 1300 is used as a turbulator. The wall 1302 has been roughened or given surface contour or texture such as ribs, lines, bosses, or other, to create a rough surface that disrupts flow across it.

In Figure 13B the turbulator is a series of turbulence causing protrusions 1312 extending inward from the wall 1310 of the pipe, and are used to caused disruption of laminar flow within the pipe 1310.

Figure 13C illustrates an example in which a plurality of turbulence causing members extend the full breadth of the pipe 1320. In this example the turbulators are in the form of open mesh elements 1322. The open mesh elements 1322 have a hole size sufficiently large that they will tend not to clog over time but will cause turbulence to be created in the pipe 1320. As will be appreciated by those skilled in the art, a range of different shaped turbulators which span across the interior of a sampling duct can be devised.

Figure 13D illustrates a further example in which a moving turbulence causing element 1332 is placed inside the pipe 1330. In this case, a series of fans 1334 and 1336 are supported in the pipe 1330. The fans may be actively driven or passively rotating, but serve to stir the air or cause turbulence therein, as the air flows past them.

In this example, it has been convenient to describe the turbulence causing structure in a region of the duct which is an adjacent sampling inlet, however it should be noted that there is no particular reason why this should be done and the turbulence causing structure could be placed away from sampling inlets.

As will be appreciated with the four examples described above, the purpose of the turbulence causing structure is to break down the flow profile across the air sampling duct such that the air entering from a sampling inlet will travel along the sampling duct to the detector like a 'packet', rather than having part of it travel relatively faster or slower than another part and thereby smear out the arrival of the sample front at the detector.

Alternatively, or in addition to the techniques described above, the present inventors have identified that additional improvements in detecting which sample inlet of a plurality of sample inlets, smoke is received from by at least partially ameliorating the effect of dilution on air samples drawn into the sampling network. Consider a particle detection system such as that illustrated in Figure 11A. In such a system, the air sample drawn into sampling pipe 1108 will be drawn into the sampling pipe 1104, where it mixes with, and is diluted by a sample drawn from sampling point 1110. Similarly, the air sample drawn from sample inlet 1106 is diluted by samples drawn from all up-stream sample inlets. Thus, by the time air samples arrive at the detector 1102, the actual concentration of particles which is detected will be greatly diluted compared to the sample concentration in the atmosphere surrounding the particular sampling inlet through which the particles entered the sampling network. The present inventors have determined that certain modifications to the systems described herein can be performed to ameliorate this problem, either by increasing the concentration of samples drawn into the sampling pipe, such that they more closely reflect the actual concentration of particles in the atmosphere surrounding this sampling point and/or by providing mechanisms for delivering samples to the detector with minimal additional dilution.

Figure 14 illustrates a first exemplary system 1400 which implements such a technique. The system 1400 includes a detector 11, and an air sampling network 26 including a sampling pipe 28 having five sample inlets 29 at the far end 1402 of the air sampling pipe 28, the detector system 1400 includes a sample amplification arrangement in the form of bellows 1404, which are driven by an actuation means 1406. The bellows 1404 perform the function of blowing or sucking air along or from the sampling pipe network in a manner to be described below. As will be appreciated by those skilled in the art, a wide variety of systems could be used to replace the bellows structure, for example, a reciprocating pneumatic piston, or reversible fan or pump or other like air movement device could be used in place of the bellows 1404.

Operation of system 1400 will now be described. Initially, once particles at a threshold level have been detected by the detector 11, the system 1400 enters a localisation mode in which the location of particles in the system will be determined. In this mode, the primary air movement system, e.g. the aspirator 16 of the detector 11 is stopped and the system enters a sample amplification phase in which the controller communicates via communications channel 1408 with the actuation device 1406 of the bellows 1404. With the fan stopped, or alternatively with a valve at the detector end of the sampling network 26 closed, the sampling pipe 28 contains a fixed volume of air, in use the bellows 1404 is used to increase and decrease the volume of air contained within the sampling pipe network 26. When the bellows is expanded the volume increases and additional sample fluid is drawn into each of the sampling inlets 29. When the bellows is contracted some portion of the air within the sampling network 26 is expelled from the sampling inlets 29. By expanding and contracting the volume of air within the sampling pipe network, air is repeatedly pumped into and out of each of the sampling inlets creating a localised sample portion within the sampling pipe 28, surrounding each of the sampling inlets 29, which more closely reflect the level of particles of interest in the environment directly adjacent each of the sampling inlets 29, than would be the case with the continually drawn and continually diluted sample stream.

Consider the situation at a single one of the sampling inlets 29, the air sample drawn into the sampling inlet enters the sample pipe network and mixes with the existing flow within the pipe 28. The existing air flowing past the sampling inlet dilutes the sample with samples drawn from all upstream sampling inlets. When the flow in the pipe 28 is stopped by closing a valve 1410 at the detector end of the pipe 28 or possibly by stopping the aspirator of the detector 11, then the bellows 1404 are contracted and then, some portion of air within the sampling pipe 28 surrounding the sampling point 29 is expelled from the sampling point 29, as air is pushed along the sampling pipe 29 by the bellows. However, the air which is expelled from each sampling point includes the diluting samples from the upstream sampling points. Suction is again applied to the pipe network 28 by expanding the bellows 1404 and an additional air sample is drawn into each sampling point. Whilst this sample is also diluted by the fluid which already exists within the sampling pipe adjacent the sampling point, part of this diluting air is the air sample which was previously drawn into the sampling point of interest. Therefore, the total concentration after the second sampling is increased compared to the first. With repeated cycles of expelling and sampling via a sampling inlet, the proportion of air within the pipe 28 in a portion of the sample surrounding the sampling inlet begins to approach increases and the particle level begins to approach that in the atmosphere surrounding sampling inlet. Using this method, discrete sample portions within the sampling pipe 29 are formed which represent, more closely, the environment surrounding the sampling inlets. Because dilution is reduced, the methods described above which rely on detection of the onset of a smoke level increase i.e. a smoke front to determine the location of entry of particles along the sampling network can be improved. Once the sample amplification phase is completed the system enters a transportation phase and moves the sampled air, now including sample packets which are relatively localised, back to the detector for analysis.

Figures 14A to 14E illustrate an exemplary system that uses a vibrating membrane, e.g. a speaker to perform sample amplification. The system 1420 includes a particle detector 11 coupled to an air sampling network 26. The air sampling network 26 includes a sampling pipe 28 having a plurality of air sample inlets 29. The air sampling network is coupled to the detector via a sample amplification arrangement 1422 and aspirator 1424. The aspirator 1424 operates to draw samples into the sampling network and push them to the detector 11 for analysis in a manner that will be described in more detail bellow. The sample amplification arrangement 1422 performs a similar job to the bellows of figure 14 in that it causes oscillation of the flow direction in the air sample system to promote mixing of air in the region of surrounding each sample inlet 29 and air in the sampling pipe 28. In this example the sample amplification arrangement 1422 includes a membrane 1426 that is mounted within a housing 1428 and driven back and forth in reciprocating motion by an actuator. The actuator and membrane can be provided by a loudspeaker. Preferably the membrane is made to oscillate at a subsonic frequency, and most preferably at between 2 and 10 Hz.

In ordinary operation the aspirator 1424 runs at a first speed setting that is sufficient meet sample transport time requirements and draws air samples to the detector 11. Once particles are detected in the sample flow, the system 1420 enters a localisation mode beginning with a sample amplification phase. In this phase, illustrated in figure 14A, the fan enters a low speed operation and the sample amplification arrangement 1422 is activated. The membrane 1426 oscillates and agitates the air in the pipe 28 to cause mixing with air nearby the entrance to each sample inlet 29. Because the fan is running at low speed, a mixed air sample that more closely approaches the true particle concentration in the air surrounding the sampling network 26 enters each sampling inlet 29 and slowly builds a packet of air downstream of each inlet. In figures 14B to 14D the agitation is continued as the fan 1424 runs slowly and builds the sample packet 1430.

Next in figure 14E, the system 10 enters transportation phase. In this mode the fan 1424 increases speed, and the membrane 1426 is stopped. The sample packets, e.g. 1430 are then drawn back to the detector 12 with the fan running in fast mode. As described below, various techniques (e.g. by blocking sampling inlets, opening the end of the pipe etc.) can be employed to minimise mixing or smearing of the sample packets to thereby increase the reliability the localisation techniques applied. Figure 15 illustrates a second embodiment of a system 1500 which performs a similar method to that described in connection to Figure 14.

In Figure 15 like features have been like numbered with respect to Figure 14 and the earlier embodiments and for brevity will not be re-explained. In this example, the sampling network 26, at its distal end 1502 includes a fan 1504, and a valve 1506. Optionally at the end 1508 of the sampling pipe 28 which is closest to the detector 11, there may additionally be a second valve 1510. In this example, the valve 1506 is normally closed while valve 1510 is open during ordinary operation of the detector 11. Once the detector goes into its localisation mode however, the position of the valves 1510 and 1506 is changed and valve 1510 is closed and valve 1506 is opened. The fan 1504 is then used to perform the same function as the bellows 1404 of Figure 14. In this regard the fan 1504 is used to either blow some of the contents of the sampling pipe 26 from the sampling points 29, or suck samples in through the sampling points 29 as described above. As will be appreciated, this oscillation of between sucking and blowing samples can be performed by the primary aspirator of the particle detector 11. However, by putting the fan 1504 at the far end of the sampling pipe network 28, an additional advantage can be gained, namely that the fan 1504 can be used at the end of this process to push the contents of the sampling pipe 126 to the detector 11, rather than using the aspirator of the detector 11 to suck air samples down the sampling pipe 28. The advantage of using a blower fan 1504 at the end of the pipe 28 is that the sampling pipe 28 becomes positively pressurised and thus during the transportation phase does not draw any additional air samples from the environment surrounding the sampling points 29. In this way, a relatively undiluted column of sampling air containing packets/portions of sample air corresponding to each sampling inlet 29 is delivered to the detector 11 such that the 'packets' of sample which were formed by the oscillation process can be distinctly detected by the detector 11. As will be further appreciated the oscillation of between sucking and blowing samples during sample amplification can be performed by using the primary aspirator of the particle detector 11 and the fan 1504 operating in concert. For example, both fans may be set to operate synchronously, i.e. moving air in one direction and then the other to enhance localised mixing of samples around their respective sampling holes, or alternatively the fans can be set to alternately apply suction to their respective ends of pipe 26 to draw the sample fluid along the pipe in one direction. Thus rather than using the bellow-like push/pull on the sample flow from one end of the pipe 26 an alternating pull/pull mechanism from two ends of the pipe is used. At the non-pulling end a valve can be closed (or partially closed) to control the amount of sample flow entering the pipe's 26 end. Advantageously this mechanism allows the system to increase the concentrating effect of bellows action. It also allows the sample packet to be formed on both upstream and downstream of the sample inlet position. The increased concentrating effect also enables the system to cut down on the number of flow oscillation cycles for any given concentration increase or mixing increase, relative to a system that acts at one end. This scheme may also average out (and possibly neutralise) the effect that fires closer to the detector end up with a higher slug concentration. As will be described below in connection with figures 18 and 19 a double ended flow modulation can be advantageously used to selectively perform sample amplification.

The system of Figure 15 can be further modified as illustrated in Figure 15B. In this example the particle detection system 1350 includes an air sampling system similar to that of figure 15 and similar features have been like numbered. However this system 1520 additionally includes two branch pipes 1522 and 1524 which enable additional modes of operation. The first branch 1522 is located at the downstream end of the pipe network, ideally between the entry to the detector 11 and the nearest sampling point 29. The branch pipe 1522 includes:

A fan 1526, which can be used to purge the sampling system in a manner to be described.

A filter 1528, which may inter alia be a HEPA filter or the like, which is used to clean the purging air delivered by the fan 1526.

A valve 1530 for selectively opening and closing the branch 1522 as needed.

The second branch pipe 1524 includes a valve 1532, and is used as an exhaust from the sampling pipe 28 during purging, as will be described below.

The system 1520 operates the in the same way as the system 1500 of figure 15 in detection mode, namely with the main aspirator of the detector 11 acting to draw air samples through the sampling inlets 29, along the sampling pipe 28 to the detector 11 for analysis. In detection mode the valves 1530, 1532 and 1502 are closed to prevent the air which is not associated with a sampling inlet 29 from being drawn into the system and diluting the air samples. Valves 1510 is open.

Once particles are detected to a sufficient extent, the system 1520 goes into localisation mode and the following steps occur:

Valve 1510 is closed and the fan of the main detector 11 stops drawing air down the sampling pipe 28.

Valves 1530 and 1532 (and possibly also 1502) are opened to enable purging of the sample air from the sampling pipe 28.

The fan 1526 is activated, and air is drawn into the branch 1522, through the filter 1528, where it is cleaned and into the sampling pipe 28. This clean air purges the pipe 28 of particle laden air and displaces it with clean air.

Valves 1530, 1532 and 1502 are closed and valve 1510 is opened and the main detector 11 fan is used to draw new air samples into the sampling inlets 29. This process only operates for a short period of time, say between 5 and 20 seconds, or as long as possible so as to avoid mixing of air samples that are drawn into adjacent sampling inlets 29. In this way packets of particle laden air are built up in the pipe 28. As will be appreciated this step could be augmented by performing one of the various concentrating techniques described herein, but in this embodiment sufficient sensitivity might be achieved without this added complication. As noted above, the use of the pusher fan 1504 also aids in delivering a relatively undiluted column of sampling air to the detector 11, which may obviate the need for an amplification stage in some embodiments.

The detector then moves into a transportation phase in which the main detector's 11 aspirator is then deactivated and valve 1502 opened. Valve 1510 remains open.

The pusher fan 1504 is activated and the packets of sample air are pushed down the pipe 28 for analysis.

The air samples are them analysed and the presence of particles versus volume (or other techniques) is used to determine though which inlet 29, the particles entered the system. In this example, analysis of the sample air in the localisation phase is performed by second particle detector 1534. This detector has a relatively fast response compared to that of detector 11.

This detector 1534 may not be as sensitive or stable in its output as detector 11, but as the particle level is likely to have increased (e.g. because of an increase in fire activity) as the localisation process is taking place, speed of detection may be a priority over sensitivity or accuracy. Furthermore actual particle concentration data can still be obtained by the main particle detector 11 as the air samples can pass through both detectors in series.

The main detector 11 and high speed detector 1534 may be part of the same particle detector (e.g. two particle detection chambers in a single device) or may be different devices, e.g. located in series. Furthermore the main detector 11 may be used alone. In this case the main detector could optionally be configured to operate in a high speed mode in which it has an improved response rate compared to its ordinary detection mode. This could be achieved by temporarily changing software parameters of the detector 11 e.g. reducing periods over which particle concentration levels are averaged etc. or by activating a second data processing path which receives detection chamber output data (or similar) and which is optimised for response rate.

As will be apparent from the foregoing the branches 1522 and 1524 and their respective components, and the fast response detector 1534, are optional additions to the system 1500 of figure 15. In order to implement the foregoing method all that is really needed over and above the system 1500 of figure 15 is a mechanism for delivering purging air to the pipe network 26 and a mechanism for controlling the system's valves to enter and exit the purge mode.

Figure 16 illustrates a further example of a system implementing the oscillation method and a mechanism for reduced dilution of delivery of final, increased concentration, air samples to the detector. The system 1600 includes a detector 11, and sampling pipe network 26, as described in connection with Figures 14 and 15, and similar features have been labelled with the same reference numerals. In this example, the process of oscillating between sucking and blowing samples is performed by the primary aspirator of the detector 11. The sampling network 26 is additionally provided with a valve 1602 located upstream of the final sampling inlet 29. After sample concentration has been increased, as described above, using the main aspirator of the detector 11, the valve 1602, which is coupled to the controller of the detector 11 by communications channel 1604, is opened. The valve 1602 is configured to open the end of the sampling network to the atmosphere such that it approximates an open pipe which has substantially less flow impedance than any one of the sampling inlets 29. When the aspirator of the detector 11 then applies suction to the sampling network 26, drawing air is preferentially drawn into the end of the sampling pipe 28, and the sample packets already within the pipe 28 are drawn along to the detector 11. Because the open pipe end has low flow impedance, the level of air drawn into each of the sampling inlets 29 is greatly reduced, thus greatly reducing dilution of the samples as they are delivered to the detector 11. The reduced tendency for air to be drawn into the sampling inlets 29, when the valve 1602 is opened will also reduce the modification of the sample packets by smoke in the environment at or near the location of other sampling holes. The reduced flow into the sampling holes 29 when the valve 1602 is open will also make the calculation of the smoke source position less dependent on the flow at the sampling holes. As described above, the system is initially trained to determine which hole a sample packet has arrived from based on how much air is drawn through the sampling network once the localisation phase has been entered. However, because the sampling holes may block in a variable way over time the reliability of volume or time measurements based on the initial training may vary over time. By opening the valve 1602 the sample inlets 29 become less influential in the flow in the sampling pipe 28 and consequently the effect of differential blocking of the sampling inlets 29 over system life will be reduced. Finally opening the valve 1602 will reduce flow impedance and the transportation phase faster. e.g. 40 sec for a 100 m pipe at 50 L/min rather than 110 sec with the end of the pipe closed.

In some embodiments the valve 1602 of sampling network 28 beyond the last sampling inlet 29 can be provide with a filter, e.g. a HEPA filter through which air is drawn. This assists the sample packet from the last sample inlet 29 in standing out from the air being drawn into the end of the pipe which might also contain particles or interest or even dust. Such a HEPA filter could also be used in conjunction with a pusher fan to implement a purging phase similar to that described in connection with figure 15B, by suitable operation of the valves 1602 and fans of the system.

As will be appreciated in the examples given herein, valves could additionally be applied to each of the sampling inlets 29 to further facilitate the effect of the flow control mechanisms (eg. bellow, fan, valve and equivalent structures) applied to the end of the pipe. For example, each of the sampling inlets 29 can be provided with a valve which is controlled in concert with the pipe end flow control system to optimise its performance.

Figures 20A and 20B illustrate two embodiments of the present invention, which may offer a particularly convenient set up compared to some of the embodiments illustrated above. These embodiments can be used in a manner equivalent to the systems of figures 14 and 15 respectively, and like features have been like numbered.

The system 2010 of figure 20A differs from the embodiment of figure 14 in that the air sampling pipe 28 is provided with a return portion 2002 connected to the upstream end of sampling pipe portion 2012. This brings the far end 1402 of the sampling network 26 back to a location near to the detector 11. In this example, the bellows 1404 and its associated actuation means 1406 along with valve 1510 are mounted together in a common module 2004. Most preferably module can be connected mechanically and electrically to the detector 11. In a similar fashion, the system 2000 of figure 20B differs from the embodiment of figure 15 in that the air sampling pipe 28 is provided with a return pipe portion 2002 connected to the upstream end of sampling pipe portion 2012. The far end 1502 of the sampling network 26 is thus located near to the detector 11 such that the fan 1504 and with valves 1506 and 1510 can be mounted together in a common module 2004.

A localisation module (e.g. module 2004) can be used to implement any embodiments of the present inventions described herein in a convenient manner. Such modules could be retrofitted to detector systems not originally intended to perform localisation or provided as optional add-on modules so that purchasers of new equipment can be provided with a choice as to whether or not to buy a detector with these features. For example a module could be provided which implements the system of figure 15B by housing the following equipment:

the branch 1524 with vales 1532,

valve 1506 and pusher fan 1504

branch 1522 with its fan 1526, 1528 and valve 1530 along with valve 1510.

Similarly the valve 1602 and possibly also a HEPA filter could be housed in a similar module.

Whilst these embodiments require an extra length of pipe for the pipe network to loop back to near the detector 11, they offer the advantage that power and electrical communications lines do not need to be run to a position remote from the detector 11 to power and control the components of the system mounted to the upstream end 1402/1502 of the sampling pipe network 26, This may assist in making system installation more straightforward. Moreover it facilitates commissioning and testing since the most complex components are now located at a single location.

In the various embodiments illustrated in figures 8, 9a and 9b, 14 through to 20b. Various components of the systems described are required to communicate with the detector 11 or other control component of the particle detection system illustrated. In the previously described embodiments communication takes place usually over a hard wired communications channel, or optionally via a wireless (e.g. radio) communication channel, for example communications link 1408 in figure 14). The present inventors have realised that a hard wired communication path need not be present but that the airflow path through the detection system could be used for communication between the detector or other controlling entity and another component or accessory of the system.

In most embodiments, the accessory will comprise a flow control device such as a valve, fan, filter or other element of the system that takes part in performing localisation technique described herein for example the accessory could include the valve 1502 and/or fan 1504 as used in the example of figure 15. Details of an exemplary accessory, in the form of a valve, are illustrated in figure 28.

The accessory 2800 is mounted to a portion of a sampling pipe 28 and has access to the airflow path 2802 contained within the sampling pipe 28. The accessory 2800 includes one or more sensors 2804 which are used to sense the condition in the airflow path 2802, such as flow speed, direction and/or pressure. The sensors 2804 are connected to controller 2806 and pass output signals indicative of their sensed condition to it. The controller 2806 receives sensor signals and processes these, and in turn controls the operation of the accessory as required.

In the present example the accessory 2800 includes a valve 2808 which may be selectively opened and closed under control of the controller 2806. The accessory 2800 is preferably powered by a battery 2810, rather than by hard wired power connection (although this is possible) in order to minimise wiring and installation requirements for the accessory.

In use, sensors 2804 are used by the accessory 2800 to sense the present state of the primary particle detector by receiving and detecting changes in airflow in the air sampling pipe 28. The controller 2806 interprets changes in the air flow 2802 as a communication from the detection system, and in response determines what action it should be taking at for the present instant.

For example, in the localisation techniques described herein, the localisation phase may be begun by temporarily shutting down, slowing or changing direction of the main aspirator of the detector 11 or by changing the condition of one or more valves at the detector end of the system. This in turn causes the air flow 2802 in the sampling pipe 28 to change. The variation in air flow is sensed by the sensors 2804 as a changing air flow speed and pressure in the pipe 28. The change is interpreted by the controller 2806 to be a control signal from the detector 11 to take an appropriate control step in response to the sensed change in flow pattern. For example, detecting a cease in airflow 2802 may signal to the controller 2806 that the detection system has gone into a localisation mode and that the valve 2808 should be opened. Alternatively, more complex operations may be performed upon detection of a control signal through the air flow path 2802. For example, when the accessory 2800 senses that the system had entered localisation mode, the accessory enters its localisation mode in which a localisation routine is performed. This may involve the accessory operating in a first condition for first time period and then in second condition for a second time period and so on. To give a more concrete example, the valve 2802 may be controlled to remain closed for a predetermined period of time, say one minute while the other elements of the particle detection system perform a sample amplification routine. After the predetermined time elapses the controller may cause the valve 2808 to open in order for the detector to operate in a "transportation phase" of the localisation process to enable the delivery of concentrated sample "packets" back to the detector 11 for analysis.

As would be appreciated, if the localisation process includes an oscillation in flow in order to perform sample amplification, the sensors 2804 can sense the oscillation and the controller can respond to this to ensure that the valve or other flow control structure of the like is set in its appropriate operating condition.

Patterns of temporal changes in airflow can also be created by the detection system to encode control messages for an accessory, or to allow addressing of particular accessories in systems with multiple accessories that require independent control (e.g. the valves 802, 902 in figures 8 and 9A)

This principle of operation to be extended to use the air flow path within the air sampling system 26 of a detector system to communicate in other ways such as by the application of sound pulses or the like. Clearly in such embodiments sensors in the form of suitable acoustic transducers would be needed in the accessory to sense these communication signals.

Figure 29 illustrates a particle detection system 2900 including a particle detector 11, a localisation module 2004 and sampling pipe network 26 and an accessory 2902 similar to that described in connection with figure 28. The sampling pipe network 26 includes a sampling pipe 28 having a series of sampling inlets 29 spaced along its length. The localisation module includes 2004 includes a reciprocating piston 2904 which acts as a sample amplification arrangement in the localisation process.

The accessory 2900 in this example includes a fan 2908 and a valve 2910 which are controlled by a controller of the accessory in response to the accessory's sensors (being a flow sensor and pressure sensor, that are not shown) detecting signals in the sampling pipe 28 that indicate the state of the system.

In ordinary detection mode the accessory has its valve 2910 closed so that samples are drawn through the sample inlets 29. When the detector 11 detects particles at a predetermined level it enters a localisation mode. This initially involves a purge phase in which the main aspirator is reversed and air blown out of the sampling pipe 28. This causes an increase in pressure in the (previously slightly negatively pressurised) sampling pipe. The sensors of the accessory 2900 detect this and it interpreted by the accessory's controller as a signal that localisation mode has been activated. The controller then opens the valve and allows air to be purged out through the end of the pipe 28 to atmosphere instead of out through the sample inlets.

When this flow ceases the reduction in pipe pressure and flow is detected by the sensors of the accessory 2900 and the processor interprets this as a signal to close the valve 2910.

Next the localisation module 2004 performs sample amplification by using the piston to oscillate the sample flow in the sampling pipe in a manner described above. The sensors of the accessory 2900 and detect the oscillations in flow and/or pressure and the processor interprets this as a signal to keep the valve 2910 in the closed position while sample amplification occurs.

Upon detecting ceasing of the oscillation phase, the accessory 2900 interprets this as an instruction that the transportation phase has begun and opens its valve 2910 and activates its pusher fan 2908 to push the sample to the detector 11 for analysis.

The transportation phase is stopped upon the accessory 2900 sensing a change flow caused by the detector or localisation module. For example, the main aspirator of the detector 11 could be temporarily stopped, slowed or reversed, a valve closed, to cause a pressure change that signals the end of the transportation phase to the accessory 2900. In embodiments with a pusher fan 2908 such as this one, the transportation phase could be run for a predetermined time if running the pusher fan makes receiving a signal from the detector via the airflow path unreliable.

At the end of the transportation phase the accessory closes the valve 2910 and the system returns to normal detection operation.

Figure 21 illustrates a further embodiment of an aspect of the present invention that leverages the existence of a pair of side by side pipe portions provided in embodiments like that of figures 20A and 20B. The particle detection system 2100 is similar to the system of figures 20 and 20A, however the positioning of the sample inlets along the pipe network 26 have been adjusted to aid the process of localisation. In this regard one of the difficulties in a practical implementation of the localisation techniques described herein is that of the ability to resolve neighbouring addresses, i.e. if the sample inlets join a sampling pipe too close together, it can be very difficult to detect when an air sample from one sampling inlet ends and an air sample from the next sample inlet begins. In the present embodiment, and that of figures 22 and 23, the ability to resolve samples has been enhanced by arranging the position of the sampling inlets along the sampling points such that they are spaced out further than the minimum spacing. Turning now to figure 21 which illustrates a particle detection system 2100 including a particle detector 11, a localisation module 2004 and sampling pipe network 26. The sampling pipe network includes a sampling pipe 28 having a series of sampling inlets 29 spaced along its length. Similar to figures 20A and 20A, the sampling pipe is a loop arrangement, or rather has two pipe portions following a similar path, e.g. two pipes 28A and 28B running parallel or generally in a side by side arrangement. However in contrast to the embodiment of figures 20A and 20B the sampling inlets 29 in the system 2100 are spaced along both pipes portions 28A and 28B, thus the upstream pipe 28B is not provided to simply allow convenient connection of the upstream end of pipe particle portion 28A to the localisation module 2004. Instead, some of the sampling inlets 29 are positioned along the upstream pipe portion 28B and others on the downstream pipe portion 28A. This enables the spacing between sampling inlets to be increased by interleaving sampling points 29 positioned along the upstream pipe portion 28B with those positioned on the downstream pipe portion 28A as the sampling pipe 28 traverses neighbouring regions R1 to R8. As will be appreciated, in some embodiments the sampling pipe 28 extends through the regions R1 to R8 being monitored and the sampling inlets may be directly coupled to the sampling pipes or even be a hole directly formed in the pipe wall, however, a sampling pipe 28 does not need to actually pass through the regions R1 to R8 in order to service the region. In fact in many installations a sampling pipe will pass by the region but just outside it, e.g. above a ceiling panel of a room being monitored for particles, outside a housing of a series of cabinets being monitored or the like. These installations may use a length of pipe connected to the main sampling pipe which leads to a sampling point arrangement that is in fluid communication with the region being monitored.

In embodiments of this aspect of the present invention, the spacing of the sampling point arrangements of neighbouring regions is closer together than the distance between their points of connection to the sampling pipe network when measured along the flow path in the pipe.

Figures 22 and 23 illustrate additional implementations. Figure 23 illustrates a system 2300 including a particle detector 11 connected to an air sampling network 26. The air sampling network includes a single run of three side-by-side, preferably parallel sampling pipe portions 2202, 2204, 2206. The downstream pipe portion 2202 is connected to the particle detector 11 on one end and to the next sampling pipe portion 2204 on its other end. The sampling pipe portion 2204 is also connected to the upstream sampling pipe portion 2206. The sampling points 29 are arranged such that each sampling point 29 connects to a different sampling pipe portion to its neighbours. That is, the sampling point servicing R1 connects to pipe portion 2202, whereas the sampling point servicing R2 connects to sampling pipe portion 2204, and the sampling point servicing R3 is connected to sampling pipe portion 2206. This pattern is repeated such that the sampling point servicing R4 connects to sampling pipe portion 2202 etc. In this way the distance between the sampling points 29, when measured along the length of the flow path of the sampling pipe is three times what is would be if a single run sampling pipe is used. The added separation between the points of connection makes resolving samples that are drawn from one sampling inlet from another more straightforward.

A further advantage that may be realised, in addition to the spreading out of the sampling points along the pipe network, arises from the (relative) re-ordering of the connection order to the pipe network, which it may increase reliability of localisation. In some cases the mixing or merging of samples in the sampling pipe network may mask (or falsely suggest) the presence of particles in physically neighbouring regions. By separating the points of connection of the air sampling points of one region, from that of its neighbours, in the sampling pipe network (most preferably by connecting a sampling point servicing at least one non-neighbouring region between them) the level independence of the air samples within the sampling system may be maintained to a higher degree.

Accordingly there is provided an air sampling system for a particle detection system for monitoring a plurality of regions, said regions being arranged such that at least one region physically neighbours another of the regions, wherein the air sampling system includes a sampling pipe network including a plurality of sample inlet arrangements, each of which services a respective region, and which is connected to the sampling pipe such that the sampling inlet arrangement of at least one region has a point of connection that is separated from the point of connection of a physically neighbouring region. Most preferably the point of connection of a sampling point arrangement of at least one non-neighbouring region is located between the points of connection of sampling inlet arrangements of the neighbouring regions. A particle detection system , including the air sampling system and at least one particle detector is also provided.

Figure 23 illustrates another embodiment which implements this scheme. In this example the particle detector 11 is coupled to a localisation module 2004 and sampling pipe network 26. The sampling pipe network 26 includes a single sampling pipe 28 having four air sampling pipe portions 2302, 2304, 2306, 2308 connected to each other and co-extending past (or through) the regions R1 to R8. In this example, the far upstream end of the pipe 28 connects to the localisation module 2004 as described above. The downstream end of the pipe 28 connects to the detector 11, via the localisation module 2004. Localization can be performed using any of the methods described herein.

The sampling inlets of each region R1 to R8 are connected to the pipe segment 2302 to 2308 as follows:

Region	R1	R2	R3	R4	R5	R6	R7	R8
Pipe segment	2302	2304	2308	2306	2302	2306	2304	2308

Thus the regions are connected to the pipe network from downstream to upstream (i.e. the end nearest the detector to the end farthest from the detector) in the following order:

R1, R5, R7, R2, R4, R6, R8, R3

In this way no region has its air sampling arrangement 29 connected to the sampling pipe 28 next to a neighbouring region, and the points of connection are widely spaced along the pipe network.

In all other respects this embodiment can operate in accordance with the other schemes described herein.

The pipe portions may be individual lengths of pipe interconnected with fittings at their ends as will be known to those skilled in the art, or alternatively special purpose multi channel pipes can be used. The interconnections of pipe segments then takes place using interconnection fittings e.g. that may be attached over or into the ends of the channels of the pipe. The use of multi channel pipes can offer an installation advantage in that the installation technician need only handle a single element instead of multiple pipes.

Whilst the present example has been described with reference to a group of regions R1 to R8 that are arranged in a straight line, there is no reason that this need be the case. In reality the regions may be arranged in any geometry. Moreover there is no requirement that the regions need to be physically separated, e.g. as rooms are, but may be regions within one larger space or volume.

In order for the above techniques to work reliably in the field, it is necessary to calibrate or train the system e.g. to as to the volume of air moved before an air sample entering a each sampling inlet arrives at the detector (or each detector), thus effectively characterising the system. Most preferably the system is trained while the air is being moved through the system in the same way as during the system's localisation mode. For example, if the system uses a pusher fan method, described below in connection with figure 15, a significant localisation error is likely to occur if the system is trained using normal detection operation when the pusher fan is not running. In one form, in which the system has a single air moving device, e.g. fan or the like or there is no mechanism to dramatically change the flow impedance or flow path through the detection system when changing from the detection mode to localisation mode, a relatively simple, but time consuming process can be implemented in training mode. In this case the system can be trained as follows. With the system operating normally, the system measures the volume of air moved starting from the time at which a test smoke e.g. smoke spray is dispensed, until the smoke arrives at the detector. This measurement is made for each sampling inlet. However this is can be time consuming as the training sequence needs to be performed for each inlet separately and the system may need to be left to return to normal operation between each cycle. Preferably the training mode uses a modified behaviour to reduce training time.

In other embodiments, e.g. a system which has an open valve plus a filter at end of the pipe during its transportation phase, the training mode involves opening the valve at the end of the pipe for a period of time. Smoke can then be selectively administered to each sample hole (or to multiple holes in selected patterns) so that the system will still suck smoke through the holes.

In training mode the system operates as follows:

a. The system then opens valve at the end of the pipe.

b. User then inputs to the detector when smoke is administered at a sampling inlet.

c. The detector measures the volume of air moved starting from the indicated time until smoke is detected for each sample inlet.

In embodiments with a pusher fan (and preferably a valve and filter at the end of the pipe) it is more difficult to simulate smoke entering a sampling pipe. For example, it is not possible to get spray smoke into a sampling inlet with the pusher fan continuously running. Therefore an alternative method is needed. Such as:

a. Replicate the standard bellows operation, but with introduced smoke, including:

i. Run the system normally;

ii. Enter the calibration process;

iii. Activate the bellows as if particles had been detected, and indicate to a user that this process has begun;

iv. User applies spray smoke at the sampling inlet under test.

v. Deactivate the bellows and turn on the pusher fan to go into the transportation phase as normal, and record the volume of air transported before the smoke arrives at the detector.

vi. System indicates that the hole has been calibrated.

vii. System closes valve and turns off pusher fan.

viii. Other sample inlets are then calibrated in the same way.

b. A Special training mode:

i. System running normally.

ii. User puts the system into the test mode.

iii. The system continues to draw air in normally and the user applies spray smoke at hole and indicates this to the system.

iv. The system then immediately turns on pusher fan.

v. The system then records volume of air through flow sensor between indication of "spray start" and smoke being detected.

vi. The system then indicates that a sample inlet has been calibrated.

vii. System closes valve and turns off pusher fan.

viii. The next hole is then calibrated using the same process.

c. Special smoke injector.

This method is faster for the user but the user needs special equipment. This method involves use of an injection device which allows smoke to be sprayed into a sample inlet in a manner that other positive pressure in the pipe. One way of doing this involves use of a test smoke generator unit that seals around the sample inlet and sprays smoke into the inlet. For example the smoke generator can have an outlet that includes a foam gasket which clamps around the sample inlet so air is not coming out the sample hole. Once fitted and a sample is injected into the sampling inlet the user inputs to the system that this smoke was sprayed. The system records the volume of air moved before the smoke pulse arrives at the detector. Figure 27 shows an example device. Although this device includes adaptations that can advantageously be used with video verification systems, this device may be used without these adaptations if needed.

Rather than empirically testing the behaviour of the system a simulator can be used. The simulator is similar to Aspire (from Xtralis Pty Ltd) The simulator works out the expected volumes per hole during the transportation phase based on the actual system hole dimensions and distances.

In the above testing methods a user can either interact with the detector directly to communicate inputs to it, e.g. to enter training mode, or indicate when test smoke has been sprayed etc. However in a preferred embodiment the detector system includes an interface, preferably wireless, by which the detector communicates with a user device, e.g. a portable computer, tablet computer, smart-phone or the like, and the user device runs an application that allows the detector to be controlled to operate as described.

In some particle detection systems, an enhancement can be provided by interfacing the particle detection system with a video security or surveillance system. Such systems use the images captured by the video security system either to perform additional particle detection methods (e.g. by performing video analytics to attempt to verify the detection of particles) or to allow a human operator of a monitoring station (CMS) to view an area in which particles have been detected so as to have human verification of the particle detection event. This may aid in determining threat level and determining an appropriate response to the detection event. An example system including a particle (in particular smoke) detector and video security system is illustrated in figure 24. Further details of such systems and their operation are described in the Applicant's co-pending PCT application filed on 7 June 2013 and entitled Multi-Mode Detection.

Figure 24 is a floor plan of a building 2400 including plurality of rooms. Each of the rooms is indicated as belonging to a zone which is monitored by a respective camera. In this regard, zone 1 is monitored by camera 2401; zone 2 by camera 2402; zone 3 by camera 2403; zone 4 by camera 2404; zone 5 by camera 2405; zone 6 by camera 2406; zone 7 by camera 2407; and zone n by camera 2408.

Each of the zones also includes a means for detecting particles 2410.1 to 2410.n. means for detecting particles 2410.1 to 2410.n could be of any type, including point detectors, aspirated detectors, beam detectors, open area active video detectors. In the present example the means for detecting particles 2410.1 to 2410.n is an air sampling inlet to an air sampling pipe 2413 that is connected to a particle detector 2411 thus forming a particle detection system of any one of the types described herein. The particle detection system is arranged to determine which sampling point 2410.1 to 2410.n particles entered, as described herein and indicates a particle level or alarm level for each detector point 2410.1 to 2410.n. The particle detector 2411 connected to sampling points 2410.1 through 2410.n and is connected to a building fire alarm system either in the form of an FACP or central controller 2412, and arranged to individually identify each sampling point as having an address on that system to enable the location of fire detection within the building 2400 to be indicated by the fire alarm system. Each of the cameras 2401 to 2408 are connected to a central control system 2412. The central control system 2412 is a video analytics system which receives and analyses video feeds from the multiple cameras. The central controller can also store and transmit video feeds to a central monitoring station either in real time or on demand as events are detected. The controller 2412 is connected via a communications channel to a central monitoring station (CMS) 2414, at which alarm situations, both fire related and security related, can be monitored. In alternative embodiments the functions of the controller 2412 and FACP can be combined into a single device. Also the functions of the central monitoring station 2414 could be performed at the controller 2412. Similarly the cameras and other security systems (not shown) and fire and/or smoke can connect directly to a remote CMS which performs all monitoring and analysis (i.e. the functions of the controller 2412 and FACP) directly.

Consider now a situation in which a fire starts in zone 2 of the building 2400 of Figure 24. In this case, the sampling point 2410.2 located within the room will draw an sample air indicating the presence of smoke particles in plume 2413. Once an initial detection is made the detector 2411 will then perform localization as described above and send an alert signal to the fire alarm control panel (FACP) indicating the position of the suspected fire. As is conventional in such systems the output signal of the detector 2411 can indicate a level of particles detected or an alarm state determined according to alarm logic of the detector. The fire alarm control panel will communicate this alert data via central controller 2412 back to the central monitoring station 2414 where staff can monitor conditions in the building 240. Because the system includes video verification capabilities, upon detection of particles in zone 2 via inlet 2410.2, video verification using camera 2402 is activated. The camera 2402 begins either capturing (if it was not previously capturing images) images or analysing images to determine whether smoke can be verified to be present from the images. The video feed from the camera 2402 is provided to the central controller 2412. The central controller 2412 performs video analytics on a series of frames captured by camera 2402 to determine if there are visual features in the images which indicate either the presence of smoke or flame within the field of view 2402.1 of the camera 2402. This video analytics can be performed either in the controller 2412 or at the central monitoring station 2414. If the analysis is to be performed at the central monitoring station 2414 the video images, perhaps in a compressed form, will need to be transmitted from the site controller 2412 to the central monitoring station 2414 for analysis. Upon detection of smoke or fire in the images captured by camera 2402 the alert system running at the central monitoring station 2414, can modify its output to indicate that the alert condition indicated by the smoke detector 2410.2 is verified by the video analytics system. From this verification a user can infer that the chance of a false alarm is low.

By indicating to the user monitoring the central monitoring station 2414 that a fire or smoke alarm has been verified, the importance level of that alarm will be raised. Accordingly the person monitoring the system will be encouraged to act more quickly on the alert. Figures 25 and 26 show two alternative interfaces which can be provided for the central monitoring station according to embodiments of the present invention. Turning firstly to Figure 25, the interface includes a plurality of video display panes 2501, 2502, 2503 and 2504 each of which displays images captured from different cameras within the building 2400 which is being monitored. The large viewing pane 2501 is provided in order to give a closer view of a location to the user of the monitoring system such that they can visually inspect a scene at which an alert has occurred. The smaller display panes 2502 through 2504 may cycle according to an appropriate scheme or alternatively be ranked in a priority order according to alert levels in the corresponding zones. The bottom portion of the interface 2500 includes a list of events 2507. For each event, event data is displayed and the user of the system is provided with a series 2509 of buttons for performing certain response actions. For each event the following data is displayed: an event number 2512 being a numerical listing of events, an "Event ID 2514 being a system-wide, unique identifier for the event used for indexing logged event data for access at a later time; an event description 2516 explaining the nature of the event; an event level 2518 being a priority ranking for the event; an indicator of the status 2520 of the event e.g. whether it is an alarm or fault or other particular type of alert a series of action buttons 2522.1, 2522.2, 2522.3.

Event number 5 in the present example, has the highest alert status and will be described herein in more detail. Event number 5 is an indication that smoke has been detected in zone 2. The smoke in this example has been detected by particle detector 2410.2 at a level indicating that alarm should be raised. In the status column, the event is indicated as "alarm verified" because the video analytic system has analysed the output of camera 2402 and determined that smoke and fire is present. In order to indicate the verification to the user of the system, the interface has highlighted the status box corresponding to event number 5 and indicated in text form that the alarm is "verified". As will additionally be noted the image of zone 2 includes a visual indicator 2508 of the location of the smoke and fire detected by video analytics system. In this regard, the video analytic system has performed an analysis of a series of images captured by camera 2402 and has indicated a boundary or edge around a region within the image which is determined to represent smoke. Additionally, an indication of a zone within the image 2510 is indicated as appearing to represent flame which is causing the fire.

Figure 26 shows an alternative interface to that of Figure 25 the only difference between the interfaces of the two figures is that rather than simply indicating that the status of event number 5 has been "verified" the interface of Figure 26 orders each of the events in the event list according to their alarm level and verification level. This additionally highlights that greater priority should be given to event number 5 compared to the other events within the system.

Once an event has been detected and verified by the automatic video verification system it will be up to a human user of the system to determine an action to be performed in response to the event. The person may choose to dismiss the event (2522.2) or view the video feed (button 2522.1) corresponding to the event to further investigate or to raise an external alarm (2522.3) by either calling Police, fire brigade or other appropriate emergency response services. This can be performed using the interfaces of Figures 25 and 26 using the buttons view (2522.1), dismiss (2522.2) or call (2522.3) as indicated.

In an additional embodiment of the present invention, it is advantageous that the video analytic system further assists the user in their investigation of pending events. In this regard, a user of the system may wish to investigate the cause of an alert, for example by determining where the event has originated, or what the true cause of an event is, for example what or thing is on fire or in danger of being set alight and is causing a smoke detection event. Such information can be particularly valuable in determining a response strategy to an alert condition. For example, if it is known exactly what is on fire an appropriate suppression strategy can be implemented. Moreover, anything surrounding the fire can be visually inspected to determine what level of response is needed. For example, if important equipment or hazardous or flammable items surround the area above the fire is, a faster response may be needed or total evacuation whereas if a fire is detected in a relatively open area or area in which non-flammable items are located a slower (or at least different) response may be acceptable.

In order to assist in the investigation process, the central monitoring station can be provided with software which analyses alarm outputs from one or more cameras and condition sensors and makes a recommendation to a user as to the order of recommended investigation as to the source or nature of the event. For example, the software system can store a map or other geographical data as to the relative position of rooms and items in the premises being monitored, and using data representing which sampling inlets have received particles, determine either a likely central point at which the fire has originated or an investigation priority. For example, in Figures 25 and 26 a verified alarm has been sensed in zone 2 and an unverified alarm has been sensed in zone 3. A pre-alarm has also been sensed in zone 1. In a situation in which verification of the presence of flame (indicated at 2510 in figure 25) is not possible, the central monitoring station will recommend an order of manual analysis of other zones in order of zone 2, then zone 3, followed by zone 1, followed by zone N. This is based on received alert levels of zones 2, 3 and 1 and the proximity of the doorways of zones 2, 3, N and 7, and the fact that zone 1 is a corridor between them. In other embodiments other factors can also play a role in determining investigation order, e.g. if the building's air conditioning return duct is located at position 2420 abnormal particle levels detector via points 2410.12 may be treated as lower priority other air sampling points as it will tend to indicate smoke more often than other air sampling points.

Thus should smoke be detected at in e.g. zone 2 and zone 1 at sampling point 2410.12 then zone 2 is likely to be the source of the fire. Conversely if only sampling points 2410.11 and 2410.12 are determined to have drawn a sample containing smoke, but no other sampling points, then zone 1 is the likely source of the fire condition.

It is also useful to note that without the video verification process applied to event 5 in figures 25 the alarm level of zones 2 and 3 would be otherwise identical. Without video verification there will be no additional information on which to base a decision that the fire is actually present in zone 2 and not zone 3 other than physical inspection. This clearly aids with the response strategy which because of the video verification process described herein enables a response to be targeted on zone 2 first which is where the fire is actually present.

The sensors (e.g. cameras) described in the illustrated may be fixed cameras or be capable of changing their field of view, e.g. be pan-tilt-zoom (PTZ) cameras. If a PTZ camera is used the camera can be programmed to pan, tilt, and zoom either to isolate locations that are identified as potentially causing an alert condition to enable investigation, Alternatively or additionally the PTZ camera can be controlled such that is captures images of a first view, and then moves to a second view and possibly one or more additional views successively, pausing for a specified time at each view. The sequence can be repeated indefinitely.

Video analysis can be performed on each view independently of the other views. In general terms this can be considered a process of performing time division multiplexing of images taken with the one camera at different PTZ settings, with each PTZ setting corresponding to a time slot. The video analytics can be performed on a series of images from successive instances of each PTZ time slot. Images captured in corresponding PTZ time slots can be treated as a "camera" and video analytics can be performed using the techniques described in earlier examples for a single camera.

Systems such as this add an extra dimension to the commissioning/calibration process described above, in that it is necessary to correlate the location of the air sampling inlets with their physical locations and also with the views of the cameras of the security system. In some cases it might even be desirable to correlate PTZ parameters of a particular cameras with a sampling point.

An apparatus and method for correlating an address in a particle detection system, said address corresponding to a physical location, with a location being monitored in a video capture system that monitors a plurality of locations will now be described in connection with figure 27. Figure 27 illustrates an exemplary apparatus 2700 that can be used for conveniently commissioning, calibrating and/or testing particle detection systems. It could also be used in non-video enabled particle detection systems such as conventional Aspirating particle detections systems, as will be apparent from the following description.

The apparatus is arranged to provide a mechanism to perform smoke tests such that the location of the smoke can be learned by the smoke detector system and in the case of a system with video verification of alerts, the security system also in a simultaneous fashion. The apparatus enables the operator to inject smoke (or other test particle) at each sampling inlet of an air sampling particle detection system, point detector or other smoke sensing device, preferably in no particular sequence, and record e.g. on an integral computer device such as tablet computer or the like, the physical location of the inlet or sensing device. The data can be transferred to the particle detector either in real time or afterwards, so that the particle detector knows which inlet is mapped to which physical location. Preferably (but not essentially) the apparatus enables the security system to identify which particular camera (and optionally PTZ parameters) is associated with each inlet's address location. Association of the inlet or sensor location with a location in the video security may be achieved by visible means. As the smoke injection occurs, the visual indicator is activated, e.g. by flashing a code for a time. The security system searches for the visual indicator and identifies images of it amongst the images captured by its various cameras. The security system can then correlate the right camera and optionally PTZ position with location of the air sampling inlet or sensor. Thus the apparatus 2700 according to the preferred embodiment includes:

a mechanism for delivering (and preferably generating) smoke to the a sampling inlet;

means for enabling detection of the apparatus in an image captured by the video security system, and optionally means to communicate data over this optical means.

means for synchronising the actions of the apparatus with the particle detection system and/or security system.

More particularly the exemplary device 2700 includes:

A controller 2702 that controls operation of the device apparatus 2700.

A power supply 2704, which will typically be a battery.

A smoke generator 2706 to produce test smoke for introduction to the sampling points as needed.

A fan 2710 to push the smoke to the point of delivery.

A duct 2712 to guide the smoke generated by the smoke generator 2706 to the point of delivery. In this example the duct 2712 is an extendible, e.g. telescopic, pipe to enable convenient use with sampling points at different heights and convenient device storage. The duct 2712 terminates in an exit port 2714 that is shaped to enable easy coupling to or around a sampling point. In this example the exit port 2714 is a funnel shaped exit port, that can fit over or around a sampling point.

A user interface 2716, which in this case includes one or more control buttons 2718 and a touch screen display 2720. These can be configured, in a manner know to those skilled in the art to control operation of the apparatus 2700 and enter data as will be described below.

A synchronisation port 2722, which can be a wired or wireless communications means for establishing data communications with external devices, e.g. the smoke detection system, video security system or elements of these systems. In the case that the port 2722 is wireless, the port 2722 can be used for real-time communications. If the port 2722 is adapted for making a physical connection, communications could be made in real time (e.g. my being plugged into the other systems during use) or asynchronously (e.g. sharing stored data and/or synchronisation of the device with one or both of the smoke detection system and video security systems after use).

A visual communications system 2724, which in this case includes an arrangement of radiation emitters 2724.1, 2724.2 , 2724.3. The visual communications system can be used to communicate with the security system during use of the apparatus 2700, in a manner described below. The visual communications system 2724 may emit visible or invisible radiation, so long as it can be received and relayed to the video surveillance system. Most preferably the radiation is received by the security system and captured in its video images of a region. In this way, the presence of the apparatus 2700 and (optionally data) is conveyed by the state of the visual communications system 2724.

An exemplary use of the test apparatus 2700 will now be described in connection with commissioning a particle detection system that has a video verification performed by a video security system. The objective of the apparatus 2700 is to assist and preferably automate the configuration and verification of the integration between smoke detection system and video security system. Specifically, the tool aids the smoke detection system and video security system to have the same sense of physical locations that is being protected.

Prior to the start of the training process, the particle detector system and video security system is set to a "training" mode.

At each sampling inlet of the particle detector system smoke is generated by the technician using the apparatus 2700. When triggered, the apparatus 2700 generates an amount of smoke sufficient to trigger the particle detection system to detect particles. The trigger to generate smoke will also switch on a visual indicator that is distinguishable from background entities in the images captured by the security system. While in the "training" mode the video security system analyses the imaged captured by it, and searches (either periodically or continuously) for the visual indicator 2724 in the images. Once found, it will record the apparatus's location (camera and PTZ presets if necessary) to identify which video camera will have the area surrounding the sampling hole in its field of view.

At the point of generating the smoke, the technician also records a name (and optionally a description) of the physical space e.g. using a keyboard interface on the touch screen display 2720. This text is stored along with the smoke test start and end time, and is optionally transmitted to the smoke detector and/or security system for correlating with detected events in these systems. During normal operation the text entered at this point can be presented to the CMS operator when the sampling hole is identified during actual use of the system.

The apparatus 2700 is configured e.g. programmed to guide the technician as to what action to take next, e.g. when move to a new sampling point, whether the technician needs to wait before triggering the smoke, the period that the technician needs to dwell with the smoke generator at the current hole, prompt for technician for name of the sampling hole etc.

Sampling points are typically located near the ceiling though there will be exceptions. The generated smoke needs to reach the sampling hole quickly and directly. However, it is strongly desirable that the technician always remain on the ground even when they trigger smoke to be presented in close proximity to a sample hole mounted high up in the ceiling, thus all controls are located at the bottom of duct 2712, and the duct 2712 is extensible.

The smoke generation start and end events for each sampling hole is synchronised with the particle detection system and video security system. This synchronisation can be done in real time over a wireless network. Optionally or alternatively the apparatus 2700 can provide the same capability without the real time use of wireless networks in an offline mode. For this later case, at the completion of the commissioning process the apparatus 2700 will need to be connected with the particle detection system and video security system to synchronise the recorded data including the name of the physical spaces. This could be performed via any communications medium or channel, including but not limited to, USB, Ethernet or WiFi.

In the example of figure 24 the following series of data are generated in the "training" mode by the test apparatus, smoke detection system and security system respectively.

Start time	End time	Physical location name	Co-ordinate (optional)
1:00	1:01	Main Corridor	-37.813621 144.961389
1:05	1:06	Boardroom	-37.813637 144.961398
1:08	1.09	Library	-37.813624 144.961398
...	...	...	...
1:30	1:31	Cleaner's Cupboard	-37.813610 144.961372

TABLE 1 – Test Apparatus data table

Start	End	Location parameter	Inlet number
1:00	1:01	130 Litres	5
1:05	1:06	125 Litres	4
1:08	1.09	100 Litres	2
...	...	...	...
1:30	1:31	16 Litres	1

TABLE 2 – Smoke Detector table

Start	End	Camera	PT2
1:00	1:01	2401	P=5 T=20 Z=200mm
1:05	1:06	2403	-
1:08	1.09	3402	-
...	...	...	...
1:30	1:31	2405	-

TABLE 3 – Security System table

Once the training data has been recorded by the test apparatus 2700, smoke detector system and security system, this data needs to be correlated in order for the video verification system and smoke detection systems to work together in the event of an actual smoke detection event. As can be seen the start and end times in each table can be used to correlate smoke test data with the smoke detector data and security system data.

In use, in the event that smoke is detected by the smoke detection system it will determine where in its system smoke was detected. If the system includes one or more point detectors "addressing" i.e. determining where the event was detected is relatively straightforward and only requires knowledge of which detector has detected smoke. If the system includes or is an aspirated particle detection system with an air sampling network the system can performs one of the localisation methods in any one of the following Australian patent applications 2012904516, 2012904854 or 2013200353 filed by the applicant or other localisation technique to identify the location of the source of the particles. The output could be a location, name (e.g. the name given by the technician during commissioning) room address or a smoke localization parameter (such as a volume of air sample that has passed through the detector between detection events whilst in the localisation phase, which identifies which of the sampling holes the smoke entered the smoke detection system through, using any of the methods described herein. This output is passed to the security system. On the basis of this name, identifier or localization parameter the security system is able to determine which of its cameras provide a view of the determined air sampling point.

In this case, the security system will identify camera 2405 as the camera which will show a view of the region in which the smoke detection event has taken place.

As will be appreciated, additional information could be gathered during commissioning to aid the CMS operator in determining an appropriate action when smoke or a fire is detected.

Additional features can also be included in some embodiments of the apparatus 2700. For example, in some embodiments other methods can be used to determine the location of the apparatus 2700 to assist or automate identification of the location and sampling inlet. For example satellite positioning (e.g. GPS or DGPS) or triangulation from electromagnetic emitters, could be used to determine which room the apparatus is in, thereby obviating or minimising the need to enter data into the system. The sampling point may be provided with a short range communications mechanism, e.g. an RFID tag, that is read by a reader mounted near the end of the duct 2712 to identify which sampling point is being commissioned in each step. This communication could also be used as the trigger for beginning the test procedure for the sampling point.

Figure 17 illustrates a variant of the system of figures 14A to 14E. The system 1700 is identical in all respects to the system of figures 14A to 14E and operates in the same manner, with the exception that the sample amplification arrangement 1702 is located at the upstream end of the sampling pipe 28. This simplifies the detector end of the sampling network 26 and facilitates retrofitting of a sample amplification arrangement 1702 to a legacy detection system that was originally installed without such a capability.

Figure 18 illustrates a particle detection system including an air sampling network that has a sample amplification arrangement comprising a plurality vibrating membranes. Essentially this system 1800 is a double ended version of the systems of figure 14A to 14E and figure 17. In this embodiment the two pistons 1802, 1804 (formed from the vibrating membranes of loudspeakers) act together to form the sample amplification arrangement. These can be operated in concert as described in connection with opposing fans of figure 15. However, being loudspeakers (or other similar air movement device capable of causing rapidly oscillating air flow) these pistons 1802, 1804 offer new the ability to selectively perform sample amplification at one or more sample inlets 29 along the sampling pipe 28. This can be achieved by oscillating the pistons with a selected phase difference between them. This causes selective reinforcement or cancellation of the sample amplification action at different places along the sampling pipe 28.

Figure 19 illustrates another particle detection system including an air sampling network with branched sampling pipes and which has a sample amplification arrangement comprising a plurality vibrating membranes. The system 1900 includes a particle detector 11, coupled to an air sampling system 26. The air sampling system 26 is branched such that it has sampling pipes28A and 28B each of which includes a plurality of sample inlets 29A and 29B arranged in series along their length. At the upstream ends of the pipes 28A and 28B are located pistons 1902, 1904. A common piston 1906 is placed at the downstream end of the sampling network 26. The sample amplification arrangement comprising the pistons 1902, 1904, 1906 can be operated to selectively cancel its oscillation effect by choosing appropriate phase differences between oscillation of the pistons in the sample amplification phase. For example in the example the downstream piston 1906 is operated in phase with the upstream piston 1902 on the pipe 28A, but out in anti-phase to the upstream piston 1904 on the pipe 28B. The result is that sample amplification occurs only on the sample inlets 29A but not on inlets 29B.

This process can be extended and combined with the method described in connection with figure 18. In this regard, greater selectivity can be achieved by operating the downstream piston 1906 is with a selected phase difference to the with the upstream piston 1902 on the pipe 28A, and no oscillation of piston 1904. Most preferably, if a node in the oscillation pattern coincides with the junction between the pipes 28A and 28B sample amplification will be minimised (or possibly eliminated) on pipe 28B and selective sample amplification can be achieved along the length of pipe 28A.

As will be appreciated the double-ended sample oscillation techniques described in connection with figures 18 and 19 could also be implemented with other types of air flow movement devices, e.g. bellows, fans (as illustrated in figure 15) or the like.

The systems of figures 17 to 19 could be implemented such that the localisation hardware is provided in a detector-end module, such as module 2004, described above. As will be appreciated this may necessitate the use of a return pipe segment to enable location of the upstream components (e.g. pistons 1702, 1804, 1902) physically near to the downstream end of the pipe 28 so that they can be housed together in the module.

Although a purge step is only described in connection with the example of figure 15B, it should be appreciated that a purge phase may optionally be used in all embodiments described herein to improve accuracy of localisation. A purge step, generally speaking involves filling the air sampling network with clean air (or at least air that is distinguishable from sample air), which will typically necessitate means for providing said air, e.g. a filter arrangement that is selectively insertable into the system to enable delivery of clean air. Therefore, where applicable such means can be provided in the systems described herein.

As will be appreciated from the foregoing, a number of techniques have been described within this document to improve addressing in aspirated particle detection systems which include centralised detector and a plurality of sample inlets placed along a duct or pipe of an air sampling system. It will be apparent to those skilled in the art that elements of each of the systems could be combined to further enhance system performance. To give but one example, the pipe network work system of Figures 14, 15 or 16 could be used to increase smoke concentrations within the pipe network to deliver a clearer smoke concentration front to the detector for use in the cross-correlation method described in connection with Figures 5 and 6. Moreover, instead of using time based correlation, volume based correlation could be used as described above. Other combinations will be readily apparent to those skilled in the art.

It will be appreciated that the present invention, although described in relation to the detection of smoke, can equally be applied to any other material that can be usefully detected by a sampling system, including gases, dust, vapour, or biological materials.

Figure 30 illustrates a further embodiment of a localisation module 3000 that can be used as a localisation module 2004 in any one of the embodiments illustrated herein. The localisation module 3000 contains the following main elements:

A main flow path 3002 that extends from the sampling pipe 28 at one end (the inlet 3004 to the localisation module 3000) to the detector 11 at the other end (the outlet 3006 from the localisation module 3000). The main flow path 3002 includes an additional particle detector 3010. The particle detector 3010 may be a particle detection chamber that is either the same or different to the main particle detection chamber 14, or of a different type. In a preferred form the secondary particle detector provides a faster response to particles than the main detection chamber 14, although this is not necessary in all embodiments. The main flow path 3002 also includes a valve (3012) that can be used to close off the main flow path 3002 and divert all flow into a primary branch flow path 3014, described below in more detail.

The primary branch flow path 3014 includes a first branch 3016 leading to a sample amplification device 3018. In a preferred form the sample amplification device 3018 takes the form of a reciprocating piston that can be used to rapidly switch between pushing and pulling a small amount of air within the sampling pipe. The primary branch flow path 3014 includes a second valve (3020) that can be used to block access to the piston and divert flow from the primary branch flow path 3014 into a secondary branch flow path (3022).

The secondary branch flow path 3022 contains a fan 3024 and a filter 3026 that are arranged to enable air to be drawn into the secondary branch flow path 3022 from outside the system, filter the air, and pass it to the additional particle detector 3010 in a manner described below.

Figure 31 illustrates a localisation module 2004 that has been extended to operate with an air sampling network 26 having multiple air sampling pipes 28.2, 28.2. The localisation module 2004 could be extended to handle multiple sampling pipes by duplicating the components described above. However in order to reduce parts count, cost of goods certain components may be shared. In this embodiment independent main flow paths 3002.1 and 3002.2 are provided. In this case the valves (3012.1 and 3012.2) are operated together and connected to respective branches of the primary branch flow path and operated in concert with each other. In most multi-pipe systems e.g. Vesda Laser Scanner or Vesda Laser industrial (both sold by Xtralis Pty Ltd) the main particle detector still only has one detection chamber and the air samples from each of the pipes are mixed together in a manifold prior to analysis in the detection chamber.

In all other respects the multipipe localisation module is the same as that of figure 30 and matching reference numerals have been used. As will be appreciated a multipipe localisation module can be made to handle any number of sampling pipes required.

Figures 32 and 33 illustrate two additional embodiments of the accessory 2800. The accessories 2800 may be used as pipe end-caps that are mounted at the far upstream end of a sampling pipe 28. However they may also be placed at other points in the sampling network e.g. at the upstream end of a branch pipe or off a T junction at an intermediate point in a sampling pipe, such that selective opening of the accessory flow path allows air into the sampling pipe.. The embodiment of figure 32 has a fan 3202 and a valve 3204 (equivalent of valve 2808 of figure 28) that can be activated under control of the localisation module. In normal smoke detection operation the valve 3204 is closed and the fan 3202 does not run. When activated, the valve 3204 is opened and the fan 3202 is activated so that air is drawn into the end of the pipe 28 and blown down the sampling pipe towards the detector 11. The accessory 2800 can also optionally include a filter, such as a HEPA filter so that the air entering the pipe is better able to be distinguished from sample air drawn into the system from sampling points.

The accessory 2800 of figure 33 is very similar to the embodiment of figure 28 and like features have been like numbered. The accessory includes a valve 2802 that can selectively open the pipe, but no fan. It also includes a filter 3302. The valve 2802 is actuated by the controller 2806 upon sensing low pressure or back-flow in the sampling pipe 28. When a high negative pressure is detected, the end cap is opened to allow air to be drawn into the end of the pipe.

In use in a preferred embodiment the particle detection system using a localisation module of the type illustrated in either of figures 30 and 31 and an accessory illustrated in either of figures 32 or 33 will have the same general architecture as that show in other embodiments such as figure 29, with a main particle detector, localisation module 2004, sampling network 26 with sampling pipes 28 and at least one accessory mounted upstream of the localisation module. Operation of such a system will now be desecribed assuming use of the accessory of figure 32.

In overview, the detector 11 operates in a normal particle mode drawing air samples and analysing them continuously. However once particles are detected above a trace level the system does into a localisation mode and activates the localisation module 2004. The main detector 11 is then de-activated and air samples cease to the drawn through the main detector 11. The localisation module 2004 then performs a sample amplification routine as described above. As noted above "amplification" mixes the air in the pipe with the local atmosphere surrounding each sample hole and causes packets of air in the sampling pipe adjacent each sampling hole to form – these packets have a composition similar to the atmosphere immediately surrounding the sampling point. As will be apparent from the foregoing description, in normal steady state operation the air sample drawn in through each sampling hole is diluted by the air drawn into all other sampling holes as it passes through the sampling network 26. However, in this embodiment, because the amplification only sucks and blows a small amount of air back and forth through the system the packets are not diluted in this way.

The contents of the sampling pipe with "packets" is then drawn back to the additional particle detector 3010 for analysis by re-activating the main fan of the main detector and, if an accessory with a fan is used (e.g. that of figure 32) by pushing it with the accessory's fan. During this "transportation" process the volume (or a related value) is measured. When the additional particle detector 3010 detects a packet of smoke, the drawn volume is read off and compared to a look-up table to determine which sampling hole corresponds to the smoke packet that was detected.

The secondary branch flow path does not play any part in this localisation process. However, it is only used to flood the additional particle detector 3010 with clean air for calibration. This process happens periodically, say once a day.

In tabular form the process can be viewed as follows:

Normal operation

Main aspirator	Main Detection chamber	Flow sensor	Valve 3012	Valve 3020	Sample Amplifier	Additional particle detector 3010	Fan in branch 3024	Volume or volume-related measure)	Valve 3204	End cap fan 3202 (if present)
On	On	Active	Open	Closed	Inactive	Inactive	Off	Inactive	closed	Off

Where for Valve 3012

Open = main flow path open and primary branch flow path blocked

Closed = main flow path blocked and primary branch flow path open

for Valve 3020

Open = primary branch flow path open so sampling pipe open to amplifier

Closed = secondary branch flow path open so sampling pipe open to fan and filter

If trace level smoke detected by the main detection chamber then normal detection is ceased and an amplification mode is entered.

Amplification

In this state the localisation module 2004 enters its amplification mode and in this example the sample amplification device, e.g. piston 3018,, repeatedly draws and pushes air to perform sample amplification. The volume of air moved in this process is low compared to the total volume of air in the air sampling system and is preferably less than half the volume of the sampling pipe between neighbouring sampling inlets.

Main aspirator	Main Detection chamber	Flow sensor	Valve 3012	Valve 3020	Sample Amplifier 3018	Additional particle detector 3010	Fan in branch 3024	Volume or volume-related measure)	Valve 3204	End cap fan 3202 (if present)
Off	Off	inactive	closed	Closed	Oscillating	Inactive	Off	Inactive	Closed	Off

After some predetermined time or number of oscillations, amplification is ceased and the system moves into Transportation mode.

Transportation

In this mode the system moves the amplified sample packets back to the additional particle detector 3010 for analysis. The volume of sample air that has passed through the system since transportation started, or a volume related value is measured, e.g. by integrating flow rate. This value is correlated with detection events in the additional particle detector 3010 to determine entry point of smoke.

As noted elsewhere herein transportation is preferably done at high speed. This is aided by opening a large port into the sampling pipe e.g. by opening valve 3204 (and if present) activating the pusher fan 3202. Opening the pipe's 28 end and blowing into the pipe's end causes a positive pressure in at least part of the pipe (the portion closest to the fan 3202) and minimises negative pressure (reduces suction) closer to the main aspirator of the system. This minimises the suction at the sampling inlets of the sampling pipe and consequently minimises the drawing of additional air into the sampling inlets during transportation, thus minimising dilution of the sample packets as they are sent to the particle detector for analysis.

Drawback is also preferably done at high enough speed to ensure turbulent flow in the sampling pipe, which minimises smearing out of packets along the pipe (as described elsewhere herein). .A further advantage of high speed drawback during transportation is that it reduces transport time of packets from the far end of the sampling pipe 28 to the detector(s) enabling quicker response.

Main aspirator	Main Detection chamber	Flow sensor	Valve 3012	Valve 3020	Sample Amplifier 3018	Additional particle detector 3010	Fan in branch 3024	Volume or volume-related measure)	Valve 3204	End cap fan 3202 (if present)
On	Off or on	Active	open	Closed	inactive	Active	Off	Active	open	On

After drawback is complete, the system goes back into normal operation.

The process can be cycled so as to update localisation data periodically, and also monitor smoke development.

Use of the secondary branch flow path 3022

As will be appreciated from the above description the secondary branch flow path 3022 plays no role in normal detection, amplification or transportation phase. The main use of the secondary branch flow path is to provide a source of clean air that can be used to calibrate or zero either one or both the main detection chamber 14 or additional particle detector 3010 either periodically or when needed. This is performed by going into a zeroing mode in which filtered air is blown back through the secondary branch flow path into the main flow path until at least the additional particle detector 3010 is full of clean, filtered air. In the zeroing phase the system configuration is as follows:

Main aspirator	Main Detection chamber	Flow sensor	Valve 3012	Valve 3020	Sample Amplifier 3018	Additional particle detector 3010	Fan in branch 3024	Volume or volume-related measure)	Valve 3204	End cap fan 3202 (if present)
Off	Off	Inactive	Closed	open	inactive	Active	On	inactive	closed	Off

It is only necessary to blow enough clean air into the localisation module 2004 to fill the additional particle detector 3010. This can be done, for example, by running the fan 3024 for some pre-set time that is sufficient to blow as acceptable volume of clean air into the system. Alternatively clean air could be blown back into the additional particle detector 3010 until a relatively steady minimum particle reading is detected by the additional particle detector 3010.

In a further embodiment there is provided a in a particle detection system having a particle detector in fluid communication with an air sampling network including at least one air sampling pipe and a plurality of air sampling points. The method generally involves, filling at least one air sampling pipe which has a plurality of air sampling inlets with a calibration substance (e.g. test smoke, or other substance detectable by the particle detector such as FM200 or the like) that is able to be detected by the particle detection system, said air sampling pipe being filled with said substance at a level detectable by the particle detection system. Next the method involves drawing an air sample into the sampling pipe to cause localised dilution of the substance around at least one air sampling inlet. Preferably the dilution process involves changing flow direction in the sampling pipe. Most preferably the dilution process is similar to sample amplification as described elsewhere herein. The contents of the sampling system are then moved to the detector whilst detecting the level of calibration substance in the contents of the air sampling system, whilst also monitoring a quantity that can be correlated with the movement of the contents of the sampling system (e.g. volume, a volume related value, or time (although this is not preferred). Detecting said localised dilution in the substance in the contents of the sampling pipe and correlating said detection with the monitored quantity, to determine a value of said quantity corresponding a sampling hole that caused the localised dilution. Detecting said localised dilution in the substance in the contents of the sampling pipe comprises detecting a reduction in particle level by a particle detector of the system.

The present method can form part of a commissioning process and in essence is the converse of the typical localisation technique, insofar as instead of amplifying a sample to create packets of sample, the substance-laden (e.g. smoke filled) sampling pipe has diluted packets created within it by the "amplification" process. Since the whole pipe can be flooded with the calibration substance simultaneously and multiple, and physically separated dilution packets created simultaneously, calibration can be performed of a greater number of sampling holes at the same time.

In order to implement such a system a method, filling of the sampling pipe can be manual via a sampling inlet or more preferably the sampling network can be fitted with an inlet such as a spigot (e.g. as part of the accessory 2800 or localisation module 2004). The latter is probably more convenient since in multi-pipe embodiments all pipes can be calibrated at once. The inlet is in fluid communication with a supply of calibration substance that has an approximately regulated output. The source of calibration substance can be connected to the inlet temporarily during calibration or permanently and enable periodic calibration and self test.

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 method of determining at least one point of entry of smoke into a smoke detection system, the system having a sampling pipe network including at least one sampling pipe and a plurality of sampling inlets through which an air sample can enter the at least one sampling pipe of the smoke detection system for analysis by a particle detector, said method including:

determining a volume of sample air that has passed through at least part of the smoke detection system since a predetermined event or a value corresponding to said volume; and

determining through which sampling inlet of the plurality of sampling inlets the smoke entered the smoke detection system based, at least in part, on the determined volume or value.

2. The method according to claim 1, wherein the predetermined event is any one or more of:

a smoke detection event;

a change in an air sample flow characteristic in the smoke detection system.

3. The method according to claim 1 or 2, which includes continuously determining a flow rate of the air sample passing through at least part of smoke detection system.

4. The method according to claim 1 or 2, wherein the method includes commencing determination of the volume of sample air or a related value upon the occurrence of the predetermined event.

5. The method according to any one of the preceding claims, wherein the volume of the air sample that has passed through at least part of smoke detection network or a related value is determined by accumulating a flow rate measurement over time.

6. The method according to claim 5, wherein the rate of flow measurement is a volumetric flow rate measurement.

7. The method according to claim 6, wherein the flow rate measurement is determined using an ultrasonic flow sensor.

8. The method according to any one of the preceding claims wherein the step of determining a volume of sample air that has passed through at least part of the smoke detection system since a predetermined event or a value corresponding to said volume, includes:

determining any one of more of

a mass;

a length;

a pressure;

a temperature,

a second volume;

an accumulated count of volume-related events,

or other parameter that that relates to a volume of sample air that has passed through at least part of the smoke detection system since the predetermined event.

9. A method as claimed in any one of the preceding claims which includes collecting all or a proportion of the sample air that has passed through at least part of the smoke detection system since the predetermined event.

10. The method according to any one of the preceding claims, wherein the method further includes changing an air sample flow characteristic in response to a first smoke detection event.

11. The method according to claim 10, wherein the step of changing an air sample flow characteristic in the smoke detection system includes one or more of the following:

- opening a valve;
- closing a valve;
- changing a direction of an air sample flow in at least part of the smoke detection system;
- changing a rate of air sample flow in at least part of the smoke detection system;
- starting an aspiration system; and

- stopping an aspiration system.

12. An apparatus for determining at least one point of entry of smoke into a smoke detection system of the type having a particle detector in fluid communication with an air sampling network, the air sampling network having at least one sampling pipe and a plurality of sampling inlets through which an air sample can enter the at least one sampling pipe of the smoke detection system for analysis by the particle detector, and an aspirator for drawing the air sample through the air sampling network to the detector, the apparatus including:

means for determining a volume of sample air that has passed through at least part of the smoke detection system since a predetermined event or a value corresponding to said volume; and

means for identifying at least one point of entry of particles into the sampling network based on the detected volume or value.

13. The apparatus according to claim 12, wherein the apparatus identifies one or more of said points of entry by reference to one or more corresponding sampling inlets through which smoke determined to have entered the system.

14. The apparatus according to claim 12 or 13, wherein the means for determining a volume of sample that has passed through at least part of the particle detection system, or value related to said volume, includes a flow sensor.

15. The apparatus according to claim 14, wherein the flow sensor comprises an ultrasonic flow sensor.

16. The apparatus according to any one of claims 12 to 15, wherein the apparatus is configured to perform a method in accordance with any one of claims 1 to 11.

17. A smoke detector including a particle detection chamber to detect particles in an air sample, an inlet to receive an air sample from an air sampling network, said the sampling network having at least one sampling pipe and a plurality of sampling inlets through which a sample can enter the at least one sampling pipe for analysis by the particle detection chamber, and an aspirator for drawing the sample through the air sampling network to the detector, the detector further including a processor configured to:

identify at least one point of entry of smoke into the sampling network based, at least in part, on a volume of sample air that has passed through at least part of the smoke detector or sampling network since a predetermined event, or a value corresponding to said volume.

18. The smoke detector as claimed in claim 17 wherein the smoke detector includes a flow sensor configured to detect rate of flow of sample air passing through at least a part of the smoke detector.

19. The smoke detector as claimed in claim 18 wherein the smoke detector includes an ultrasonic flow sensor.

20. The smoke detector as claimed in claimed in any one of claims 17 to 19 wherein the processor is configured to cause the smoke detector to perform a method as claimed in any one of claims 1 to 11.

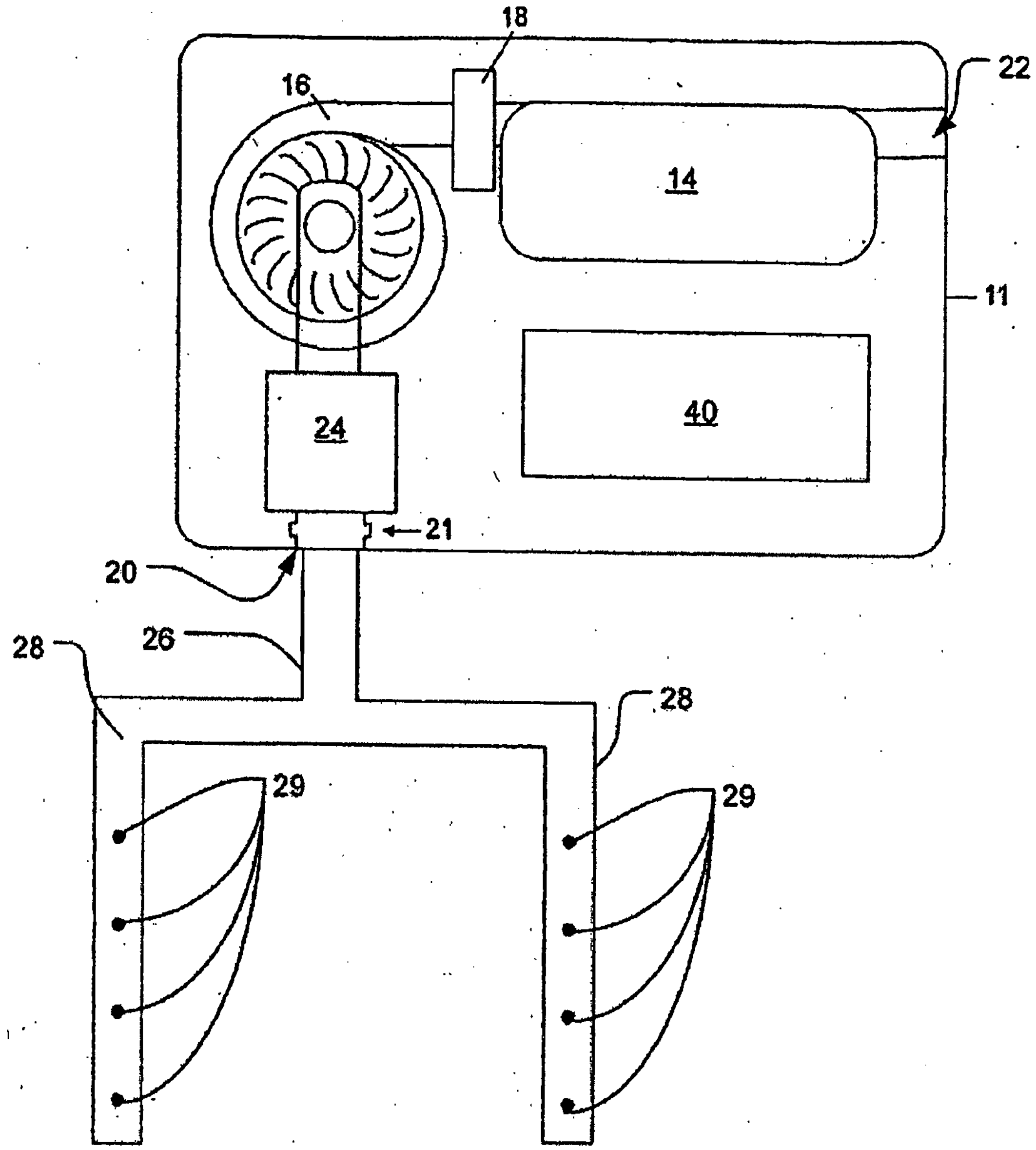


FIG 1

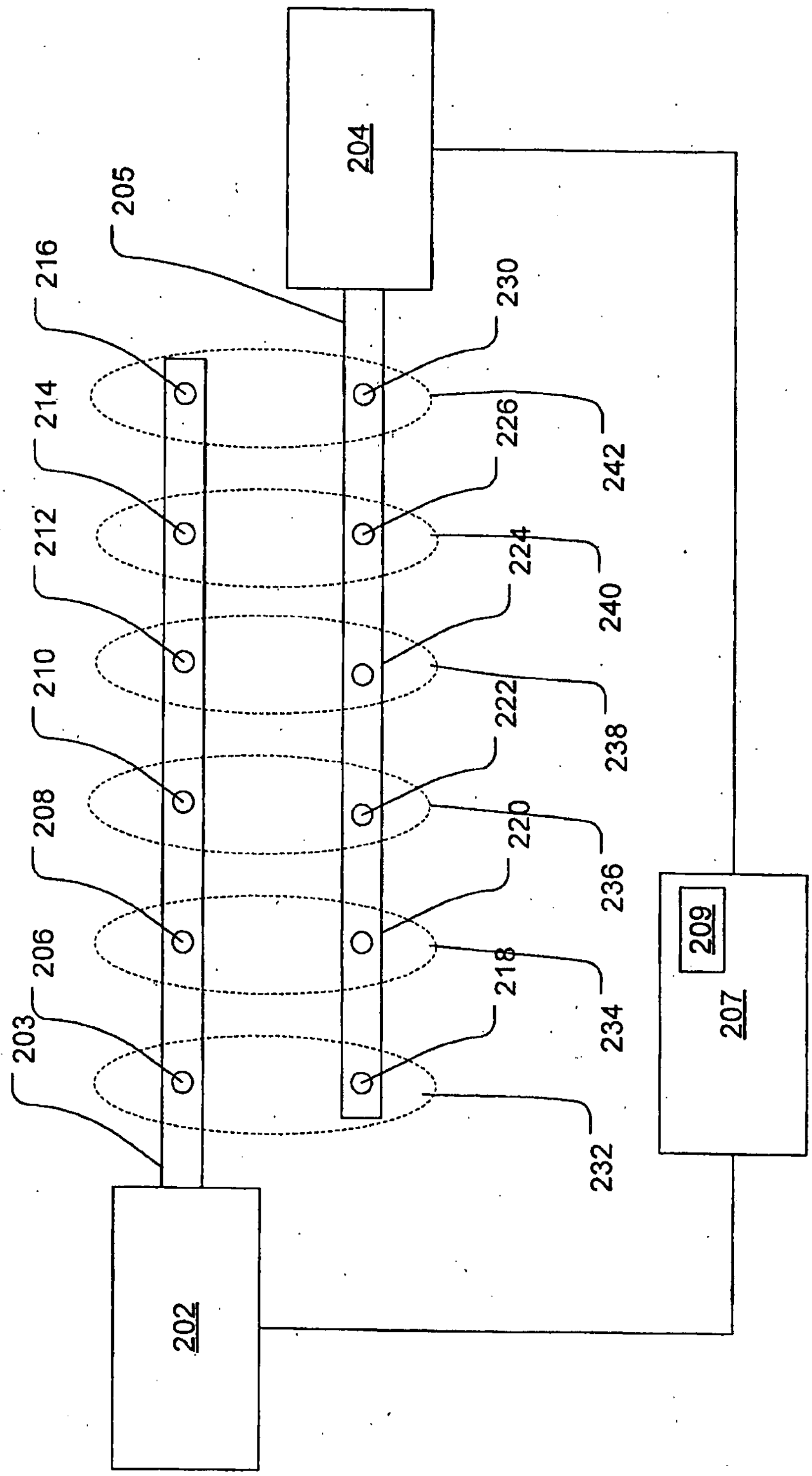

202
203
204
205
206
207
208
209
210
212
214
216
218
220
222
224
226
230
232
234
236
238
240
242

FIG 2

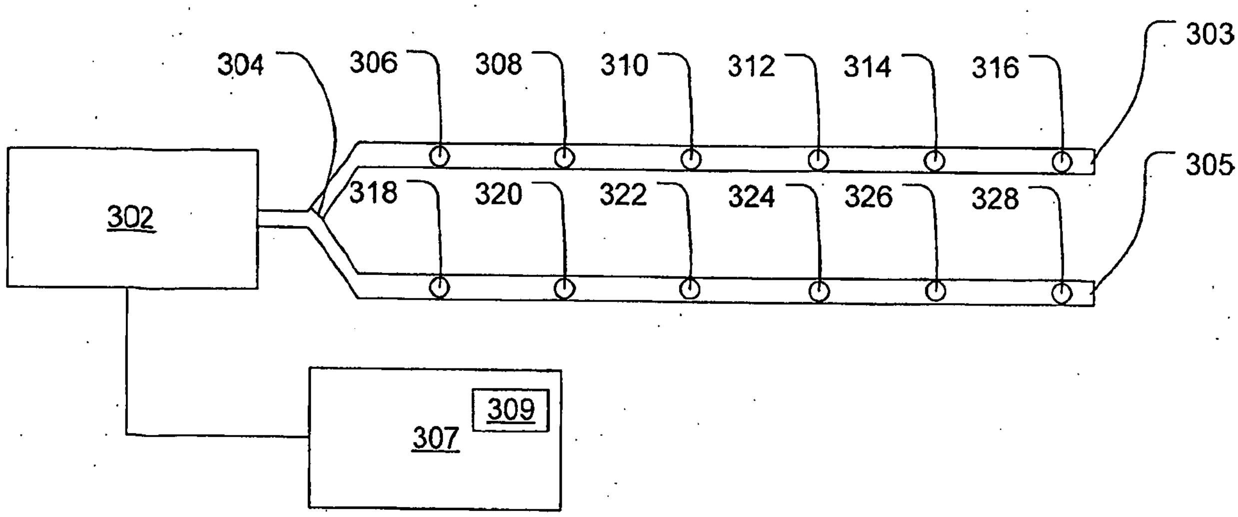


FIG 3

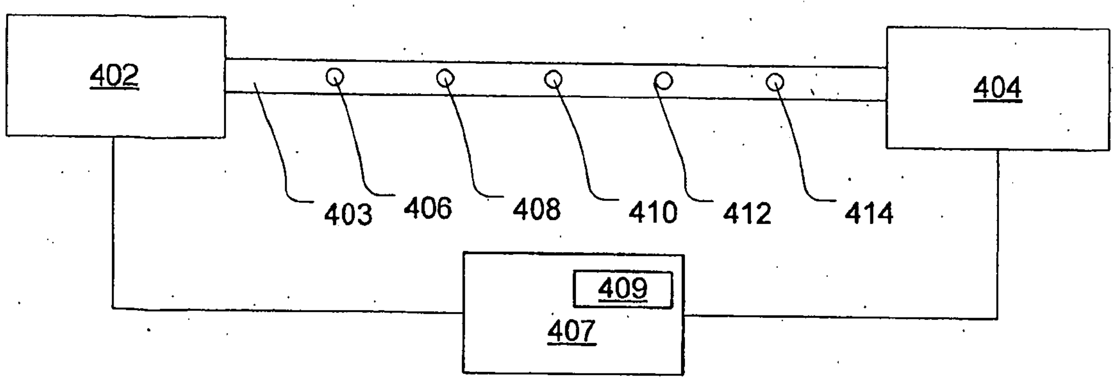


FIG 4

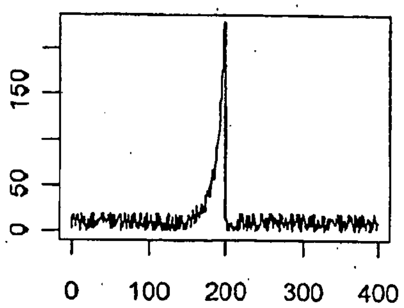


FIG 5

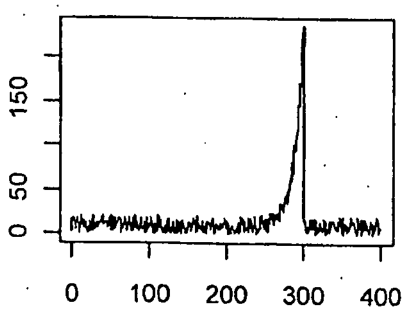
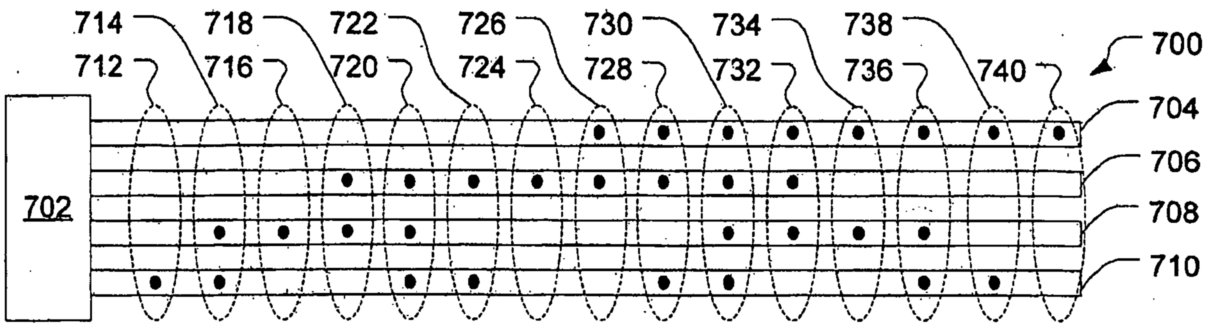


FIG 6



Location	Grey code address	Smoke detected?			
		Pipe 1	Pipe 2	Pipe 3	Pipe 4
1	0001	No	No	No	Yes
2	0011	No	No	Yes	Yes
3	0010	No	No	Yes	No
4	0110	No	Yes	Yes	No
5	0111	No	Yes	Yes	Yes
6	0101	No	Yes	No	Yes
7	0100	No	Yes	No	No
8	1100	Yes	Yes	No	No
9	1101	Yes	Yes	No	Yes
10	1111	Yes	Yes	Yes	Yes
11	1110	Yes	Yes	Yes	No
12	1010	Yes	No	Yes	No
13	1011	Yes	No	Yes	Yes
14	1001	Yes	No	No	Yes
15	1000	Yes	No	No	No

FIG 7

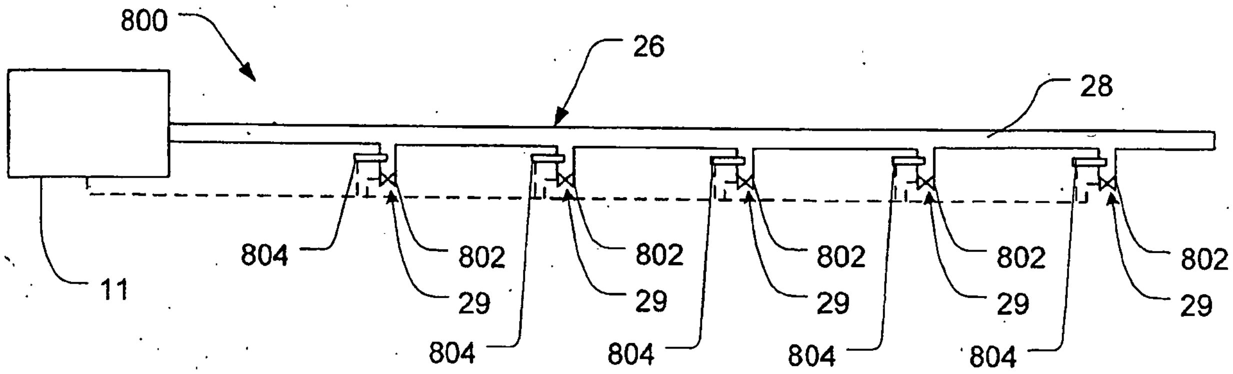


FIG 8

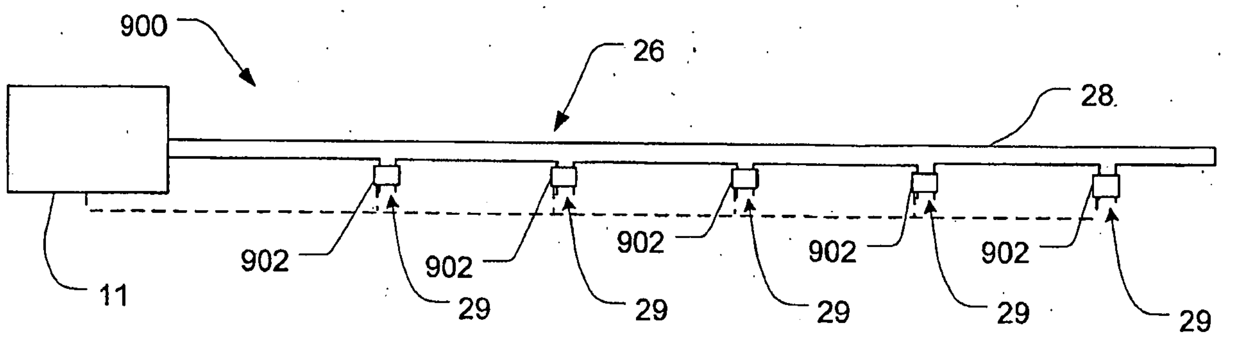


FIG 9A

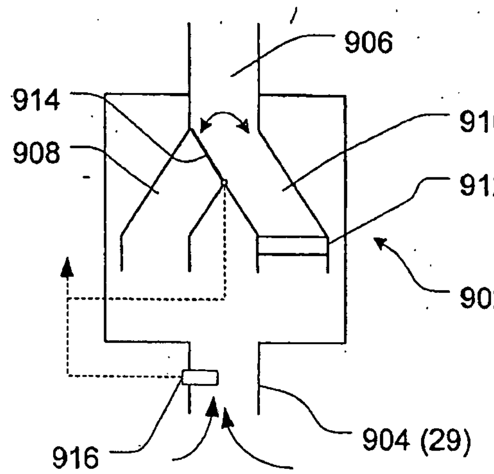


FIG 9B

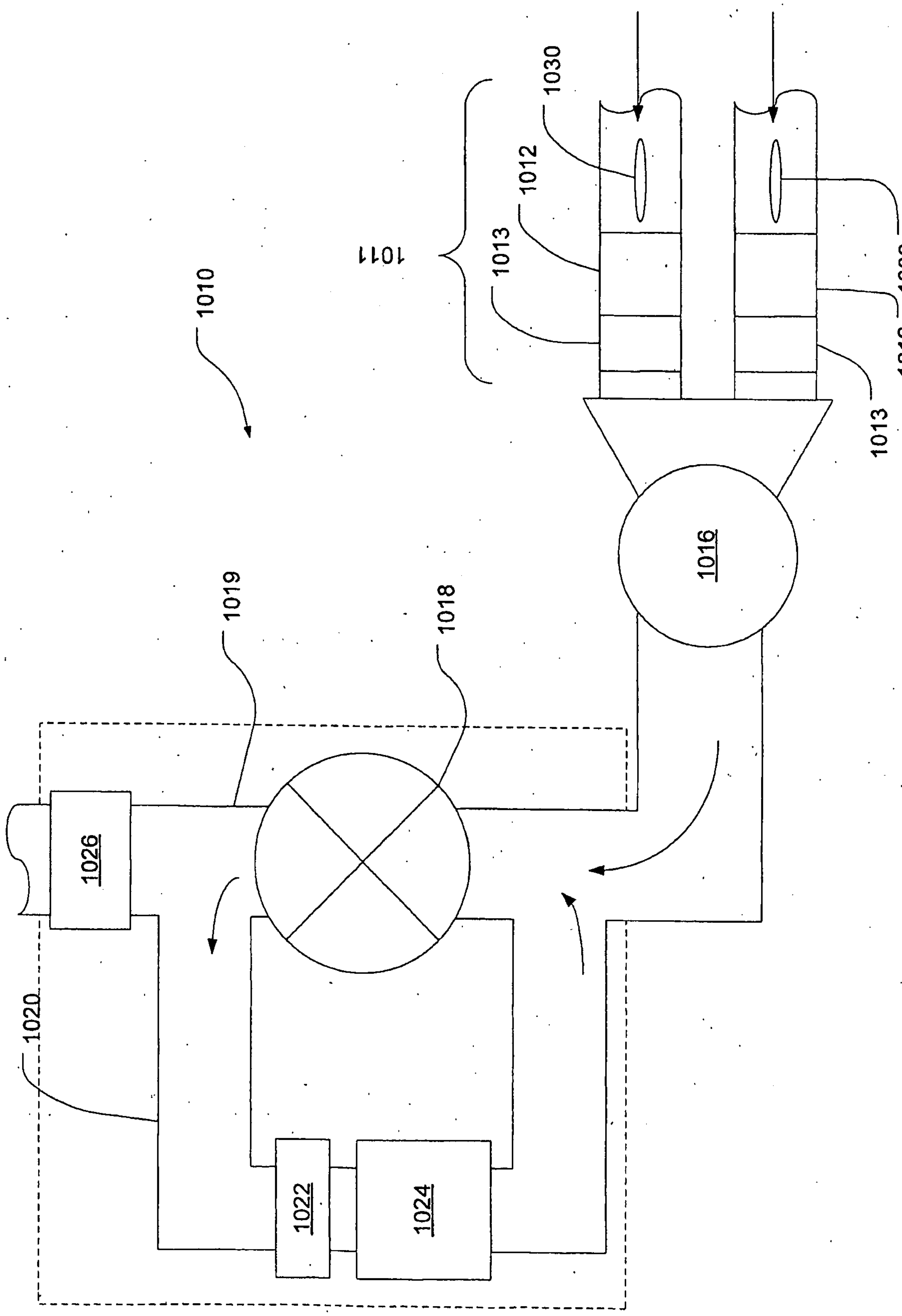

1010
1011
1030
1012
1013
1030
1012
1013
1016
1019
1018
1026
1020
1022
1024

FIG 10A

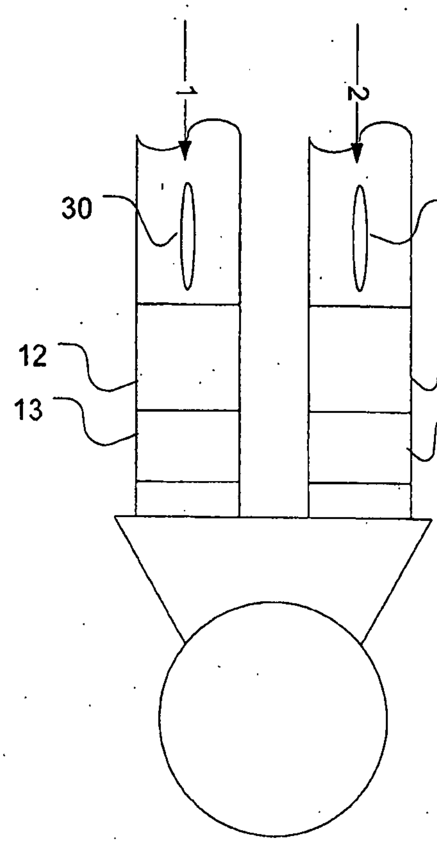


FIG 10B

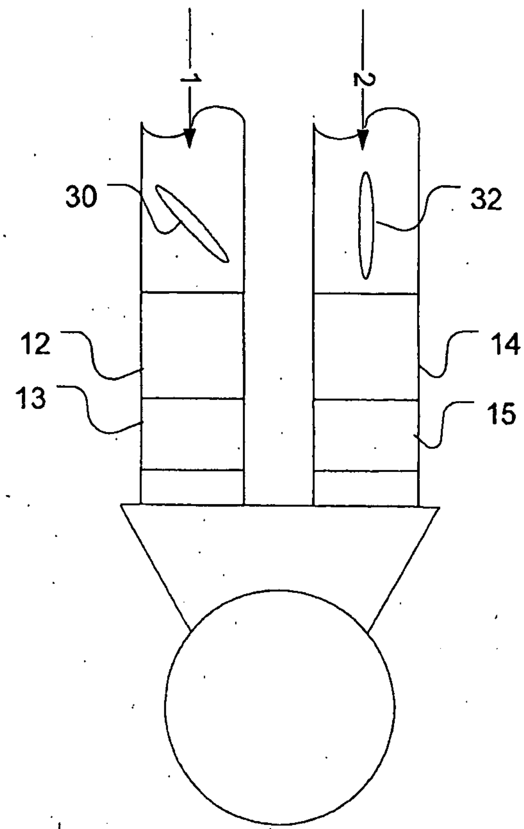


FIG 10C

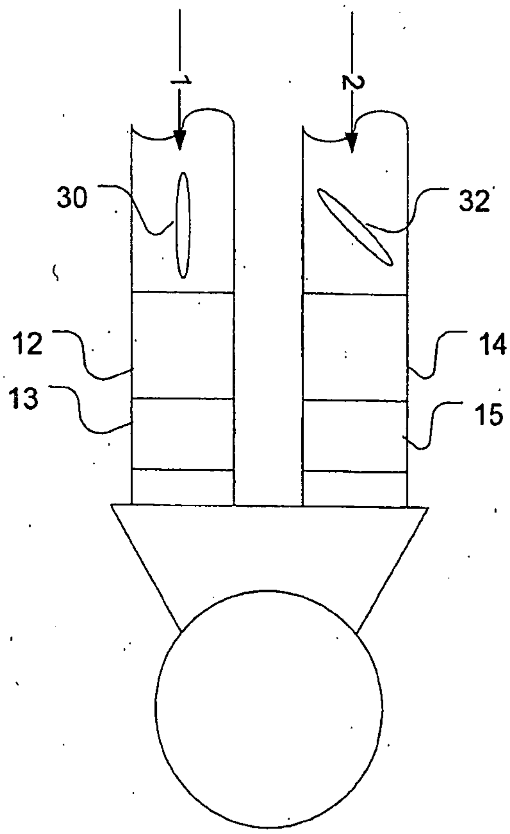


FIG 10D

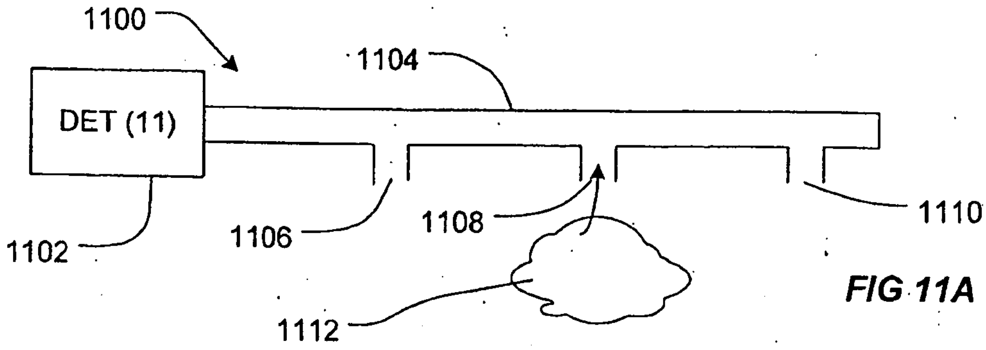


FIG 11A

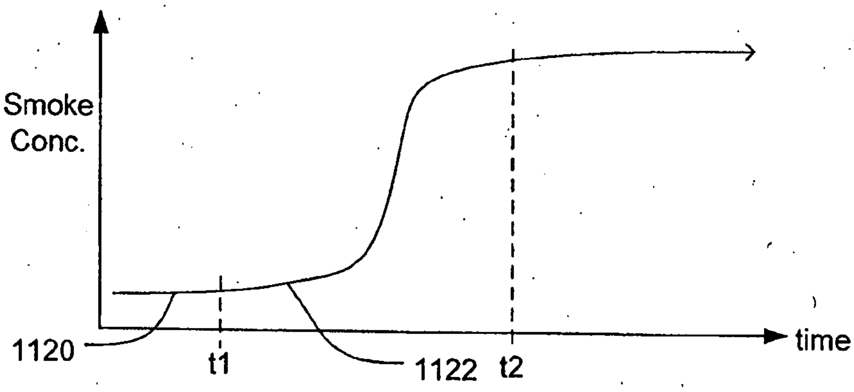


FIG 11B

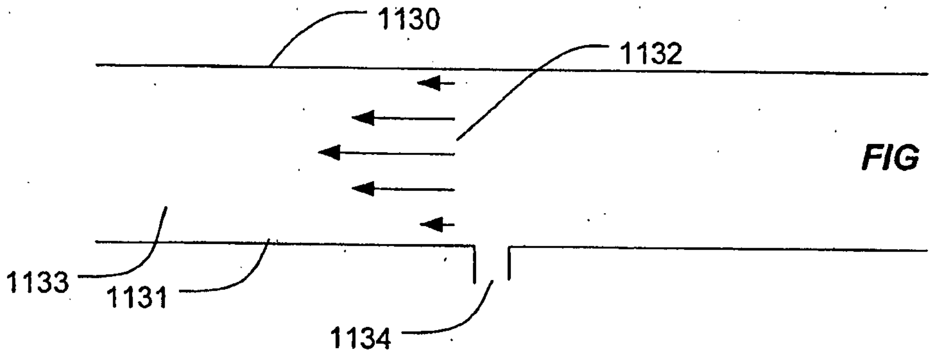


FIG 11C

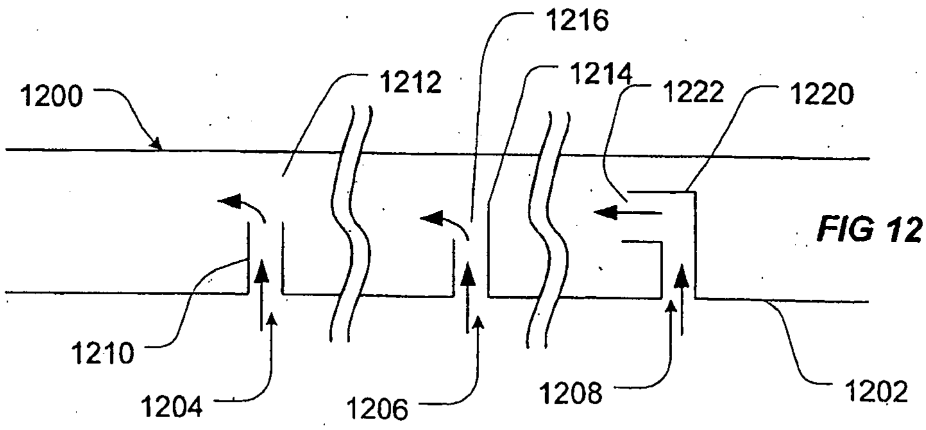


FIG 12

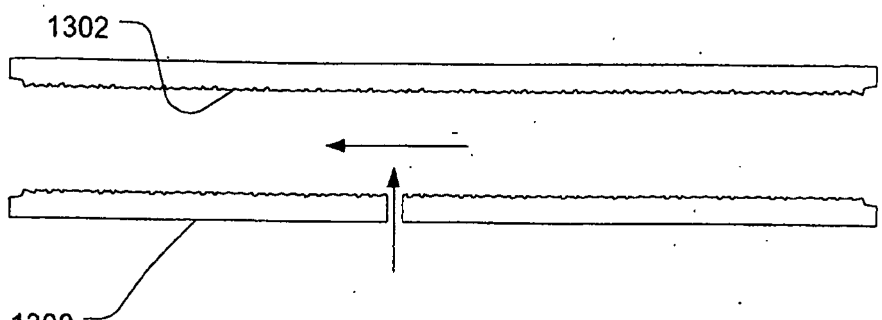


FIG 13A

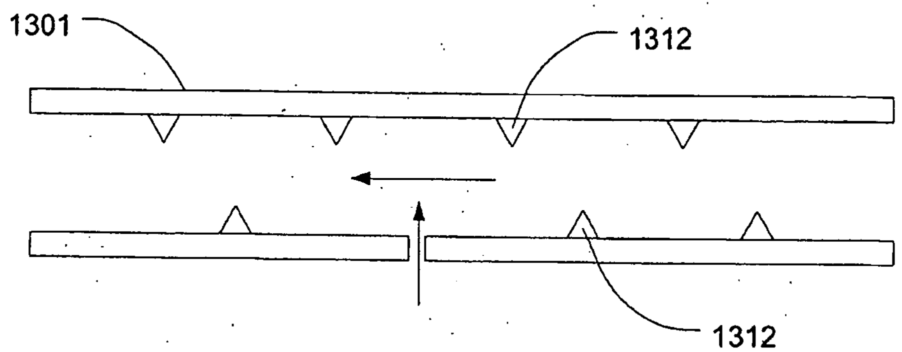


FIG 13B

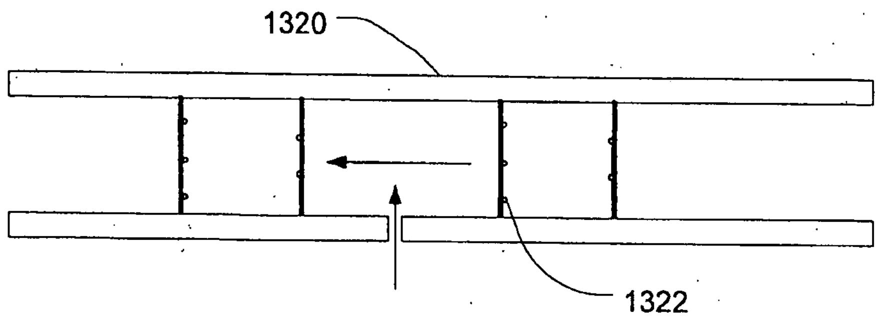


FIG 13C

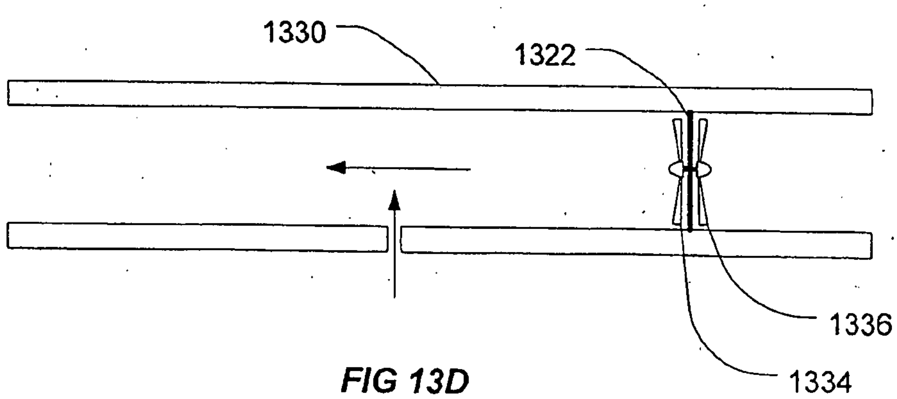
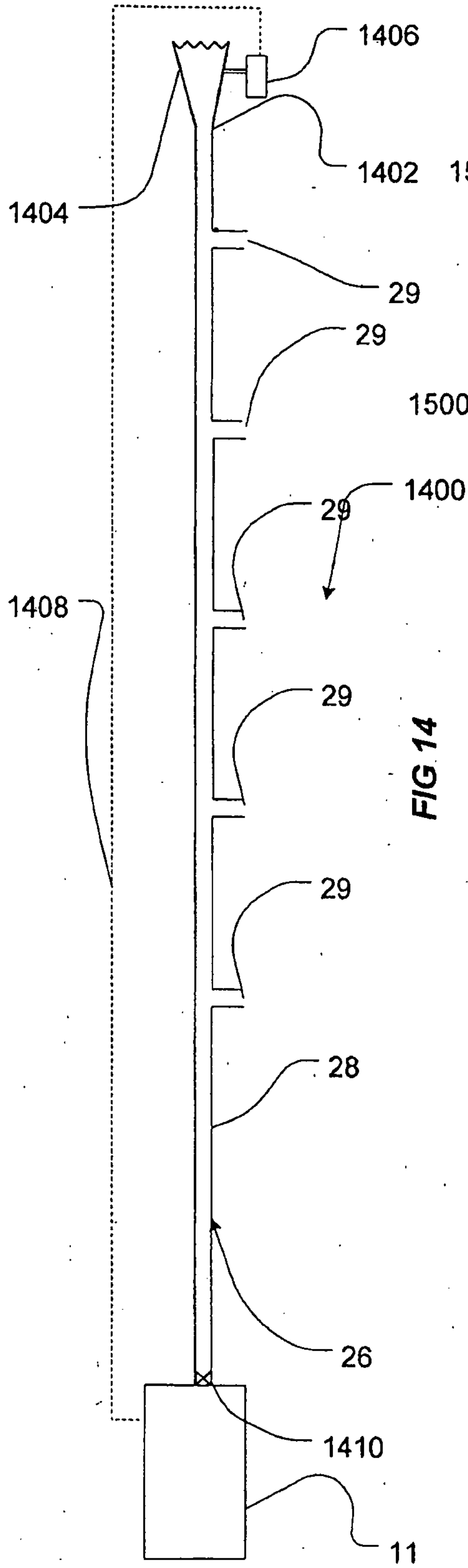
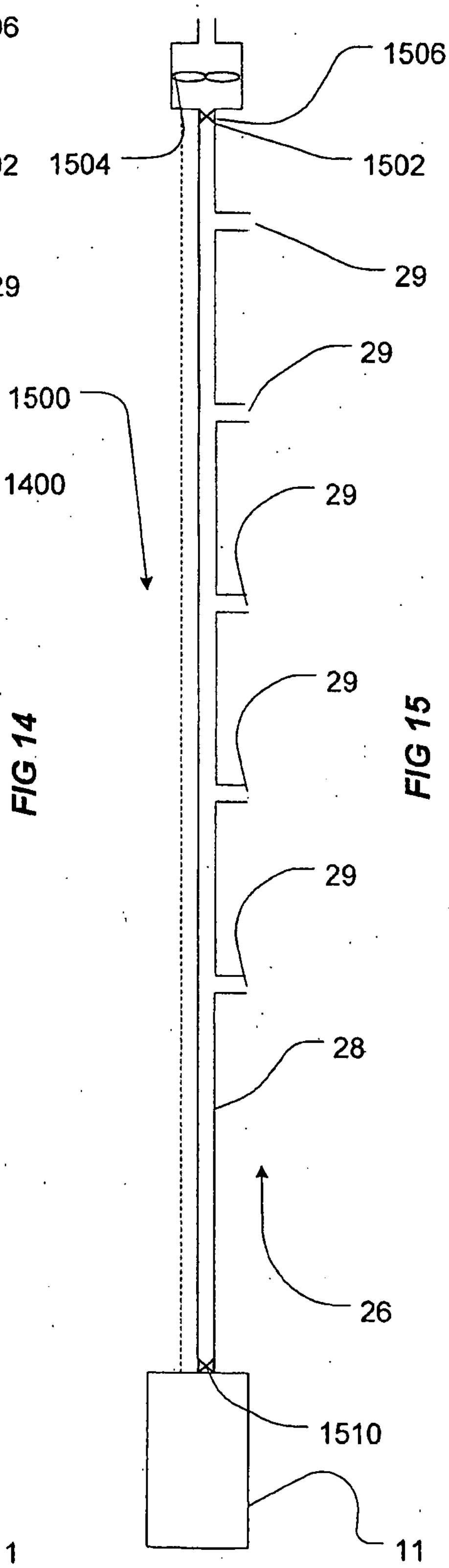


FIG 13D



1406
1402
1404
29
29
1400
29
1408
29
29
28
26
1410
11

FIG 14



1506
1504
1502
29
29
1500
29
29
29
28
26
1510
11

FIG 15

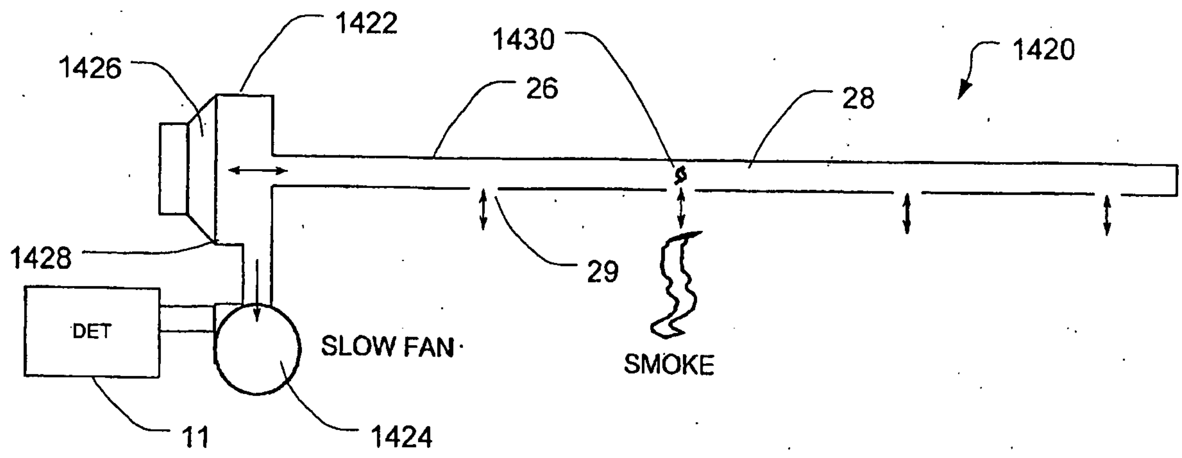


FIG 14A

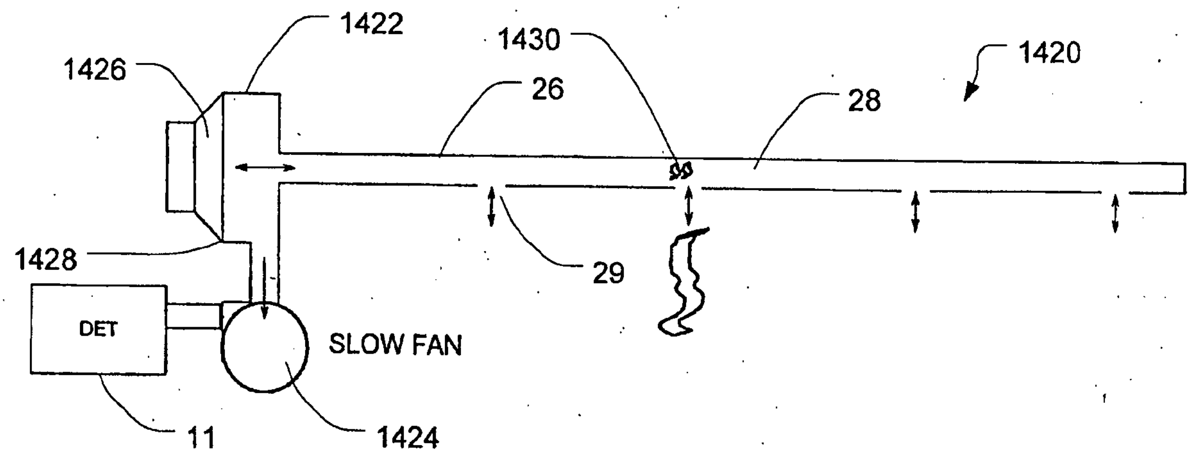


FIG 14B

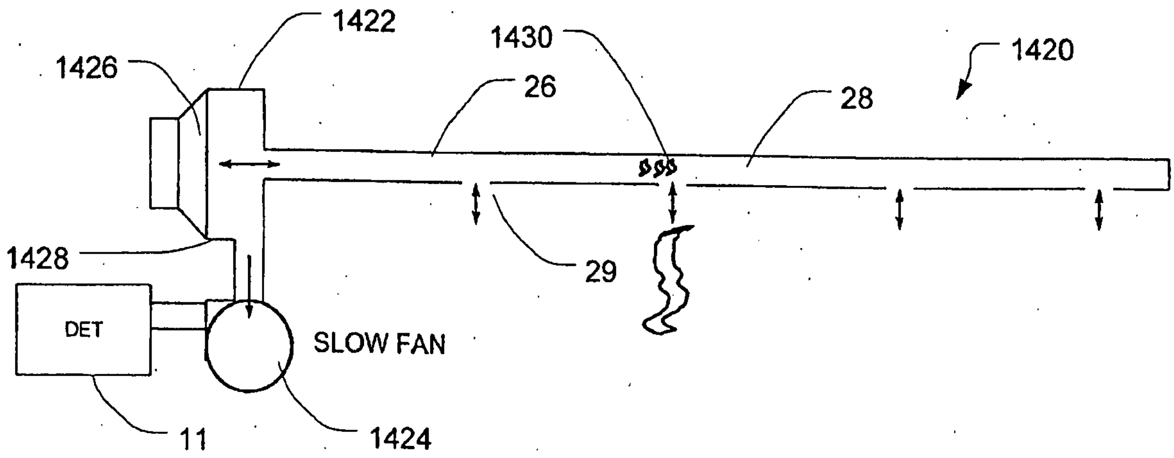


FIG 14C

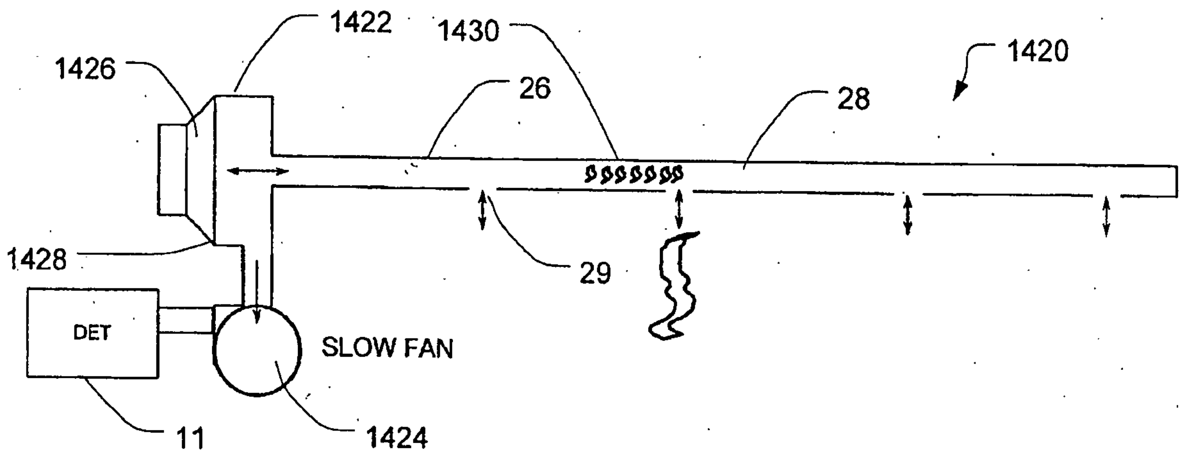


FIG 14D

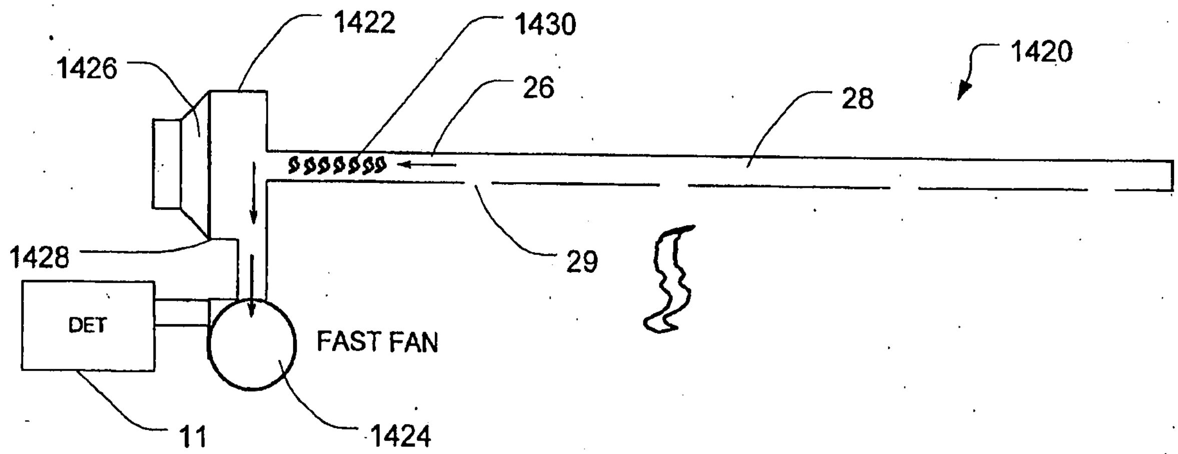


FIG 14E

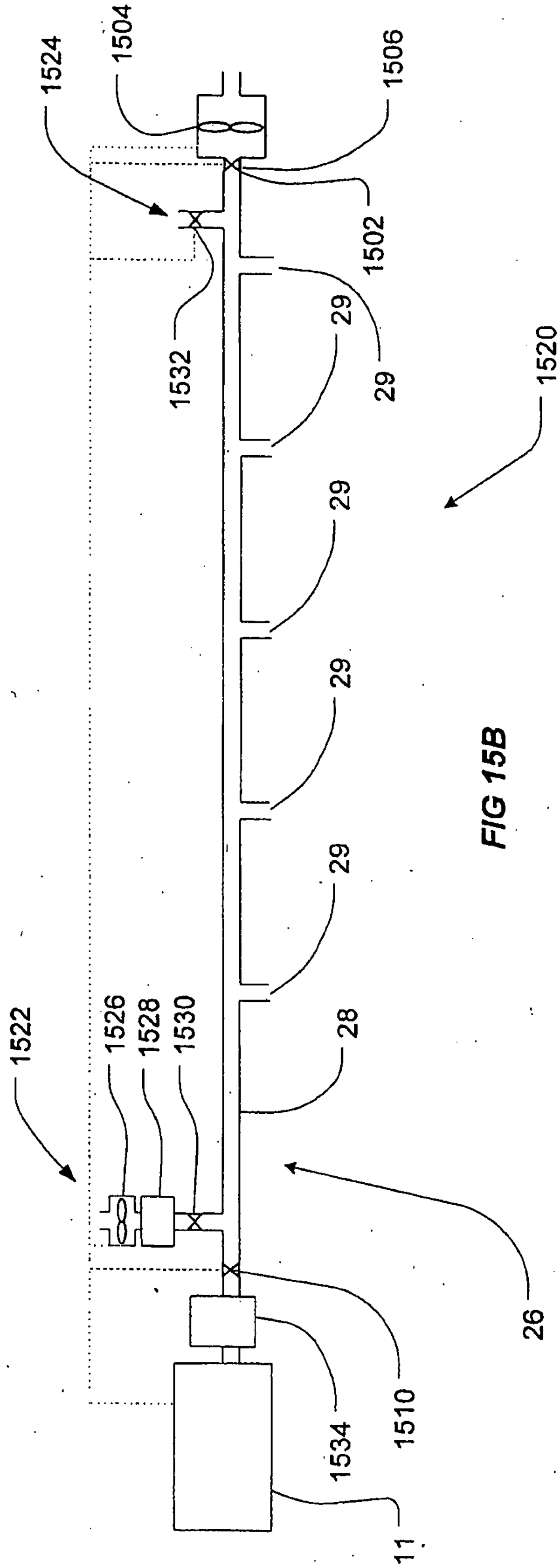


FIG 15B

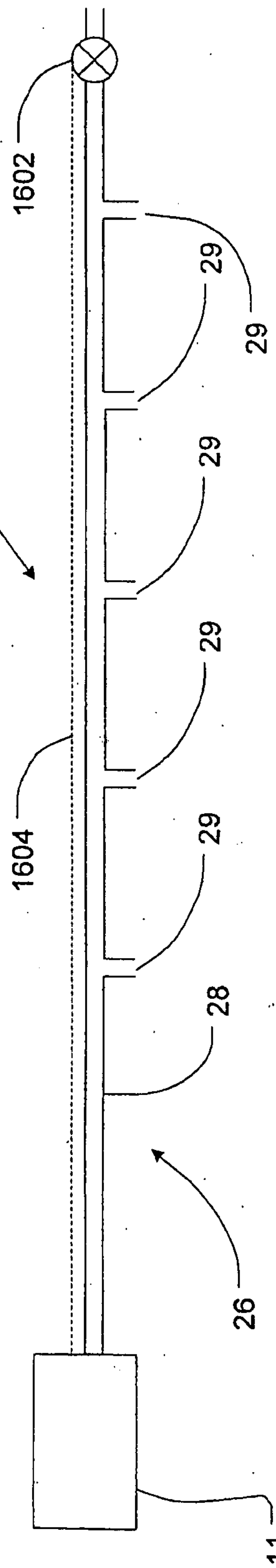


FIG 16

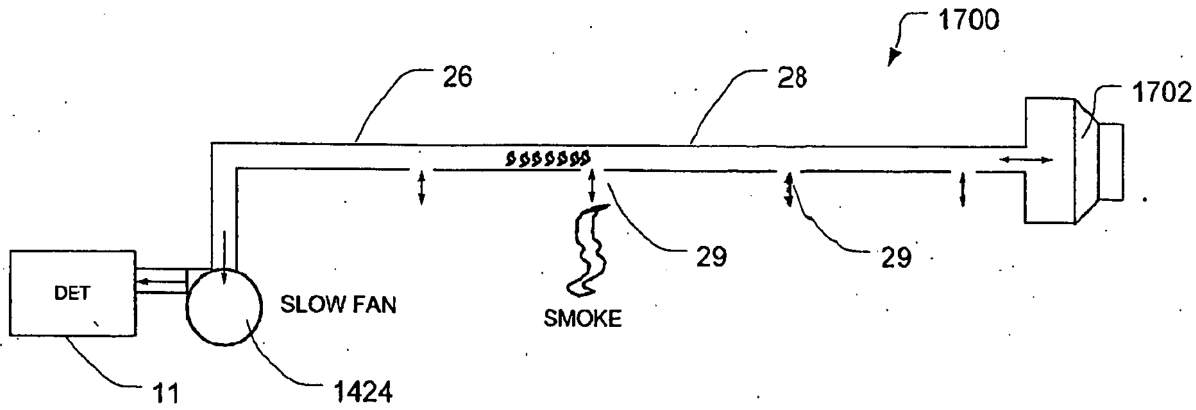


FIG 17

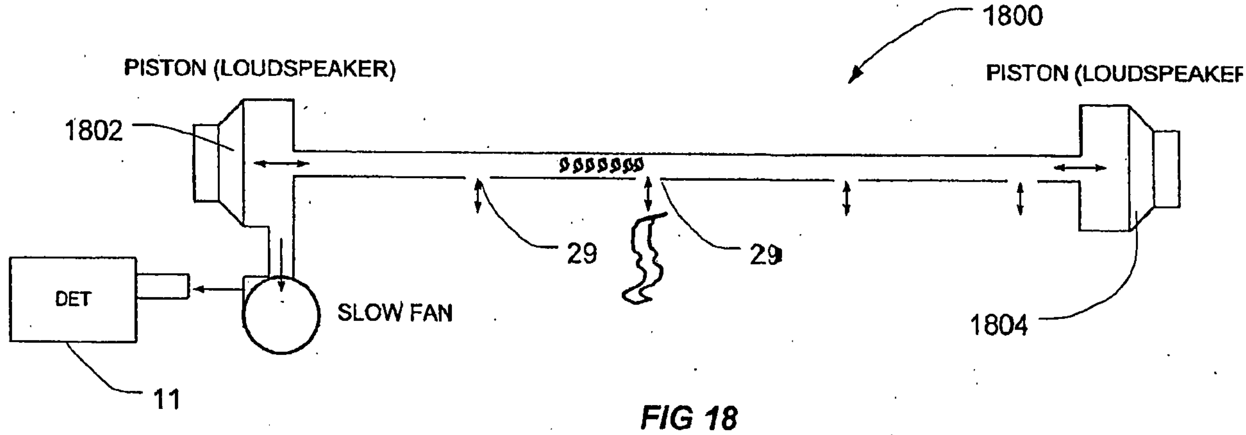


FIG 18

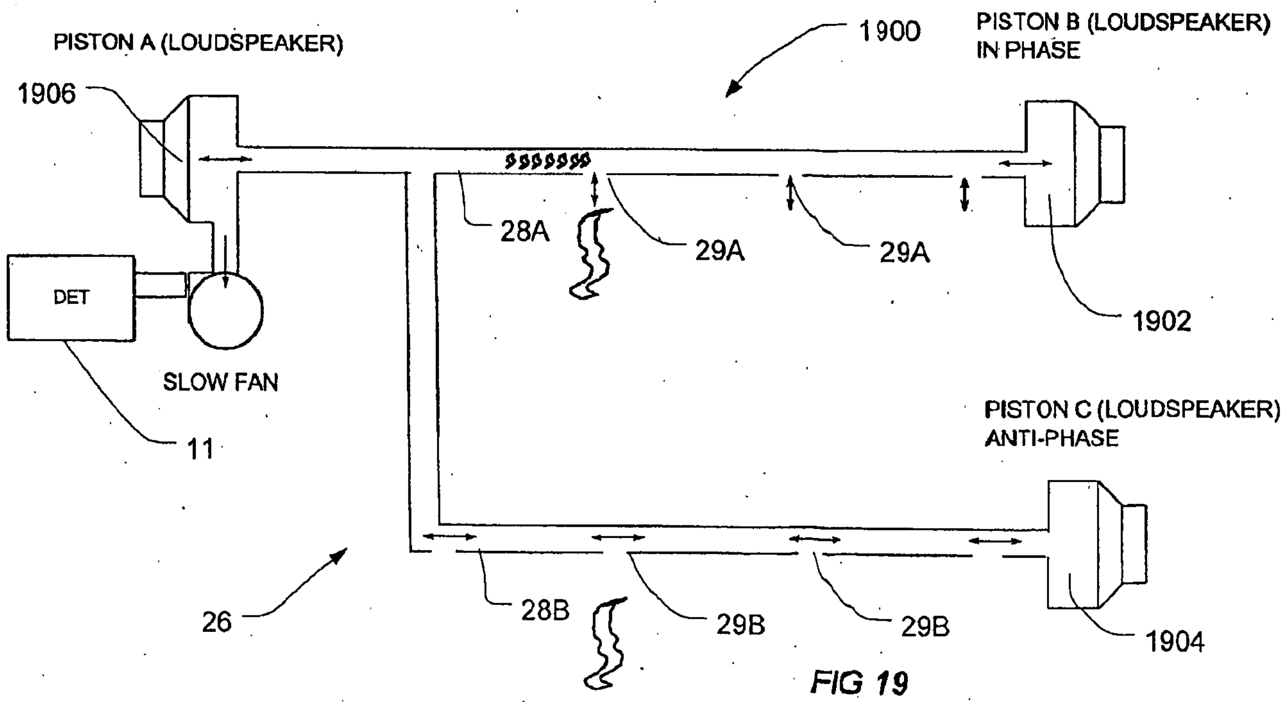


FIG 19

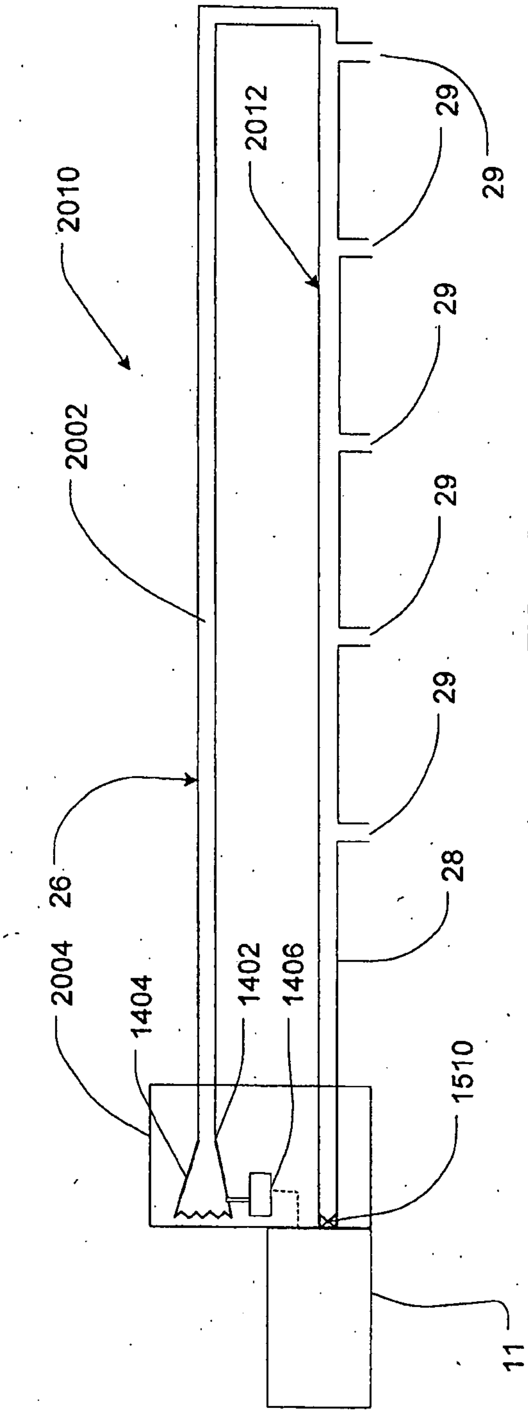


FIG 20A

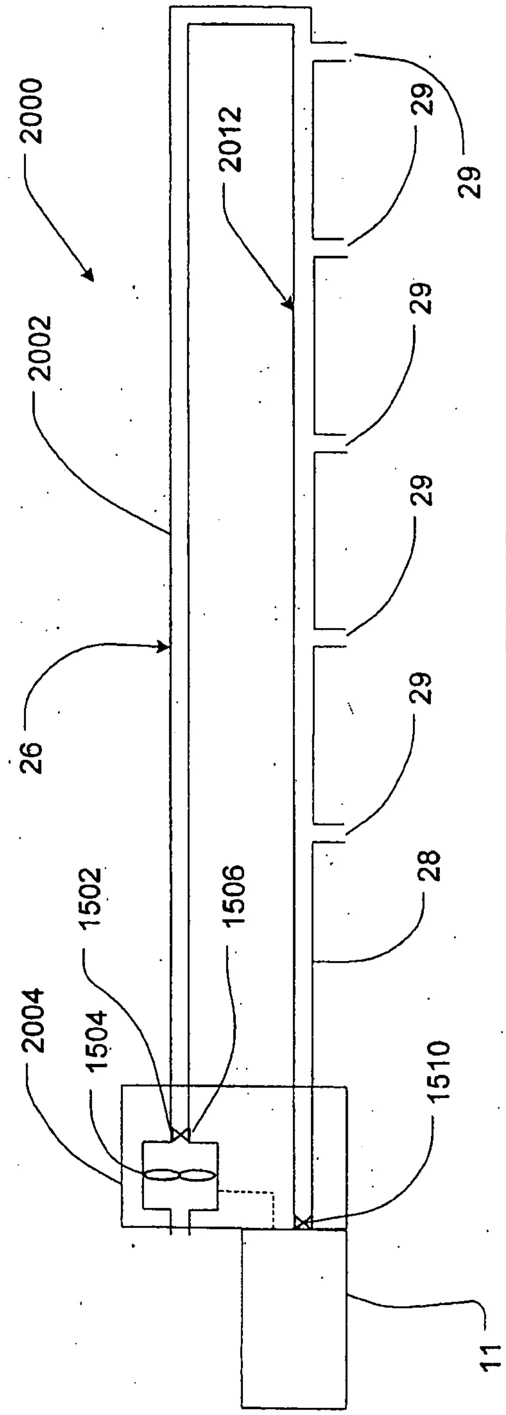


FIG 20B

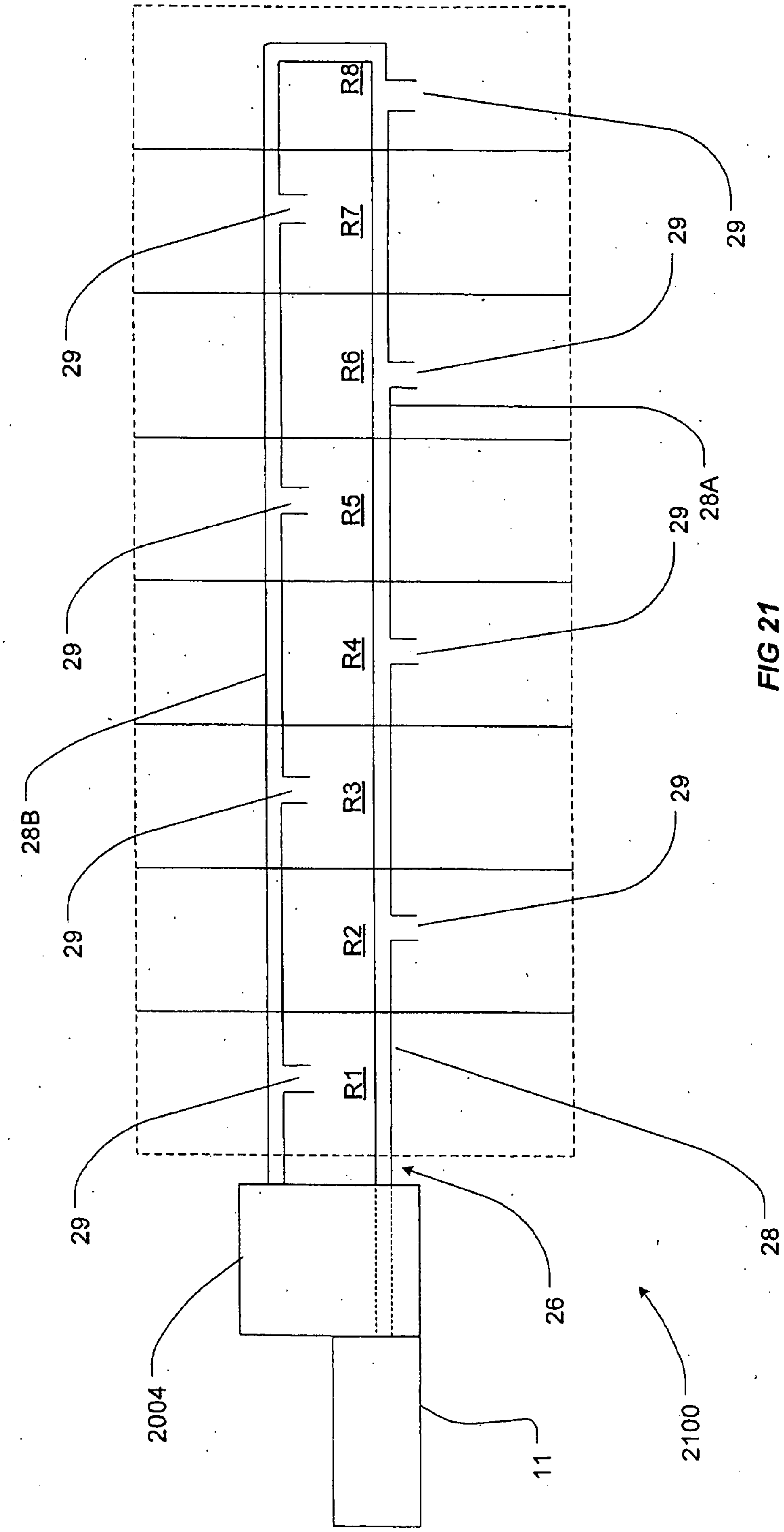


FIG 21

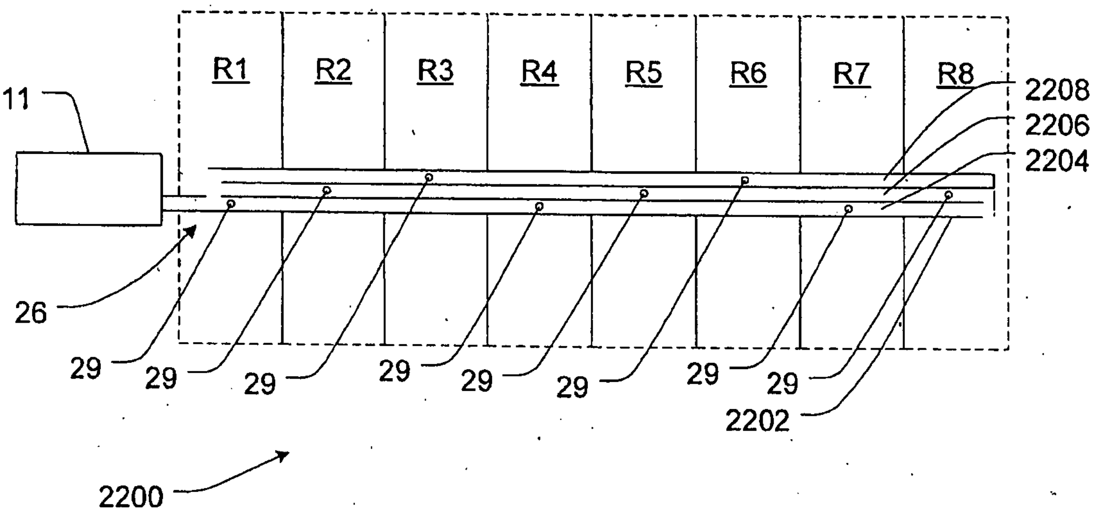

R1
R2
R3
R4
R5
R6
R7
R8
11
2208
2206
2204
26
29
29
29
29
29
29
29
29
2202
2200

FIG 22

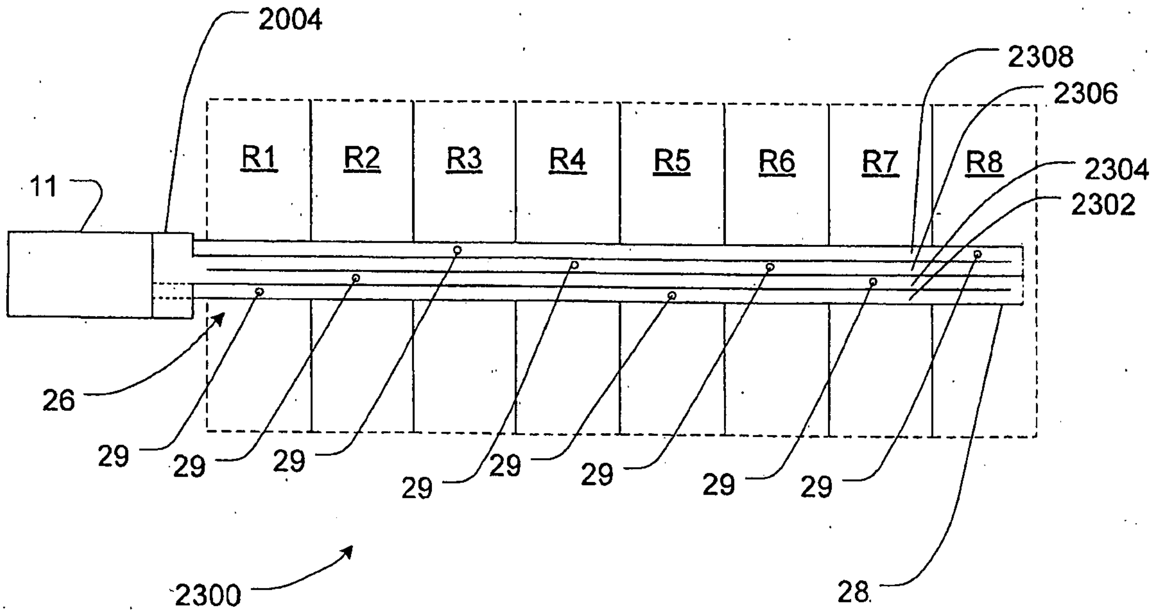

2004
2308
2306
R1
R2
R3
R4
R5
R6
R7
R8
2304
2302
11
26
29
29
29
29
29
29
29
29
2300
28

FIG 23

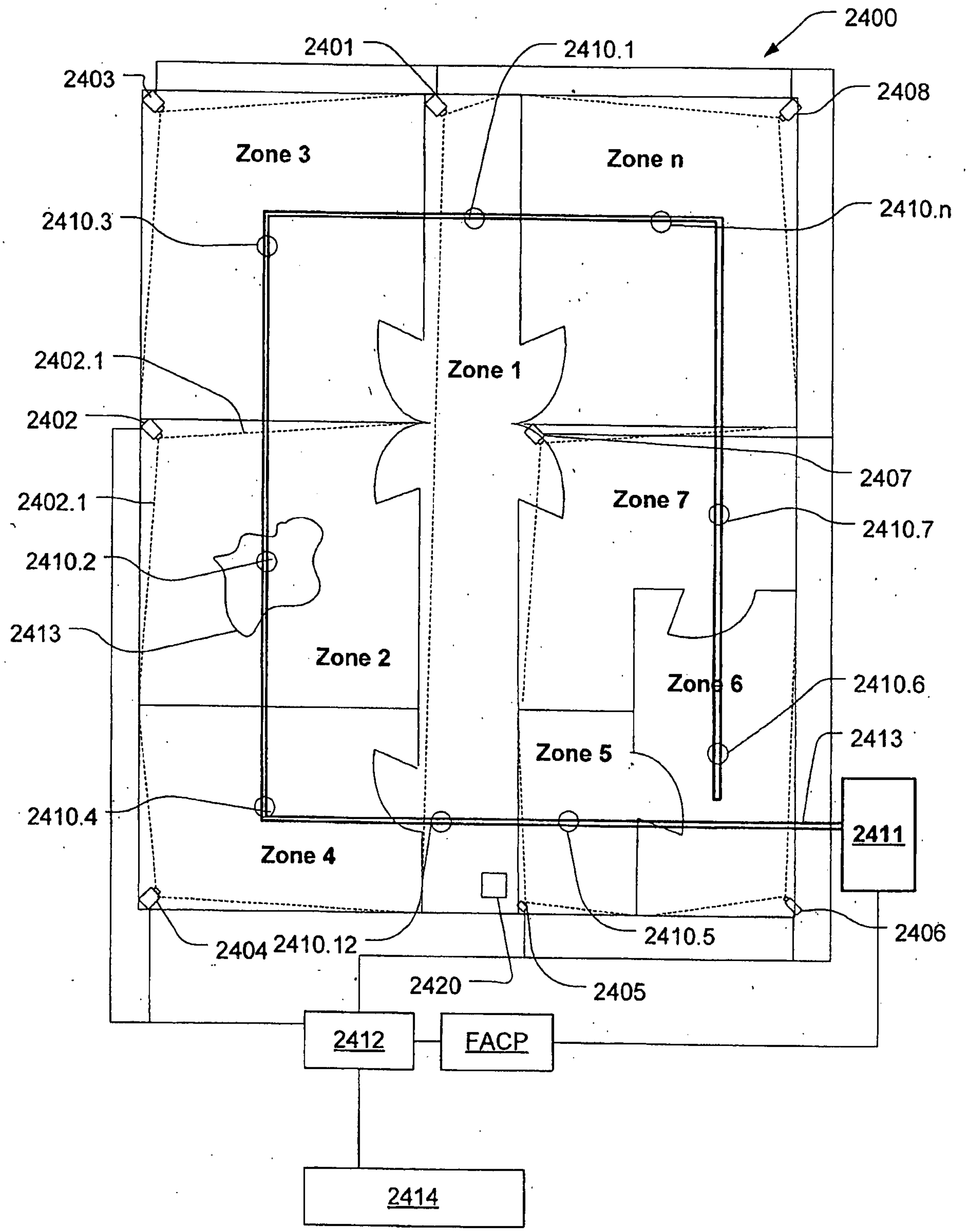

2400
2401
2410.1
2403
2408
Zone 3
Zone n
2410.3
2410.n
Zone 1
2402.1
2402
2407
Zone 7
2402.1
2410.7
2410.2
2413
Zone 2
Zone 6
2410.6
2413
Zone 5
2410.4
2411
Zone 4
2404
2410.12
2410.5
2406
2420
2405
2412
FACP
2414

FIG 24

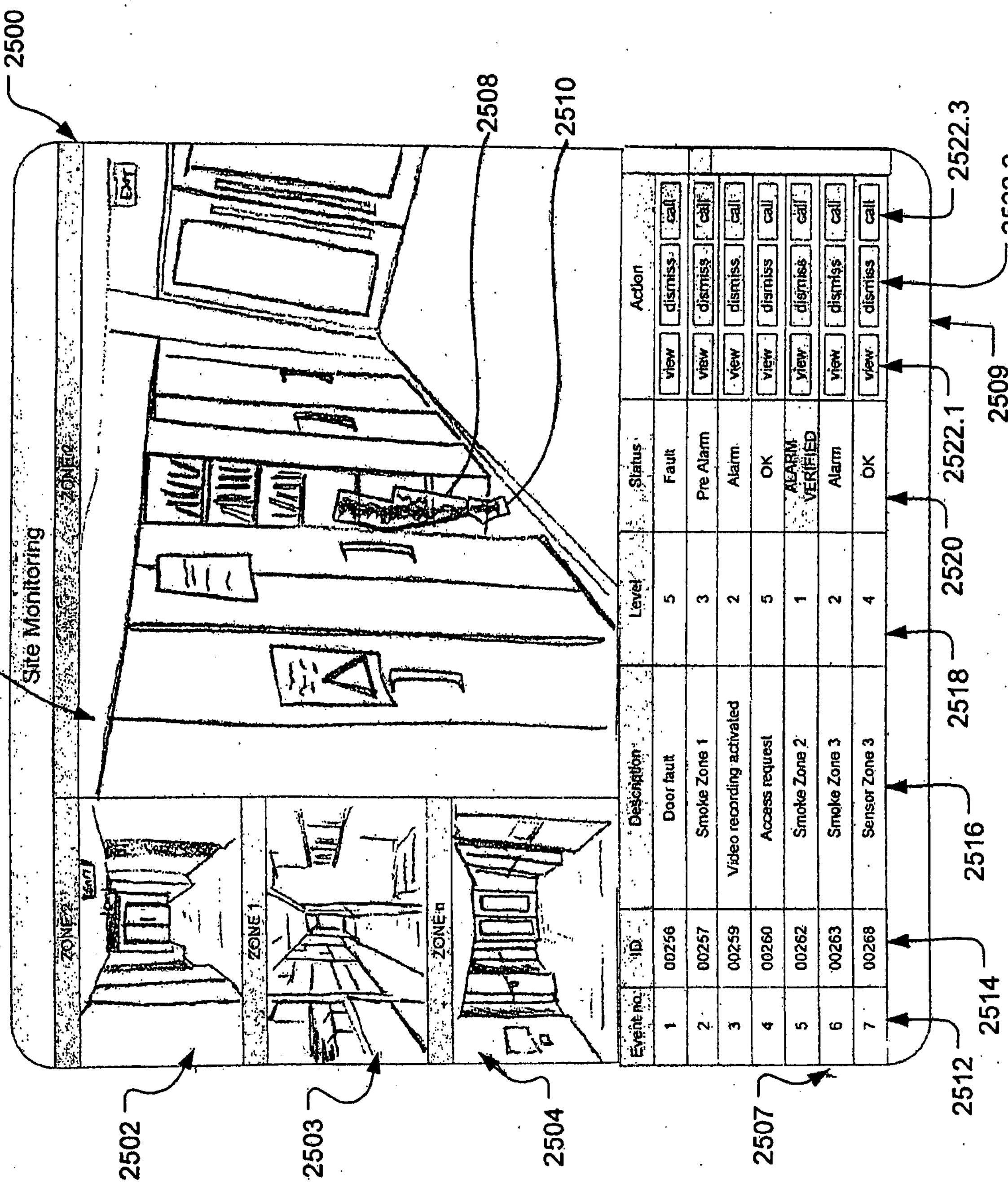

2500
2501
Site Monitoring
ZONE 2
ZONE 1
ZONE n
Exit
2502
2503
2504
2507
2508
2510
2509
2512
2514
2516
2518
2520
2522.1
2522.2
2522.3
Event no.
ID
Description
Level
Status
Action
1
00256
Door fault
5
Fault
view
dismiss
call
2
00257
Smoke Zone 1
3
Pre Alarm
3
00259
Video recording activated
2
Alarm
4
00260
Access request
5
OK
5
00262
Smoke Zone 2
1
ALARM VERIFIED
6
00263
Smoke Zone 3
2
Alarm
7
00268
Sensor Zone 3
4
OK

FIG 25

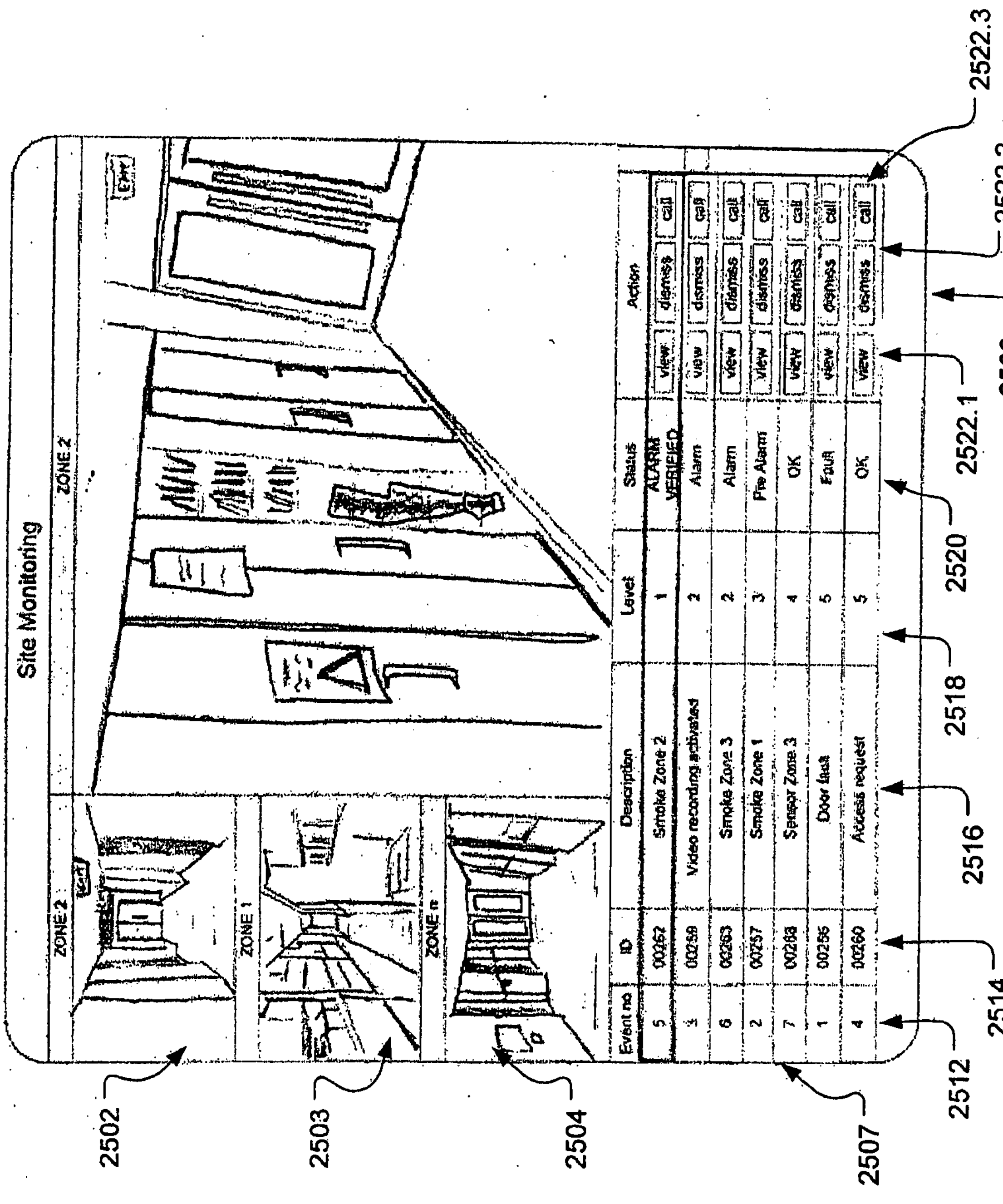

Site Monitoring
ZONE 2
ZONE 1
ZONE n
ZONE 2
Event no
ID
Description
Level
Status
Action
5
00262
Smoke Zone 2
1
ALARM VERIFIED
3
00259
Video recording activated
2
Alarm
6
00263
Smoke Zone 3
2
Alarm
2
00257
Smoke Zone 1
3
Fire Alarm
7
00268
Sensor Zone 3
4
OK
1
00255
Door fault
5
Fault
4
00260
Access request
5
OK
view
dismiss
call
2502
2503
2504
2507
2512
2514
2516
2518
2520
2522.1
2509
2522.2
2522.3

FIG 26

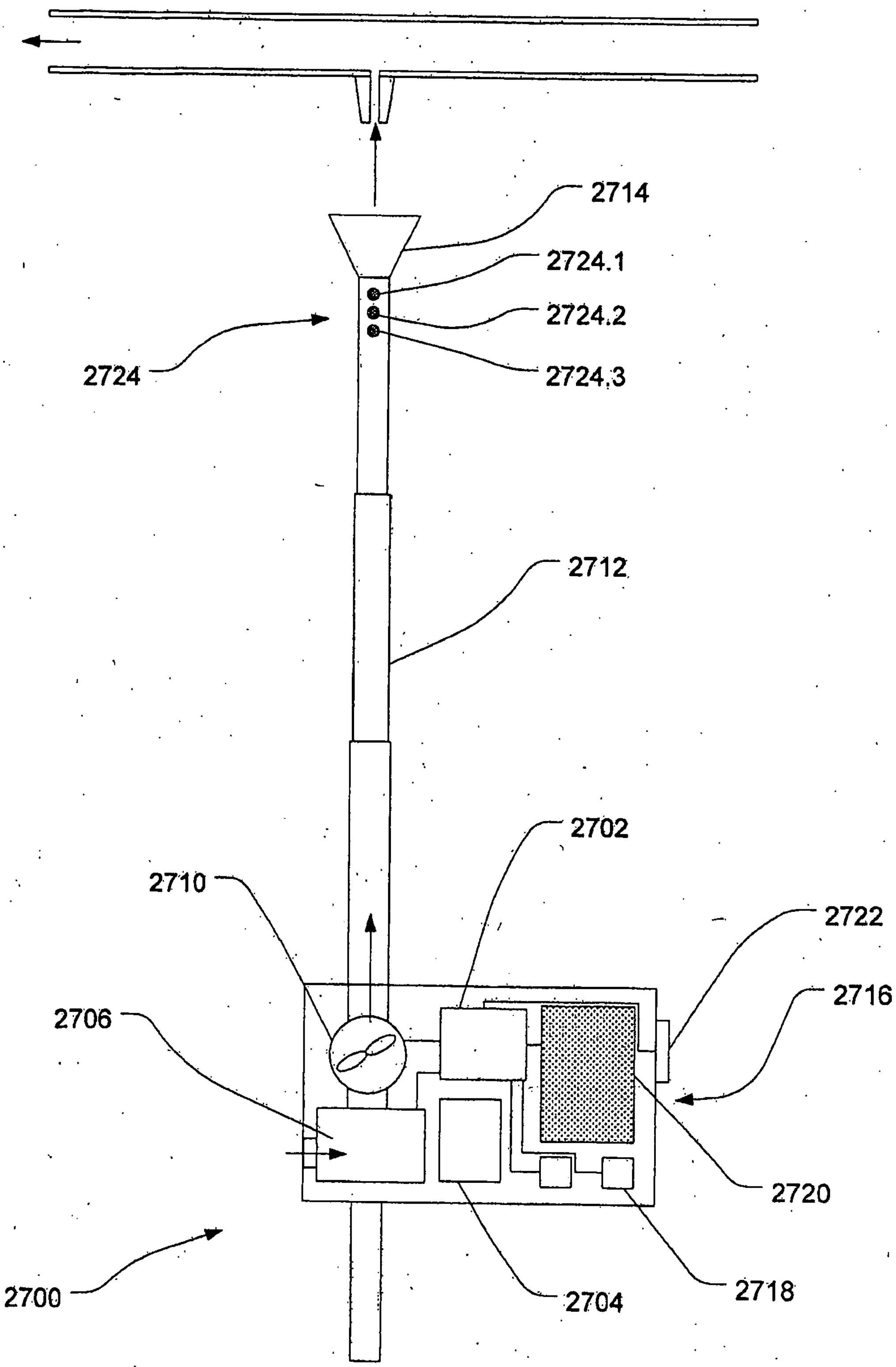

2714
2724.1
2724.2
2724
2724.3
2712
2702
2710
2722
2716
2706
2720
2700
2704
2718

FIG 27

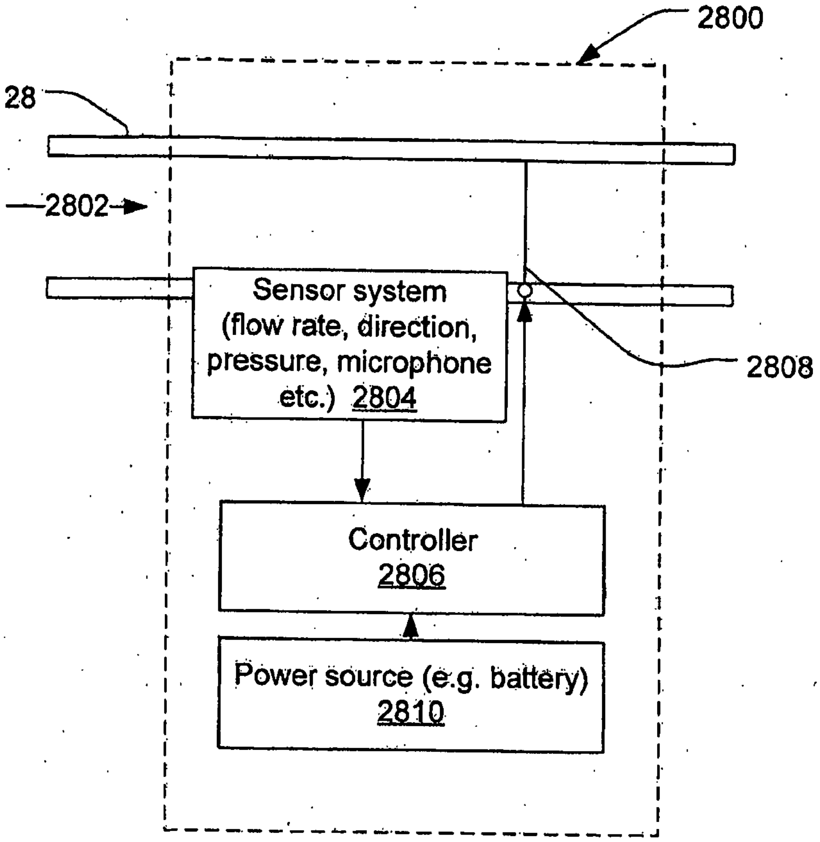

2800
28
2802
Sensor system (flow rate, direction, pressure, microphone etc.) 2804
2808
Controller 2806
Power source (e.g. battery) 2810

FIG 28

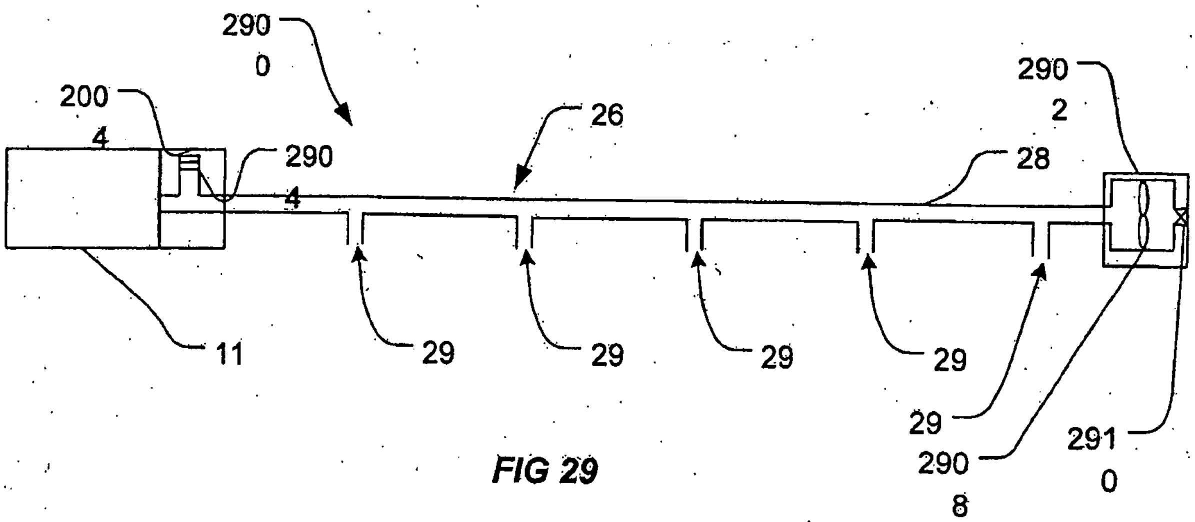

290
0
200
4
290
4
26
28
290
2
11
29
29
29
29
29
290
8
291
0

FIG 29

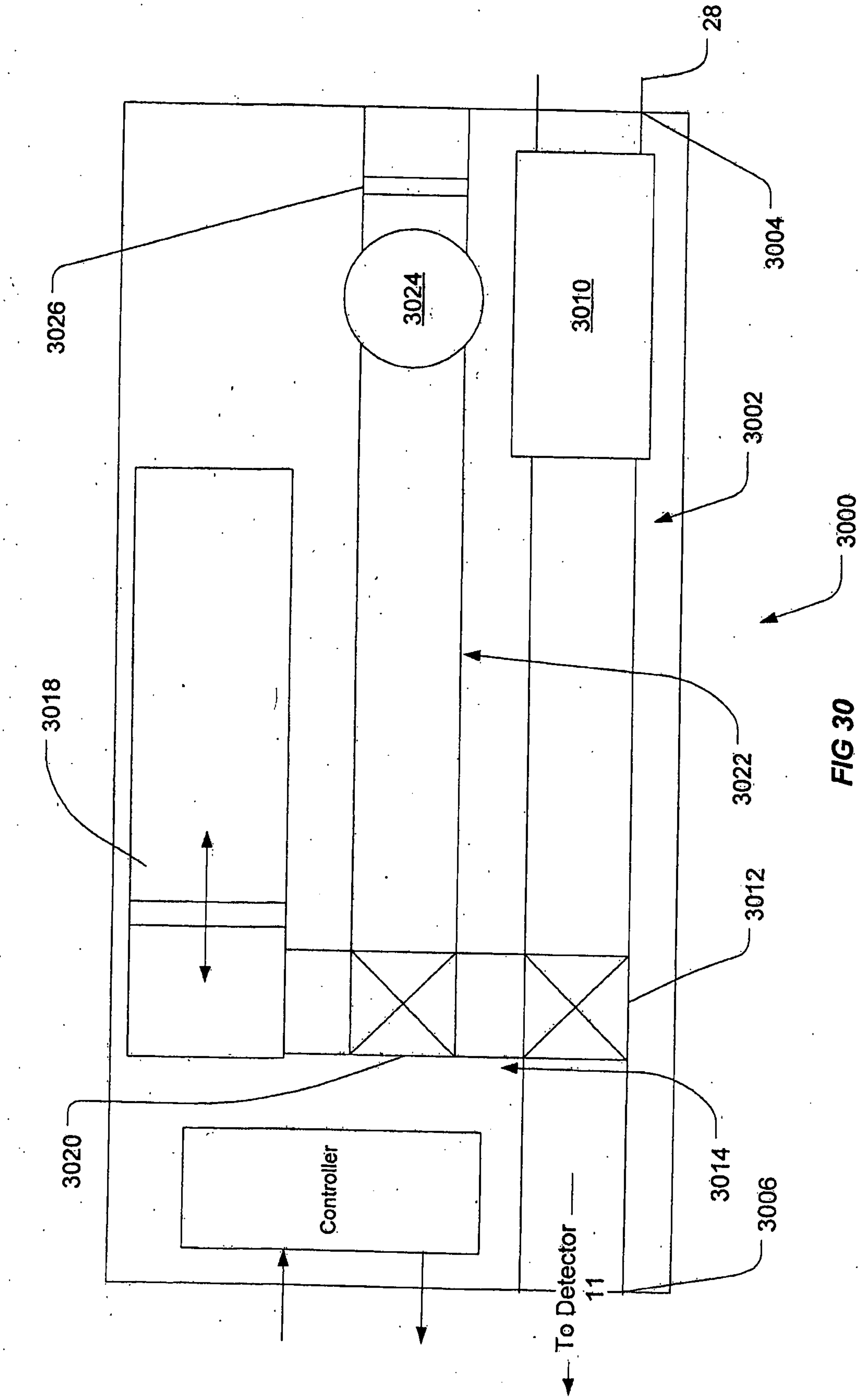

28
3004
3026
3024
3010
3002
3000
3018
3022
3012
3020
3014
3006
Controller
To Detector
11

FIG 30

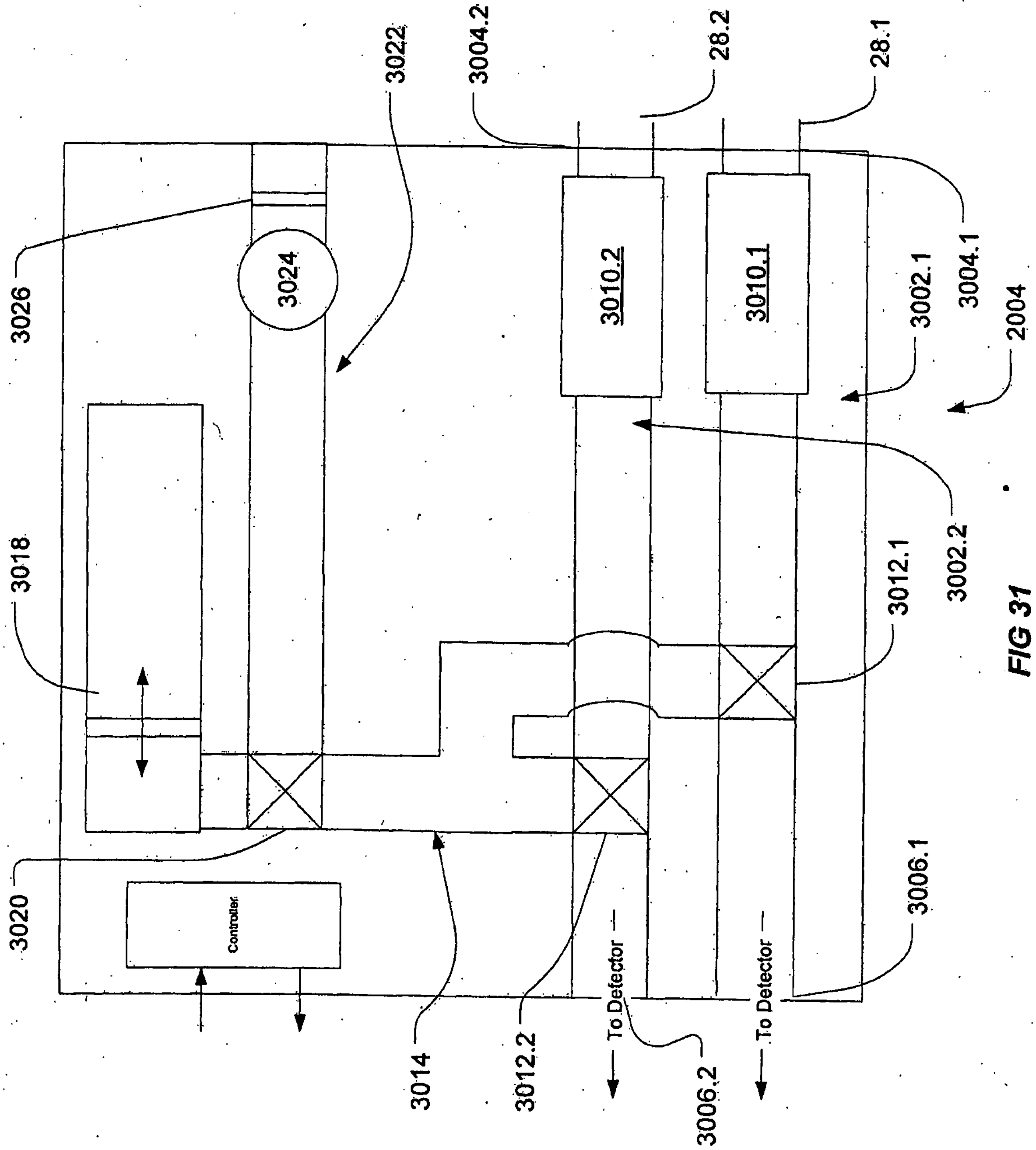

3026
3024
3022
3004.2
28.2
28.1
3010.2
3010.1
3002.1
3004.1
2004
3018
3002.2
3012.1
3020
Controller
3014
3012.2
To Defector
3006.2
To Detector
3006.1

FIG 31

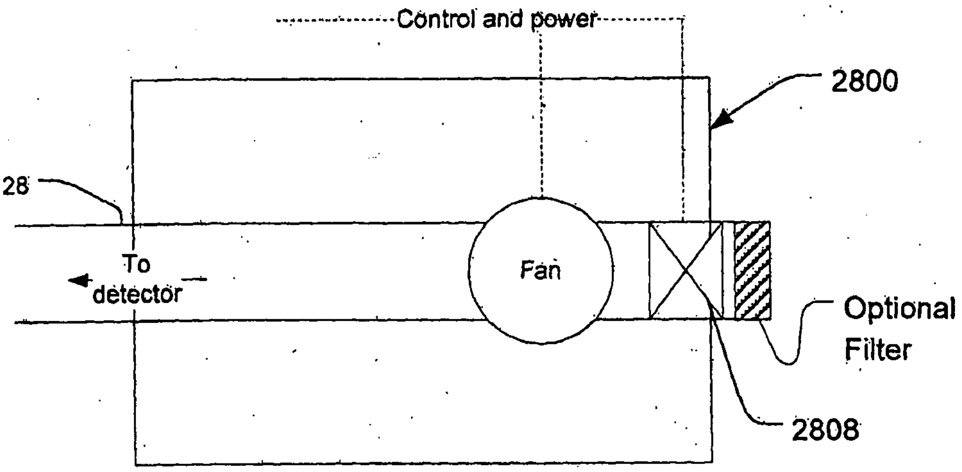

Control and power
2800
28
To detector
Fan
Optional Filter
2808

FIG 32

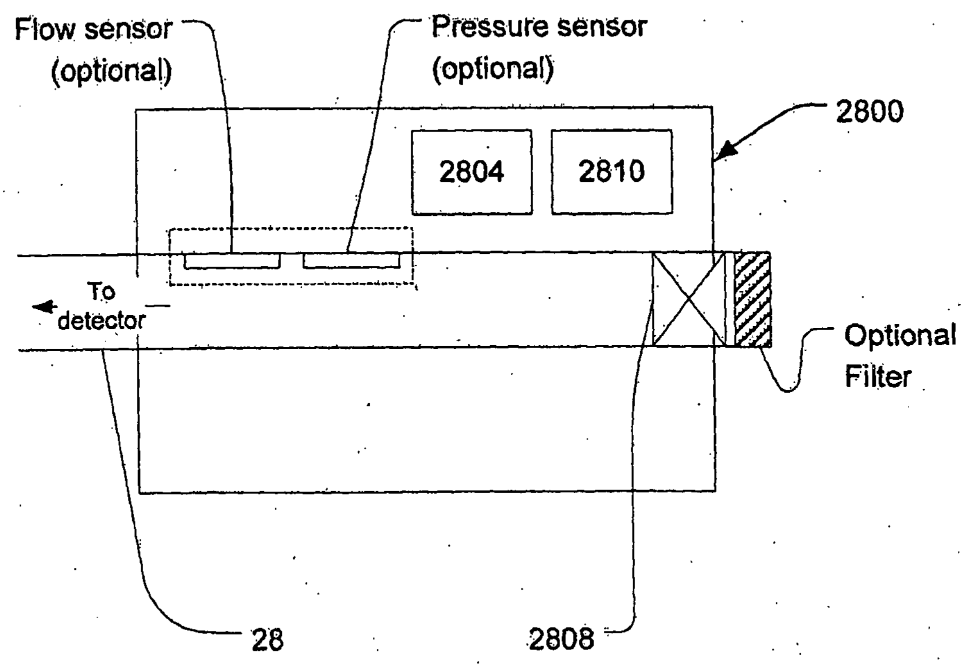

Flow sensor (optional)
Pressure sensor (optional)
2800
2804
2810
To detector
Optional Filter
28
2808

FIG 33

INTERNATIONAL SEARCH REPORT	International application No. PCT/AU2013/001201

A. CLASSIFICATION OF SUBJECT MATTER

G01F 1/66 (2006.01) G08B 17/00 (2006.01) G01N 1/26 (2006.01) G01N 35/08 (2006.01) G01N 1/00 (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; keywords: pipe, channel, network, duct, conduit, tube; smoke, particle, fire, event; inlet, nozzle, hole, aperture, entry, enter, ingress; detect, determine, sense, analyze, estimate, calculate, identify, locate, position, address; air, gas, fluid, sample; volume, mass, flow, speed; aspirate, suck, pump, draw and synonims;
IPC mark: G08B17; G01N

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[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	Date of mailing of the international search report
26 November 2013	26 November 2013

Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au Facsimile No.: +61 2 6283 7999	Eva De Kool AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832477

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 7375642 B2 (SIEMENS et al.) 20 May 2008	
X	Entire document and in particular see Abstract, columns 1, 3-7, 9 and 12, Figure 1	1-6, 8-14, 16-18, 20
Y	Entire document and in particular see Abstract, columns 1, 3-7, 9 and 12, Figure 1	7, 15, 19
	WO 2008/138877 A1 (SIEMENS AKTIENGESELLSCHAFT) 20 November 2008	
X	See in particular Abstract and Figures	1-6, 8-14, 16-18, 20
Y	Abstract and Figures	7, 15, 19
	US 8035527 B2 (POWELL) 11 October 2011	
X	Figure 2, Claim 1, columns 3-4, 7-8	1-6, 8-14, 16-18, 20
Y	Figure 2, Claim 1, columns 3-4, 7-8	7, 15, 19
	US 2010/0194575 A1 (RODRIGUEZ) 05 August 2010	
Y	Abstract	7, 15, 19
	US 8224621 B2 (AJAY et al.) 17 July 2012	
Y	Abstract	7, 15, 19
	US 5708218 A (JAX) 13 January 1998	
X	See in particular Abstract, Figures and columns 2-5	1-6, 8-14, 16-18, 20
Y	Abstract, Figures and columns 2-5	7, 15, 19
	EP 1811478 B1 (HEKATRON VERTRIEBS GMBH) 25 July 2007	
X	See in particular Abstract, Claims, paragraphs 9-32 and Figures 1-7b	1-6, 8-14, 16-18, 20
Y	Abstract, Claims, paragraphs 9-32 and Figures 1-7b	7, 15, 19

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2013/001201**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 7375642 B2	20 May 2008	AU 2004290115 B2	03 Sep 2009
		CA 2538881 A1	26 May 2005
		CN 1864181 A	15 Nov 2006
		DE 10348565 A1	25 May 2005
		EP 1634261 A1	15 Mar 2006
		EP 1634261 B1	18 Oct 2006
		HK 1084765 A1	02 Feb 2007
		JP 2007509390 A	12 Apr 2007
		JP 4268189 B2	27 May 2009
		KR 20060109872 A	23 Oct 2006
		KR 100906206 B1	07 Jul 2009
		NO 20061699 A	18 Apr 2006
		RU 2006107768 A	10 Nov 2007
		TW I270826 B	11 Jan 2007
		US 2007008157 A1	11 Jan 2007
		US 7375642 B2	20 May 2008
		WO 2005048207 A1	26 May 2005
WO 2008/138877 A1	20 Nov 2008	EP 1993082 B1	20 Jul 2011
		US 2012319853 A1	20 Dec 2012
		WO 2008138877 A1	20 Nov 2008
US 8035527 B2	11 Oct 2011	AU 2006288956 B2	24 Feb 2011
		CN 101297333 A	29 Oct 2008
		CN 101297333 B	29 Sep 2010
		GB 2430027 A	14 Mar 2007
		GB 2444664 A	11 Jun 2008
		GB 2444664 B	26 Aug 2009
		US 2009072981 A1	19 Mar 2009
		US 8035527 B2	11 Oct 2011
		WO 2007028939 A1	15 Mar 2007
US 2010/0194575 A1	05 Aug 2010	US 2010194575 A1	05 Aug 2010
US 8224621 B2	17 Jul 2012	EP 2278567 A2	26 Jan 2011
		JP 2007533967 A	22 Nov 2007
		JP 4838718 B2	14 Dec 2011
		JP 2011090000 A	06 May 2011

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2013/001201**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
		US 2007084286 A1	19 Apr 2007
		US 8224621 B2	17 Jul 2012
		US 2013013227 A1	10 Jan 2013
		WO 2004102499 A1	25 Nov 2004
US 5708218 A	13 Jan 1998	EP 0692706 A2	17 Jan 1996
		US 5708218 A	13 Jan 1998
EP 1811478 B1	25 Jul 2007	EP 1811478 B1	02 Apr 2008

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

(19)中华人民共和国国家知识产权局

(12)发明专利申请

(10)申请公布号 CN 104718435 A
(43)申请公布日 2015.06.17

(21)申请号 201380054236.7

(22)申请日 2013.10.16

(30)优先权数据
2012904516 2012.10.16 AU
2012904854 2012.11.02 AU
2013200353 2013.01.21 AU
2013902076 2013.06.07 AU
2013902570 2013.07.11 AU

(85)PCT国际申请进入国家阶段日
2015.04.16

(86)PCT国际申请的申请数据
PCT/AU2013/001201 2013.10.16

(87)PCT国际申请的公布数据
WO2014/059479 EN 2014.04.24

(71)申请人 爱克斯崔里斯科技有限公司
地址 巴哈马群岛拿骚

(72)发明人 凯末尔·阿贾伊 罗恩·诺克司
布赖恩·亚历山大 卡尔·波特格
拉吉夫·库马尔·辛格 托尔·诺思
斯蒂芬·詹姆斯·帕廷森
彼得·马辛贝德-芒迪

(74)专利代理机构 北京邦信阳专利商标代理有限公司 11012
代理人 梁栋

(51)Int.Cl.
G01F 1/66(2006.01)
G08B 17/00(2006.01)
G01N 1/26(2006.01)
G01N 35/08(2006.01)
G01N 1/00(2006.01)

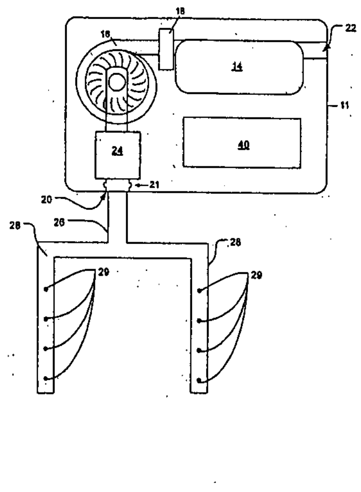
权利要求书2页 说明书47页 附图27页

(54)发明名称

微粒探测寻址技术

(57)摘要

一种确定烟雾进入烟雾探测系统中的至少一个进入点的方法，该系统具有取样导管网络，取样导管网络包括至少一个取样导管及多个取样入口，空气样本能穿过取样入口进入烟雾探测系统的至少一个取样导管，以供微粒探测器分析，该方法包括：确定自预定事件以来穿过至少部份烟雾探测系统的样本空气的体积、或对应于该体积的数值；以及至少部份地以所确定的体积或数值为基础，确定烟雾经过该多个取样入口中的哪个取样入口进入该烟雾探测系统。还描述了用于实行这种方法及相关方法的系统。



CN 104718435 A

1. 一种确定烟雾进入烟雾探测系统中的至少一个进入点的方法，该系统具有取样导管网络，该取样导管网络包括至少一个取样导管及多个取样入口，空气样本能穿过该多个取样入口进入该烟雾探测系统的该至少一个取样导管，以供微粒探测器分析，该方法包括：

确定自预定事件以来穿过至少部份烟雾探测系统的样本空气的体积、或对应于该体积的数值；以及

至少部份地以所确定的体积或数值为基础，确定烟雾经过该多个取样入口中的哪个取样入口进入该烟雾探测系统。

2. 根据权利要求 1 所述的方法，其中，该预定事件为下列的任一个或多个：

烟雾探测事件；

该烟雾探测系统中空气样本流特征的变化。

3. 根据权利要求 1 或 2 所述的方法，其包括连续地确定穿过至少部份烟雾探测系统的空气样本的流率。

4. 根据权利要求 1 或 2 所述的方法，其中，该方法包括在该预定事件发生时，开始确定样本空气的体积、或相关的数值。

5. 根据前述权利要求任一项所述的方法，其中，通过累积一段时间的流率测量，确定穿过至少部分烟雾探测网络的空气样本的体积或相关的数值。

6. 根据权利要求 5 所述的方法，其中，该流率测量为体积的流率测量。

7. 根据权利要求 6 所述的方法，其中，该流率测量利用超音波流传感器所确定。

8. 根据前述权利要求任一项所述的方法，其中，确定自预定事件以来穿过至少部份烟雾探测系统的样本空气的体积、或对应于该体积的数值的步骤包括：

确定下列的任一个或多个

质量；

长度；

压力；

温度；

第二体积；

与体积相关的事件的累积计数；

或有关于自预定事件以来穿过至少部份烟雾探测系统的样本空气的体积的其他参数。

9. 根据前述权利要求任一项所述的方法，其包括：收集全部的或一定比例的自预定事件以来穿过至少部份烟雾探测系统的样本空气。

10. 根据前述权利要求任一项所述的方法，其中，该方法进一步包括：响应于第一烟雾探测事件而改变空气样本流特征。

11. 根据权利要求 10 所述的方法，其中，改变该烟雾探测系统中的空气样本流特征的步骤包括下列的一个或多个：

· 开启阀；

· 关闭阀；

· 改变空气样本流在至少部分烟雾探测系统中的方向；

· 改变在至少部份烟雾探测系统中的空气样本流率；

· 启动呼吸系统；及

• 停止呼吸系统。

12. 一种用于确定烟雾进入烟雾探测系统中的至少一个进入点的装置，其类型是具有呼吸器以及与空气取样网络流体连通的微粒探测器，该空气取样网络具有至少一个取样导管及多个取样入口，空气样本能穿过该多个取样入口进入该烟雾探测系统的至少一个取样导管，以供该微粒探测器分析，该呼吸器以供抽取空气样本穿过该空气取样网络至该探测器，该装置包括：

用于确定自预定事件以来穿过至少部份烟雾探测系统的样本空气的体积、或对应于该体积的数值的构件；及

用于以所探测的体积或数值为基础来识别微粒进入取样网络的至少一个进入点的构件。

13. 根据权利要求 12 所述的装置，其中，该装置参考一个或多个对应的取样入口来识别该进入点中的一个或多个，烟雾被确定出穿过一个或多个对应的取样入口进入系统。

14. 根据权利要求 12 或 13 所述的装置，其中，用于确定穿过至少部份微粒探测系统的样本的体积或与该体积相关的数值的构件包括流传感器。

15. 根据权利要求 14 所述的装置，其中，该流传感器包含超音波流传感器。

16. 根据权利要求 12 至 15 中任一项所述的装置，其中，该装置被组构以执行根据权利要求 1 至 11 中任一项的方法。

17. 一种烟雾探测器，包括微粒探测腔室、入口、以及呼吸器，该微粒探测腔室可供探测空气样本中的微粒，该入口可供从空气取样网络接收空气样本，该取样网络具有至少一个取样导管及多个取样入口，样本能穿过多个取样入口进入该至少一个取样导管以供该微粒探测腔室分析，该呼吸器可供抽取样本经过该空气取样网络至该探测器，该探测器进一步包括处理器，该处理器被组构以：

至少部份地以自预定事件以来穿过至少部份烟雾探测器或取样网络的样本空气的体积、或对应于该体积的数值为基础，识别烟雾进入取样网络的至少一个进入点。

18. 根据权利要求 17 所述的烟雾探测器，其中，该烟雾探测器包括流传感器，该流传感器被组构以探测样本空气穿过至少一部份该烟雾探测器的流率。

19. 根据权利要求 18 所述的烟雾探测器，其中，该烟雾探测器包括超音波流传感器。

20. 根据权利要求 17 至 19 中任一项所述的烟雾探测器，其中，该处理器被组构以使该烟雾探测器执行如权利要求 1 至 11 中任一项所述的方法。

微粒探测寻址技术

技术领域

[0001]　本发明涉及微粒探测技术。仅供示范用途，本发明的较佳实施例将就烟雾探测系统作描述，但本发明不应视为限于该示范性使用。

背景技术

[0002]　空气取样或呼吸烟雾探测系统由经过取样网络抽取空气样本至中央高敏感度微粒探测器而运作。取样网络通常包括一个或多个样本导管，其具有沿着导管长度所设置的取样孔或取样点形式的多个空气样本入口。在这种一配置中，单个探测器可被馈送有源自于设有空气样本入口的许多不同地理位置的空气。因此，单个的这种探测器可同时地监测许多不同位置的烟雾的出现。

[0003]　如同上文所述的空气取样系统的一公认的困难在于其并未识别烟雾经过哪个空气入口进入系统。若空气入口为已知，则可推论烟雾来源的地理位置。这容许调查火势的可能部位，包括容许将人员导引至烟雾位置，使其可调查并可能干预及防止火势进一步变大、或关断该区域中的设备。替代性地，可以以局部化方式部署适当的火抑制系统，从而限制系统所造成的损害以及损失。

[0004]　已经试图提供能够确定探测烟雾的地理位置的空气取样微粒探测系统，例如 Jax 的"用于定位污染物累积的方法及器件 (Method and Device for locating accumulations of pollutants)"，美国专利 5,708,218 以及 Hekatron Vertriebs GmbH 的"Verfahren und Vorrichtung zur Erkennung eines Brandes"，EP 1811478。

[0005]　这些系统的每一个都对进行测量的两时刻之间所经过的时间进行测量，以推论所探测烟雾沿着取样导管在何处（亦即经过哪个样本入口）进入系统。然而，此推论方法时常不可靠。

[0006]　Jax 的系统测量第一烟雾水平与第二烟雾水平之间进行探测所经过的时间。在第一较低水平的烟雾、与第二较高水平的烟雾的探测之间的时间指示出沿着可供烟雾进入系统的收集线的距离。然而，此方法并不精确。例如，采用此途径的系统仰赖在第一进入点处所探测烟雾的实际水平，对于从首先探测到烟雾的点开始直到可以可靠地探测到第二进入点的贡献为止的时间期间，该实际水平保持近似恒定。更确切来说，诸如规模变大的火势所造成的烟雾水平的增高可能导致自其抽取空气的地理位置的不精确估计。

[0007]　在 Hekatron 中，第一空气取样探测单元探测烟雾的出现。回应于烟雾的探测，第二空气取样探测单元系介入，空气取样单元沿着导管网络抽取空气。测量由第一空气取样单元的初始探测与由第二空气取样单元的探测之间所经过的时间。理想上，所经过的时间指示出已经抽取充填有烟雾的空气的位置。为了确保精确，这种系统需使呼吸系统每次运作时皆以一种高度一致性方式运作。然而，这很难实现，原因在于不同的特征影响下降的运作，譬如，呼吸系统随时间经过的劣化以及空气密度等运作与环境条件的变化、或取样点随时间经过受到灰尘所拘限将改变系统内的空气流特征、并使得以所经过时间为基础的烟雾地址的推论潜在地不可靠。

[0008] 在部分方案中，空气流可暂时被逆反，而在重新抽取空气以供探测之前将洁净空气导入至取样网络。这种方案的理念在于：在经过取样网络重新抽取空气之前并在探测烟雾之前测量延迟之前，从系统冲洗实质全部的烟雾微粒。理论上，更长的延迟指示出：微粒在较远离探测器的一点进入取样网络。然而，这些方案所蒙受的缺陷在于：在洁净空气导入至取样网络的阶段期间，由于洁净空气从入口被驱出，所以所监测环境内的烟雾微粒可能在围绕空气入口的区域中被驱排。当空气随后被抽取经过系统时，在烟雾微粒再度被抽入入口中之前可能具有额外延迟。

[0009] 因此本发明的目的在于提供一种解决至少部分上述缺点的微粒探测系统。本发明的替代性目的为：对于公众提供一种优于已知产品的有用选项。

[0010] 说明书中提及的任何现有技术不是（且不应视为是）对该现有技术构成澳洲或任何其他司法管辖区的共同一般知识的部份、或者对该现有技术被合理地预期由本领域技术人员确定、理解或认为相关的认可或任何形式的启发。

发明内容

[0011] 在本发明的第一方面中，提供一确定烟雾进入烟雾探测系统中的至少一个进入点的方法，该系统具有包括至少一个取样导管及多个取样入口的取样导管网络，空气样本能穿过多个取样入口进入烟雾探测系统的至少一个取样导管，以供由微粒探测器作分析。该方法包括：确定自预定事件以来穿过至少部份烟雾探测系统的样本空气的体积、或对应于该体积的数值；以及至少部份地以所确定的体积或数值为基础，确定烟雾经过该多个取样入口中的哪个取样入口进入该烟雾探测系统。

[0012] 预定事件例如可为烟雾探测事件；或烟雾探测系统中的空气样本流特征的变化。

[0013] 在部分实施例中，该方法包括连续地确定穿过至少部份烟雾探测系统的空气样本的流率。替代性地，该方法系包括在预定事件发生时开始确定样本空气的体积或相关数值的确定。

[0014] 通过累积一段时间的流率测量，确定穿过至少部分烟雾探测网络的空气样本的体积或相关的数值。流率测量较佳地为容积的流率测量。更佳地，利用超音波流传感器来确定流率测量。

[0015] 确定自预定事件以来穿过至少部份烟雾探测系统的样本空气的体积、或对应于该体积的数值的步骤包括：确定下列的任一个或多个：质量；长度；压力；温度；第二体积；或与体积相关事件的累积计数，或有关于自预定事件以来穿过至少部份烟雾探测系统的样本空气的体积的其他参数。

[0016] 该方法可包括收集全部的或一定比例的自预定事件以来穿过至少部份烟雾探测系统的样本空气。

[0017] 该方法可进一步包括响应于第一烟雾探测事件而改变空气样本流特征。例如，改变烟雾探测系统中空气样本流特征可包括下列的一个或多个：

[0018] • 开启阀；

[0019] • 关闭阀；

[0020] • 改变空气样本流在至少部分烟雾探测系统中的方向；

[0021] • 改变在至少部份烟雾探测系统中的空气样本流率；

[0022] •启动呼吸系统；及

[0023] •停止呼吸系统。

[0024] 在本发明的第二方面，提供一种用于确定烟雾进入烟雾探测系统中的至少一个进入点的装置，其类型是具有呼吸器以及与空气取样网络流体连通的微粒探测器，该空气取样网络具有至少一个取样导管及多个取样入口，空气样本能穿过该多个取样入口进入该烟雾探测系统的至少一个取样导管，以供该微粒探测器分析，该呼吸器以供抽取空气样本穿过该空气取样网络至该探测器。该装置包括：用于确定自预定事件以来穿过至少部份烟雾探测系统的样本空气的体积、或对应于该体积的数值的构件；及用于以所探测的体积或数值为基础来识别微粒进入取样网络的至少一个进入点的构件。

[0025] 该装置较佳地参考一个或多个对应的取样入口来识别进入点中的一个或多个，烟雾被确定出穿过一个或多个对应的取样入口进入系统。

[0026] 用于确定穿过至少部份微粒探测系统的样本的体积或与该体积相关的数值的构件较佳地包括流传感器。更佳地，流传感器包含超音波流传感器。

[0027] 该装置较佳地被组构以执行根据本发明第一方面的方法。

[0028] 在本发明的第三方面，提供一种烟雾探测器，包括微粒探测腔室、入口、以及呼吸器，该微粒探测腔室可供探测空气样本中的微粒，该入口可供从空气取样网络接收空气样本，该取样网络具有至少一个取样导管及多个取样入口，样本能穿过多个取样入口进入该至少一个取样导管以供该微粒探测腔室分析，该呼吸器可供抽取样本经过该空气取样网络至该探测器，该探测器进一步包括处理器，该处理器被组构以：至少部份地以自预定事件以来穿过至少部份烟雾探测器或取样网络的样本空气的体积、或对应于该体积的数值为基础，识别烟雾进入取样网络的至少一个进入点。

[0029] 烟雾探测器包括流传感器（例如超音波流传感器），该流传感器被组构以探测样本空气穿过至少一部份该烟雾探测器的流率。

[0030] 处理器较佳地被组构以使烟雾探测器执行根据本发明第一方面的方法。

[0031] 本文亦揭露确定微粒进入微粒探测系统中的进入点的方法，该微粒探测系统包括微粒探测器及流体性导通于微粒探测器的取样网络，取样网络包括多个入口，经过其抽取流体，微粒探测系统进一步包括用于抽取流体经过取样网络至探测器的构件。该方法包括：比较第一微粒探测轮廓与第二微粒探测轮廓；确定微粒探测轮廓之间的偏移，轮廓在偏移处匹配预定的程度；及以该偏移为基础确定微粒进入探测系统中的进入位置。

[0032] 在部分实施例中，偏移为时间偏移。在其他实施例中，偏移为体积偏移。

[0033] 在部分实施例中，比较涉及微粒探测轮廓之间的交叉相关（cross-correlation）的计算。

[0034] 在部分实施例中，确定所计算交叉相关的最大数值，且确定对应于最大数值的微粒探测轮廓之间的偏移。

[0035] 在部分实施例中，确定所计算交叉相关的函数并与预定数值相比较。

[0036] 较佳地，流体为空气，且用于抽取流体经过取样网络至探测器的构件为呼吸器。

[0037] 一个实施例包括：以身为第一及第二微粒探测微粒的比较的第一微粒探测轮廓为基础来确定已经至少符合第一预定微粒探测标准。

[0038] 该方法可包括连续地储存第一及／或第二微粒探测轮廓。替代性地，可只在已经

满足至少一个预定标准之后储存其中一个轮廓。

[0039] 该方法可包括在开始第一及第二微粒探测轮廓的比较之前改变至少部份微粒探测系统的空气流特征。

[0040] 在一形式中，改变微粒探测系统中的空气流特征的步骤包括下列的一个或多个：

[0041] •开启阀；

[0042] •关闭阀；

[0043] •改变至少部分烟雾探测系统中空气流的方向；

[0044] •改变至少部分烟雾探测系统中的空气流率；

[0045] •起动呼吸系统；及

[0046] •停止呼吸系统。

[0047] 本文进一步公开一用于确定微粒进入微粒探测系统中的进入点的装置，其属于具有呼吸器以及流体性导通于空气取样网络的微粒探测器的类型，空气取样网络具有多个入口，空气可经过其进入空气取样网络，呼吸器以供抽取空气经过空气取样网络至探测器，该装置包括：用于确定通过至少一部份微粒探测系统的空气的体积的构件，该装置包括：用于接收代表经过至少一部份微粒探测系统的空气的体积的信号的构件；用于以所确定体积为基础来确定空气携载微粒进入网络的空气取样网络中的位置的构件。

[0048] 本文亦公开一用于确定微粒经过多个空气入口的一个或多个进入微粒探测系统的进入点的器件。该器件包括用于确定流过至少部份微粒探测系统的空气的体积的构件以及用于以所测量体积为基础来确定微粒的进入点的构件。

[0049] 较佳地，用于确定微粒进入微粒探测系统中的进入点的装置参考至少一个入口来识别微粒来源，微粒有可能已穿过至少一个入口进入。

[0050] 更佳地，用于确定微粒进入微粒探测系统中的进入点的装置由提供可供微粒进入空气取样网络的沿着取样网络的距离的指示来识别微粒来源。

[0051] 本文进一步公开一确定微粒进入微粒探测系统中的进入点的方法，该微粒探测系统具有拥有多个取样点的取样导管网络，微粒可经过取样点进入微粒探测系统中。该方法系包括确定通过至少部份微粒探测系统的空气的体积以及确定微粒经过多个取样点的哪个取样孔进入微粒探测系统。

[0052] 该方法包括探测第一微粒探测事件及第二微粒探测事件，及测量在微粒探测事件之间通过至少部份微粒探测网络的空气的体积。

[0053] 该方法可包括连续地测量通过至少部份微粒探测网络的空气的体积。替代性地，该方法可包括在发生预定条件时启动体积测量。

[0054] 通过至少部份微粒探测网络的空气的体积较佳由加总随时间经过的流率测量而作测量。较佳地，流率测量为体积的流率测量。最佳地，利用超音波流传感器予以确定。

[0055] 本文进一步公开微粒探测系统，其包括微粒探测器，流体性导通于微粒探测器的取样网络，及用于抽取流体经过取样网络至探测器的构件。取样网络包括多个入口，入口配置成多个位置群组。各位置群组具有由连接至多个取样导管各者的入口出现与否所界定的地址。微粒探测器组构以沿着各取样导管抽取空气，并在探测到烟雾的情况下，以微粒于取样导管各者中出现与否两者为基础来确定可供微粒经过其进入探测器的位置群组的地址。

[0056] 本文亦公开一确定微粒进入微粒探测系统中的单一进入点的方法。微粒探测系统

包括至少一个微粒探测器，流体性导通于一该微粒探测器的取样网络，及用于抽取流体经过取样网络至该探测器或抽取流体经过探测器的构件。取样网络包括多个样本导通路径，可沿着其抽取样本且其中可由探测器的至少一个独立地探测微粒的出现，其中各样本导通路径包括至少一个样本入口。该入口的每一个进一步属于由该入口的物理位置所界定的多个位置群组的其中一个。微粒探测系统组构以确定微粒是否已在来自各样本导通路径的空气样本上被探测。该方法包括：

[0057] 以微粒是已经还是尚未在各样本导通路径上被探测为基础，唯一地确定可供微粒进入微粒探测系统中的入口的一位置群组。

[0058] 在一实施例中，取样网络包含多个导管，其分别对应于样本导通路径，且确定微粒已经在位置群组被探测的步骤包含确定微粒已经或是尚未在经过多个导管各者所抽取的流体中被探测。

[0059] 本文进一步公开一用于确定微粒进入微粒探测系统中的进入点的装置，其属于具有呼吸构件以及至少一个流体性导通于取样网络的微粒探测器的类型，呼吸构件以供抽取流体经过取样网络至微粒探测器，取样网络包括多个样本导通路径，其中可分离地探测微粒。取样网络包括多个样本入口，各入口为位于多个物理位置的其中一个处的一位置群组的一元件；该装置进一步包括用于以各样本导通路径上是否已探测到微粒为基础来确定可供微粒出现的位置的构件。

[0060] 本文亦公开一微粒探测系统中的方法，该微粒探测系统具有：

[0061] 至少一个微粒探测器；及

[0062] 取样系统，其包括具有多个取样入口的取样导管，该取样系统配置以将待分析的样本从围绕取样入口的环境经由取样导管传送到至少一个微粒探测器；

[0063] 流引发器，其配置以造成空气样本在取样系统中流动到至少一个微粒探测器；

[0064] 该方法包括：

[0065] 测量从取样系统抵达的样本中的第一微粒浓度；

[0066] 改变位于次组的取样入口的取样参数；

[0067] 测量从取样系统抵达的样本中的第二微粒浓度；

[0068] 以第一及第二微粒浓度及改变的取样参数为基础；测量从取样系统抵达的样本中的微粒浓度。

[0069] 经改变的取样参数可为经过第一次组的取样入口的流率。可由开启或关闭阀或利用风扇或其他流引发器来触发改变，以增大（或减小）经过该次组的取样入口的流。在此实例中，用来确定从取样系统抵达的样本中的微粒浓度测量的经改变的取样参数可为经过该次组的取样入口的流率。

[0070] 在部分实施例中，经改变的取样参数为经过第一次组的入口所抽取的微粒浓度。可由调整被施加至第一次组的取样入口的过滤参数、譬如由在经过取样入口进入的空气的流径中插入或移除过滤器来触发改变。在此实例中，用来确定从取样系统抵达的样本中的微粒浓度测量的经改变的取样参数可为次组的取样入口的样本浓度

[0071] 在部分实施例中，第一次组的取样入口与第二次组的取样入口相同。第一或第二次组的取样入口可包括多个入口、或可为单一入口。

[0072] 本文亦公开一用于探测来自多个空气摄入路径的空气样本中的污染物的方法，该

方法包括：

[0073] 由在多个空气摄入路径的一个或多个中增加或部份地降低流来改变多个路径之间的流平衡，以生成多个不同的流图案；

[0074] 对于多个不同流图案的每一个，测量经组合的空气摄入路径的污染物水平；

[0075] 对于多个不同流图案的每一个，由利用各空气摄入路径中的已知、预定或经测量的流率数值，来确定各空气摄入路径的污染物水平；

[0076] 其中所生成的不同流图案的数量及所取得污染物水平测量的数量足以确定各空气摄入路径中的污染物水平。

[0077] 较佳地，转而由空气摄入路径的每一个中的部份流降低而对于多个不同流图案达成流平衡改变。换言之，若有四个空气摄入路径，第一次组的空气摄入路径（譬如三个路径）被部份地关闭，而剩余的摄入路径则保持开启且同时测量污染物水平。接着，该第一次组空气摄入路径重新开启且第二不同次组的空气摄入路径被部份地关闭，同时剩余的空气摄入路径保持开启且作出污染物水平的第二测量。继续此作用，直到生成四个不同的流图案同时取得污染物水平的四个测量为止。

[0078] 较佳地，由在空气摄入路径中部份地关闭阀来达成流的部份性降低。所以，各阀转而在其他阀保持开启之时被部份地关闭。在此配置中，经过各空气摄入路径的流率可能不是已知的。因此，需要对于多个不同流图案的每一个测量各空气摄入路径中的流率。

[0079] 在替代性形式中，可由在空气摄入路径内设有可移式挡板来达成改变流平衡的步骤。例如，可移式挡板可具有可移动到许多的可选择位置的可旋转碟的形式。碟具有开口，其依据所选择位置而定生成预定流率。因此，在此配置中，不需要流率测量。

[0080] 在改变流平衡的第三替代性方法中，可转而在其他导管保持未通风之时使各空气摄取路径通风。相较于上述的其他两种方法，这将转而导致经过各经通风的空气摄入路径的空气流的增加、并且亦可影响其他空气摄入路径中的流率。

[0081] 在一较佳形式中，生成有与空气摄入路径一样多个的流图案。由于已知具有与流图案一样多个的污染物水平测量，这表示污染物水平的测量数目也等于流路径的数目。这将提供足够的信息以确定各空气摄入路径中的污染物水平，其限制条件在于：各空气摄入路径中的流率对于各流图案而言亦为已知 / 预定或经过测量的。

[0082] 在部分配置中，各空气摄入路径中的流率被测量。此可较佳地由具有合理的高度精确度的流率传感器来达成。在最佳形式中，流率由超音波流传感器来测量，在各空气摄入路径中的一个。

[0083] 较佳地，由对于各流图案的所测量污染物水平以及对于各流图案的各路径中的已知 / 预定或所测量的流率，可解一系列的方程式，如下所示：

[0084] $C_1 = X_1F_{11}/(F_{11}+F_{12}+...F_{1n})+X_2F_{12}/(F_{11}+F_{12}+...F_{1n})...+X_nF_{1n}/(F_{11}+F_{12}+...F_{1n})$

[0085] $C_2 = X_1F_{21}/(F_{21}+F_{22}+...F_{2n})+X_2F_{22}/(F_{21}+F_{22}+...F_{2n})+...X_nF_{2n}/(F_{21}+F_{22}+...F_{2n})$

[0086] .

[0087] .

[0088] .

[0089] $C_n = X_1F_{n1}/(F_{n1}+F_{n2}+...F_{nn})+X_2F_{n2}/(F_{n1}+F_{n2}+...F_{nn})+...X_nF_{nn}/(F_{n1}+F_{n2}+...F_{nn})$

[0090] 其中

[0091] $X_1 \cdots X_n$＝空气摄取路径 1 至 n 中的浓度

[0092] $C_1 \cdots C_n$＝经组合的空气摄取路径中的所测量浓度水平

[0093] $F_{11} \cdots F_{n1}$＝对于流图案 1 至 n 的导管 1 中的流率

[0094] $F_{12} \cdots F_{n2}$＝对于流图案 1 至 n 的导管 2 中的流率

[0095] $F_{1n} \cdots F_{nn}$＝对于流图案 1 至 n 的导管 n 中的流率

[0096] 在一较佳形式中，空气摄入路径可为空气取样导管的形式。各空气取样导管可馈送至探测器单元上的分别的摄入端口中。流可在馈送至探测器之前于歧管中、探测器单元中被合并。

[0097] 测量污染物水平或流率的步骤可涉及自其取得平均数的多个读取。替代性地，可作出任何其他统计计算以确定多个读取的中心倾向。

[0098] 本文亦公开一用于探测来自多个空气摄入路径的空气样本中的污染物的感测系统，该系统包括：

[0099] 控制系统，以供控制每个空气摄入路径中的流控制构件来增加或部份地降低空气摄入路径的一个或多个中的流，以生成多个不同的流图案；

[0100] 探测器，以测量经组合的空气摄入路径的污染物水平，控制系统控制探测器以对于多个不同流图案的每一个测量污染物水平；

[0101] 控制系统进一步可运作以对于多个不同流图案的每一个利用各空气摄入路径中的已知、预定或所测量的流率数值来确定各空气摄入路径的污染物水平；及

[0102] 控制系统可运作以生成足够多不同流图案并控制探测器以取得足够多的测量以确定各空气摄入路径的污染物水平。

[0103] 感测系统可为一感测单元的形式，其包括对应于空气摄入路径的数目的空气摄入端口。各空气摄入端口可耦合至分别的取样导管。流控制构件的每一个可配置于感测单元内或替代性地可配置于分别的取样导管中。

[0104] 较佳地，控制系统能够控制流率的测量。

[0105] 本文亦公开一用于环境取样系统的取样点，其属于具有至少一长形取样管道的类型，长形取样导管由周边壁所界定，且具有多个取样入口，取样入口沿着管道长度所设置且延伸穿过壁以容许样本侵入，该环境取样系统组构以从环境经过取样入口抽取样本至导管中并将样本传送经过管道至分析构件，取样点包括样本注射入口，样本注射入口延伸至管道的周边壁往内的内部中。

[0106] 样本注射入口可包括延伸穿过管道的周边壁的导管。更佳地，导管具有位于或接近于管道中心、远离于管道周边壁的出口。

[0107] 样本注射入口可使其出口面对管道中的流的往下方向。在一较佳形式中，样本注射入口为 L 形导管，其具有用于从环境抽取样本的第一入口端以及位居管道内且具有面对管道中的流的往下方向的出口的第二出口端。亦公开一环境取样系统中的方法，该系统属于具有至少一长形取样管道的类型，，长形取样管道由周边壁所界定，且具有多个取样入口，取样入口沿着管道长度所设置且延伸穿过壁以容许样本侵入，该环境取样系统组构以从环境经过取样入口抽取样本至导管中并将样本传送经过管道至分析器件，该方法包括：

[0108] 提供一结构以改善随着样本部分顺管道往下移行的离散样本部分的至少一前锋沿着管道的扩散。

[0109] 该结构可为包括样本注射入口的取样点，样本注射入口延伸至管道的内部中，如上文所述。该结构亦可为在管道内生成紊扰的结构，其组构以在使用中防止管道内的层流。譬如，该结构可为管道的轮廓状或纹路状壁；紊化器；被动或主动旋转组件或类似物。

[0110] 本文亦公开一用于一环境分析系统的取样系统，该样本系统包括至少一长形取样管道，其由一周边壁所界定，且具有多个取样入口，其沿着管道长度所设置且延伸经过壁以容许样本侵入至管道中，该环境取样系统组构以从环境经过取样入口抽取样本至管道中并将样本传送经过管道至环境分析系统，取样系统进一步包括用以改善随着样本部分顺管道往下移行的离散样本部分的至少一前锋沿着管道的扩散的构件。该结构可为包括样本注射入口的取样点，样本注射入口如上述般延伸至管道的内部中。该结构亦可为在管道内生成紊扰的结构，其组构以在使用中防止管道内的层流。例如，该结构可为管道的轮廓状或纹路状壁；紊化器；被动或主动旋转组件或类似物。

[0111] 该结构可延伸于管道的基本整体长度、或局部化位居、譬如位于或接近于取样入口的一个或全部。

[0112] 本文进一步公开一环境取样系统中的方法，环境取样系统属于具有至少一长形取样管道的类型，长形取样管道具有沿着管道长度呈序列状设置的多个取样入口以容许样本从环境侵入，该环境取样系统组构以从环境经过取样入口抽取样本至管道中并将样本传送经过管道至分析器件，该方法包括：改变管道中的空气流特征以更改位于或接近于至少一个特定取样入口的局部样本浓度，以将局部样本浓度增加趋向围绕该特定取样入口的大气中的样本浓度。

[0113] 改变空气流特征可包括停止或逆反管道中的流的方向，使得相邻于特定取样入口的样本的一部分从样本入口被驱出。该方法随后可包括从环境经由特定样本入口抽取额外样本。停止或逆反管道中的流的方向使得相邻于特定取样入口的样本的一部分从样本入口被驱出及从环境经由特定样本入口抽取额外样本的步骤可重复一次或多次。

[0114] 该方法可包括使管道中流的方向振荡，使得发生驱逐及重新取样环境的重复程序发生。

[0115] 该方法可随后包括将管道的内容物运送到分析器件。较佳地以管道内的样本的最小稀释、或管道样本的纵向定位部份之间的混合来进行此运送。例如，该方法可包括下列的一个或多个：

[0116] 在运送之前关闭取样入口的一个或多个，

[0117] 在上游位置开启管道以提供低流阻抗；

[0118] 从上游位置沿着管道吹送样本。

[0119] 环境取样系统属于具有至少一长形取样管道的类型，长形取样管道具有沿着管道长度所设置的至少一个取样入口以容许样本从环境侵入，该环境取样系统组构以从环境经过该或各取样入口抽取样本至管道中并将样本传送经过管道至分析器件。该系统进一步包括样本放大配置，以改善样本受到管道中的空气流的稀释。

[0120] 样本放大配置可包括用以在管道的至少一部分中逆反流向的器件。该用以逆反流向的器件较佳配置以造成流向的多重逆反，以促进位于或接近于取样入口的空气样本的混合。该用以逆反流的器件例如可为可逆反式风扇、鼓风机、往复活塞、振动薄膜、或类似物。

[0121] 本文亦公开一环境取样系统，其属于具有至少一长形取样管道的类型，长形取样

管道具有沿着管道长度呈序列状设置的多个取样入口以容许样本从环境侵入，其组构以进行上述方法。环境取样系统可包括下列的一个或多个：

[0122]　一个或多个阀，以控制沿着管道及／或经过一个或多个取样入口的流；

[0123]　风扇、鼓风机、或其他流引发部件，以控制沿着管道及／或经过一个或多个取样入口的流。

[0124]　亦提供微粒探测系统（及较佳的烟雾探测系统），其包括上述类型的环境取样系统，以从多个位置输送空气样本以供分析。

[0125]　在一较佳形式中，微粒探测系统包含根据本发明的以下方面的探测系统。在此实例中，附件可包含下列的任一个或多个：取样入口或取样点；阀；过滤器；管道或部分管道；流引发器件，诸如风扇，活塞，鼓风机，泵，振动薄膜或类似物；及局部化模块。

[0126]　根据本发明的另一方面，提供一探测系统，诸如属于本文所描述任一类型的微粒探测系统，以供探测空气体积中的异常状况，探测系统包括探测器以供探测该空气体积中的异常状况、以及附件，其中探测器及附件由空气流径而流体性导通于彼此及该空气体积。

[0127]　其中探测器可运作以经过空气流径至少单向地导通于附件。

[0128]　探测器可为微粒探测器的形式，其用来探测所取样空气体积内的微粒的异常水平。较佳地，微粒探测器的类型为呼吸烟雾探测器，亦即包括风扇或其他类型的流体驱动件。为此，在此较佳实施例中，探测器能够由改变空气流径中的空气流特征以经过空气流径传送信号至附件。在此较佳实施例中，可由调整流速度或方向予以达成。适当地，空气流特性的变化可被附件所探测，其中附件响应于所探测的变化。因此，空气流特性的变化用来作为从探测器至附件的信号。

[0129]　较佳地，空气流径包含空气取样系统或环境取样系统，如同本文任一方面或本文所描述的实施例所描述的。

[0130]　附件可包含探测器以供探测空气体积中的异常状况。附件探测器可为下列类型的任一者：微粒探测器，气体探测器，温度／热量探测器，湿度探测器。替代性地，附件可包含过滤器。譬如，过滤器可为在微粒探测前作使用的预过滤器。附件可为被并入空气流径中的阀或风扇的形式。

[0131]　空气流径适当地包括含有导管及入口端口的取样导管网络。在利用微粒探测器的实施例中，空气流径系亦可包括经过含有呼吸器（亦即风扇与探测腔室）的探测器的流径。来自探测器的排放亦形成部份空气流径。经过附件的流径亦被理解为为部份空气流径。

[0132]　探测器及附件可以沿着空气流径的分离单元而存在。附件可被翻新成为既有探测系统，诸如已经设有包含取样导管网络的烟雾探测器单元的烟雾探测系统。

[0133]　较佳地，探测器将可运作信息传送到附件。例如，探测器可传送关于探测器运作的信息，诸如其现今的运作模式。附件对于所感测信息的响应可为调整其设定或者进行校准、或是重新校准、或改变其运作状态。

[0134]　如上文讨论，经过空气流径导通的模式使探测器造成可由附件所探测的空气流特征的变化。空气流特征的变化可包括可由附件所探测的空气流的任何偏差。这可包括空气流率或方向的变化；或空气流径中的压力波动或压力波。可由探测器内或探测器的控制内的空气流装置（诸如探测器内的呼吸器风扇）予以生成。呼吸器较佳由探测器内的可程序化控制器所控制。因此，适当的程序化将造成探测器传送所需要的信号。

[0135] 空气流径的特征的变化可改变，所以不同信号对于附件指不同事物。例如，不采用流率的单一变化，可具有多个变化，诸如增加的流的脉冲，对应于特定信息的脉冲数。替代性地，亦可利用实际所测量流或流率的变化程度来代表不同信息。

[0136] 较佳地，附件具有感测系统，其包含一或多个传感器以探测流特征的变化。

[0137] 通过空气流径的通信可由附件所探测的声音传输。例如，有可能利用风扇噪音的变化以供信号告知用。否则，声音信号（譬如声学、超音波或次声）可由探测器或系统的其他组件生成并被附件所感测。适当地，附件使用探测这种噪音的麦克风或其他换能器作为其感测系统的一部份。

[0138] 在本发明的一替代性形式中，可由探测器产生振动，譬如由设置在附件中的合适的振动传感器轻触导管。

[0139] 探测器可替代性以附件上的光传感器来传输光信号，但这种系统需要一条经过空气流径的视线。

[0140] 虽然上文讨论已着重在探测器与附件之间的单向导通，双向导通也是可以的。可由在附件中出现阀而生成从附件至探测器的通信，而对于被探测器中的流传感器所探测的空气流特征具有随之发生的效应。部分附件亦并入有风扇。此风扇亦可用来影响可被探测器所感测的空气流特征。

[0141] 根据本发明的另一方面，提供用于探测系统的附件，探测系统用于探测空气体积中的异常状况，附件可由空气流径被流体性连接至探测系统及该空气体积，其中附件可运作以接收由探测系统经过空气流径传输的通信。附件可包括根据本发明第一方面在上文所讨论的任一个特征构造。

[0142] 根据本发明另一形态，提供一探测系统以供探测空气体积中的异常状况，探测系统包括附件和以供探测该空气体积中的异常状况的探测器，其中探测器及附件流体性导通于彼此及该空气体积，其中探测器可运作以由实行流体性导通的空气流特征的变化而至少单向地通信于附件，该等变化可被附件所探测。

[0143] 根据本发明的另一方面，提供一用于探测系统的附件，探测系统用于感测空气体积中的异常状况，附件可被流体性连接至探测系统及该空气体积，其中附件可运作以探测探测系统所产生的空气流特征的变化。较佳地，附件可运作地响应于该等变化。然而，附件亦可运作地响应于缺乏任何变化。

[0144] 上述前两个方面中的探测系统及附件可并入有上文所讨论的较佳特征构造的任一个。

[0145] 根据本发明的另一方面，提供一用于运作探测系统的方法，探测系统探测空气体积中的异常状况，探测系统包括附件和以供探测该空气体积中的异常状况的探测器，探测器及附件由空气流径而流体性导通于彼此及该空气体积，该方法包括：将信号经过空气流径从探测器传送至附件，其中附件响应于信号或响应于缺乏信号。

[0146] 探测器可由实行空气流特征的变化而将信号经过空气流径传送至附件。替代性地，可关于本发明的上述方面根据上述任一替代性方法传送信号。

[0147] 对于信号或是缺乏信号的附件响应可为关停、进入故障模式或调整其运作特征。

[0148] 根据本发明的另一方面，提供一用于运作一探测系统的方法，探测系统探测空气体积中的异常状况，探测系统包括探测器以供探测该空气体积的一异常状况以及附件，探

测器及附件由空气流径而流体性导通于彼此及该空气体积，该方法包括：在附件处经由空气流径接收信号；以所接收信号为基础来控制附件。

[0149] 接收信号的步骤可包括在附件于空气流径的部份中探测诸如流率、方向或压力或类似物等流参数的变化。

[0150] 控制该附件可包括响应于所接收信号而改变附件的至少一个运作参数或状态。较佳地，运作参数的变化改变空气流径中的流状况。

[0151] 根据本发明另一方面，提供一用于运作一探测系统的方法，探测系统探测空气体积中的异常状况，探测系统包括探测器以供探测该空气体积的异常状况以及附件，探测器及附件由空气流径而流体性导通于彼此及该空气体积，该方法包括：在附件处感测空气流径中的空气流的变化；以所感测变化为基础来控制附件。

[0152] 接收信号的步骤可包括在附件于空气流径的部份中探测诸如流率、方向或压力或类似物等流参数的变化。

[0153] 控制该附件可包括响应于所接收信号而改变附件的至少一运作参数或状态。较佳地，运作参数的变化改变空气流径中的流状况。

[0154] 在上述实施例中，附件可包括下列的任一个或多个：阀、风扇、流控制器件、探测器、过滤器。

[0155] 如同将了解，系统、探测器或附件可有利地使用于本文所描述的任一个实施例中。特别来说，采用这种附件及方法降低附件装设的复杂度，原因在于：额外的通信线需被连接于附件与其他系统组件之间。

[0156] 本文亦公开一环境取样系统中的方法，该环境取样系统属于具有至少一长形取样管道的类型，长形取样管道具有沿着该或各管道的长度所设置的多个取样入口，以容许样本从环境侵入，该环境取样系统组构以从环境经过取样入口抽取样本至管道中并将样本经过管道传送至分析器件以探测样本中的威胁物质的出现，该方法包括：

[0157] 在探测模式中运作，其中监测威胁物质的出现和或浓度且在符合至少一判别标准的情况下，系统进行下列步骤：

[0158] 在局部化模式中运作，以确定威胁物质以哪个取样入口进入系统。

[0159] 该方法可包括以训练模式运作，以将经过至少一个取样管道至分析器件的样本流予以特征化，从而能够确定威胁物质在局部化模式中以哪个取样入口进入系统。

[0160] 局部化模式可包括样本放大阶段及运送阶段。

[0161] 局部化模式可包括清除阶段。

[0162] 在另一方面中，提供一微粒探测系统，其组构以监测一系列的物理位置以供微粒出现，微粒探测系统包括微粒探测器及取样导管网络，以供从系列的物理位置输送空气样本至微粒探测器以供分析，该取样导管网络配置使得：每个物理位置具有样本入口配置，空气样本经过其被抽取至取样导管网络中，每个样本入口配置在分别的取样连接位置被连接至取样导管，其中当沿着取样导管网络内的流径作测量时，邻近物理位置的样本入口配置之间的平均距离小于邻近物理位置的取样连接位置之间的平均距离。

[0163] 在样本入口配置包括多个样本入口的情况下，可利用样本入口的形心来确定到其邻近配置的距离。类似地，若物理位置的取样连接位置包括对于取样导管的多个连接点，可利用多个连接点的中心来确定沿着流径对于其邻居的距离。

[0164] 在部分实施例中，取样导管通过被监测的区以服务该区。在其他实施例中。取样导管行进接近但未经过该区（诸如有可能为其中取样导管行进房间的天花板上方、或被检测的设备柜之外），以服务该区。

[0165] 在较佳实施例中，取样导管包括延伸过或经过被取样导管所服务的区的第一部分以及连接至第一部分上游的取样导管网络的第二部分，其延伸过或经过被第一部分所服务的至少一区。较佳地，第二部分延伸过或经过第一部分所延伸过或经过的多个区。最佳地，第二部分延伸过或经过第一部分所延伸过或经过的大部分区。

[0166] 在部分形式中，第一及第二部份基本上并列状延伸，最佳地，其平行于彼此行进。

[0167] 在一较佳形式中，第二部分服务被定位于由第一部分所服务的位置之间的位置。最佳地，被定位为相邻于彼此的位置被导管网络的第一及第二部分交替地服务。这种配置用来分散沿着取样导管网络的流径的连接点，其有助于降低微粒局部化的模糊性。

[0168] 若一区的样本入口配置至取样导管网络的共同部分的给定部分产生一连接点，该区应该视为由取样导管网络的共同部分的任一给定（譬如第一或第二）部分所服务。在另一方面，提供微粒探测系统，其配置以监测多个区中的微粒，该微粒探测系统包括微粒探测器，及取样导管网络，其包括多个样本入口，微粒被抽入其中以供运送至探测器以供分析。该取样入口配置以从特定区抽取样本，其中取样导管网络包括序列式互连的多个并列状导管，其中与沿着多个并列状导管长度彼此依序相邻设置的至少两区呈现对应的取样入口连接至多个导管的不同组件。最佳地，当多个导管具有两导管时，依序相邻区的取样入口交替地连接至第一或第二导管。

[0169] 在本发明的另一方面中，提供一装置，其包含：输送系统，以供将测试物质输送至被配置以保护位置的微粒探测器；启动构件，以启动输送系统来输送测试物质；

[0170] 指示器，其以信号告知输送系统的启动，使得由被配置以撷取该位置影像的影像撷取系统自动地探测该启动。

[0171] 该装置可进一步包括界面，其能够使有关于启动的数据被输入至装置中以供储存或藉此传输。输送系统可包含下列至少一个：测试物质产生器；管道，以供将测试物资从测试物质产生器输送至微粒探测器；风扇、泵或类似物，以将测试物质移动经过装置至微粒探测器。指示器较佳包含一或多个辐射发射器，其组构以发射辐射以供在影像中撷取。该装置可包括同步化端口，以能够将数据转移至及／或转移自装置来到外部器件，诸如微粒探测系统或视频撷取系统。

[0172] 在另一方面中，本发明提供一用于使微粒探测系统中的地址交叉相关的方法，该地址对应于物理位置，其中在用以监测多个位置的视频撷取系统中监测位置；该方法包含：在该地址处造成微粒探测系统中的微粒的探测；

[0173] 视觉指示对应于该地址的物理位置；在视觉撷取系统所撷取的至少一个影像中识别该物理位置的视觉指示；

[0174] 使地址与视觉撷取系统所监测的多个位置的其中一个位置交叉相关。

[0175] 该方法较佳包括使地址与下列一个或多个交叉相关：摄影机，其撷取至少一个识别出视觉指示的影像；摄影机的摇摄、倾斜或变焦参数的一个或多个，其撷取至少一个识别出视觉指示的影像。

[0176] 该方法可包括将交叉相关数据提供至视觉撷取系统，以能够在微粒于该地址被微

粒探测系统所探测的事件中选择性撷取、储存或显示有关于与微粒探测系统中的地址呈现对应的影像。本文所描述的，此容许微粒探测事件的视频验证。

[0177] 视觉指示对应于地址的物理位置的步骤可包括：发射可在视频撷取系统所撷取的影像中被撷取及识别的辐射。这可包括选择性启动呈现可探测图案的辐射源。例如，接通－关断式调变一光源。

[0178] 造成微粒探测系统中的微粒探测的步骤较佳地包括位于或接近于该物理位置发射微粒，从而在该地址被微粒探测系统所探测。

[0179] 造成在该地址的微粒探测系统中的微粒探测；及视觉指示对应于该地址的物理位置的步骤较佳地同时地进行，以能够在视频撷取系统所撷取的影像与微粒探测系统中的微粒探测事件之间产生时间性交叉相关。

[0180] 最佳地，利用本发明先前方面的装置执行该方法。

附图说明

[0181] 现在将参照附图由非限制性范例来描述本发明的示范性实施例。图中：

[0182] 图 1 示出一微粒探测系统，其包括一空气取样网络；

[0183] 图 2 示出一微粒探测系统，其采用两个微粒探测器以能够确定可供烟雾进入一空气取样网络的位置；

[0184] 图 3 示出一微粒探测系统，其采用被耦合至一空气取样网络的单一微粒探测器，空气取样网络具有由一阀所分离的两分支；

[0185] 图 4 示出一微粒探测系统，其采用被耦合至单一空气取样管线的两个微粒探测器；

[0186] 图 5 及图 6 以图形示出如同在一微粒探测系统的分别的探测器（或分支）处所测量的一事件择时；

[0187] 图 7 示出一微粒探测系统的另一实施例，其用来确定微粒进入系统的一位置；

[0188] 图 8 示出一微粒探测系统，其包括一含有多个阀的取样系统，以供更改取样系统的一取样参数［以实行本发明一个方面的实施例］；

[0189] 图 9A 示出一微粒探测系统，其包括一含有多个过滤器的取样系统，多个过滤器被配置成更改取样系统的取样参数［以实行本发明一个方面的实施例］；

[0190] 图 9B 示出图 9A 的系统中所使用的一过滤器及阀配置；

[0191] 图 10A 是根据本发明的一较佳实施例的一微粒探测系统的示意图；

[0192] 图 10B 是图 10A 的微粒探测系统的一部分的示意图；

[0193] 图 10C 是依照图 10B 的微粒探测系统的该部分的示意图，差异在于其中一个阀位于一部份关闭位置；及

[0194] 图 10D 是依照图 10C 的该部分的示意图，差异在于其他阀的其中一个被部份地关闭；

[0195] 图 11A 示出一微粒探测系统；

[0196] 图 11B 是示出随着一样本部分顺一管道往下移行的该样本部分的一前锋的扩散的图形；

[0197] 图 11C 示出图 11A 的样本管道内的一流速度轮廓；

[0198] 图 12 示出根据本发明的不同实施例的三个取样点，其可改善图 11B 所示的扩散的效应；

[0199] 图 13A 至图 13D 是可改善图 11B 所示扩散的效应的紊化器的范例；

[0200] 图 14 示出一微粒探测系统，其包括一被连接至鼓风机的空气取样网络，鼓风机可用来使空气取样管道内的样本流方向产生振荡，以抵消受到微粒探测系统内的其他取样入口的样本稀释；

[0201] 图 14A 至图 14E 示出一示范性系统，其以一模拟于图 14 的方式使用一振动薄膜进行样本放大；

[0202] 图 15 示出一微粒探测系统，其包括一具有一上游风扇的空气取样系统，上游风扇可用来抵消受到微粒探测系统内的其他取样入口的样本稀释；

[0203] 图 15B 示出一类似于图 15 者的微粒探测系统，其已经以一样本冲洗系统被增强；

[0204] 图 16 示出一微粒探测系统，其具有一含有位于取样入口上游的一阀的空气取样系统，该阀可用来开启取样管道的端以增强样本在管道中至微粒探测器的运送以供分析；

[0205] 图 17 示出图 14A 至图 14E 的系统的一变体；

[0206] 图 18 示出一微粒探测系统，其包括一空气取样网络，空气取样网络具有一包含多个个振动薄膜的样本放大配置；及

[0207] 图 19 示出另一微粒探测系统，其包括一空气取样网络，空气取样网络具有一分支状取样导管，且其具有一包含多个振动薄膜的样本放大配置；

[0208] 图 20A 及图 20B 分别示出图 14 及图 15 的系统的一变体，其包括一专用局部化模块；

[0209] 图 21 示出根据本发明的一实施例的一微粒探测系统，其配置以探测一系列的区中的微粒；

[0210] 图 22 及图 23 示出根据本发明的一系统的另两个实施例，其配置以探测一系列的区中的微粒；

[0211] 图 24 示出一并入有采用一视频保全系统的视频验证的微粒探测系统；

[0212] 图 25 及图 26 示出图 24 的系统中供视频验证所使用的示范性用户界面；

[0213] 图 27 是供图 24 所示类型的一系统的委任及／或测试所使用的一装置的示意图；

[0214] 图 28 是一示范性附件（在此实例中为一阀），其配置以感测来自另一系统组件的空气流径中的流的一变化或状况并且回应于所感测变化或状况而控制其运作；

[0215] 图 29 示出关于同图 28 所描述的一并入有一附件的微粒探测系统；

[0216] 图 30 示出一局部化模块的一实施例；

[0217] 图 31 示出可供多个取样导管作连接的一局部化模块的另一实施例；

[0218] 图 32 及 33 示出类似于图 28 所示的附件的额外实施例。

具体实施方式

[0219] 图 1 示出一微粒探测系统，其包括一流体性导通于一取样网络 28 的微粒探测器 11。取样网络包括多个可供经过其抽取空气的入口 29。一呼吸器 16 抽取空气经过入口 21 至取样网络 28 中且亦进入一微粒探测腔室 14 中。空气样本经过出口 22 离开探测系统。

[0220] 探测器包括一流传感器 24。在本发明的一较佳实施例中，采用如 WO2004/102499

所描述的一超音波流传感器。此传感器能够实现体积性流测量。流传感器 24 提供每单位时间从取样网络 28 流入微粒探测器 10 中的空气体积的指示。可利用流传感器 24 的输出来推论 :例如何时已经发生流故障,譬如取样网络 28 的阻塞或降低的呼吸器效能。

[0221] 系统 10 亦包括一控制器 40,以供以探测器 14 的输出为基础来确定空气样本中的微粒水平,并将警示及故障逻辑施加至探测器输出以示警用户微粒的出现及系统的运作状态。来自 Xtralis Pty Ltd. 的 Vesda 或 ICAM 烟雾探测器的典型安装为此类型系统的范例。

[0222] 这种一探测系统系可施用于本发明的一实施例中以额外地确定微粒进入空气取样网络 28 中的进入点。

[0223] 图 2 示出两个微粒探测器 202 及 204,各微粒探测器为图 1 所示的类型。各探测器分别连接至取样网络 203 及 205 的各自的导管。取样网络 203 及 205 实质地平行并组构以监测相同区域。各探测器亦连接至一控制单元 207,其含有一微控制器 209。导管 203 具有多个空气入口 206-216。类似地,导管 205 具有多个空气入口 218-230。来自导管 203 的各空气入口可与来自其平行空气导管 205 的入口组成一对。在装设时,来自导管 203 的各入口被定位成靠近来自导管 205 的一对应入口。入口因此成对配置。例如,导管 203 的空气入口 206 及导管 205 的空气入口 218 一起标示为空气取样入口对 232,原因在于空气入口 206 及空气入口 218 被放置呈现物理紧邻。例如,各对的入口可位于一列办公室的相同房间中、或甚至被附接至一共同取样点。

[0224] 在正常运作中,微粒探测器 202 的呼吸器抽取空气导管 203。微粒探测器 204 的呼吸器经过导管 205 抽取空气。随着每个微粒探测器抽取空气,测量散布的光或"烟雾水平",并报告予控制单元 207。控制单元 207 的微控制器 209 在其内部存储器中储存所报告的烟雾水平。

[0225] 在烟雾于空气取样入口对 232 处进入空气取样网络的事件中,烟雾从空气入口 206 所须移行抵达微粒探测器 202 的距离远小于烟雾从空气入口 218 所须移行抵达微粒探测器 204 的距离。相应地,由于烟雾在微粒探测器 204 之前即进入空气取样入口对 232,微粒探测器 202 将登记一增加的烟雾水平。

[0226] 当探测器 202、204 的其中一个 (例如微粒探测器 202) 所探测的烟雾水平超过一预定阈值 (其亦可以是或不是警示阈值) 时,微控制器开始监测已经被抽取经过探测器的一或两者的空气体积。因为空气入口 218 处所导入的烟雾在可于探测器 204 处被探测之前必须沿着取样导管 205 长度移行。在微粒探测器 204 已抽取一定体积的空气之后,微粒探测器 204 将记录类似于微粒探测器 202 所见的一增加的烟雾水平。当此增加的烟雾水平被记录时,微控制器 209 完成监测已经被抽取经过探测器 204 的空气体积。可利用此最终体积确定可供烟雾经过其进入空气取样导管的取样孔。

[0227] 因为流传感器 (譬如 24) 输出体积性流率,通过将流传感器的输出随时间经过作积分来确定通过探测器的空气体积。例如,流率可被传感器每秒输出一或多次。这些体积可累积于探测器本身中或微控制器 209 处,以确定已经流动的样本空气的总体积。

[0228] 微控制器 209 随后利用被探测器 204 抽取的空气的所确定体积来推论可供经过其导入烟雾微粒的取样入口对。在一实施例中,微控制器利用查询诸如下列的一查阅表来达成此作用 :

[0229]

体积	空气入口对
-5L	对 1
-3L	对 2
-1L	对 3
1L	对 4
3L	对 5
5L	对 6

[0230] 查阅表含有所测量体积，其映绘回到一对应的取样孔对。各体积对应于在微粒被其探测之前经过第二探测器所抽取的空气的体积。负及正值表示由对 202 或 204 的哪个探测器来测量体积。在此实施例中，一负值表示由探测器 202 测量体积。

[0231] 例如，微控制器 209 可测量在由探测器 202 的一烟雾探测事件与由探测器 204 的一后续探测事件之间的时间中经过探测器 204 所抽取的空气的 112mL 体积。具有最接近地对应于该体积的一体积的表格的列为第四列，并对应于对 4。对 4 转而对应于空气入口对 238。若所测量体积另为 -112mL，则最接近的表格列将是 -100mL 的条目，且对 3（空气入口对 236）将确定作为可供烟雾进入系统的点。

[0232] 如同将了解，若不直接地测量体积，在本发明的其他实施例中可使用一对应于体积的数值。例如，可由一并非测量体积性流率的参数来确定已经通过系统的空气样本量，例如，若一质量流传感器出现在探测器中，由于其以一用以修正流体温度或密度的修正因子而有关于体积，这种传感器的输出系能够使用在本发明的一实施例中。

[0233] 亦可使用其他物理参数，包括但不限于长度、压力或温度或体积相关事件的一计数。例如，样本流的时间可变速度（譬如以 ms^{-1}为单位）可在位置作测量并累积（譬如加总或积分等）以确定已经以一“长度”形式通过系统的空气量。亦可利用空气样本（或其已知的比例）使一活塞位移而以一“长度”代表体积。活塞受到所收集样本（或其固定的部分）的总位移将代表已经通过系统的空气量的测量，替代性地对于一小缸筒尺寸而言，可计数活塞的循环数以产生与已经通过系统的空气样本体积呈现对应的数字数值。

[0234] 为了提供一其中用来确定通过系统的空气量的物理参数为压力或温度的范例，请考虑一其中在一密闭系统的第一腔室中撷取空气样本（或空气样本体积的一已知比例）的系统，可能不曾知道此空气量的实际体积 V_1（或是若体积为固定，则为压力）。然而，若测量所撷取样本的温度 T_1及压力 P_1（或是若压力为固定，则为体积）。所撷取样本随后被移动至已知体积 V_2的一第二腔室，且新温度 T_2及压力 P_2依照波义尔定律 (Boyle’s law) 与初始体积有关。通过在样本（或样本部分）转移到第二腔室期间控制压力或温度保持恒定，温度或压力可以用作与通过系统的样本空气的体积有关的量。

[0235] 若取代体积使用诸如质量、压力、温度及长度等数值的测量、或有可能作测量且可容忍可变流率的其他物理参数，查阅表替代性直接将这些其他物理参数映绘至空气入口对数，而不必进行计算体积的中间步骤。

[0236] 一旦已经确定空气入口对数，空气入口对数随后可被传送至一次级器件（诸如一火灾警示控制面板（FACP））或显示予用户，以能够定位火灾。

[0237] 查阅表可在系统委任期间生成，譬如由将烟雾导入至各样本入口对并测量在探测前所抽取的空气体积而成。如同将了解，若烟雾已经在取样对 232 处进入，在由探测器 202 探测后的期间中将具有探测器 204 所抽取的很大体积的空气，同时探测器 204 等待探测经增加的烟雾水平。反之，若烟雾经过取样对 242 进入系统，探测器 204 将在探测器 202 之前即探测到一经增加的烟雾水平，探测器 202 抽取一很大体积的空气，同时等待探测经增加的空气水平。若烟雾进入取样网络朝向中央，例如在样本对 236 处，探测器 202 将先探测到一经增加的烟雾水平，在由探测器 204 探测之前所抽取的空气体积相对地小于第一实例的任一者，原因在于：到了由探测器 202 探测的时间，烟雾将已经被朝向探测器 204 抽取一实质距离。

[0238] 本领域技术人员将了解：在具有大的取样导管网络长度的、微粒经过取样网络的运送时间长久的本组态中，将可以在确定烟雾的位置之前探测烟雾的出现。例如，在图 2 的取样入口对 232 处导入烟雾的事件中，进入取样孔 206 的烟雾将快速前行至探测器 202，并被探测。尽管有探测器 204 尚未探测到烟雾的事实，探测器 202 可立即发出一警示。相应地，若法规指定了导入一取样孔的烟雾所须被探测的时间，此特定组态能够在火灾出现而烟雾微粒探测时作探测及报告。随后可利用一并非警示水平的阈值水平以先前所描述方式继续进行火灾的地理位置的确定。

[0239] 为此，在一较佳形式中，用来对于各探测器确定一地址化事件的阈值高于最低警示（譬如：预警示）阈值。一较佳实施例在试图地址化之前等待，直至探测到一较高水平的微粒为止。

[0240] 在一实施例中，并不采用查阅表，体积偏移（volume offset）乘以一常数，以确定沿着可供烟雾微粒进入系统的取样网络的距离。在另一实施例中，体积偏移用来作为函数中的一变量，其在评估时产生沿着可供微粒进入的取样网络的距离的一估计。在另一实施例中，体积偏移用来作为查阅表中的一索引，所产生的查阅表为沿着导管的距离的估计。在较佳实施例中，在由将烟雾导入至各取样孔对作出委任以及测量所产生的体积偏移以产生校准数据之时，确定出上文所描述的乘法常数、函数、或查阅表。如同本领域技术人员将了解，可以由将烟雾导入至另一次组的孔、并仰赖取样对在取样网络中的已知分布，而对于一次组的取样孔推论结果。

[0241] 如同本领域技术人员将了解，本发明的修改可调适以例如确定一火灾的蔓延。系统所报告的信息可为沿着可供微粒呈现已经进入的取样网络的距离，但此距离可能并未对应于一取样入口对。

[0242] 所计算的距离或空气入口可直接提报予一终端使用者。所计算的距离或空气入口可传送至另一系统，诸如一火灾警示控制面板（FACP）。若一火灾警示控制面板已设计成从可地址化点探测器而非具有多重取样点的单一呼吸式烟雾探测器的一系统接收数据，本系统可以仿效可地址化点探测器的系统的方式将所计算的距离或入口传送至火灾警示控制面板，藉此利用 FACPs 对于火灾地理位置的理解，而不实际利用个别的可地址化点探测器。

[0243] 图 3 示出本发明的一替代性实施例，其采用被附接至一空气取样网络的单一微粒探测器，空气取样网络包含两导管 303 及 305 及一阀 304。在正常运作中，空气被抽取经过

导管 303。当烟雾探测器 202 探测到高于一预定阈值的烟雾时，阀 304 系移动以阻挡导管 303、并容许空气流过导管 305，且微控制器 309 开始记录被抽取经过探测器 302 的空气体积。当烟雾微粒被探测器 302 探测时，微控制器 309 完成记录被抽取经过探测器 302 的空气体积。采用本文所描述任一方法，随后利用在再度探测到微粒之前通过空气取样网络 305 及进入微粒探测器 302 中的空气体积来推论可供烟雾微粒进入导管 305 的点。

[0244] 图 4 示出采用被附接至单一空气取样网络的两微粒探测器另一途径。起初，烟雾探测器 402 运作且烟雾探测器 404 不可运作。烟雾经过空气入口 408 进入系统。烟雾被抽取经过空气取样网络、且被烟雾探测器 402 探测。一烟雾探测事件的确定触发烟雾探测器 402 变成不可运作，烟雾探测器 404 变成可运作，且微控制器 409 开始记录被抽取经过探测器 404 的空气体积。烟雾探测器 404 的呼吸器系在与烟雾探测器 402 的呼吸器所造成的初始流向相反的一方向沿着空气取样网络 403 抽取空气。若烟雾只经过单一空气入口 408 进入，烟雾探测器 404 在来自空气入口 408 的烟雾抵达其之前系无法探测到烟雾。根据本发明，采用本文所描述方法的任一者，在利用烟雾探测器 402 的初始探测之后及直到利用探测器 404 的后续烟雾探测为止的利用探测器 404 所抽取的空气体积系用来确定可供烟雾微粒进入空气取样网络 403 的空气入口。

[0245] 发明人已经了解：可有利地使用经过系统所抽取的空气体积或对应数值来确定微粒进入空气取样系统中的进入点。并且，由测量体积而非时间，可以改善与仰赖时间测量所相关的特定缺点或问题。例如，已知道取样入口随着使用而聚集灰尘并变成受拘束，导致较大的压降及较小的空气流。这表示空气样本的运送时间随系统寿命而变。然而，被位移令一样本来到探测器的空气的体积系随时间而呈现相对恒定，其使得位移体积与地址之间的交叉相关比起运送时间更为稳定。并且，若开启一阀或开始一呼吸器有所延迟、或是风扇比预期更慢启动，则相较于以时间为基础的系统而言，在第二次探测到微粒之前被抽取经过系统的空气的体积系可能相对不变。有利地，以体积为基础的地址化系统能够独立于流率或在一可变流速度范围被运作，从而实现诸如下文所描述的技术，其中系统打开一端盖以加速一样本流至探测器。

[0246] 其他类型的流传感器可使用在本发明的实施例中，例如一质量流传感器，其提供随时间移动过传感器的空气的质量的指示。然而，因为质量流传感器对于其所测量的空气密度并不敏感，需要诸如空气温度等其他信息，藉以确定移动过其的空气体积。

[0247] 在实行上述发明的实施例中所遇到及现有技术中的另一困难在于可靠地确定已经发生两个均等的烟雾探测事件的潜在困难，例如一信号从模拟转换至数字形式前所导入的噪声可能使得确定烟雾何时被探测器 202 或探测器 204 所探测的过程受挫。发明人已经设计出一用以避免或改善此缺陷的经改良的方法。

[0248] 诸如图 2 的一烟雾探测系统产生两不同数据组或“微粒探测轮廓”。一数据组从微粒探测器 202 抽取。第二数据组从微粒探测器 204 抽取。各数据组含有一系列的所测量烟雾水平。数据组亦可含有关于流过探测器的空气体积的信息，或可供测量一特定烟雾水平的时间。

[0249] 在下列范例中，我们将描述一用以随时间监测烟雾水平的系统。本领域技术人员将了解：该方法系可调适以相较于由系统所抽取的空气体积来测量烟雾水平（如上述），然而为了示范用，我们目前就在不同时间所取得的一系列的所测量烟雾水平来描述系统。

[0250] 图5示出一微粒探测轮廓。所探测的烟雾水平沿着其竖直轴线表示。时间沿着水平轴线测量。烟雾水平为由图2的探测器202所测量的那些。图6示出一第二微粒探测轮廓。其类似于图5,差异在于其有关于由探测器204所测量的烟雾水平。

[0251] 比较图式,探测器202探测在时间200抵达最大值的一烟雾水平,其在该时间解除启动且微粒探测输出实质地返回至零。探测器204在时间300探测一最大烟雾水平。不同时间至少部份可归因于烟雾抵达探测器204所须移动的沿着取样网络205的额外距离。将可能利用各个最大值的时间之间的差异或是可供各轮廓相交于某预定阈值(譬如竖直轴线的150的烟雾水平,其在使用中可能不同于警示阈值)的时间的差异,来估计可供烟雾经过其进入微粒探测系统的空气入口。然而,更佳地,可利用图5及6所示的数据计算一交叉相关。

[0252] 对于实数及连续函数f及g,根据下列公式计算交叉相关:

[0253] $$(f*g)(t)=\int_{-\infty}^{\infty} f(\tau)g(t+\tau)d\tau$$

[0254] 本领域技术人员将了解:此方程系可调适以配合使用离散的测量,诸如本系统中所探测的烟雾水平。例如,可由在一各别缓冲器、譬如一环缓冲器中暂时储存各探测器数据的一微粒探测轮廓而在硬件中实行这种系统。缓冲器可被选择藉以储存数据,使得可精确地计算可由系统所测量的最长的可能偏移。随后可如上式所描述般将各对的数据元素相乘、并将其相加,藉以计算位于一点的交叉相关。可随后对于各个可能的偏移t重复此程序,以确定整体交叉相关函数。交叉相关函数可随后用来估计两微粒探测事件之间的时间偏移。这转而可用来推论微粒经过哪个入口对进入取样导管网络。在部分实施例中,利用来自交叉相关函数的信息找出可能已供烟雾进入系统的进一步几何位置。

[0255] 在一实施例中,识别出交叉相关函数的多重峰值。以各峰值的位置及其对应的交叉相关数值为基础,来计算一列时间偏移。利用时间偏移来推论烟雾来源的地理位置。这可用来潜在地推论可供火灾发生的多重位置。

[0256] 图7示出一探测器微粒探测系统700,其包括一流体性导通于一呈现导管704、706、708及710形式的空气取样网络的微粒探测器702。各导管包括多个入口,其配置成取样入口群组712至740。各取样入口群组对应于一物理地址,譬如:由该探测器所服务的一房间或位置。各个样本入口群组包括介于一个与四个之间的空气入口。

[0257] 微粒探测器连接至各导管、且组构以对于一控制器提供已经在经过各导管所抽取的流体中探测到微粒的指示。探测器702可例如为四个被耦合至一中央控制器的VESDA烟雾探测器(来自Xtralis Pty Ltd.),或一能够独立探测最多四个导管的烟雾的探测器。

[0258] 取样入口群组712至740的各者包含一、二、三或四个分别的取样入口。入口配置成群组,使得相同图案不会发生两次。例如,取样入口群组730在各导管上包括一入口,但没有其他群组在各导管上包括一入口。取样入口群组712仅在导管710上包括一入口,但没有其他取样入口群组仅在导管710上包括一入口。在图7的范例中,入口对应于一4位格雷码(Gray code)以群组作配置。

[0259] 与上文就图2的讨论一致,在安装时,来自各群组的入口被定位成彼此靠近。在烟雾在一特定入口进入取样网络的事件中,烟雾应进入该群组中对其出现有一入口的导管的各者。例如,若烟雾进入接近于取样入口群组730的位置的取样网络,可预期烟雾将在该位

置进入四个导管 704、706、708 及 710 的各者。反之，若烟雾在取样网络群组 712 进入取样网络，可预期烟雾仅进入导管 710，原因在于：在该位置，没有其他导管包括一入口。在抽入分别的导管 704、706、708、710 的样本中探测到微粒时，微粒探测系统能够以横越导管 704、706、708、710 的探测的图案为基础来确定烟雾进入取样网络中的进入点。

[0260] 图 7 的表格更完整地示出横越四个导管的微粒探测状态的可能组合以及其对应的微粒探测位置。可有效地首先对表达所指示的烟雾水平的术语进行定义。对于本目的，将使用四个二进制位以对应于分别对于导管 704、706、708、710 各者所探测的烟雾水平。例如，'1111' 指示对应于从导管 704、706、708 及 710 各者所抽取空气中位于某阈值水平的烟雾的探测。'1100' 指示系指从导管 704 及 706 各者所抽取空气中的烟雾的探测。'1010' 指示系指从导管 704 及 708 各者所抽取空气中的烟雾的探测。相应地，可以一对应于一位置的地址来对待这些四位指示的各者。具有十五个非零的四位数字。相应地，这些十五个数字可用来区别十五个分离的位置。图 7 的表格列出 '格雷码 (Gray code)' 栏地址中的可能的十五个非零二进制数字各者。在各二进制数字旁边为 '位置' 栏中的 15 个位置的一个。'所探测烟雾' 栏示出烟雾是否已在导管处以所指派的阈值水平被探测。

[0261] 具有众多可能的方式可将地址分配予各位置。例如，在部分实施例中，从 1 至 15 的各个接续位置可以类似于普通计数的方式占用一后续二进制数字。根据此方案，位置 1 将具有地址 '0001'（其为十进制 '1' 的二进制代表），且位置 2 将具有地址 '0010'（其为十进制 '2' 的二进制代表）。在此方案中，位置 15 被赋予二进制地址 '1111'，其为十进数 15 的二进制代表。

[0262] 然而，所示出的实施例采用一不同的分配地址的方法，称为 '格雷码'。在图 7 的所示出的格雷码中，位置 1 被赋予地址 '0001'。位置 2 被赋予地址 '0011'（其对应于十进制 '3' 的二进制）。位置 3 被赋予地址 '0010'（其对应于十进制 '2' 的二进制）。当考虑二进制代表的各者时，此顺序的编号具有一特殊性质。特别来说，各对的相邻位置具有一确切相差一位的二进制代表。例如，位置 4 具有地址 '0110'，而位置 5 具有地址 '0111'，所以只有各数字的第四位不同。类似地，位置 11 具有地址 '1110'，而位置 12 具有地址 '1011'，且所以这些数字亦仅有其第二位不同。

[0263] 选择地址的方式可能影响探测错误出现下的效能。特别来说，比起一由接续的二进制数字来地址化接续的位置的直率"计数"地址方案而言，利用一格雷方案可能对于地址化误差而言更加强大。为了显示这点，在一如图 7 所描述采用格雷码编号的系统中，粗略有 50％机会使得对于单一位错误而言，所确定的火灾位置将是相邻于烟雾实际位置的一位置，原因在于各相邻位置的地址仅相差单一位。

[0264] 本领域技术人员将了解：样本入口群组的明智选择以及增加馈送探测器的导管数会导致局部化决策目的的增加的冗余性。实际来说，导入此冗余性可能例如藉此区别烟雾在多重样本入口的同时进入，或替代性地，这种系统可简单地提供对于错误的较大韧性。

[0265] 图 8 及图 9 示出另一用于在图 1 所描述类型的一呼吸式微粒探测系统内提供可地址化的机构的两实施例。

[0266] 首先参照图 8，其示出一微粒探测系统 800，包括一微粒探测器 11，其耦合至一空气取样系统 26。空气取样系统 26 包括一取样导管 28，取样导管 28 包括五个样本点 29。如同对于图 1 所描述，微粒探测器 11 的呼吸器经过样本入口 29 抽入空气样本，其随后沿着导

管 28 移行且进入探测器 11 中以供分析。在此实施例中，各取样孔 29 额外包括一阀 802。各阀 802 能够独立地调整经过其各自取样孔 29 的流。阀系由探测器 11 的中央控制器所控制，并组构以在探测器 11 的控制下被开启及关闭。在部分实施例中，阀 802 可以关于图 28 作更详细描述的方式通过将发光变化诠释成来自探测器 11 的信号，而接收到感测改变状态的需求。

[0267]　各取样入口 29 上的阀 802 用途在于使得烟雾探测器 11 能够改变其系统的取样参数的一者，以帮助确定相关微粒已经经过哪个取样入口 29 进入系统 800。在相关微粒被探测器 11 作一初始探测时，在一预定阈值水平，探测系统 800 进入一定位例程。在此例程中，探测器 11 使得阀 29 改变进入取样入口的空气的一取样参数，在此实例中为流率。可以逐一入口为基础、或以多个入口的群组来进行此变化。在流率的各变化之后，作出一新的微粒浓度测量。可使用初始微粒浓度测量及第二微粒浓度测量连同一变化参数来确定相关微粒是经过哪个样本入口进入。

[0268]　这能够成功是因为在探测器 11 所探测的微粒水平为各个分别的入口 29 处的样本流的流率及微粒浓度的一加权总和。由改变经过取样入口的烟雾水平或流率，因此可以解出联立方程式组，以确定进入任一样本入口或入口群组的微粒水平。

[0269]　为了示范一简单范例，请考虑一烟雾探测系统，其包括一烟雾探测器及一取样网络，其具有一包含两样本入口的导管。

[0270]　在此范例中，由下列方程式提供当所有阀皆开启时所探测的烟雾水平：

[0271]

$$\text{所有阀开启的探测器烟雾} = \frac{\text{烟雾1} * \text{流1} + \text{烟雾2} * \text{流2}}{\text{流1} + \text{流2}}$$

[0272]　其中，所有阀开启的探测器烟雾为由烟雾探测器所探测的总烟雾；

[0273]　烟雾 1 是进入样本入口 1 的样本中的烟雾水平；

[0274]　流 1 是经过样本入口 1 进入的样本的流率；

[0275]　烟雾 2 是进入样本入口 2 的烟雾水平；及

[0276]　流 2 是经过样本入口 2 的流率。

[0277]　现在，当第一样本入口被其阀所关闭时，抵达探测器的烟雾的加权总和变成：

[0278]

$$\text{阀关闭的探测器烟雾} = \frac{\text{烟雾1} * 0 + \text{烟雾2} * \text{流2}}{0 + \text{流2}}$$

[0279]　将注意到：此加权总和与方程式 1 相同，差异在于流 1 ＝ 0，原因是样本入口 1 上的阀已经被完全关闭。

[0280]　我们现在处于一可对于烟雾 1 解出这些方程式的情形，以确定已经经过样本入口 1 进入的烟雾量，如下列：

[0281]

$$\text{烟雾1} = \frac{\text{所有阀开启的探测器烟雾}\ (\text{流1} + \text{流2}) - \text{阀关闭的探测器烟雾}\ (0 + \text{流2})}{\text{流1}}$$

[0282]　因此，若我们知道流 1、流 2 及流的变化，则可解出方程式并确定有什么烟雾水平在样本入口 1 进入。此原理亦可成功用于阀 802 仅在关闭时部份地拘限经过其分别的取样

孔的流的事件中，只要可以确定各取样入口 29 处的流率即可。为了容许探测流率，系统 800 在各样本入口 29 处包括一流传感器 804。流传感器 804 可为一高敏感度流传感器，诸如属于本领域技术人员已知类型的一超音波流传感器或一低成本热流传感器。

[0283]　在部分实施例中，阀 802 并未将经过其分别的样本入口的流率降低至 0、而是只将其降低某比例。下列方程式示范：如同对于前一范例所描述，若阀用来降低经过其分别的取样孔的流率以将其先前流率减半，可如何在一二孔系统中计算经过样本入口 1 的烟雾水平（烟雾 1）。

[0284]

$$烟雾1=\frac{所有阀开启的探测器烟雾（流1+流2）-阀关闭的探测器烟雾（0.5流1+流2）}{0.5流1}$$

[0285]　在本发明的另一实施例中，并不改变经过样本流的流率解出联立方程式，可以改变进入入口各者的烟雾水平。可由经过样本入口 29 各者将一过滤器选择性插入流径中来达成此作用。这种系统的一范例示出于图 9A 及 9B。图 9A 的系统 900 包括一连接至一取样网络 26 的探测器 11，取样网络 26 包括取样导管 28，空气样本经过多个样本入口 29 被抽入其中。各样本入口额外包括一可选择过滤器配置 902，其更详细示出于图 9B。可选择过滤器配置 902 在一端呈现一空气样本入口 904（等同于入口 29）且在另一端呈现一样本出口 906。空气样本入口 904 对于环境开启，且容许一空气样本从环境被抽入可选择过滤器配置 902 中。样本出口 906 连接至取样导管 28。两个流径位于可选择过滤器配置 902 内侧，即一未过滤的流径 908 及另一包括一过滤器 912 的流径 910。可选择过滤器配置 902 额外包括一阀 914。阀 914 可移动于其中阻挡住经过滤流径 910 的第一位置、及一其中阻挡住未过滤流径 908 的第二位置之间。在烟雾已经被探测器 11 初始地探测之后，处于一阈值水平，且探测器进入其局部化模式，其中试图确定微粒已经从何者样本入口 29 进入系统，阀 914 被触发以切换于其中容许经过入口 904 抽入的微粒通过来到出口 906 的第一位置之间，进入一其中任何进入入口 904 的微粒皆被过滤器 912 从传出出口 906 的空气流所移除的第二位置。在一较佳形式中，过滤器 912 为将从空气流移除实质全部微粒的一 HEPA 过滤器或其他高效率过滤器。

[0286]　取样点 29、且在此实例中为可选择过滤器配置 902 包括一流传感器 916 以测量进入取样点 29 的流率。

[0287]　可选择过滤器配置 902 可组构以经由系统 900 的空气流径与探测器 11 通信。在一如同此例的范例中，探测器 11 所使用的通信协议将需要发送信号，使得各个可选择过滤器配置 902 可被分别地地址化、或各个可选择过滤器配置被程序化而以一协调的选时作运作。连同图 28 来描述一范例通信方法的更多细节。

[0288]　如同了解，与第一范例所描述的类似的一组方程式可施用至图 9A 及 9B 所示类型的系统。

[0289]　对于一二孔系统，如上文所讨论，可以下列方程式表示当全部样本入口皆使其输入未经过滤时抵达探测器的烟雾水平：

[0290]

$$全未过滤的探测器烟雾=\frac{烟雾1*流1+烟雾2*流2}{流1+流2}$$

[0291] 其中，全未过滤的探测器烟雾为当全部的流未经过滤时在探测器所接收的烟雾水平，且所有其他术语如同上文连同方程式 1 至 4 所描述。

[0292] 在第一取样孔的可选择过滤器配置被移入其过滤模式之后，探测器处的烟雾水平的加权总和如下表示：

[0293]

$$经过滤的探测器烟雾1=\frac{0*流1+烟雾2*流2}{流1+流2}$$

[0294] 其中，经过滤的探测器烟雾 1 为当经过样本入口 1 的流被完全过滤时在探测器所接收的烟雾水平。

[0295] 联立求解这些方程式产生下列方程式，可自其确定抵达样本入口 1 的烟雾水平。

[0296]

$$烟雾1=\frac{全未过滤的探测器烟雾（流1+流2)-经过滤的探测器烟雾（流1+流2）}{流1}$$

[0297] 为了处理可能会改变此类型局部化程序的可靠度的烟雾水平增大或减小，可重复在一第一状态及一第二状态取得测量的顺序，且均等状态以一数量的循环予以平均。例如，可取得全部阀皆开启的第一测量，接着为具有改变的参数的一烟雾水平测量，接着再度为全部阀再次开启的一均等的初始读取。两个阀开启测量随后可被平均并使用于后续计算中。

[0298] 可实行本系统的进一步变化，其中并未拘束或降低经过取样点各者的流，由开启一阀以增大取样孔尺寸来减低其流阻抗（因此增加被抽过该取样点的来自系统的总空气流的比例）来增加取样点处的流率；抑或由将一风扇放在各取样点并致动或改变风扇速度以一已知量增加或减少经过取样点的流来增加位于取样点的流率。

[0299] 已经以一简单的二入口系统描述上述实施例。然而，将了解如图 8 及 9A 所述，系统有可能具有不只二个取样入口。在这种系统中，可能个别地扫瞄经过入口的每一个，并一次只在一入口处改变取样参数。然而，可有益地以群组方式进行改变，其中一次组的入口总数在各测量循环中使其取样参数作调整。在部分实例中，可能可以一不同量改变全部测量入口的取样参数以确定各者的贡献。如同了解，系统中有愈多入口，则需要进行愈多次改变取样参数及测量微粒浓度的程序，以收集足够的数据解出所需要的方程式组。

[0300] 连同图 8、9A 及 9B 所描述的概念可更一般地延伸至一用于探测从多个空气摄入路径所抽取的空气样本中的污染物及确定各者中的污染物水平的方法。例如，该方法可施用至与一具有多个馈送至单一探测器的空气取样导管的取样网络相耦合的呼吸微粒探测器，其中将确定来自取样系统的各导管或分支的贡献。图 7 描述一采用此类型“每导管”局部化或地址化的系统。

[0301] 在图 7 的范例中，多导管空气取样系统可馈送至单一污染物探测器中，使得其需要一次取样一导管，以确定哪个导管在空气流束中具有污染物。可由密封一者除外的全部导管并容许一样本一次从一导管进入探测器同时探测器测量污染物水平，以达成此作用。对于多导管空气取样网络中的每个导管重复此作用。经密封的导管必须对于空气流被完全密封，以获得开启导管中的污染物水平的精确测量。然而，在低成本或成本合理的阀中很难达成完全密封。然而利用与连同图 8、9A、9B 所描述者类似的一方法，则可免除完全密封的

要求。

[0302]　图 10A 示意性示出一感测系统 1010，其具有由总共二个取样导管 1012、1014 所构成的一取样导管网络 1011。各取样导管 1012、1014 界定一经过其的空气摄入路径。空气摄入路径在歧管 1016 处组合。歧管 1016 可包括适当的挡板以帮助空气流作组合。空气利用风扇 1018 被抽取经过感测系统 1010。一来自经组合的空气流的次样本系被抽取经过探测器回路 1020，其中设置一过滤器 1022 及一微粒探测器 1024。一旦空气流已经通过探测器回路 1020，其重新加入主空气流径 1019。一流传感器 1026 可被选用性设置于系统 1010 的出口 1028 之前。如同了解，感测系统 1010 等同于图 1 的探测器 11。

[0303]　取样导管 1012、1014 的每一个具有一阀，诸如一蝶阀或另一类型的流修改器 1030、1032。此外，各取样导管 1012、1014 包括一超音波流传感器 1013 及 1015。

[0304]　应注意：阀 1030、1032、流传感器 1013、1015 及歧管 1016 虽示出为形成取样网络 1011 的部份，其同样可以被物理性设置于感测系统 1010 的壳体内且因此形成感测系统 1010 的部份而不改变本发明的运作。

[0305]　现在将连同图 10B 至 10D 来描述根据本发明的一方法。在正常运作中，各阀 1030、1032 完全开启，如图 10B 所示。然而，当微粒探测器 1024 探测到一污染物以一预定水平出现于所取样空气流中时，则进行根据本发明的扫瞄方法开始执行。首先，第一取样导管 1012 部份地关闭，如图 10C 所示。在此状况中，微粒探测器 1024 取得污染物的一测量 (C_1)。此外，在取样导管 1012、1014 中分别以流传感器 1013 及 1015 来测量流率 (F_{mp}，其中 F 系为流，m 为测量数字且 p 为导管数字，因此，流率测量将为 F_{11}及 F_{12})。

[0306]　在下个步骤，由将蝶阀移至图 10D 所示位置而使另一取样导管 14 部份地受阻挡。在此状况中，微粒探测器测量污染物水平 (C_2)。此外，取得流率测量 (F_{21}，F_{22})。

[0307]　假设污染物量（或导管之间污染物的相对量）在扫瞄期间中并未显著改变，可从下列联立方程式组计算一导管的个别污染物测量：

[0308]　$C_1 = X_1F_{11}/(F_{11}+F_{12})+X_2F_{12}/(F_{11}+F_{12})$

[0309]　$C_2 = X_1F_{21}/(F_{21}+F_{22})+X_2F_{22}/(F_{21}+F_{22})$

[0310]　其中 X_1为导管 1 中的实际污染且 X2 为导管 2 中的实际污染。

[0311]　有利地，本发明的实施例能够消除对于一给定污染物物种由于样本导管不完美密封所造成的样本导管之间的串扰而不用昂贵、精密的阀件。取而代之，低成本蝶阀或其他类型流修改器即足以精确地消除串扰，并容许达成导管可地址化。

[0312]　如上述，并不采用阀来部份地关闭导管，可将一过滤器选择性插入导管中，以一已知量暂时地降低各导管中的污染物水平（较佳降低至 0），且该方法该方法作调整以如上述般解出污染物水平供孔地址化之用。

[0313]　在本文所描述的不同实施例中所进行的一共同步骤为探测器处的微粒的一初始探测，且更特别是精确地识别从取样系统的一特定取样入口的烟雾接收的一尝试。特别来说，最常企图探测的事件系为顺取样导管往下传播的一烟雾前锋的抵达，且其代表在样本网络中的一运作变化、譬如阀的开启或关闭或以洁净流体冲洗导管网络、或是使流方向逆反或类似作用之后进入一特定样本入口的烟雾。图 11A 及 11B 示出此概念。

[0314]　图 11A 示出一微粒探测系统 1100，其包括一探测器 1102，及一取样导管网络 1104。取样网络 1104 具有三个样本入口 1106、1108 及 1110。一烟雾烟云 1112 设置为相邻于取样

入口 1108。举一种使取样网络 1104 中的流向被逆反且探测器 1102 试图确定从取样孔 1108 进入系统的烟雾抵达时间的情形为例。图 11B 示出所确定烟雾浓度相对于时间的图形。初始地，对于某期间 1020，由于抵达探测器的样本流体只含有来自样本入口 1106 的样本流体而探测到低烟雾水平。在时间 T1，探测到烟雾的增加。在下个时间期间 1022，当来自入口 1108 的样本开始抵达探测器时，所探测的烟雾水平爬升直至当探测到近似稳态水平的时间 T2 为止。在图 11B 的图形中，爬升 1022 并非由于烟雾水平增加所致，而是由于进入取样孔 1108 的样本的烟雾前锋的脏污或扩散所致。若从环境至取样网络中的微粒进入为均匀且瞬间，在来自孔 1108 的样本抵达探测器 11 时的 T1，探测器 1102 所探测的烟雾水平将具有一阶跃变化。

[0315] 本发明人相信：有一系列因素会对于烟雾前锋的扩散作出贡献，其代表包括被抽取经过取样系统的样本入口特定一个的一空气样本的样本部分的抵达。其中主要是怀疑存在有横越空气取样管道的横截面的一流速度梯度。图 11C 示出经过一空气取样管道 1130 诸如导管 1104 的横截面。箭头 1132 指示出：管道 1130 的中央部分的流率大于接近管道壁处的流率。

[0316] 相信经过一样本入口譬如 1134 所抽入的一样本需要花费某时间量闯入管道 1130 中的流的快速流动中央区中，且因此烟雾前锋在抵达探测器处时脏掉。然而，此机制具有相竞争的因素，亦即起初一样本将被导入至管道内的慢流动周边空气中，这将延迟其抵达探测器。然而，随时间经过，样本的部份将找到路来到快速流动中央区中，这将尽量减小其来到探测器的运送时间。

[0317] 发明人已经提出一可被放置在取样网络的管道中（譬如取样网络的导管中）的物理结构，以改善此问题。在解决方案的第一家族中，发明人提出一样本注射入口，其从导管 1130 的壁 1131 往内延伸，朝向导管 1130 的中心 1133，以在样本流的快速流动区中输送样本。图 12 示出这种样本注射入口的三个范例。

[0318] 在图 12 中，示出呈现导管 1200 形式的一用于形成一空气取样系统的部份的管道。导管 1200 由一壁 1202 所界定。亦示出三个样本注射入口 1204、1206 及 1208。第一样本注射入口 1204 为一短管 1210，其从侧壁延伸至导管 1200 中，朝向其中心 12-12。样本注射入口 1206 类似于入口 1210 但在其内侧端 1214 上终止于一倒角梢端。梢端具有相对于导管内的流而言在一下游方向使出口 1216 在功能上成为点的效应。

[0319] 最后，样本注射入口 1208 实行一倒 L 形管 1220 的形式。其入口位于管道 1200 外部，且其出口 1222 面对一下游方向并对准于管道 1200 中心，从而在最快速流动流体流中于导管中心注射被抽入样本入口 1208 中的样本。这三个范例利用导管内的流的较快流动中央区来降低经过样本入口被抽入的样本的脏污。

[0320] 图 13A 至 13D 示出注射方法的一替代方式。此系列的范例利用一在取样系统的管道内生成紊扰的结构，以防止或扰乱取样管道内的层空气流，从而降低图 11C 所示类型的流梯度。图 13A 至 13D 各分别示出导管 1300、1310、13,20、1330 的一分段。

[0321] 在图 13A 中，管道 1300 的内侧壁 1302 用来作为一紊化器。壁 1302 已被粗化或是提供表面轮廓或纹路诸如肋、线、隆起或其他，以生成一用以扰乱横越其的流的粗表面。

[0322] 在图 13B 中，紊化器为从导管的壁 1310 往内延伸的一系列的紊扰造成突件 1312，并用来造成导管 1310 内的层流的扰乱。

[0323] 图 13C 示出一其中使多个紊扰造成构件延伸于导管 1320 全宽的范例。在此范例中，紊扰为开放网状组件 1322 的形式。开放网状组件 1322 具有够大的孔尺寸，使其倾向于不随时间而阻塞而是将造成导管 1320 中生成紊扰。如本领域技术人员所了解，可设计横跨一取样管道内部的一系列不同形状的紊化器。

[0324] 图 13D 示出其中使一移动的紊扰造成组件 1322 放置在导管 1330 内侧的另一范例。在此实例中，一系列的风扇 1334 及 1336 被支撑在导管 1330 中。风扇可被主动地驱动或被动地旋转，但用来搅拌空气或随着空气流经过其而造成其中的紊扰。

[0325] 在此范例中，已经方便地描述身为一相邻取样入口的管道的一区中的紊扰造成结构，然而应注意：并没有特别理由应该作出此作用，且紊扰造成结构可被放置远离取样入口。

[0326] 如同上述四个范例所将了解，紊扰造成结构的目的在于破解横越空气取样管道的流轮廓，俾使从一取样入口进入的空气将沿着取样管道移行至探测器，就像一‘封包’，而非使其部份比起另一部份相对更快或更慢地移行，并因此弄脏探测器处样本前锋的抵达。

[0327] 可替代地或除了上述技术以外，本发明人已经识别出由至少部份地改善被抽入取样网络中的空气样本上的稀释效应而对于探测从多个样本入口的哪个样本入口接收烟雾的额外改良。请考虑一微粒探测系统，诸如图 11A 所示。在这种系统中，抽入取样导管 1108 中的空气样本将被抽入取样导管 1104 中，其在该处混合于从取样点 1110 所抽取的一样本且被该样本所稀释。类似地，从样本入口 1106 所抽取的空气样本被从所有上游流束样本入口抽取的样本所稀释。因此，到了空气样本抵达探测器 1102 之时，相较于围绕可供微粒经过其进入取样网络的微粒样本入口的大气中的样本浓度而言，所探测的微粒的实际浓度将被大幅地稀释。本发明人已经确定：可由增加被抽入取样导管中的样本的浓度使其更紧密地反映围绕此取样点的大气中的微粒的实际浓度及 / 或由提供以最小的额外稀释将样本输送至探测器的机制，来进行对于本文所描述系统的特定修改以改善这个问题。

[0328] 图 14 示出用以实行这种技术的第一示范性系统 1400。系统 1400 包括一探测器 11 及一包括一取样导管 28 的空气取样网络 26，取样导管 28 在空气取样导管 28 的远端 1402 具有五个样本入口 29，探测器系统 1400 包括鼓风机 1404 形式的一样本放大配置，其被一致动部件 1406 所驱动。鼓风机 1404 以一下述方式进行沿着或从取样导管网络吹送或吸取空气的功能。如同本领域技术人员将了解：可使用广泛不同的系统取代鼓风机结构，例如一往复气动活塞，或者可使用可逆反式风扇或泵或是其他类似的空气运动器件来取代鼓风机 1404。

[0329] 现在将描述系统 1400 的运作。起初，一旦探测器 11 已经探测到一阈值水平的微粒，则系统 1400 进入一局部化模式，将在其中确定系统中的微粒的位置。在此模式中，主要空气运动系统、譬如探测器 11 的呼吸器 16 停止且系统进入一样本放大阶段，其中控制器经由通信通路 1408 通信于鼓风机 1404 的致动器件 1406。随着风扇停止，或替代性地随着位于取样网络 26 的探测器端的一阀关闭，取样导管 28 含有一固定体积的空气，在使用中，利用鼓风机 1404 增加及减少取样导管网络 26 内含的空气体积。当鼓风机扩大时，体积增加且额外样本流体被抽入取样入口 29 的各者中。当鼓风机收缩时，取样网络 26 内的空气的某部分从取样入口 29 被驱出。由扩大及收缩取样导管网络内的空气体积，空气被重复泵送进入及离开取样入口的各者而生成取样导管 28 内的一局部化的样本部分，围绕于每个取

样入口 29,其比起连续抽取及连续稀释样本流束的实例而言更紧密地反映了与每个取样入口 29 直接相的环境中的相关微粒水平。

[0330] 考虑到位于取样入口 29 的单一一个的情形,被抽入取样入口中的空气样本进入样本导管网络并混合于导管 28 内的既有的流。流过取样入口的既有的空气流以从所有上游取样入口所抽取的样本来稀释样本。当由关闭位于导管 28 的探测器端的一阀 1410 或可能由停止探测器 11 的呼吸器而停止导管 28 中的流时,则鼓风机 1404 收缩且随后随着空气沿着取样导管 29 被鼓风机推动,围绕于取样点 29 的取样导管 28 内的空气的某部分从取样点 29 被驱出。然而,从各取样点被驱出的空气包括来自上游取样点的稀释样本。再度由扩大鼓风机 1404 而将吸力施加至导管 28,且一额外空气样本被吸入各取样点中。虽然此样本亦被已经存在于与取样点相邻的取样导管内的流体所稀释,此稀释空气有部份为先前被抽入相关取样点中的空气样本。因此,第二取样之后的总浓度相较于第一者而言增加。由经由一取样入口驱出及取样的重复循环,位于围绕于取样入口的样本一部分中的导管 28 内的空气的比例开始趋近增加,且微粒水平开始趋近于围绕取样入口的大气中的水平。利用此方法,形成位于取样导管 29 内的离散的样本部分,其更紧密地代表围绕取样入口的环境。因为稀释被降低,可改良仰赖一烟雾水平增高开端、亦即一烟雾前锋的探测来确定微粒沿着取样网络进入的位置的上述方法。一旦样本放大阶段完成,系统进入一运送阶段并将此时包括有相对局部化的样本封包的所取样空气移回到探测器以供分析。

[0331] 图 14A 至 14E 示出一使用一振动薄膜、譬如一扬声器以进行样本放大的示范性系统。系统 1420 包括一耦合至一空气取样网络 26 的微粒探测器 11。空气取样网络 26 包括一具有多个空气样本入口 29 的取样导管 28。空气取样网络经由一样本放大配置 1422 及一呼吸器 1424 被耦合至探测器。呼吸器 1424 运作以将样本抽入取样网络中并将其推至探测器 11 以供利用一将在下文更详细描述的方式作分析。样本放大配置 1422 因为造成空气样本系统中的流向振荡而进行一与图 14 的鼓风机相类似的工作,以促进围绕各样本入口 29 的区中的空气与取样导管 28 中的空气作混合。在此范例中,样本放大配置 1422 包括一薄膜 1426,其安装于一壳体 1428 内且以往复动作被一致动器来回驱动。致动器及薄膜可由一扩音器提供。较佳令薄膜以次音速频率、且最佳以 2 与 10Hz 之间作振荡。

[0332] 在普通运作中,呼吸器 1424 以一充分符合样本运送时间要求的第一速度设定作运转并将空气样本抽取至探测器 11。一旦微粒在样本流中被探测,系统 1420 进入一以一样本放大阶段开始的局部化模式。在此阶段中,如图 14A 所示,风扇进入一慢速运作且样本放大配置 1422 被启动。薄膜 1426 振荡并搅动导管 28 中的空气以造成混合于接近对于各样本入口 29 的进入口的空气。因为风扇以低速运转,一更紧密趋近于围绕样本网络 26 的空气中真正微粒浓度的经混合的空气样本进入各取样入口 29 并在各入口下游缓慢地累积一空气封包。在图 14B 至 14D,随着风扇 1424 缓慢地运转并累积样本封包 1430 而继续搅动。

[0333] 接着在图 14E,系统 10 进入运送阶段。在此模式中,风扇 1424 增大速度,且薄膜 1426 停止。样本封包譬如 1430 随后被抽回到探测器 12,其中风扇以快速模式运转。如下文描述,可采用不同技术(譬如由阻挡住取样入口,开启导管端等)来降低样本封包的混合或脏污,从而提高所施加的局部化技术的可靠度。图 15 示出一用以进行与连同图 14 所述相类似的一方法的系统 1500 的第二实施例。

[0334] 在图 15 中,类似的特征构造关于图 14 及早先实施例作类似编号,且为求简洁不予

赘述。在此范例中，取样网络 26 在其远端 1502 包括一风扇 1504，及一阀 1506。选用性地，在最靠近探测器 11 的取样导管 28 的端 1508 可额外具有一第二阀 1510。在此范例中，阀 1506 正常被关闭，而阀 1510 则在探测器 11 普通运作期间开启。然而一旦探测器进入其局部化模式，阀 1510 及 1506 的位置改变，且阀 1510 关闭、阀 1506 开启。随后利用风扇 1504 执行与图 14 的鼓风机 1404 相同的功能。关于这一点，利用风扇 1504 从取样点 29 吹送取样导管 26 的部分内容物、抑或如上述般经过取样点 29 吸入样本。如同将了解：可由微粒探测器 11 的主要呼吸器来进行吸取与吹送样本之间的此振荡。然而，由将风扇 1504 放在取样导管网络 28 的远端，可获得一额外优点，亦即风扇 1504 可在此程序终点用来将取样导管 126 的内容物推动至探测器 11、而非使用探测器 11 的呼吸器顺取样导管 28 往下吸取空气样本。在导管 28 端使用一鼓风机风扇 1504 的优点在于取样导管 28 变成被正加压，且因此在运送阶段期间并未从围绕取样点的环境抽取任何额外空气样本。利用此方式，含有对应于各取样入口 29 的样本空气封包 / 部分的一般相对未经稀释的取样空气被输送至探测器 11，使得由探测器 11 独特地探测振荡程序所形成的样本的‘封包’。如同将进一步了解，可利用和谐运作的微粒探测器 11 的主要呼吸器及风扇 1504 来进行样本放大期间吸取与吹送样本之间的振荡。譬如，两风扇可设定成同步地运作，亦即在一方向然后在另一方向移动空气以增强其分别的取样孔周围的样本的局部化混合，或替代性地，风扇可被设定成交替地施加吸力至导管 26 的其分别的端以沿着导管在一个方向吸取样本流体。因此，并不在来自导管 26 的一端的样本流上使用鼓风机状推 / 拉，而是使用来自导管两端的一交替的拉 / 拉机制。在非拉端，一阀可被关闭（或部份地关闭）以控制进入导管 26 端的样本流的量。有利地，此机制容许系统提高鼓风机作用的集中效应。其亦容许样本封包形成于样本入口位置的上游及下游。相对于一在一端产生作用的系统，增加的集中效应亦使得系统能够对于任何给定的浓度增加或混合增加而言缩减流振荡循环的数目。这个方案还可以平衡（并可能中和）更靠近探测器的火灾以更高的废料 (slug) 浓度结束的效果。如同下文就图 18 及 19 所描述，可有利地使用一双端式流调制来选择性进行样本放大。

[0335] 图 15 的系统可如图 15B 所示作进一步修改。在此范例中，微粒探测系统 1350 包括一与图 15 相类似的空气取样系统，且类似的特征构造已作类似编号。然而，此系统 1520 额外地包括两个分支导管 1522 及 1524，其能够具有额外的运作模式。第一分支 1522 位居导管网络的下游端，理想上位于对于探测器 11 的入口与最近的取样点 29 之间。分支导管 1522 包括：

[0336] 风扇 1526，其可用来以一将作描述的方式清除取样系统。

[0337] 过滤器 1528，其可尤其为一 HEPA 过滤器或类似物，其用来清理风扇 1526 所输送的清除空气。

[0338] 阀 1530，用于依需要选择性开启及关闭分支 1522。

[0339] 第二分支导管 1524 包括一阀 1532，其用来在清除期间作为来自取样导管 28 的一排放件，如下文描述。

[0340] 系统 1520 在探测模式中以与图 15 的系统 1500 相同的方式运作，亦即探测器 11 的主呼吸器用来抽取空气样本经过取样入口 29、沿着取样导管 28 来到探测器 11 以供分析。在探测模式中，阀 1530、1532 及 1502 关闭以防止未与一取样入口 29 相联结的空气被抽入系统中并稀释空气样本。阀 1510 为开启。

[0341] 一旦微粒被探测到充足的程度，系统 1520 进入振荡模式并发生下列步骤：

[0342] 阀 1510 关闭，且主探测器 11 的风扇停止顺取样导管 28 往下抽取空气。

[0343] 阀 1530 及 1532（及可能亦包括 1502）开启以能够从取样导管 28 清除样本空气。

[0344] 风扇 1526 被启动，且空气被抽入分支 1522 中，经过过滤器 1528，其在该处被清理且进入取样导管 28 中。此洁净空气将导管 28 清除载有微粒的空气且用洁净空气予以驱排。

[0345] 阀 1530 及 1532 及 1502 关闭且阀 1510 开启，且利用主探测器 11 风扇将新空气样本抽入取样入口 29 中。此程序只运作一段很短的时间，例如 5 与 20 秒之间，或只要可以避免被抽入相邻取样入口 29 中的空气样本作混合即可。利用此方式，载有微粒的空气的封包累积于导管 28 中。如同将了解：可由进行本文所描述的不同集中技术的其中一种来增强此步骤，但在此实施例中有可能实现充分敏感度而不增添复杂度。如上述，利用推器风扇 1504 也有助于将一股相对未经稀释的取样空气输送至探测器 11，其可在部分实施例中不再需要一放大阶段。

[0346] 探测器随后移动进入一运送阶段，其中主探测器 11 的呼吸器随后被停用且阀 1502 开启。阀 1510 保持开启。

[0347] 推器风扇 1504 被启动且样本空气的封包顺导管 28 往下被推动以供分析。

[0348] 空气样本随后被分析，且利用微粒的出现 vs. 体积（或其他技术）来确定微粒经过哪个入口 29 进入系统。在此范例中，由第二微粒探测器 1534 进行局部化阶段中的样本空气的分析。此探测器相较于探测器 11 具有一相对快速的响应。

[0349] 探测器 1534 的输出可能不如探测器 11 般敏感或稳定，但随着局部化程序正在发生而微粒水平可能已经增加（譬如由于火势活动的增加），探测速度可以优先于敏感度或精确度。尚且，由于空气样本可序列地通过两探测器，仍可由主微粒探测器 11 获得实际的微粒浓度数据。

[0350] 主探测器 11 及高速探测器 1534 可为相同粒子探测器的部份（譬如单一器件中的两个微粒探测腔室），或可为不同的器件，譬如序列式设置。而且，主探测器 11 可单独使用。在此实例中，主探测器可选用性组构以一高速模式运作，其在该模式中相较于其普通探测模式而言具有一经改良的响应速率。可由暂时改变探测器 11 的软件参数（譬如降低使微粒浓度水平平均化的期间等）、或由启动一接收探测腔室输出数据（或类似）且对于响应速率被优化的第二数据处理路径，来达成此作用。

[0351] 如同将从上文得知：分支 1522 及 1524 及其各自的组件以及快速响应探测器 1534 选用性添加至图 15 的系统 1500。为了实行上述方法，对于图 15 的系统 1500 所真正另外需要的为一用于将清除空气输送至导管网络 26 的机制及一用于控制系统的阀以进入及离开清除模式的机制。

[0352] 图 16 示出一用于实行振荡方法的系统及一用于降低最终增高浓度空气样本输送至探测器的稀释的机制的另一范例。系统 1600 包括一探测器 11、及取样导管网络 26，如同就图 14 及 15 所描述，且类似的特征构造标示相同的附图标记。在此范例中，由探测器 11 的主要呼吸器来进行在吸取与吹送样本之间振荡的程序。取样网络 26 额外地设有一位居最终取样入口 29 上游的阀 1602。在样本浓度已经增加之后，如上述，利用探测器 11 的主呼吸器，被通信通路 1604 耦合至探测器 11 的控制器的阀 1602 开启。阀 1602 组构以使取样网络的端对大气开启，使得其逼近一比起取样入口 29 的任一者而言具有实质更小流阻

抗的开放导管。当探测器 11 的呼吸器随后将吸力施加至取样网络 26 时，抽取空气优先被抽入取样导管 28 端中，且已经位于导管 28 内的样本封包连带被抽至探测器 11。因为开导管端具有低的流阻抗，被抽入取样入口 29 各者中的空气水平大幅降低，因此随着其被输送至探测器 11 而大幅降低样本的稀释。当阀 1602 开启时空气被抽入取样入口 29 中的降低的倾向亦将降低样本封包在位于或接近于其他取样孔位置的环境中受到烟雾的修改。当阀 1602 开启时进入取样孔 29 中的降低的流亦将使得烟雾来源位置的计算较少依据位于取样孔的流而定。如上述，系统初步受到训练，以一旦已经进入局部化阶段有多少空气被抽取经过取样网络为基础，来确定一样本封包已经从哪个孔抵达。然而，因为取样孔可能随时间经过而以一可变方式产生阻挡，以初始训练为基础的体积或时间测量的可靠度可能随时间而变。由开启阀 1602，样本入口 29 变成在取样导管 28 中的流中较不具影响性，且因此取样入口 29 的不同阻挡对于系统寿命的效应将降低。最后，开启阀 1602 将降低流阻抗，且运送阶段对于 50L/min 的 100m 导管更为快速（譬如 40 秒），而非导管端关闭的 110 秒。

[0353] 在部分实施例中，超过取样入口 29 的取样网络 28 的阀 1602 可设有一过滤器、譬如一供空气被抽取经过的 HEPA 过滤器。这有助于自最后样本入口 29 的样本封包从被抽入有可能亦含有相关微粒或甚至灰尘的导管端中的空气突显出来。由系统的阀 1602 及风扇的适当运作，这种 HEPA 过滤器亦可连同一推器风扇用来实行与图 15B 所描述的相类似的清除阶段。

[0354] 如同在本文所提供范例中将了解：阀可额外被施加至每个取样入口 29，以进一步便利于被施加至导管端的流控制机构（譬如鼓风机、风扇、阀及等同结构）的效应。例如，每个取样入口 29 可设有一阀，该阀连同导管端流控制系统被控制以使其效能最优化。

[0355] 图 20A 及 20B 示出本发明的两个实施例，其可提供相较于部分上述实施例而言的一特别方便的装配 (set up)。这些实施例可以分别等同于图 14 及 15 的系统的方式使用，且类似的特征构造已经作类似编号。

[0356] 图 20A 的系统 2010 相异于图 14 的实施例之处在于：空气取样导管 28 设有一被连接至取样导管部分 2012 上游端的返回部分 2002。这将取样网络 26 的远端 1402 带回到一接近于探测器 11 的位置。在此范例中，鼓风机 1404 及其相联结的致动部件 1406 连同阀 1510 一起安装在一共同模块 2004 中。更佳地，模块可机械及电性连接至探测器 11。利用一类似方式，图 20B 的系统 2000 相异于图 15 的实施例之处在于：空气取样导管 28 设有一被连接至取样导管部分 2012 上游端的返回导管部分 2002。取样网络 26 的远端 1502 因此设置成接近于探测器 11，使得风扇 1504 且连同阀 1506 及 1510 可被一起安装在一共同模块 2004 中。

[0357] 可以一方便的方式利用一局部化模块（譬如模块 2004）来实行本文所描述的本发明的任何实施例。这种模块可被翻新成为原本无意用来进行局部化的探测器系统，或是设置成为选用性添加式模块，使得新设备的购买者可以选择是否购买一拥有这些特征构造的探测器。例如，可由容置有下列设备而提供一用以实行图 15B 的系统的模块：

[0358] 分支 1524，其具有阀 1532，

[0359] 阀 1506 及推器风扇 1504

[0360] 分支 1522，其具有其风扇 1526、1528 及阀 1530 连带具有阀 1510。

[0361] 类似地，阀 1602 及可能亦包括 HEPA 过滤器可被容置在一类似的模块中。

[0362] 虽然这些实施例需要一额外长度的导管以供导管网络绕回到接近于探测器 11，但是其提供下列优点：功率及电力通信线不需运行至一远离探测器 11 的位置以供电并控制被安装至取样导管网络 26 上游端 1402/1502 的系统的组件。这有助于使系统安装更加直接。并且，由于最复杂的组件此时位居单一位置，其利于委任及测试。

[0363] 在图 8、9a 及 9b、14 至 20b 所示的不同实施例中，所描述系统的不同组件需要通信于探测器 11 或所示出微粒探测系统的其他控制组件。在先前所描述的实施例中，通信通常发生于一硬配线式通信通路上、或选用性经由一无线（譬如无线电）通信通路（譬如图 14 中的通信链路 1408）。本发明人已经理解到：不需要出现一硬配线式通信路径，而是可使用经过探测器系统的空气流径以供探测器或其他控制实体以及系统的另一组件或附件之间的通信所用。

[0364] 在大部分实施例中，附件将包含一流控制器件，诸如阀、风扇、过滤器或参予进行本文所描述的局部化技术的系统的其他组件，例如附件可包括如图 15 范例中所使用的阀 1502 及 / 或风扇 1504。图 28 示出一呈现阀形式的示范性附件的细节。

[0365] 附件 2800 安装至一取样导管 28 的一部分并可接近至取样导管 28 内所含的空气流路径 2802。附件 2800 包括一或多个传感器 2804，其用来感测空气流 2802 中的诸如流速度、方向及 / 或压力等状况。传感器 2804 连接至控制器 2806，并使得用来指示所感测状况的输出信号通往传感器 2804。控制器 2806 接收传感器信号并予以处理，且转而依需要控制附件的运作。

[0366] 在本范例中，附件 2800 包括一阀 2808，阀 2808 可在控制器 2806 的控制下被选择性开启及关闭。附件 2800 较佳被一电池 2810 而非硬配线式功率连接（但也可能如此）所供电，以降低对于附件的配线及安装的要求。

[0367] 在使用中，传感器 2804 由接收与探测空气取样导管 28 中的空气流的变化而被附件 2800 用来感测主要微粒探测器的目前状态。控制器 2806 中断空气流 2802 的变化成为来自探测系统的一通信，并响应而确定其应该对于该瞬间采取什么行动。例如，在本文所描述的局部化技术中，局部化阶段开始可将探测器 11 的主呼吸器暂时地关停，减慢或改变方向、或改变位于系统的探测器端的一或多个阀的状况。这转而造成取样导管 28 中的空气流 2802 产生改变。空气流的变化以导管 28 中的一改变的空气流速度及压力被传感器 2804 所感测。该变化被控制器 2806 中断成为来自探测器 11 的一控制信号，以响应于流模式的所感测变化而实行一适当控制步骤。例如，探测空气流 2802 的停止可以讯号告知控制器 2806：探测系统已经进入一局部化模式且阀 2808 应开启。替代性地，可在探测到经过空气流径 2802 的一控制信号时进行更复杂的运作。例如，当附件 2800 感测到系统已经进入局部化模式时，附件进入其局部化模式，其中进行一局部化例程。这可涉及附件对于第一时间期间以一第一状况运作，然后对于一第二时间期间以第二状况运作，依此类推。为了提供一较具体范例，阀 2802 可被控制以保持关闭一预定时间期间，例如一分钟，同时微粒探测系统的其他组件进行一样本放大例程。在预定时间经过之后，控制器可造成阀 2808 开启，以使探测器在局部化程序的‘运送阶段’中运作以能够使经集中的样本‘封包’输送回到探测器 11 以供分析。

[0368] 如同将了解：若局部化程序包括流的振荡，以进行样本放大，传感器 2804 可感测振荡，且控制器可对此作响应，以确保阀或类似的其他流控制结构被设定在其适当的运作

状况中。

[0369] 亦可由探测系统生成空气流的时间性变化的图案，以编码用于附件的控制消息，或容许具有需要独立控制的多个附件（譬如图 8 及 9A 中的阀 802、902）的系统中的特定附件的地址化。

[0370] 此运作原理被延伸至使用一探测器系统的空气取样系统 26 内的空气流径而以其他方式作通信，诸如由施加声音脉冲或类似物。显然在这种实施例中，在附件中将需要适当声学换能器形式的传感器，以感测这些通信信号。

[0371] 图 29 示出一微粒探测系统 2900，其包括一微粒探测器 11、一局部化模块 2004 及取样导管网络 26 及一类似于图 28 所描述的附件 2902。取样导管网络 26 包括一取样导管 28，取样导管 28 沿着其长度具有一系列的取样入口 29。局部化模块包括 2004 包括一往复活塞 2904，其作为局部化程序中的一样本放大配置。

[0372] 附件 2900 在此范例中包括一风扇 2908 及一阀 2910，其响应于探测用以指示系统状态的取样导管 28 中的信号的附件的传感器（为未图示的一流传感器及压力传感器）而被附件的一控制器所控制。

[0373] 在普通探测模式中，附件使其阀 2910 关闭，使得样本被抽取经过样本入口 29。当探测器 11 探测到处于一预定水平的微粒时，则其进入一局部化模式。这初步涉及一清除阶段，其中主呼吸器被逆反且空气被吹出取样导管 28 外。这造成（先前被略微负加压的）取样导管中的压力增加。附件 2900 的传感器探测此作用且其被附件的控制器诠释成一已经启动局部化模式的信号。控制器随后开启阀并容许空气经过导管 28 端被清出至大气、而非经过样本入口。

[0374] 当此流停止时，导管压力及流的降低被附件 2900 的传感器所探测，且处理器将此诠释成一关闭阀 2910 的信号。

[0375] 接着，局部化模块 2004 以一上述方式利用活塞来振荡取样导管中的样本流以进行样本放大。附件 2900 的传感器探测流及 / 或压力的振荡，且处理器将此诠释成一在样本放大发生之时使阀 2910 保持位于关闭位置的信号。

[0376] 当探测振荡阶段停止时，附件 2900 将此诠释成一指令，该指令为运送阶段已经开始且开启其阀 2910 并启动其推器风扇 2908 将样本推至探测器 11 以供分析。

[0377] 运送阶段在附件 2900 感测到探测器或局部化模块所造成的一变化流时停止。例如，探测器 11 的主呼吸器可暂时地停止、减慢或逆反，一阀关闭，以造成压力变化，其以信号将运送阶段的终点告知附件 2900。在具有一诸如此者的推器风扇 2908 的实施例中，若运转推器风扇使得经由空气流路径从探测器接收一信号变得不可靠，则运送阶段可运转一预定时间。

[0378] 在运送阶段的终点，附件系关闭阀 2910 且系统返回至正常探测运作。

[0379] 图 21 示出本发明的一个方面的另一实施例，其利用如同图 20A 及 20B 的实施例中所提供的一对并列状导管部分的存在。微粒探测系统 2100 类似于图 20 及 20A 的系统，但样本入口沿着导管网络 26 的定位已作调整以帮助局部化的程序。因此，本文所描述的局部化技术的一实际实行方式的困难之一在于解析邻近地址的能力，亦即若样本入口太近地与一取样导管接合在一起，会很难探测来自一取样入口的一空气样本何时终止以及来自下个样本入口的一空气样本何时开始。在本实施例及图 22 与 23 中，已经由沿着取样点配置取

样入口的位置使其比最小间隔作更进一步分隔，以增强解析样本的能力。现在参照图 21，其示出一微粒探测系统 2100，其包括一微粒探测器 11，一局部化模块 2004 及一取样导管网络 26。取样导管网络包括一取样导管 28，具有沿着其长度分布的一系列的取样入口 29。类似于图 20A 及 20A，取样导管为一回路配置，或另行具有遵循一类似路径的两个导管部分，譬如两个平行地行进或呈现并列状配置的导管 28A 及 28B。然而，不同于图 20A 及 20B 的实施例，系统 2100 中的取样入口 29 沿着导管部分 28A 及 28B 两者分布，因此未提供上游端 28B 以单纯地容许导管微粒部分 28A 的上游端方便地连接至局部化模块 2004。取而代之，有些取样入口 29 被定位为沿着上游导管部分 28B，且其他的被定位于下游导管部分 28A 上。这能够由随着取样导管 28 横越邻近区 R1 至 R8 使沿着上游导管部分 28B 所定位的取样点 29 交插于位居下游导管部分 28A 上的而增大取样入口的间隔。如同将了解 :在部分实施例中，取样导管 28 延伸经过被监测的区 R1 至 R8，且取样入口可直接被耦合至取样导管或甚至为一直接形成于导管壁中的孔，然而，一取样导管 28 不需实际通过区 R1 至 R8 以服务该区。事实上，在许多安装件中，一取样导管将路过该区但恰位于其外，譬如位于被监测微粒的一房间的一天花板面板上方，被监测的一系列的柜的一壳体外等等。这些安装件可使用被连接至主取样导管的一长度的导管，其导往一流体性导通于被监测区的取样点配置。

[0380] 在本发明的这个方面的实施例中，邻近区的取样点配置的间隔比当沿着导管中的流径测量时其对于取样导管网络的连接点之间的距离更靠近在一起。

[0381] 图 22 及 23 示出额外的实行方式。图 23 示出包括微粒探测器 11 的系统 2300，微粒探测器 11 连接至一空气取样网络 26。空气取样网络包括单一连串的三个并列状、较佳平行的取样导管部分 2202、2204、2206。下游导管部分 2202 在一端连接至微粒探测器 11 且在其另一端连接至下个取样导管部分 2204。取样导管部分 2204 亦连接至上游取样导管部分 2206。取样点 29 配置使得各取样点 29 连接至对于其邻居的不同取样导管部分。亦即，取样点服务 R1 连接至导管部分 2202，而取样点服务 R2 则连接至取样导管部分 2204，且取样点服务 R3 连接至取样导管部分 2206。重复此图案使得取样点服务 R4 连接至取样导管部分 2202 等。利用此方式，取样点 29 之间的距离当沿着取样导管的流径长度测量时为若采用单一连串取样导管时的情形的三倍。在连接点之间增添的分隔使得从来自另一个的一取样入口所抽取的样本的解析更为直率。

[0382] 除了使取样点沿着导管网络散开外，可实现的另一优点导因于对于导管网络的连接次序的（相对）重新排序，其可提高局部化的可靠度。在部分实例中，取样导管网络中的样本的混合或合并可遮蔽（或错误地建议）微粒在物理邻近区中的出现。由在取样导管网络中将一区的空气取样点的连接点与其邻居的连接点分离（最佳地由在其间连接一服务至少一非邻近区的取样点），取样系统内的空气样本可维持较高程度的水平独立性。

[0383] 相应地，提供用于一微粒探测系统的一空气取样系统，以供监测多个区，该多个区配置使得至少一区物理性邻近于该多个区中的另一个区，其中，空气取样系统包括一包括多个样本入口配置的取样导管网络，多个样本入口配置的每一个服务一各自的区且连接至取样导管使得至少一区的取样入口配置具有一与一物理邻近区的连接点呈分离的连接点。最佳地，至少一非邻近区的一取样点配置的连接点位居邻近区的取样入口配置的连接点之间。亦提供一微粒探测系统、包括空气取样系统及至少一微粒探测器。

[0384] 图 23 示出用以实行此方案的另一实施例。在此范例中，微粒探测器 11 耦合至一

局部化模块 2004 及取样导管网络 26。取样导管网络 26 包括单一取样导管 28，其具有四个彼此连接且共同延伸过（或通过）区 R1 至 R8 的空气取样导管部分 2302、2304、2306、2308。在此范例中，导管 28 的远上游端如上述般连接至局部化模块 2004。导管 28 的下游端经由局部化模块 2004 连接至探测器 11。可利用本文所描述的任一方法进行局部化。

[0385]　各区 R1 至 R8 的取样入口连接至导管分段 2302 至 2308，如下：

[0386]

区	R1	R2	R3	R4	R5	R6	R7	R8
导管分段	2302	2304	2308	2306	2302	2306	2304	2308

[0387]　因此，区以下列次序从下游到上游（亦即最接近探测器的端到最远离探测器的端）被连接至导管网络：

[0388]　R1、R5、R7、R2、R4、R6、R8、R3

[0389]　利用此方式，并没有区使其空气取样配置 29 在一邻近区旁被连接至取样导管 28，且连接点沿着导管网络呈宽广分布。

[0390]　在所有其他方面，此实施例可根据本文所描述的其他方案运作。

[0391]　导管部分可为在其端点与配件互连的个别长度的导管，如本领域技术人员所将得知，或可替代性使用特殊用途多通路导管。随后利用互连配件（譬如其可被附接在导管的通路端上方或其内）以发生导管分段的互连。利用多重通路导管可提供的一装设优点在于：装设技术只需应付单一组件、而非多个导管。

[0392]　虽然已经参照配置于一直线中的一群组的区 R1 至 R8 来描述本范例，没有理由必须如此。实际上，区可以任何几何结构作配置。并且，并未要求区必须被物理分隔（譬如房间的情形），而是可为一较大空间或体积内的区。

[0393]　为了使上述技术在现场可靠地运作，需要校准或训练该系统，譬如使一空气样本进入各取样入口前所移动的空气体积抵达该探测器（或各探测器），从而有效地将该系统予以特征化。最佳地，利用与系统的局部化模式期间相同的方式，系统在空气被移动经过系统之时受到训练。例如，若系统使用下文连同图 15 所描述的一推器风扇方法，若推器风扇未运转时系统利用正常探测运作受到训练则有可能发生一显著的局部化错误。在其中系统具有譬如风扇或类似物等单一空气移动器件的一形式中，或当从探测模式改变成局部化模式时没有显著地改变经过探测系统的流径或流阻抗的机制，可以训练模式实行一相对简单但耗时的程序。在此实例中，系统可如下般训练。由于系统正常地运作，系统测量自从一供譬如烟雾喷洒等测试烟雾作配送的时间以来直到烟雾抵达探测器为止所移动的空气体积。对于各取样入口作测量。然而，由于训练顺序需对于各入口分开地进行，且系统可能需在各循环之间被留待返回至正常运作，这将会耗时。较佳地，训练模式使用一经修改的行为来降低训练时间。

[0394]　在其他实施例中，譬如一在其运送阶段期间具有位于导管端的一开启的阀加上一过滤器的系统，训练模式涉及在导管端将阀开启一时间期间。烟雾可随后被选择性施用至各样本孔（或呈现经选择图案的多个的孔），使得系统仍将烟雾吸取经过孔。

[0395]　在训练模式中，系统如下运作：

[0396] a. 系统随后将位于导管端的阀开启。

[0397] b. 当在一取样入口施用烟雾时,使用者随后输入至探测器。

[0398] c. 探测器测量从指示时间开始直到对于各样本入口探测到烟雾为止所移动的空气体积。

[0399] 在一推器风扇(及较佳位于导管端的一阀及过滤器)的实施例中,更难以模拟进入一取样导管的烟雾。例如,不可能以推器风扇连续运转而使喷洒烟雾进入一取样入口。因此,需要一替代性方法。诸如:

[0400] a. 复制标准鼓风机运作,但具有导入的烟雾,包括:

[0401] i. 使系统正常地运转;

[0402] ii. 进入校准程序;

[0403] iii. 启动鼓风机,彷佛已经探测到微粒般,并将此程序已经开始指示予使用者;

[0404] iv. 使用者在受测试的取样入口处施加喷洒烟雾。

[0405] v. 将鼓风机解除启动并接通推器风扇如正常般进入运送阶段,并记录在烟雾抵达探测器前所运送的空气体积。

[0406] vi. 系统指示出孔已被校准。

[0407] vii. 系统关闭阀并关断推器风扇。

[0408] viii. 其他样本入口随后以相同方式被校准。

[0409] b. 特殊训练模式:

[0410] i. 系统正常地运转。

[0411] ii. 用户将系统置于测试模式。

[0412] iii. 系统继续至正常地抽入空气,且使用者在孔处施加喷雾烟雾并将此指示予系统。

[0413] iv. 系统随后立即接通推器风扇。

[0414] v. 系统随后记录在'喷洒开始'的指示与烟雾被探测之间经过流传感器的空气的体积。

[0415] vi. 系统随后指示出一样本入口已被校准。

[0416] vii. 系统关闭阀并关断推器风扇。

[0417] viii. 下个孔随后利用相同程序被校准。

[0418] c. 特殊烟雾注射器

[0419] 此方法对于使用者而言较快速,但使用者需要特殊设备。此方法涉及使用一注射器件,其容许烟雾以一种导管中其他正压力的方式被喷入一样本入口中。予以执行此方法的一种方式涉及使用一密封在样本入口周围且将烟雾喷入入口中的测试烟雾产生器单元。例如,烟雾产生器可具有一包括一泡绵垫片的出口,泡绵垫片钳夹于样本入口周围使得空气不跑出样本孔外。一旦被配合且一样本注入取样入口中,使用者将此烟雾被喷洒输入至系统。系统记录在烟雾脉冲抵达探测器前所移动的空气的体积。图 27 示出一范例器件。虽然此器件包括可有利地配合使用视频验证系统的转接件,但是可依需要在没有这些转接件的情况下使用此器件。

[0420] 并不实证地测试系统的行为,可使用一仿真器。仿真器类似于(来自 Xtralis Pty Ltd)的 Aspire。仿真器以实际系统孔维度及距离为基础得出运送阶段期间每孔的预期体

积。

[0421] 在上述测试方法中，一使用者可直接与探测器互动以将输入传送给探测器（譬如输入训练模式），抑或指示出何时已经喷洒测试烟雾，等。然而，在一较佳实施例中，探测器系统包括一较佳为无线的接口，探测器据以通信于一用户器件（譬如一便携计算机、平板计算机、智能电话或类似物），且用户器件执行一应用程序，其容许探测器受到控制以如描述般运作。

[0422] 在部分微粒探测系统中，可由使微粒探测系统与一视频保全或监视系统构成接口来提供改进。这种系统使用视频保全系统所撷取的影像来进行额外的微粒探测方法（譬如由进行视频分析以试图验证微粒的探测），抑或容许一监测站 (CMS) 的一操作人员观看一其中已经探测到微粒的区域以具有微粒探测事件的人员验证。这可帮助确定出威胁水平并确定对于探测事件的一适当响应。图 24 示出一包括一微粒（特别是烟雾）探测器及视频保全系统的范例系统。这种系统及其运作的进一步细节描述于申请人的 2013 年 6 月 7 日提交的、名称为“多模式探测”、共同审查中的 PCT 申请中。

[0423] 图 24 为一包括多个房间的建筑物 2400 的楼层平面图。各房间指示成属于由分别的摄影机所监测的一分区。因此，分区 1 由摄影机 2401 监测；分区 2 由摄影机 2402 监测；分区 3 由摄影机 2403 监测；分区 4 由摄影机 2404 监测；分区 5 由摄影机 2405 监测；分区 6 由摄影机 2406 监测；分区 7 由摄影机 2407 监测；且分区 n 由摄影机 2408 监测。

[0424] 各分区亦包括一用于探测微粒的部件 2410.1 至 2410.n。用于探测微粒的部件 2410.1 至 2410.n 可属于任何类型，包括点探测器、呼吸式探测器、束探测器、开放区域主动视频探测器。在本范例中，用于探测微粒的部件 2410.1 至 2410.n 为对于一空气取样导管 2413 的一空气取样入口，其连接至一微粒探测器 2411，从而形成属于本文所述类型任一者的一微粒探测系统。微粒探测系统配置以确定微粒进入哪个取样点 2410.1 至 2410.n，如本文所描述，并指示出对于各探测点 2410.1 至 2410.n 的微粒水平或警示水平。微粒探测器 2411 连接至取样点 2410.1 至 2410.n 并连接至呈现一 FACP 抑或中央控制器 2412 形式的一建筑物火灾警示系统，并配置以将各取样点个别地识别成为具有该系统上的地址，以能够由火灾警示系统指示出建筑物 2400 内的火灾探测的位置。摄影机 2401 至 2408 中的每一个连接至一中央控制系统 2412。中央控制系统 2412 为一视频分析系统，其接收且分析来自多个摄影机的视频馈送物。中央控制器亦可随着探测到事件而实时地抑或随选地储存及传输视频馈送物至一中央监测站。控制器 2412 经由一通信通路被连接至一中央监测站 (CMS) 2414，可在该处监测火灾相关及保全相关的警示情形。在替代性实施例中，控制器 2412 及 FACP 的功能可组合成单一器件。并且，中央监测站 2414 的功能可在控制器 2412 处进行。类似地，摄影机及其他保全系统（未图标）及火灾及/或烟雾可直接地连接至一远程 CMS，其直接地进行全部的监测及分析（亦即控制器 2412 及 FACP 的功能）。

[0425] 现在请考虑一在图 24 的建筑物 2400 的分区 2 中开始有一火灾的情形。在此实例中，位居房间内的取样点 2410.2 将抽取一样本空气，其指示出烟雾微粒出现在烟云 2413 中。一旦作出一初始探测，探测器 2411 将随后如上述般进行局部化且将一示警信号传送到火灾警示控制面板 (FACP) 指示出疑似火灾的位置。如同在这种系统中所习见，探测器 2411 的输出信号可指示出所探测的一微粒水平或根据探测器的警示逻辑所确定的一警示状态。火灾警示控制面板将经由中央控制器 2412 将此示警数据传送回中央监测站 2414，其中人

员可监测建筑物 240 中的状况。因为系统包括有视频验证能力，经由入口 2410.2 在分区 2 中探测到微粒时，则启动采用摄影机 2402 的视觉验证。摄影机 2402 开始撷取（若其未先行撷取影像）影像抑或分析影像以确定烟雾是否可从影像中被验证为出现。来自摄影机 2402 的视频馈送物被提供至中央控制器 2412。中央控制器 2412 对摄影机 2402 所撷取的一系列帧进行视频分析，以确定影像中是否具有用以指示出摄影机 2402 视场 2402.1 内出现烟雾抑或火焰的视觉特征构造。可在控制器 2412 中抑或中央监测站 2414 处进行此视频分析。若在中央监测站 2414 进行分析，可能呈现压缩形式的视频影像将需从现场控制器 2412 被传输至中央监测站 2414 以供分析。探测到摄影机 2402 所撷取影像中的烟雾或火灾时，在中央监测站 2414 执行的示警系统可修改其输出，以指示出烟雾探测器 2410.2 所指示的示警状况受到视觉分析系统的验证。使用者可从此验证推论出假警示的机率很低。

[0426] 由对于监测中央监测站 2414 的使用者指示出一火灾或烟雾警示已受到验证，警示的重要性程度将升高。为此，将促使监测该系统的人员对于该警示更快采取行动。图 25 及 26 示出根据本发明的实施例可对于中央监测站所提供的两替代性界面。首先参照图 25，界面包括多个视频示出面板 2501、2502、2503 及 2504，其各示出从被监测建筑物 2400 内的不同摄影机所撷取的影像。提供大观看面板 2501 以对于监测系统的用户提供位置的更近观看，使其可视觉地检验已经发生一示警的场景。更小的显示面板 2502 至 2504 可根据一适当方案作循环，或替代性根据对应分区中的示警水平以优先级作排名。界面 2500 的底部部分包括一事件清单 2507。对于各事件，显示事件数据，且系统的用户将被提供一系列的按钮 2509 以供进行特定响应的动作。对于各事件，显示下列数据：以数字形式将事件列出的事件编号 2512、“事件 ID 2514（用于事件的系统范围的唯一的标示符，其用来索引所登记的事件数据以供稍后访问）；事件描述 2516（其说明事件的本质）；事件级别 2518（事件的优先级排名）；事件状态 2520 的指示器（譬如是警示还是故障或其他特定类型的示警）；一系列的行动按钮 2522.1、2522.2、2522.3。

[0427] 事件编号 5 在本范例中具有最高的示警状态且本文将作更详细描述。事件编号 5 为烟雾已经在分区 2 中被探测的指示。在该范例中，微粒探测器 2410.2 已探测出烟雾处于应拉响警报的水平。在状态栏中，因为视频分析系统已经分析摄影机 2402 的输出并确定烟雾及火灾出现，故事件指示成“经验证的警示”。为了对于系统的用户指示出该验证，界面已经突显出对应于事件编号 5 的状态方块并以文字形式指示出警示受到“验证”。如同将额外注意到：分区 2 的影像包括由视频分析系统所探测的烟雾及火灾的位置的视觉指示器 2508。因此，视频分析系统已经进行摄影机 2402 所撷取的一系列影像的分析并已经指示出被确定为代表烟雾的影像内的一区周围的边界或边缘。此外，影像 2510 的一分区的指示被指示成呈现代表造成火灾的火焰。

[0428] 图 26 示出对于图 25 的一替代性界面，两图的界面之间唯一差异在于：并非仅简单指示出事件编号 5 的状态已作“验证”，图 26 的界面根据其警示级别及验证级别来排序事件清单中的每个事件。这额外突显出：相较于系统内的其他事件，应该对于事件编号 5 给予较高优先级。

[0429] 一旦一事件已经被自动视频验证系统所探测及验证，将由系统的一使用人员来确定响应于该事件要执行的动作。该人员可选择不理会事件（2522.2）或观看对应于事件的视频馈送物（按钮 2522.1），以进一步调查或由通报警方、消防队或其他适当紧急响应服务

来拉响一外部警示 (2522.3)。可如同指示般利用观看按钮 (2522.1)、不理会按钮 (2522.2) 或通报按钮 (2522.3)，使用图 25 及 26 的界面进行这个动作。

[0430] 在本发明的一额外实施例中，可有利地使视频分析系统进一步帮助用户调查悬疑事件。因此，系统的一用户可能希望调查一示警的成因，例如由确定事件已经源自何处、或一事件的真正成因为何（譬如何物或东西着火、或有点燃的危险，并造成一烟雾探测事件）。这种信息在确定对于示警状况的响应策略上会特别有价值。例如若确切知道是什么着火，则可实行适当的抑制策略。并且，可视觉检测围绕火灾的任何物品来确定需要哪种级别的响应。例如，若重要设备、或有害或易燃物品围绕于火灾上方的区域，则可能需要更快速的响应或完全撤离，而如果在相对开放区域或设有非易燃物品的区域中探测到火灾，则可接受更慢（或至少不同）的响应。

[0431] 为了帮助调查程序，中央监测站可设有软件，软件分析来自一或多部摄影机及状况传感器的警示输出并对于使用者建议关于事件来源或本质的所建议调查的次序。例如，软件系统可储存在被监控的上述房屋中关于房间及物品的相对位置的地图或其他地理数据，并利用代表哪个取样入口已经接受微粒的数据来确定调查优先级或已供火灾起源的可能中央点。例如，在图 25 及 26 中，已经在分区 2 中感测到经验证的警示，且已经在分区 3 中感测到未验证的警示。亦已经在分区 1 中感测到预警示。在不可能验证火焰出现（图 25 以 2510 指示）的情形中，中央监测站将以分区 2、然后分区 3、接着是分区 1、接着是分区 N 的次序建议其他分区的人工分析的次序。这以分区 2、3 及 1 的所接受的示警级别、以及分区 2、3、N 及 7 的门道近邻性、以及分区 1 为其间的走廊的事实为基础。在其他实施例中，其他因素亦会在确定调查次序上扮演角色，譬如，若建筑物的空调返回管道位于位置 2420，可以比其他空气取样点更低的优先级来对待经由点 2410.12 的异常微粒水平探测器，原因在于其倾向于比其他烟雾取样点更常指示出烟雾。

[0432] 因此，要是譬如在取样点 2410.12 于分区 2 及分区 1 中探测到烟雾，则分区 2 有可能是火的来源。反之，若确定仅有取样点 2410.11 及 2410.12 已经抽取含有烟雾的样本，而无其他取样点，则分区 1 有可能是火灾状况的来源。

[0433] 而且注意到以下情况很有用 :若没有被施加至图 25 的事件 5 的视频验证程序，分区 2 及 3 的警示级别原本将相同。若没有视频验证，则除了实体检视以外将没有可供据以作出火灾实际出现在分区 2 而非分区 3 中的决策的额外信息。因为本文所描述的视频验证程序能够首先在其中实际出现火灾的分区 2 上标定响应，所以这显然有助于响应策略。

[0434] 图中所描述的传感器（譬如摄影机）可为固定式摄影机或能够改变其视场（譬如为摇摄 - 倾斜 - 变焦 (PTZ) 摄影机）。若使用 PTZ 摄影机，摄影机可被程序化作摇摄、倾斜、变焦，以隔离出被识别成潜在造成示警状况的位置而能够作调查。可替换地或额外地，PTZ 摄影机可被控制以撷取第一观看的影像，然后移动至第二观看且可能接续地移动至一或多个额外的观看，在各观看暂停指定时间。该顺序可无限地重复。

[0435] 可对于各个观看独立于其他观看进行视频分析。一般来说，这可视为是对摄影机以不同 PTZ 设定所取得的影像进行时分复用的过程，其中各 PTZ 设定对应于时隙。可对于来自各 PTZ 时隙的接续案例的一系列影像进行视频分析。在对应 PTZ 时隙中所撷取的影像可以“摄影机”被对待，且可利用早先范例对于单一摄影机所描述的技术进行视频分析。

[0436] 如此的系统对于上述委任 / 校准程序添加一额外维度，原因在于需使空气样本入

口的位置与其物理位置、且亦与保全系统的摄影机的观看产生交叉相关。在部分实例中，甚至欲使特定摄影机的 PTZ 参数与取样点产生交叉相关。

[0437] 现在将参照图 27 描述一用于使微粒探测系统中的地址与视频撷取系统中被监测的位置产生交叉相关的装置及方法，其中该地址对应于物理位置，该视频撷取系统监测多个位置。图 27 示出可用来方便地委任、校准及／或测试微粒探测系统的示范性装置 2700。如同将从下文描述得知，其亦使用在具有非视频能力的微粒探测系统中，诸如传统的呼吸微粒探测系统。

[0438] 该装置配置以提供进行烟雾测试的机构，使得由烟雾探测器系统得知烟雾的位置，且在具有示警的视频验证的系统的实例中，保全系统亦利用同时性方式。该装置能够使操作者在空气取样微粒探测系统、点探测器或其他烟雾感测构件（较佳未呈现特定顺序）的各取样入口处注射烟雾（或其他测试微粒），并譬如在诸如平板计算机或类似物整体性计算机构件上记录入口或感测构件的物理位置。数据可实时或之后被转移至微粒探测器，使得微粒探测器知道哪个入口映绘至哪个物理位置。较佳（但非重要）地，该装置能够使保全系统识别出哪个特定摄影机（及选用性 PTZ 参数）与各入口的地址位置相关联。可由可见式部件实现入口或传感器位置与视频保全中的位置的关联。随着发生烟雾注射，视觉指示器譬如由闪烁码达一段时间而被启动。保全系统搜寻视觉指示器并在其不同摄影机所撷取的影像之中识别其影像。保全系统可随后使正确的摄影机及选用性使 PTZ 位置与空气取样入口或传感器的位置交叉相关。因此，装置 2700 根据较佳实施例包括：

[0439] 用于将烟雾输送（且较佳产生）至取样入口的机构；

[0440] 用于能够使装置在视频保全系统所撷取的影像中作探测的构件，及选用性地，用以在此光学部件上传送数据的构件。

[0441] 用于使装置的行动与微粒探测系统及／或保全系统同步化的构件。

[0442] 更特别来说，示范性器件 2700 包括：

[0443] 控制器 2702，其控制器件装置 2700 的运作。

[0444] 电源 2704，其通常为电池。

[0445] 烟雾产生器 2706，用来产生测试烟雾以供依需要导入至取样点。

[0446] 风扇 2710，以将烟雾推动至输送点。

[0447] 管道 2712，以将烟雾产生器 2706 所产生的烟雾引导至输送点。在此范例中，管道 2712 为可延伸式（譬如伸缩式）导管，以能够方便地配合使用位于不同高度的取样点及方便的器件储存。管道 2712 终止于出口端口 2714，出口端口 2714 被定形以能够容易耦合至取样点或附近。在此范例中，出口端口 2714 为漏斗形出口端口，其可配合在取样点上方或附近。

[0448] 用户界面 2716，其在此实例中包括一个或多个控制按钮 2718 及触控屏显示器 2720。这些可以本领域技术人员所了解的方式组构，以控制装置 2700 的运作输入数据，并如将要描述的。

[0449] 同步化端口 2722，其可为配线式或无线通信部件，以供与譬如烟雾探测系统、视频保全系统或这些系统的组件等外部器件建立数据通信。在端口 2722 为无线的实例中，端口 2722 可用于实时通信。若端口 2722 调适以供产生物理连接，通信可被实时地产生（譬如在使用期间被插接至其他系统中）或异步地产生（譬如共享所储存的数据及／或在使用之后

器件与烟雾探测系统及视频保全系统中的一个或两个的同步化）。

[0450] 视觉通信系统 2724，其在此实例中包括辐射发射器 2724.1、2724.2、2724.3 的配置。视觉通信系统可以下述方式用来在装置 2700 使用期间通信于保全系统。视觉通信系统 2724 可发射可见或不可见辐射，只要其可被接收并中继至视频监视系统即可。最佳地，辐射被保全系统所接收且在一区的其视频影像中被撷取。利用此方式，由视觉通信系统 2724 的状态来传达装置 2700 及（选用性包括数据）的出现。

[0451] 现在将就委任微粒探测系统来描述测试装置 2700 的示范性使用，微粒探测系统具有由视频保全系统所进行的视频验证。装置 2700 目的在于辅助烟雾探测系统与视频保全系统之间整合的组态及验证并且较佳使其自动化。确切来说，工具帮助烟雾探测系统及视频保全系统对物理位置具有被保护的相同意义。

[0452] 在训练程序开始之前，微粒探测系统及视频保全系统设定至“训练”模式。

[0453] 在微粒探测器系统的各取样入口处，技术人员利用装置 2700 产生烟雾。当触发时，装置 2700 产生足以触发微粒探测系统来探测微粒的烟雾量。用以产生烟雾的触发亦将接通可在保全系统所撷取影像中与环境实体区别的视觉指示器。在“训练”模式时，视频保全系统分析其所撷取的影像，并搜寻（周期地或连续地）影像中的视觉指示器 2724。一旦找到，其将记录装置的位置（依需要而定，摄影机及 PTZ 预先设置）以识别哪个视频摄影机将在其视场中具有围绕取样孔的区域。

[0454] 在产生烟雾的点，技术人员亦譬如利用触摸屏幕显示器 2720 上的键盘界面来记录物理空间的名称（及选用性包括描述）。此文字连同烟雾测试开始及结束时间被储存，且选用性传输至烟雾探测器及／或保全系统以供与这些系统中的所探测事件交叉相关。在正常运作期间，当取样孔在系统实际使用期间被识别时，在此点所输入的文字可被提报予 CMS 操作者。

[0455] 装置 2700 被组构（譬如被编程）以引导技术人员接着采取什么行动，譬如何时移至新取样点，在触发烟雾之前、技术人员需在当前的孔处与烟雾产生器待在一起这段时间之前、将取样孔的名称提示予技术人员之前技术人员是否需等待，等。

[0456] 取样点通常接近于天花板，但将有例外。所产生的烟雾需快速且直接地触及取样孔。然而，强烈希望技术人员总是保持在地上，即使当其触发烟雾以呈现紧邻于安装天花板高处的样本孔时亦然，因此所有的控制件位居管道 2712 的底部，且管道 2712 可延伸。

[0457] 对于各取样孔的烟雾开始及结束事件与微粒探测系统及视频保全系统呈现同步。可在无线网络上实时达成此同步化。选用地或替代地，装置 2700 可以脱机模式提供相同能力而不实时使用无线网络。对于此后者实例，在委任程序完成时，装置 2700 将需要连接于微粒探测系统及视频保全系统，以将包括物理空间的名称的所记录数据予以同步化。这可经由任何通信媒介或通路进行，包括但不限于 USB、以太网络或 WiFi。

[0458] 在图 24 的范例中，分别由测试装置、烟雾探测系统及保全系统以“训练”模式产生下列系列的数据。

[0459]

开始时间	结束时间	物理位置名称	坐标(选用性)
1: 00	1: 01	主走廊	-37.813621 144.961389
1: 05	1: 06	会议室	-37.813637 144.961398
1; 08	1.09	图书馆	-37.813624 144.961398
…	…	…	…
1: 30	1: 31	清洁橱柜	-37.813610 144.961372

[0460]

[0461] 表 1- 测试装置数据表

[0462]

开始	结束	位置参数	入口数字
1 :00	1 :01	130 公升	5
1 :05	1 :06	125 公升	4
1 :08	1 :09	100 公升	2
…	…	…	…
1 :30	1 :31	16 公升	1

[0463] 表 2- 烟雾探测器表

[0464]

开始	结束	摄影机	PT2
1: 00	1: 01	2401	P=5 T=20 Z=200mm
1: 05	1: 06	2403	–
1: 08	1: 09	3402	–
…	…	…	…
1: 30	1: 31	2405	–

[0465] 表 3- 保全系统表

[0466] 一旦训练数据已被测试装置 2700、烟雾探测器系统及保全系统所记录，此数据需作交叉相关用于视频验证系统和烟雾探测系统在实际烟雾探测事件的情况中一起运作。如

同可看到：可利用各表中的开始及结束时间使得烟雾测试数据与烟雾探测器数据及保全系统数据交叉相关。

[0467] 在使用中，在烟雾被烟雾探测系统所探测的情况中，将确定烟雾在其系统中何处被探测。若系统包括一或多个点探测器，"地址化"（亦即确定事件在何处被探测）相对地直接且只需要知道哪个探测器已经探测到烟雾。若系统包括或身为具有空气取样网络的呼吸式微粒探测系统，系统可进行申请人所提交的澳洲专利申请 2012904516、2012904854 或 2013200353 任一个中的局部化方法的一个、或其他的局部化技术，以识别微粒来源的位置。输出可为位置、名称（譬如技术人员在委任期间所提供的名称）、房间地址或烟雾局部化参数（诸如在探测事件之间同时在局部化阶段中已经通过探测器的空气样本的体积，其利用本文所描述的任一种方法识别烟雾经过哪个取样孔进入烟雾探测系统。此输出被传递到保全系统。以此名称、标示符或局部化参数为基础，保全系统能够确定其哪个摄影机提供所确定的空气取样点的观看。

[0468] 在此实例中，保全系统将摄影机 2405 识别成为将示出其中已发生烟雾探测事件的区的观看的摄影机。

[0469] 如同将了解：可在委任期间收集额外信息以帮助 CMS 操作者确定当探测到烟雾或火灾时的适当行动。

[0470] 在装置 2700 的部分实施例中亦可包括额外的特征构造。例如，在部分实施例中，可使用其他方法确定装置 2700 的位置，以辅助取样入口及位置的识别或使其自动化。可利用例如卫星定位（譬如 GPS 或 DGPS）或来自电磁发射器的三角测量以确定装置位于哪个房间中，从而排除或降低将数据输入系统中的需求。取样点可设有一短程通信机构，譬如 RFID 标签，其由被安装接近于管道 2712 端的读取器所读取，以识别哪个取样点在各步骤中被委任。亦可利用此通信作为令取样点的测试过程开始的触发器。

[0471] 图 17 示出图 14A 至 14E 的系统的变化。系统 1700 在所有方面皆等同于图 14A 至 14E 的系统且以相同方式运作，例外在于样本放大配置 1702 位居取样导管 28 的上游端。这简化了取样网络 26 的探测器端并便利于样本放大配置 1702 翻新成为原本未具备这种能力的旧有探测系统。

[0472] 图 18 示出包括空气取样网络的微粒探测系统，空气取样网络具有包含多个振动薄膜的样本放大配置。基本上，此系统 1800 为图 14A 至 14E 及图 17 的系统的双端式版本。在此实施例中，两活塞 1802、1804（由扩音器的振动薄膜形成）一起作用以形成样本放大配置。这些组件可和谐地运作，如同就图 15 的相对风扇所描述。然而，身为扩音器（或能够造成快速振荡空气流的其他类似的空气运动器件），这些活塞 1802、1804 提供沿着取样导管 28 在一或多个样本入口 29 选择性进行样本放大的新能力。可由使活塞振荡且其间具有经选择的相位差来达成此作用。这造成沿着取样导管 28 的不同地方的样本放大作用的选择性强化或抵消。

[0473] 图 19 示出另一包括空气取样网络的微粒探测系统，空气取样网络具有分支状取样导管且具有包含多个振动薄膜的样本放大配置。系统 1900 包括耦合至空气取样系统 26 的微粒探测器 11。空气取样系统 26 为分支状使其具有取样导管 28A 及 28B，取样导管 28A 及 28B 各包括沿着其长度呈序列状配置的多个样本入口 29A 及 29B。在导管 28A 及 28B 的上游端设有活塞 1902、1904。共同的活塞 1906 系放置取样网络 26 的下游端。包含活塞

1902、1904、1906 的样本放大配置可运作，以由在样本放大阶段中选择活塞振荡之间的适当相位差来选择性抵消其振荡效应。例如，在范例中，下游活塞 1906 与导管 28A 的上游活塞 1902 呈同相位运作、但与导管 28B 的上游活塞 1904 呈反相位运作。结果为 :样本放大只发生于样本入口 29A 上，而未发生于入口 29B 上。

[0474] 此程序可延伸并与图 18 所描述的方法相组合。因此，可由运作下游活塞 1906 达成较大选择性，其中具有对于导管 28A 上游活塞 1902 的经选择相位差，且活塞 1904 并无振荡。最佳地，若振荡图案的节点重合于导管 28A 及 28B 之间的接点，将尽量降低（或可能消除）导管 28B 上的样本放大，且可沿着导管 28A 长度达成选择性样本放大。

[0475] 如同将了解 :亦可以其他类型的空气流运动器件譬如鼓风机、风扇（如图 15 所示）或类似物，来实行图 18 及 19 所描述的双端式样本振荡技术。

[0476] 可实行图 17 至 19 的系统使得局部化硬件设置于探测器端模块（诸如模块 2004）中，如上文所述。将了解 :这需采用返回导管分段以能够令上游组件（譬如活塞 1702、1804、1902）的位置物理性接近于导管 28 下游端，使其可一起被容置在模块中。

[0477] 虽然仅就图 15B 的范例描述清除步骤，应了解可在本文描述的所有实施例中皆选用性使用清除阶段来改良局部化的精确度。清除步骤，概括来说涉及以洁净空气（或至少可与样本空气区别的空气）来充填空气取样网络，其通常需要用于提供该空气的部件，譬如可选择性插入系统中以能够输送洁净空气的过滤器配置。因此，若适用的话，这种部件可设置于本文所描述的系统中。

[0478] 如同从上文了解 :已经在此文件内描述许多技术以改良呼吸式微粒探测系统中的地址化，呼吸式微粒探测系统包括集中化的探测器及沿着空气取样系统的管道或导管所放置的多个样本入口。本领域技术人员将了解 :每个系统的组件可组合以进一步强化系统效能。为了提供一范例，可利用图 14、15 或 16 的导管网络工作系统来增加导管网络内的烟雾浓度，以将更洁净的烟雾浓度前锋输送至探测器以供在图 5 及 6 所描述的交叉相关方法中使用。并且，并不采用以时间为基础的交叉相关，可如上述般利用以体积为基础的交叉相关。本领域技术人员将易于得知其他组合。

[0479] 将了解 :本发明虽就烟雾探测作描述，亦可同样适用于可被取样系统有效地探测的任何其他材料，包括气体、灰尘、蒸气或生物材料。

[0480] 图 30 示出局部化模块 3000 的另一实施例，其可被用来作为本文所示出的任一个实施例的局部化模块 2004。局部化模块 3000 包含有下列主要组件 :

[0481] 主流径 3002，其从位于一端（对于局部化模块 3000 的入口 3004）的取样导管 28 延伸至位于另一端（来自局部化模块 3000 的出口 3006）的探测器 11。主流径 3002 包括额外的微粒探测器 3010。微粒探测器 3010 可为相同抑或不同于主微粒腔室 14 的微粒探测腔室，或属于不同类型。在一较佳形式中，次级微粒探测器比起主探测腔室 14 而言提供对于微粒的更快响应，但所有实施例中未必皆如此。主流径 3002 亦包括阀 (3012)，其可用来关闭主流径 3002 并将全部的流转向至主要分支流径 3014 中，下文作更详细描述。

[0482] 主要分支流径 3014 包括导往一样本放大器件 3018 的第一分支 3016。在一较佳形式中，样本放大器件 3018 实行可用来在取样导管内推动与拉取小量空气之间作快速切换的往复活塞形式。主要分支流径 3014 包括第二阀 (3020)，其可用来阻挡住进入活塞并将流从主要分支流径 3014 转向至次级分支流径 (3022) 中。

[0483] 次级分支流径 3022 含有风扇 3024 及过滤器 3026,风扇 3024 及过滤器 3026 配置成能够使空气从系统外被抽入次级分支流径 3022 中、过滤空气、且以下述方式将其传递至额外微粒探测器 3010。

[0484] 图 31 示出一局部化模块 2004,其已经延伸以与一具有多个空气取样导管 28.2、28.2 的空气取样网络 26 运作。局部化模块 2004 可延伸以由复制上述组件来应付多个取样导管。然而,为了降低组件数、销售成本,可共享某些组件。在此实施例中,提供独立的主流径 3002.1 及 3002.2。在此实例中,阀 (3012.1 及 3012.2) 一起运作且连接至主要分支流径的分别的分支并彼此和谐地运作。在大部分的多导管系统(譬如 Vesda 雷射扫描仪或 Vesda 雷射工业用(皆由 Xtralis Pty Ltd 销售))中,主微粒探测器将仅具有一个探测腔室,且来自每个导管的空气样本在探测腔室中作分析之前于歧管中被混合在一起。

[0485] 在所有其他方面,多导管局部化模块与图 30 中的相同,且已经采用相符合的附图标记。如同将了解 :可使一多导管局部化模块应付所需要的任何数量的取样导管。

[0486] 图 32 及 33 示出附件 2800 的两个额外实施例。可使用附件 2800 作为被安装在取样导管 28 远上游端的导管端盖。然而,其亦可放置在取样网络中的其它点(譬如分支导管的上游端或是取样导管的中间点的 T 接头外),使得附件流径的选择性开启容许空气进入取样导管中。图 32 的实施例具有风扇 3202 及阀 3204(等同于图 28 的阀 2808),其可在局部化模块的控制下被启动。在正常烟雾探测运作中,阀 3024 关闭且风扇 3202 未运转。当启动时,阀 3204 开启且风扇 3202 被启动,使得空气被抽入导管 28 端中且顺取样导管往下吹送朝向探测器 11。附件 2800 亦可选用性包括过滤器(诸如 HEPA 过滤器),使得进入导管的空气更能够与从取样点被抽入系统中的样本空气相区别。

[0487] 图 33 的附件 2800 很类似于图 28 的实施例,且类似的特征构造已作类似编号。附件包括阀 2802,其可选择性开启导管、而非风扇。其亦包括过滤器 3302。阀 2802 在取样导管 28 中感测到低压力或背压力时由控制器 2806 所启动。当探测到高负压力时,端盖开启以容许空气被抽入导管端中。

[0488] 在使用中,一较佳实施例中,使用图 30 及 31 任一者所示出类型的局部化模块及图 32 或 33 任一者所示出的附件的微粒探测系统将具有与诸如图 29 等其他实施例中所示出的相同的一般架构,其具有主微粒探测器、局部化模块 2004、包含取样导管 28 的取样网络 26 以及安装在局部化模块上游的至少一个附件。现在将假设采用图 32 的附件来描述这种系统的运作。

[0489] 综观之,探测器 11 以一正常微粒模式运作,而连续地抽取空气样本并予以分析。然而,一旦微粒被探测为高于痕量水平,系统确实进入局部化模式且启动局部化模块 2004。主探测器 11 随后被解除致动且空气样本停止被抽过主探测器 11。局部化模块 2004 随后进行样本放大例程,如上述。如上文所注意 :"放大"使导管中的空气混合于围绕各样本孔的局部大气并造成与各取样孔相邻的取样导管中的空气封包形成——这些封包具有类似于紧接着围绕取样点的大气的组成物。如同上文描述所得知,在正常稳态运作中,经过各取样孔所抽入的空气样本随着其通过取样网络 26 时而被抽入所有其他取样孔中的空气所稀释。然而,在此实施例中,因为放大只来回吸取及吹送少量空气经过系统,所以封包并未以此方式被稀释。

[0490] 随后由重新启动主探测器的主风扇、且若使用具有风扇的附件(譬如图 32 的)则

由附件的风扇予以推动，而使具有“封包”的取样导管的内容物被抽取回到额外的微粒侦器3010以供分析。在此“运送”程序期间，测量体积（或相关数值）。当额外的微粒探测器3010探测到烟雾封包时，所抽取体积被读取并与查阅表比对以确定哪个取样孔对应于被探测的烟雾封包。

[0491] 次级分支流径并未在此局部化程序上扮演任何角色。然而，其只用来由洁净空气淹没额外的微粒探测器3010以供校准。此程序周期性发生，例如每天一次。

[0492] 该程序可以是表格形式，如下所见：

[0493] 正常运作

[0494]

主呼吸器	主探测腔室	流感测器	阀3012	阀3020	样本放大器	额外微粒探测器3010	分支中的风扇3024	体积或体积相关测量)	阀3204	端盖风扇3202(若出现的话)
接通	接通	主动	开启	关闭	非主动	非主动	关断	非主动	关闭	关断

[0495] 其中对于阀3012

[0496] 开启＝主流径开启且主要分支流径被阻挡

[0497] 关闭＝主流径被阻挡且主要分支流径开启

[0498] 对于阀3020

[0499] 开启＝主要分支流径开启，所以取样导管对于放大器开启

[0500] 关闭＝次级分支流径开启，所以取样导管对于风扇及过滤器开启

[0501] 若主探测腔室探测到痕量水平烟雾，则正常探测停止，且进入放大模式。

[0502] 放大

[0503] 在此状态中，局部化模块2004进入其放大模式且在此范例中，样本放大器件（譬如活塞3018）重复地抽取及推动空气以进行样本放大。相较于空气取样系统中的总空气体积而言，在此程序中所移动的空气体积为低值，且较佳小于邻近取样入口之间的取样导管体积的一半。

[0504]

主呼吸器	主探测腔室	流感测器	阀3012	阀3020	样本放大器3018	额外微粒探测器3010	分支中的风扇3024	体积或体积相关测量)	阀3204	端盖风扇3202(若出现的话)
关断	关断	非主动	关闭	关闭	振荡	非主动	关断	非主动	关闭	关断

[0505] 在某预定时间或一定数量的振荡之后，放大停止且系统移动进入运送模式。

[0506] 运送

[0507] 在此模式中，系统将被放大的样本封包移回到额外的微粒探测器 3010 以供分析。譬如由将流率作积分，以测量从运送开始以来已经通过系统的样本空气的体积、或与体积相关的数值。此数值与额外微粒探测器 3010 中的探测事件交叉相关以确定烟雾的进入点。

[0508] 如本文其他地方所描述，较佳以高速度运送。由开启进入取样导管中的大端口（譬如由开启阀 3204（若出现的话））、启动推器风扇 3202 予以辅助。开启导管 28 端以及吹入导管端中造成导管的至少部份（最靠近风扇 3202 的部分）中的正压力，并尽量降低较靠近系统的主呼吸器的负压力（降低吸力）。这尽量降低位于取样导管的取样入口的吸力并因此尽量降低运送期间额外空气吸入取样入口中的作用，从而尽量降低样本封包随着其被送到微粒探测器以供分析的稀释。

[0509] 较佳地，还以足够高的速度作回抽，以确保取样导管中的紊流，其尽量降低沿着导管的封包的脏污（如本文其他地方所描述）。运送期间高速回抽的另一优点在于：其降低封包从取样导管 28 远端至探测器的运送时间，而能够更快地响应。

[0510]

主呼吸器	主探测腔室	流感测器	阀 3012	阀 3020	样本放大器 3018	额外微粒探测器 3010	分支中的风扇 3024	体积或体积相关测量)	阀 3204	端盖风扇 3202 (若出现的话)
接通	关断或接通	主动	开启	关闭	非主动	主动	关断	主动	开启	接通

[0511] 在回抽完成后，系统回到正常运作。

[0512] 该程序可循环以周期性更新局部化数据，且监测烟雾的发展。

[0513] 次级分支流径 3022 的使用

[0514] 如同从上文描述将了解：次级分支流径 3022 在正常探测、放大或运送阶段中并未扮演角色。次级分支流径的主要用途在于提供洁净空气来源，其可用来周期性或依需要校准或归零主探测腔室 14 或额外微粒探测器 3010 的一个或两个。由进入其中经过滤空气经过次级分支流径被吹回到主流径中直到至少额外微粒探测器 3010 充满洁净、过滤空气为止的归零模式来进行此作用。在归零阶段中，系统配置如下：

[0515]

主呼吸器	主探测腔室	流感测器	阀3012	阀3020	样本放大器3018	额外微粒探测器3010	分支中的风扇3024	体积或体积相关测量)	阀3204	端盖风扇3202(若出现的话)
关断	关断	非主动	关闭	开启	非主动	主动	接通	非主动	关闭	关断

[0516]　仅需要将足够的洁净空气吹入局部化模块 2004 中来充填额外的微粒探测器 3010。可譬如由使风扇 3024 运转某预设时间足以将可接受体积的洁净空气吹入系统中完成此作用。替代性地，洁净空气可被吹回到额外的微粒探测器 3010 中直到额外微粒探测器 3010 探测到相对稳定的最小微粒读数为止。

[0517]　在另一实施例中，提供具有微粒探测器的微粒探测系统，微粒探测器流体性导通于包括至少一个空气取样导管及多个空气取样点的空气取样网络。该方法大体上涉及以能够被微粒探测系统所探测的校准物质（譬如测试烟雾、或可被微粒探测器所探测的其他物质（诸如 FM200 或类似物））来充填至少一个具有多个空气取样入口的空气取样导管，该空气取样导管以处于一个水平的可由微粒探测系统所探测的所述物质所充填。接着，该方法涉及将空气样本抽入取样导管中以造成至少一个空气取样入口附近的物质的局部化的稀释。较佳地，稀释程序涉及改变取样导管中的流向。更佳地，稀释程序类似于如本文其他地方所描述的样本放大。取样系统的内容物随后被移动至探测器，同时探测空气取样系统的内容物中的校准物质的水平，同时亦监测可与取样系统内容物的运动交叉相关的数量（譬如体积、一与体积相关的数值、或时间（但这并非较佳方式））。探测取样导管的内容物中的物质中的该局部化稀释并使该探测与所监测数量交叉相关，以确定对应于用以造成局部化稀释的取样孔的该数量的数值。探测取样导管的内容物中的物质的该局部化稀释包含由系统的微粒探测器来探测微粒水平的降低。

[0518]　本方法可形成委任程序的部份且实质上为典型局部化技术的逆反，就下列范围而言：并不放大样本以生成样本的封包，载有物质（譬如充填有烟雾）的取样导管已经稀释被“放大”程序在其内所生成的封包。由于整体导管可同时被校准物质所淹没，且同时生成多个、物理性分离的稀释封包，所以在同一时间有更大数目的取样孔可进行校准。

[0519]　为了实行这种系统和方法，取样导管的充填可经由取样入口以人工进行，或更佳地，取样网络可配合有入口，诸如栓嘴 (spigot)（譬如附件 2800 或局部化模块 2004 的部份）。由于在多导管实施例中可一次校准所有的导管，所以后者或许更为方便。入口流体性导通于具有经近似调节的输出的校准物质的供应件。校准物质的源可被永久性或在校准期间暂时性连接至入口并能够周期性校准及自我测试。

[0520]　将了解：此说明书中所公开及限定的发明延伸至从文字或附图中所提及或得知的两个或更多个分别的特征构造的所有替代性组合。所有这些不同组合构成本发明的不同的可替代方面。

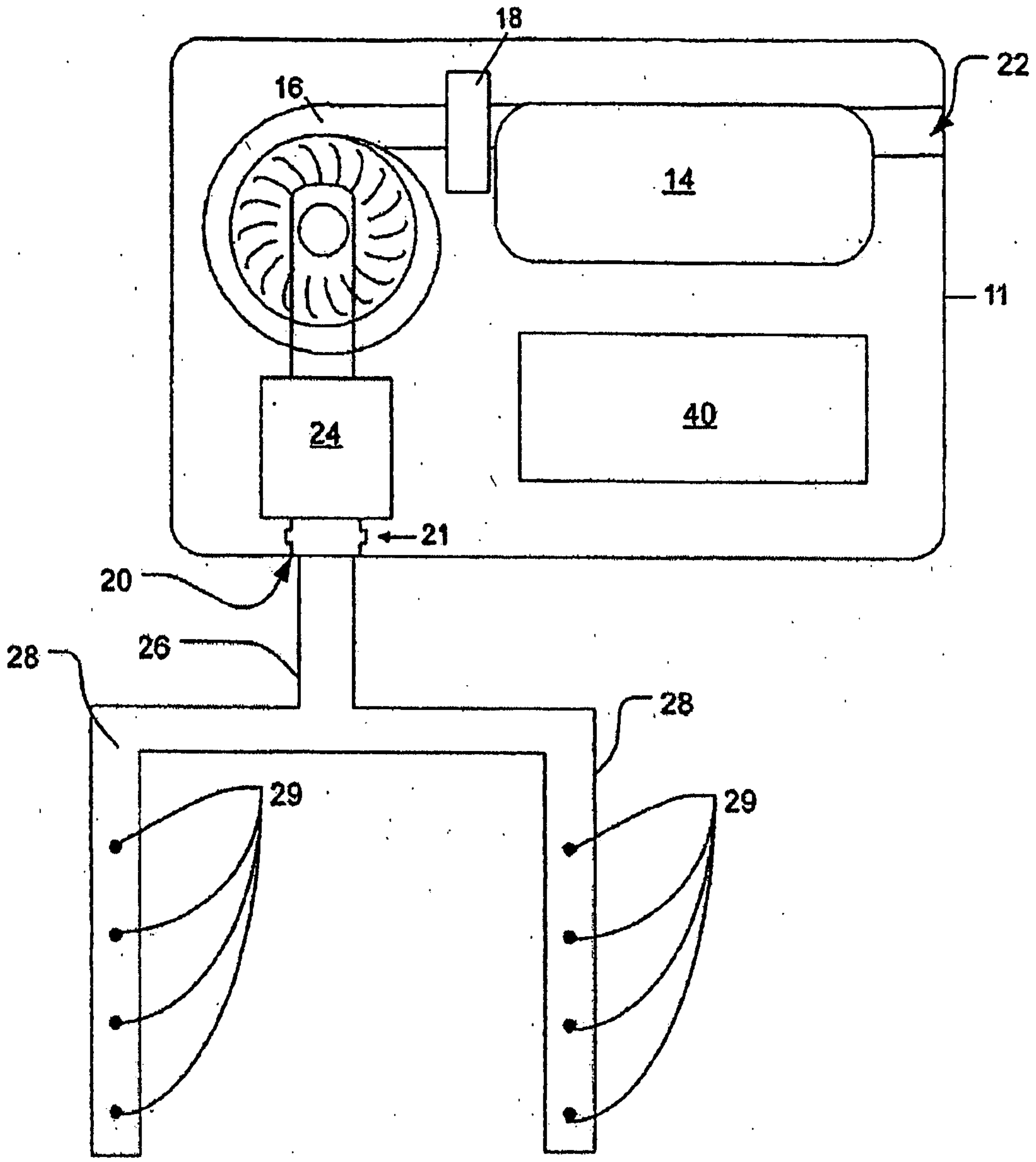


图 1

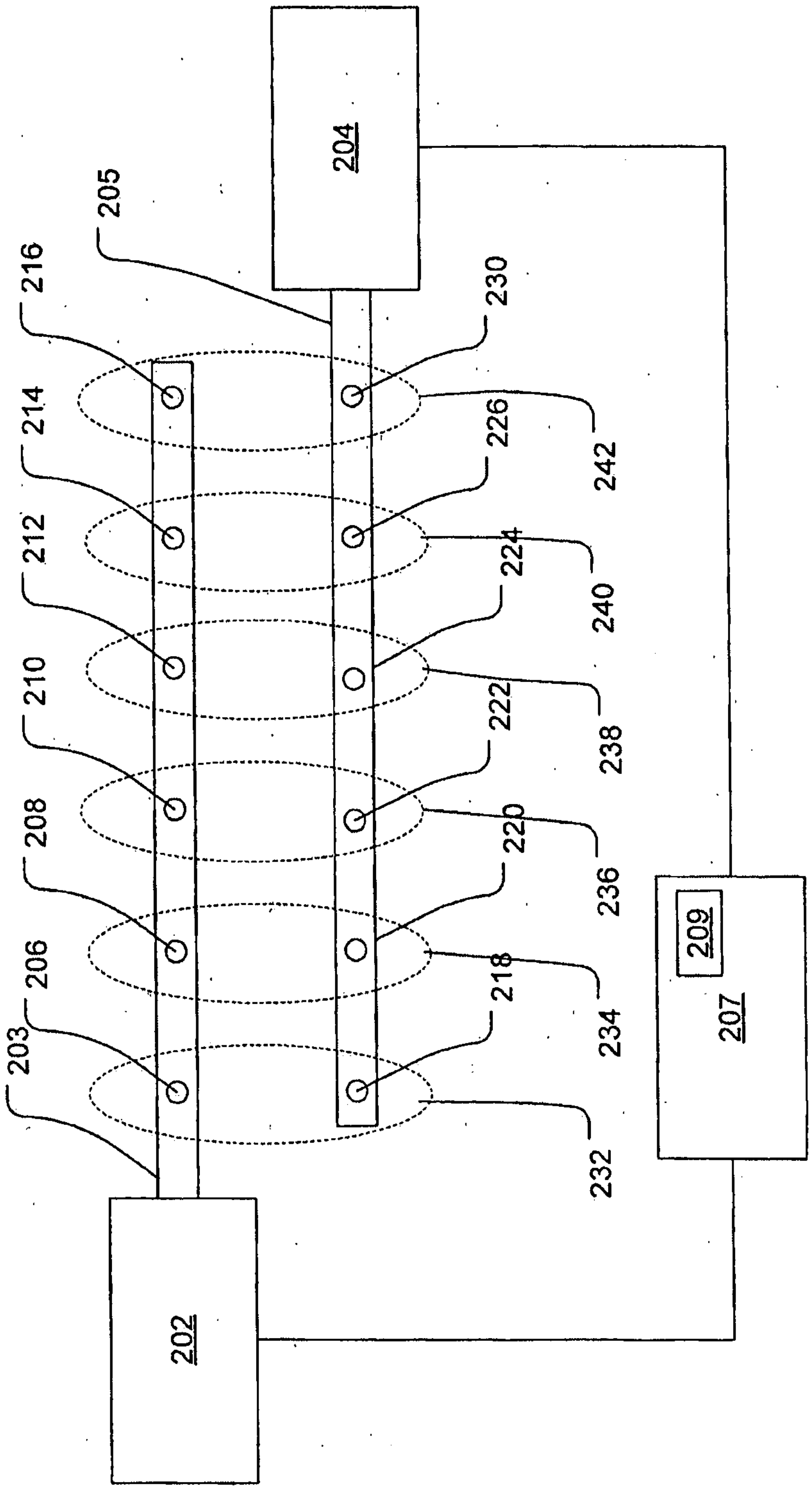

204
205
216
230
214
226
242
212
224
240
210
222
238
208
220
236
206
203
218
234
209
207
232
202

图 2

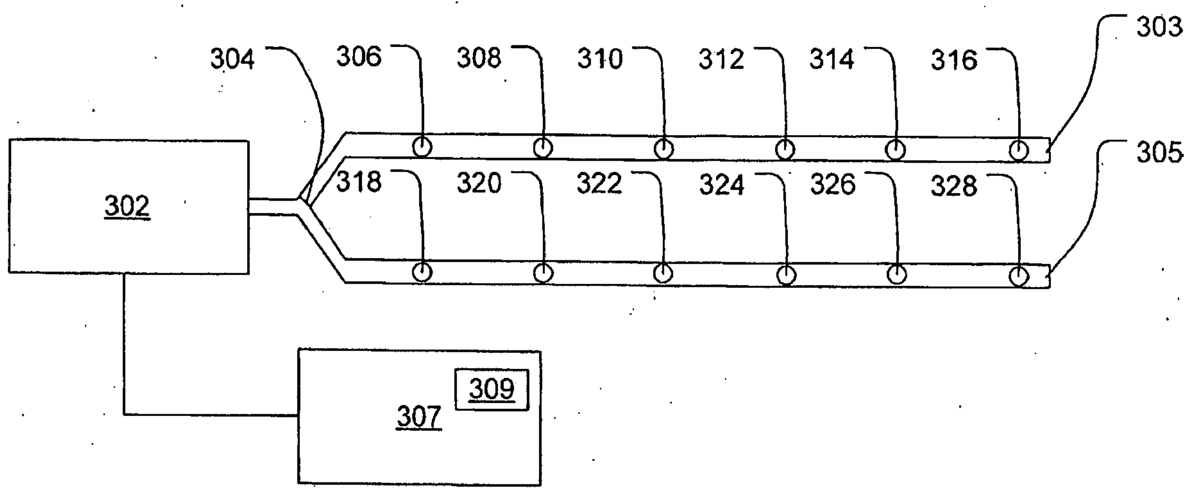

304
306
308
310
312
314
316
303
305
318
320
322
324
326
328
302
307
309

图 3

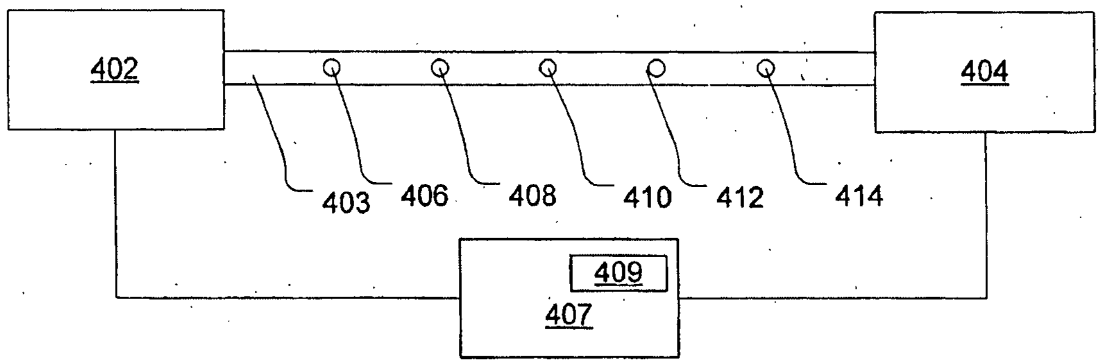

402
404
403
406
408
410
412
414
409
407

图 4

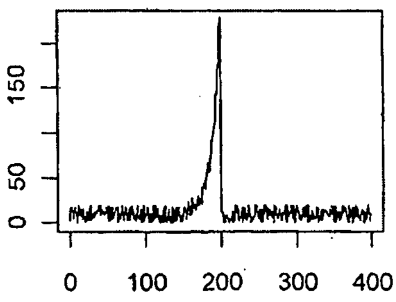

150
50
0
0
100
200
300
400

图 5

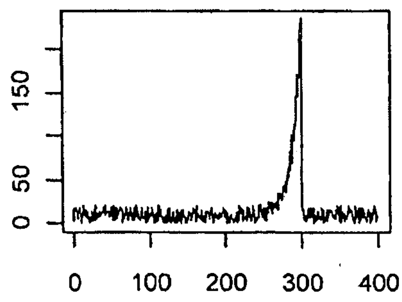
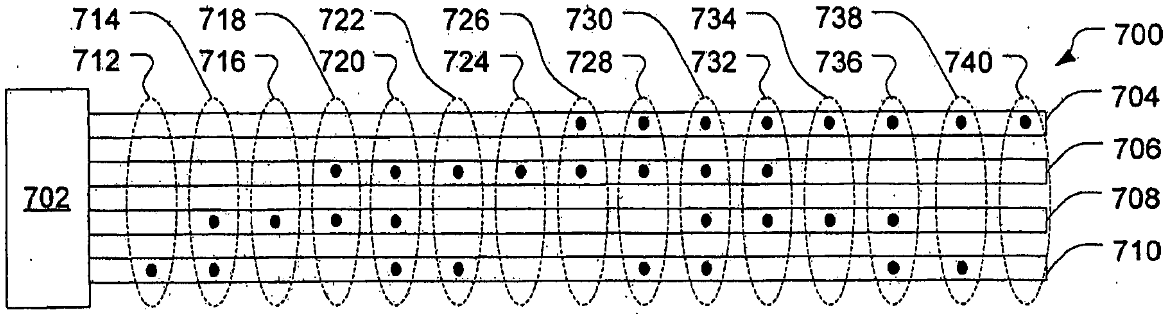

150
50
0
0
100
200
300
400

图 6



位置	格雷码地址	探测到烟雾？			
		导管1	导管2	导管3	导管4
1	0001	否	否	否	是
2	0011	否	否	是	是
3	0010	否	否	是	否
4	0110	否	是	是	否
5	0111	否	是	是	是
6	0101	否	是	否	是
7	0100	否	是	否	否
8	1100	是	是	否	否
9	1101	是	是	否	是
10	1111	是	是	是	是
11	1110	是	是	是	否
12	1010	是	否	是	否
13	1011	是	否	是	是
14	1001	是	否	否	是
15	1000	是	否	否	否

图 7

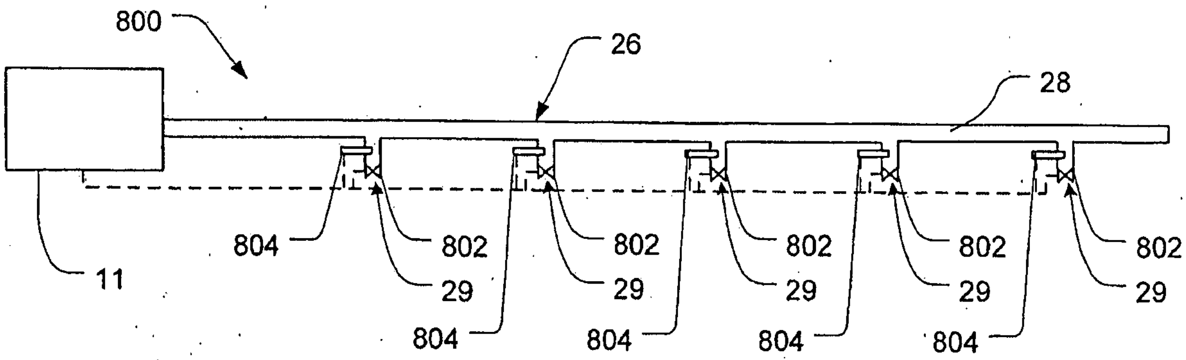


图 8

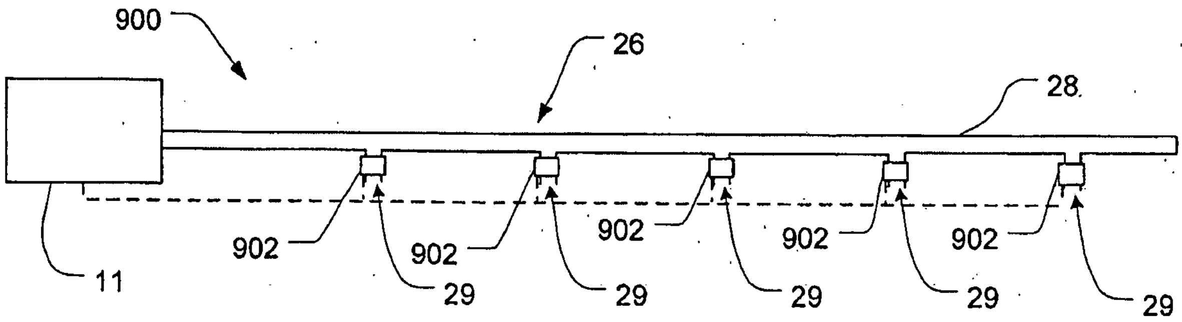

900
26
28
902
902
902
902
902
11
29
29
29
29
29

图 9A

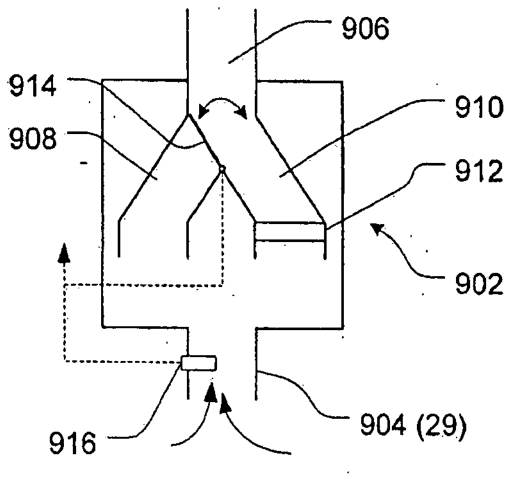

906
914
910
908
912
902
916
904 (29)

图 9B

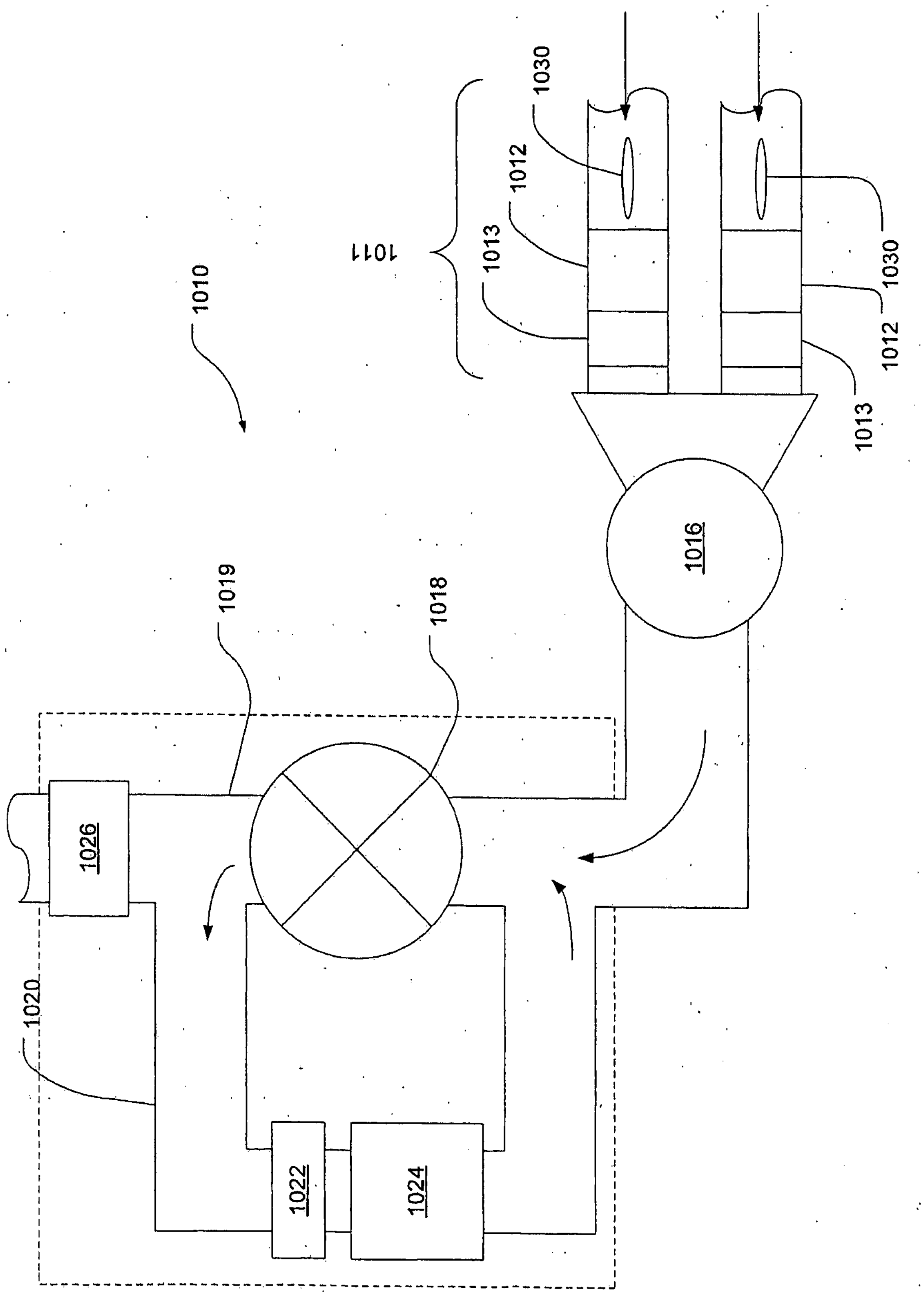

1030
1012
1013
1011
1030
1012
1013
1010
1016
1019
1018
1026
1020
1022
1024

图 10A

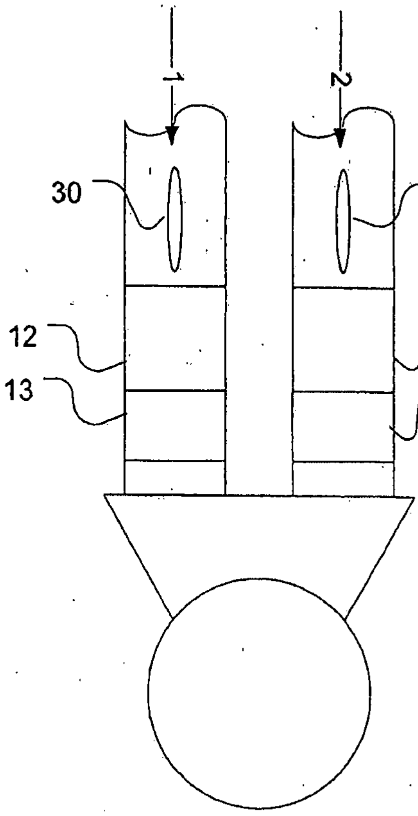


图10B

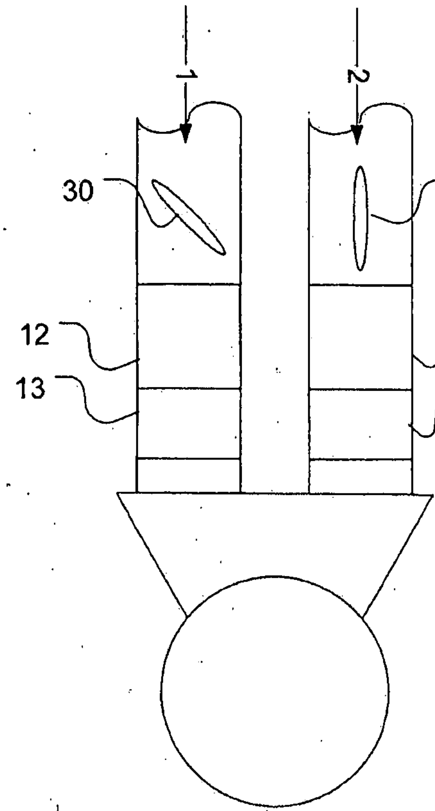


图10C

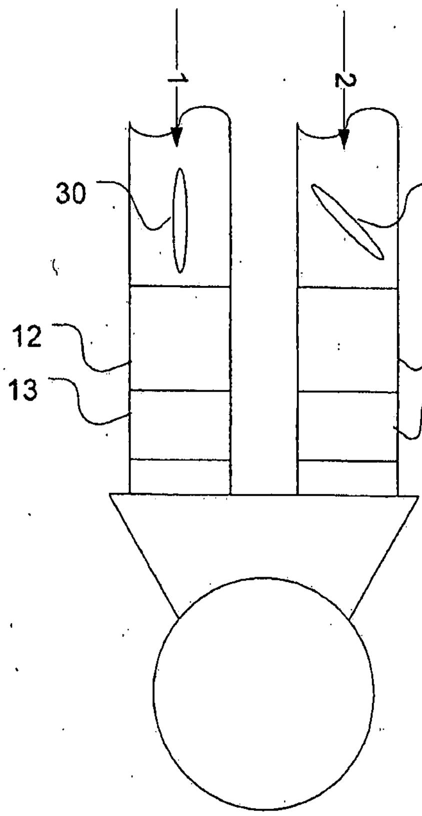


图10D

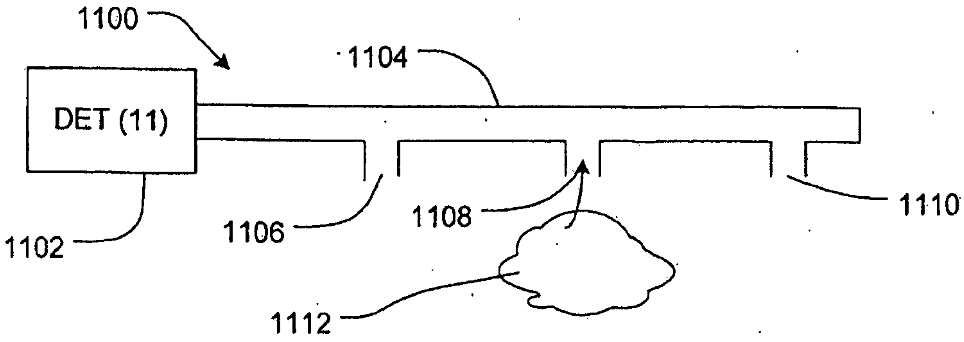


图 11A

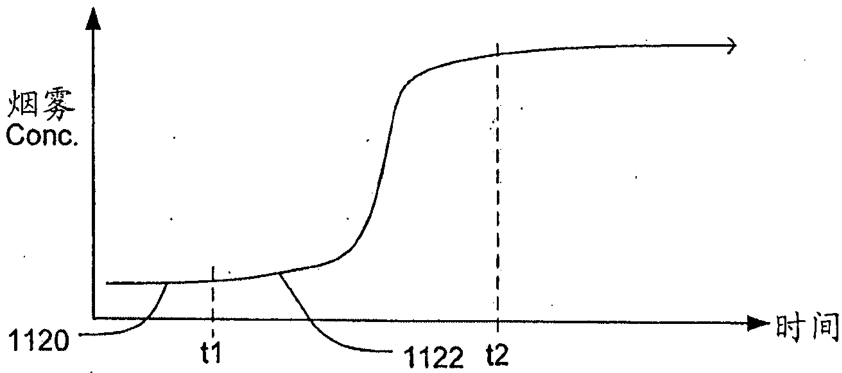


图 11B

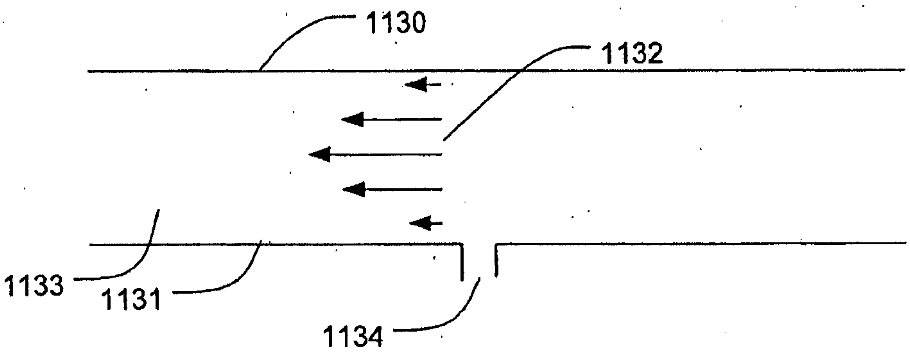


图 11C

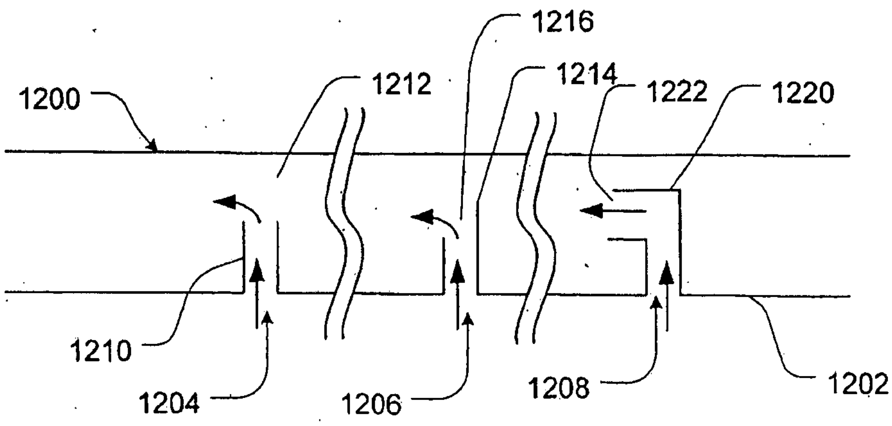


图 12

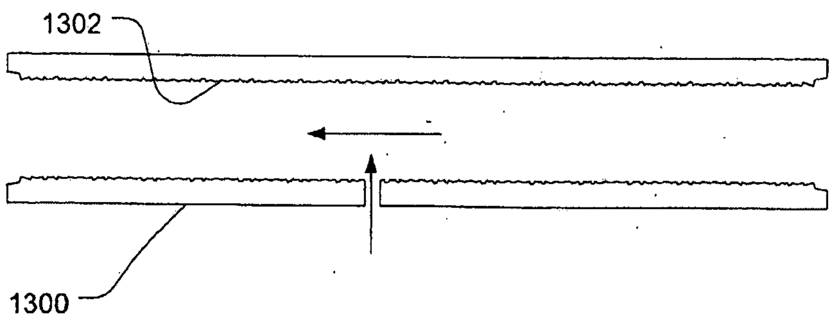


图 13A

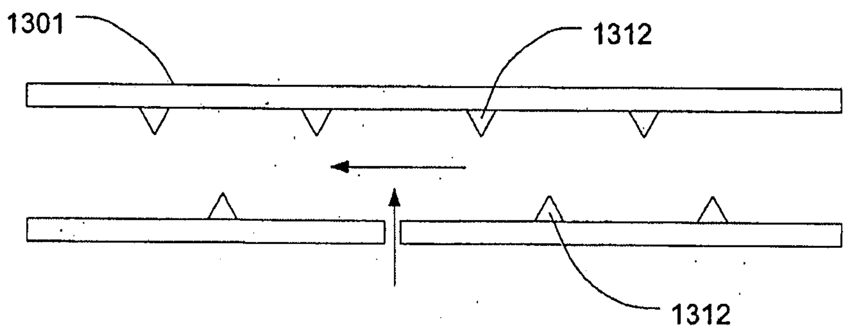


图 13B

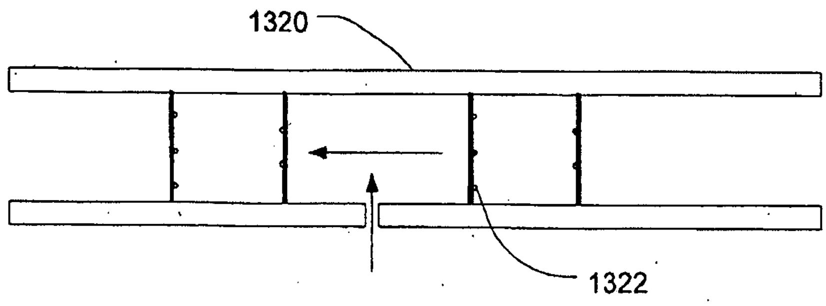


图 13C

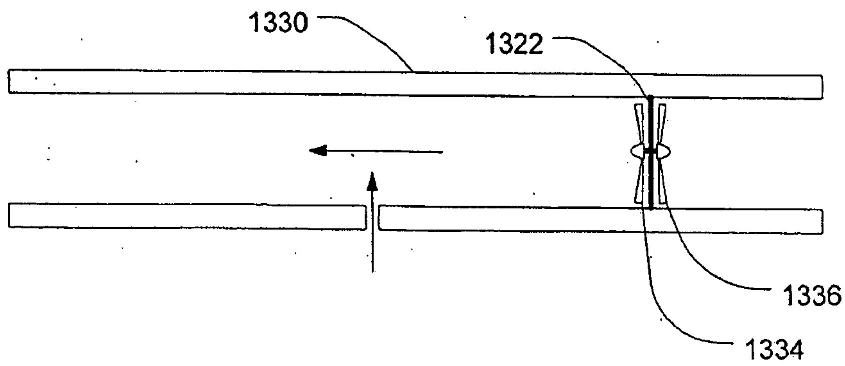


图 13D

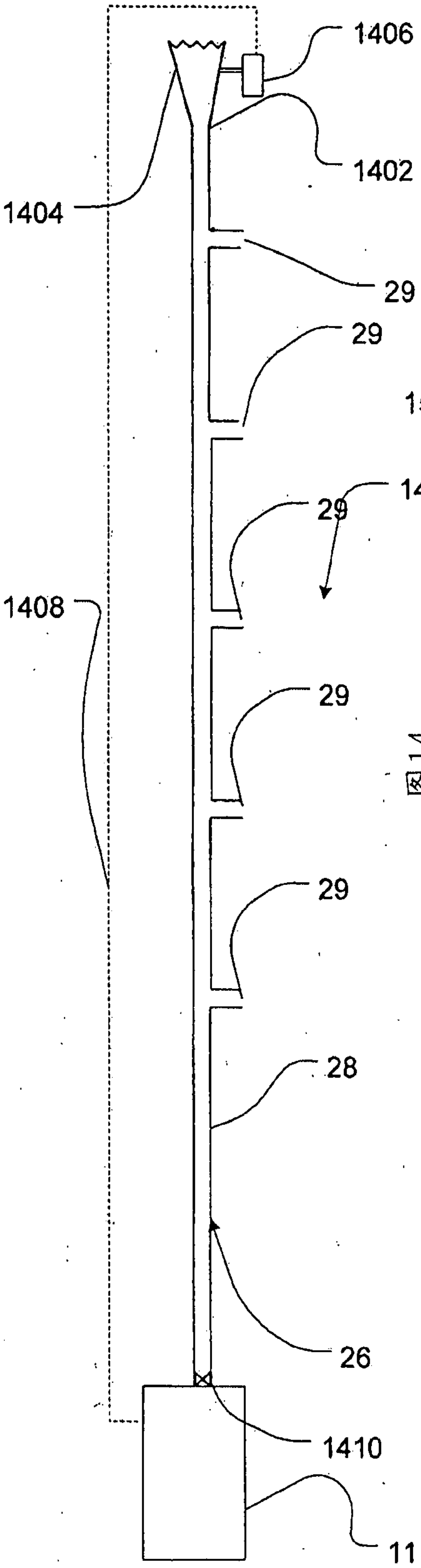

1406
1402
1404
29
29
1400
29
1408
29
29
28
26
1410
11

图14

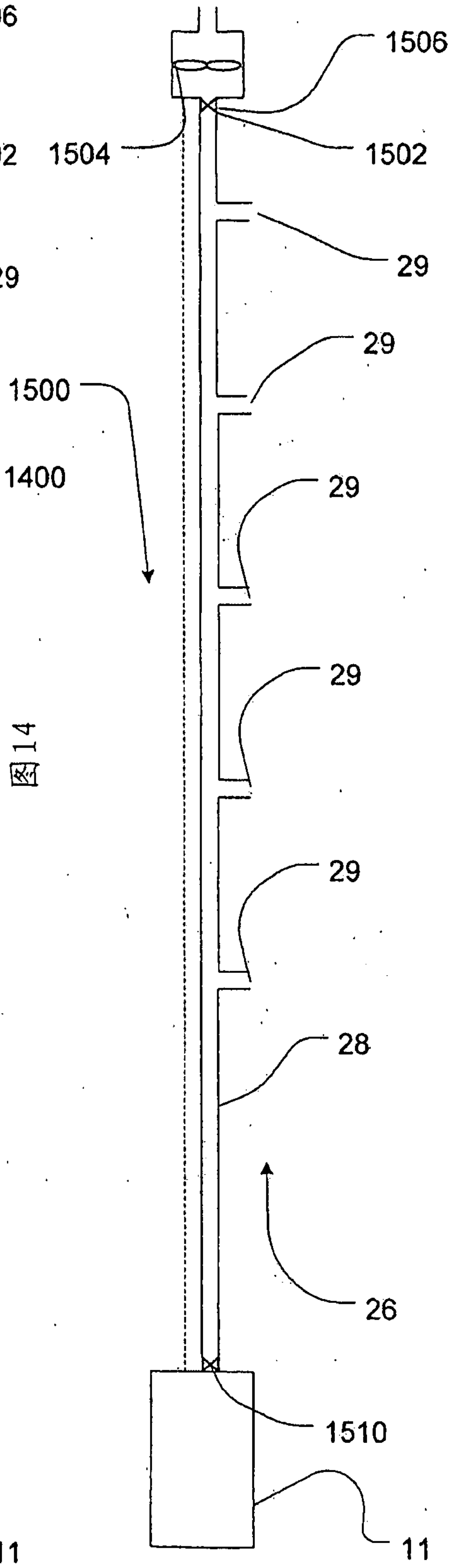

1506
1504
1502
29
29
1500
29
29
29
28
26
1510
11

图15

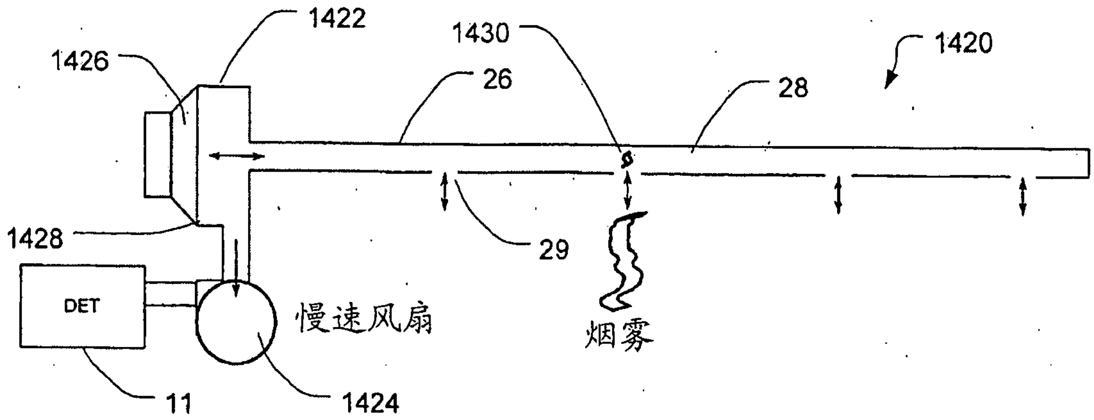


图 14A

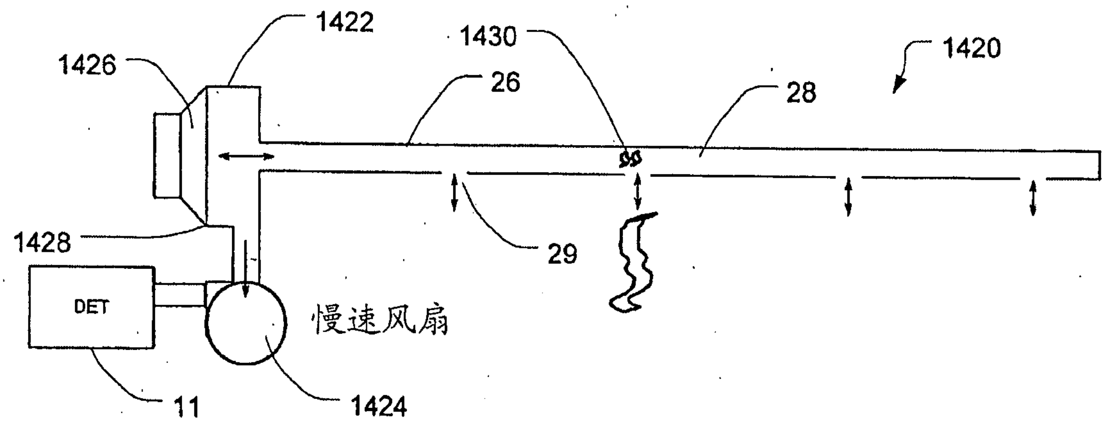


图 14B

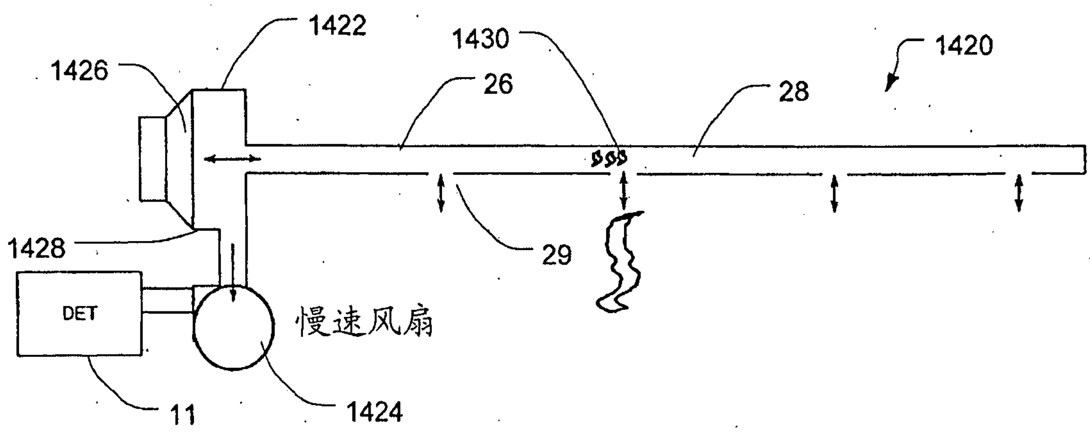


图 14C

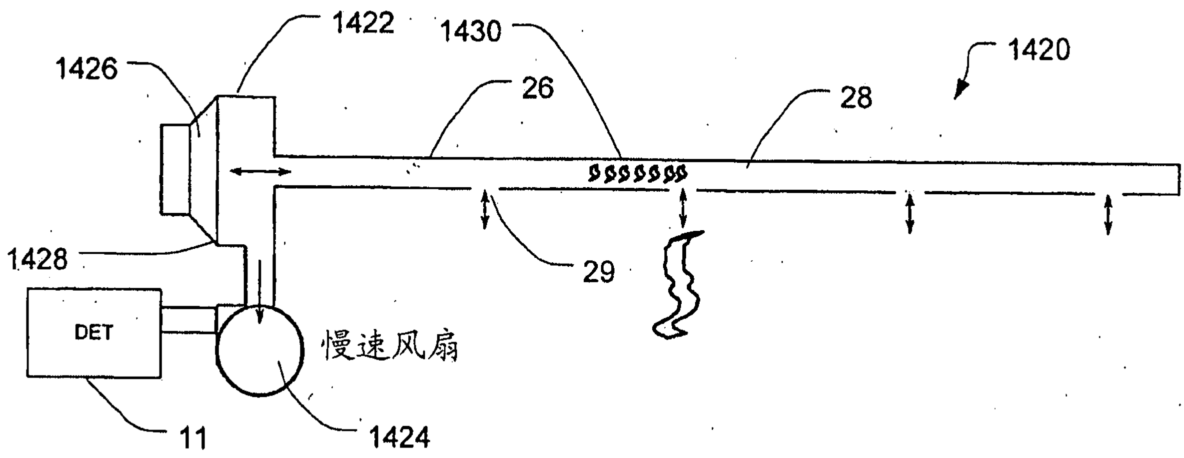

1422
1430
1420
1426
26
28
1428
29
DET
慢速风扇
11
1424

图 14D

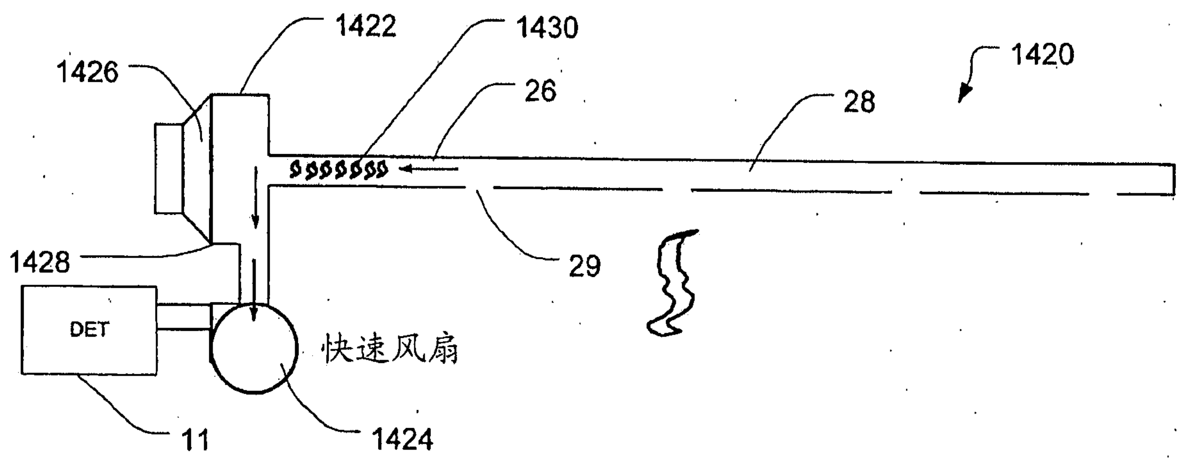

1422
1430
1420
1426
26
28
1428
29
DET
快速风扇
11
1424

图 14E

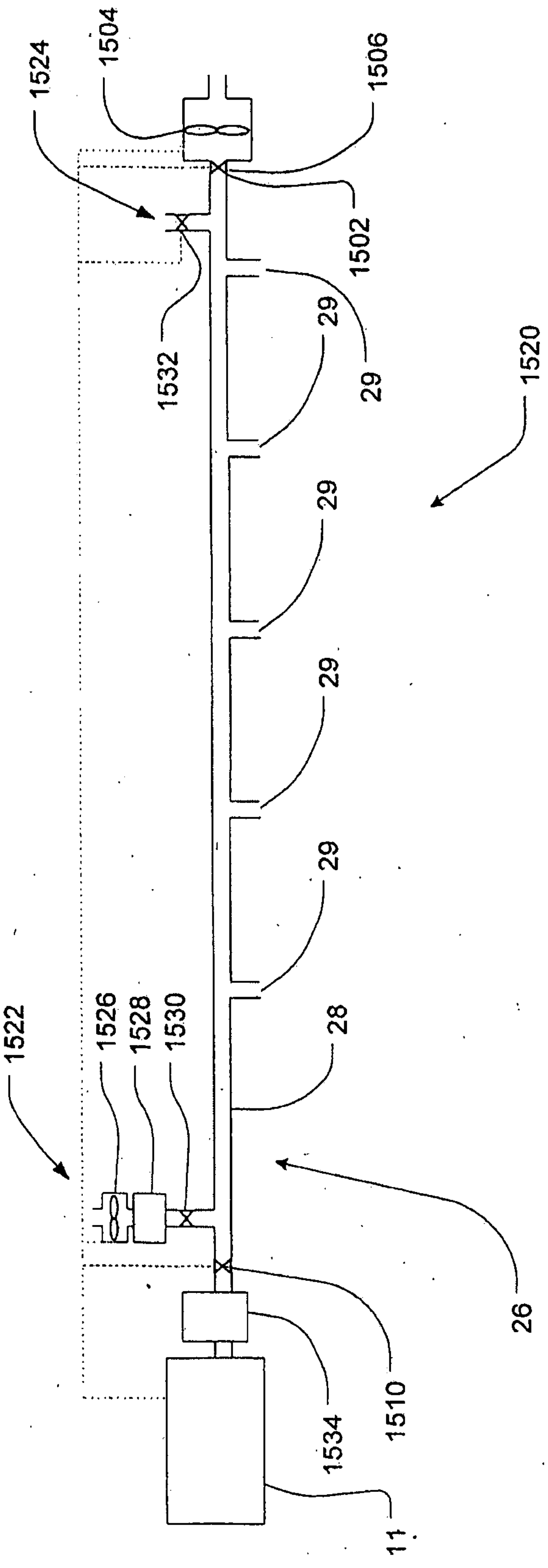

1524
1504
1506
1502
1532
29
29
29
29
29
29
1520
1522
1526
1528
1530
28
26
1534
1510
11

图 15B

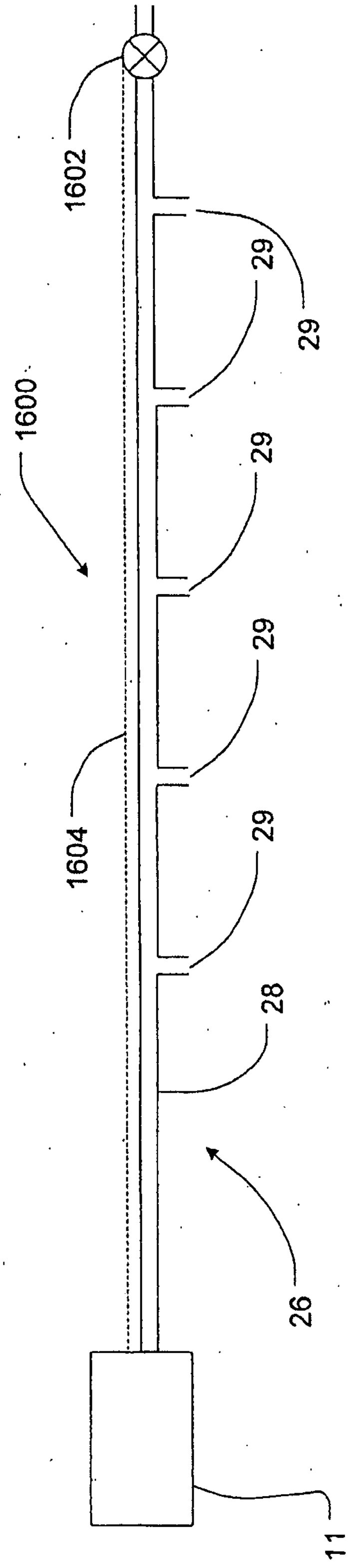

1602
29
29
29
29
29
1600
1604
28
26
11

图 16

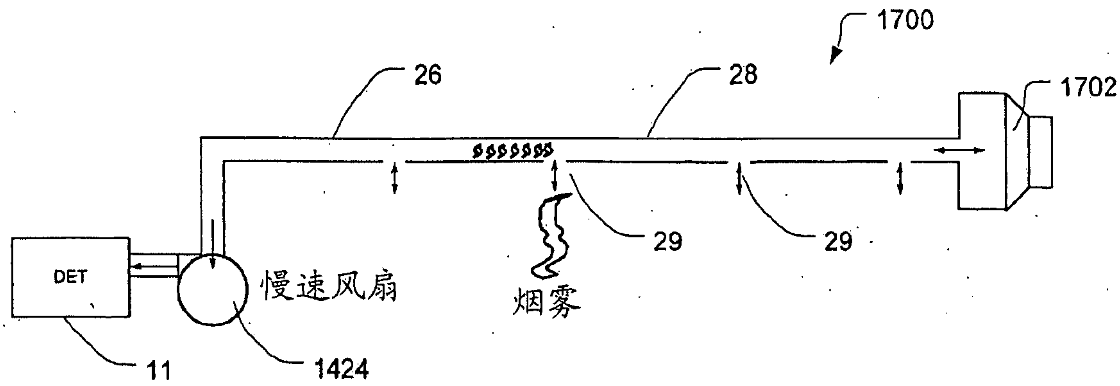

1700
26
28
1702
29
29
DET
慢速风扇
烟雾
11
1424

图 17

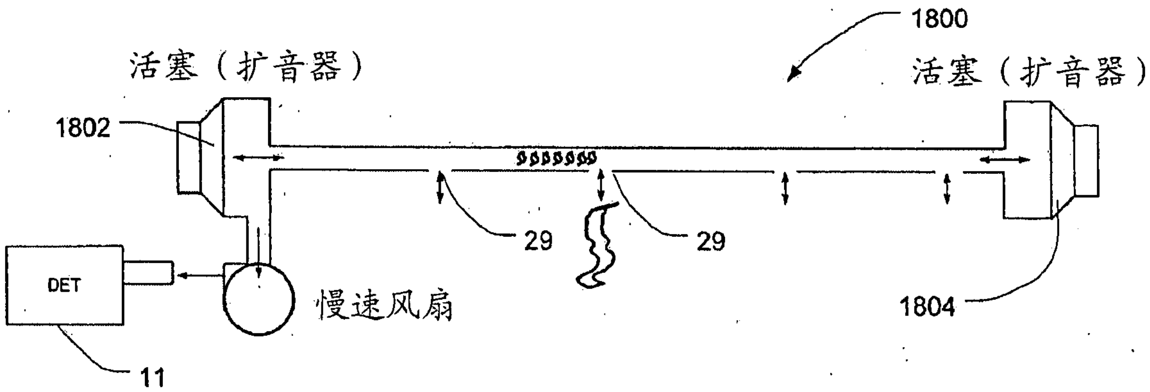
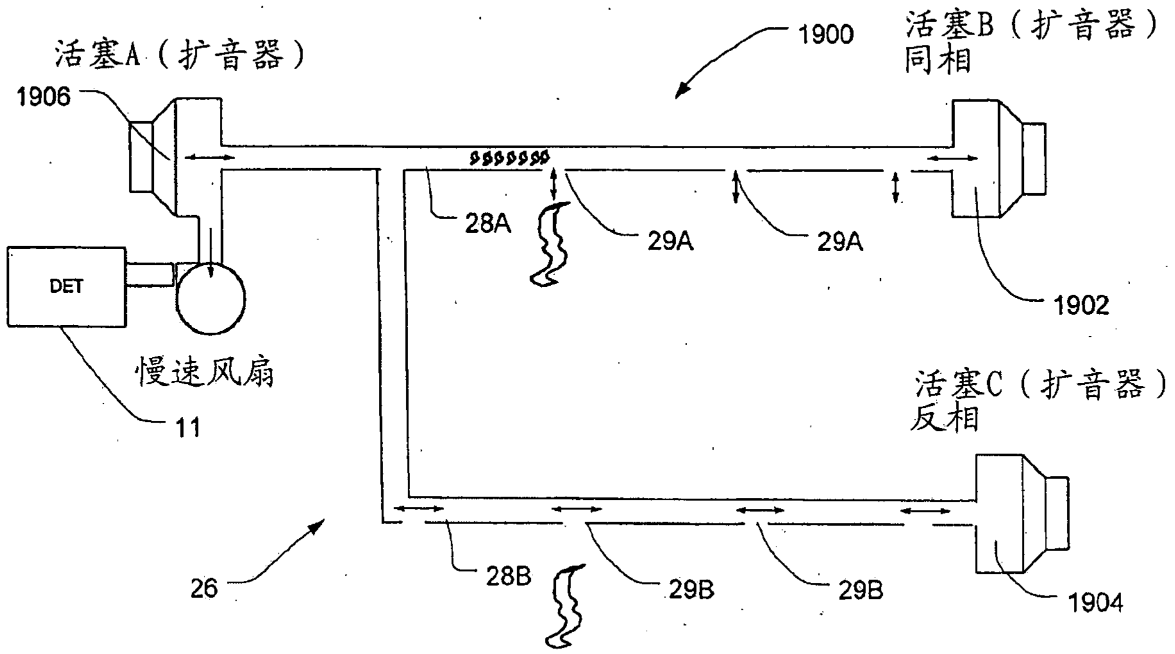

1800
活塞（扩音器）
活塞（扩音器）
1802
29
29
DET
慢速风扇
1804
11

图 18



活塞A（扩音器）
1906
1900
活塞B（扩音器）
同相
DET
28A
29A
29A
1902
慢速风扇
11
活塞C（扩音器）
反相
26
28B
29B
29B
1904

图 19

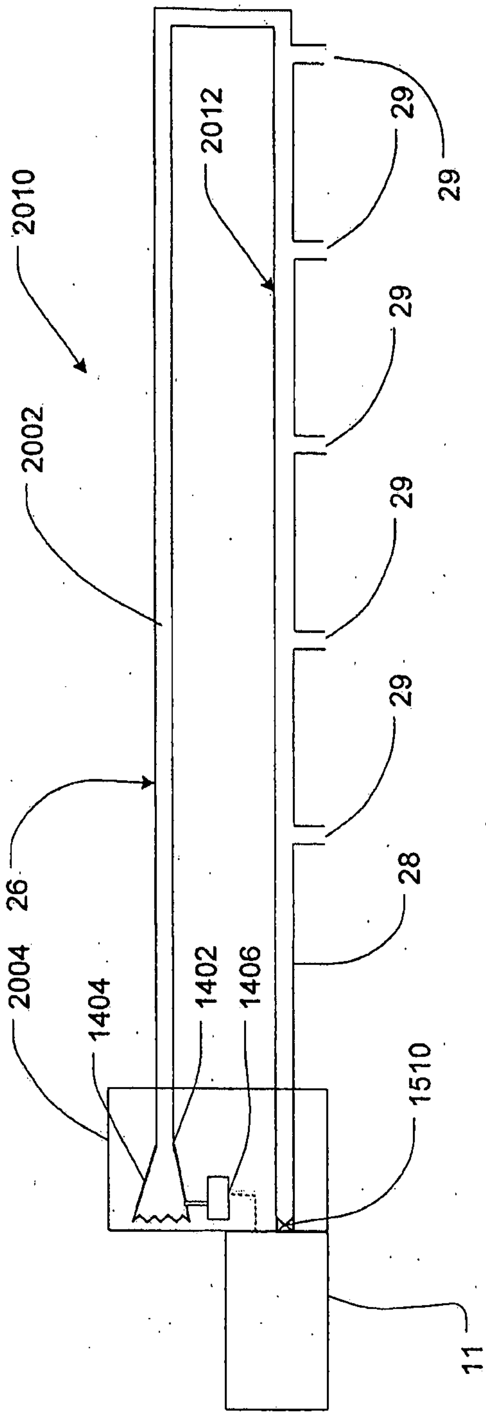

2010
2012
29
29
29
29
29
29
2002
26
2004
1404
1402
1406
28
1510
11

图 20A

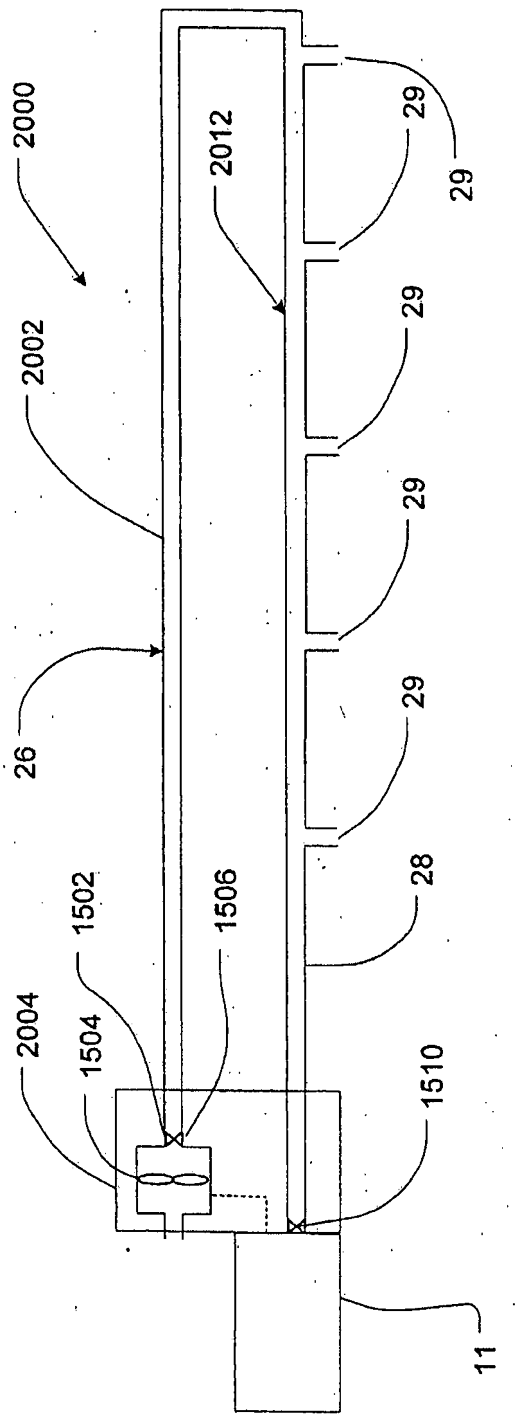

2000
2012
29
29
29
29
29
29
2002
26
1502
1506
2004
1504
28
1510
11

图 20B

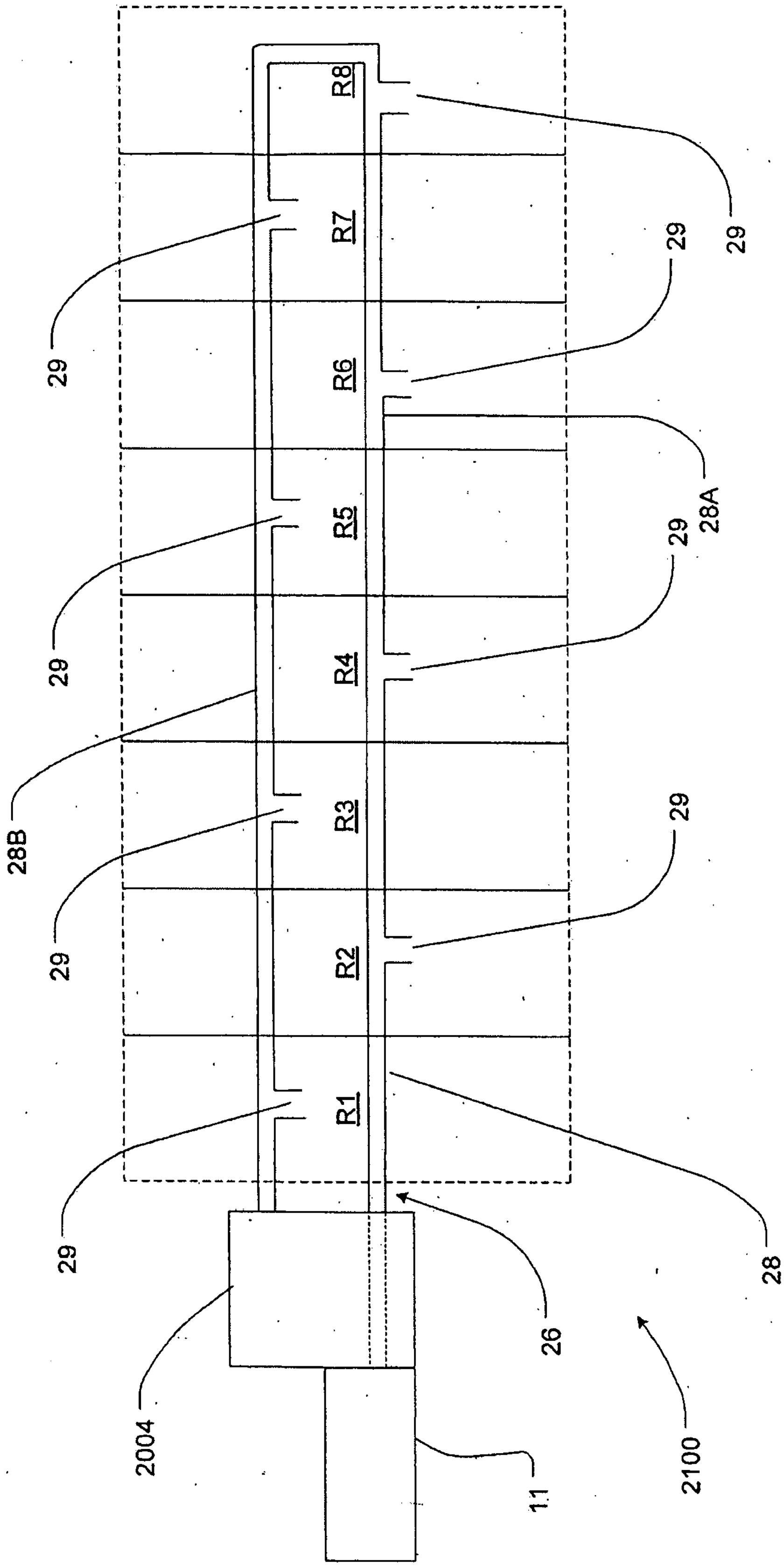


图 21

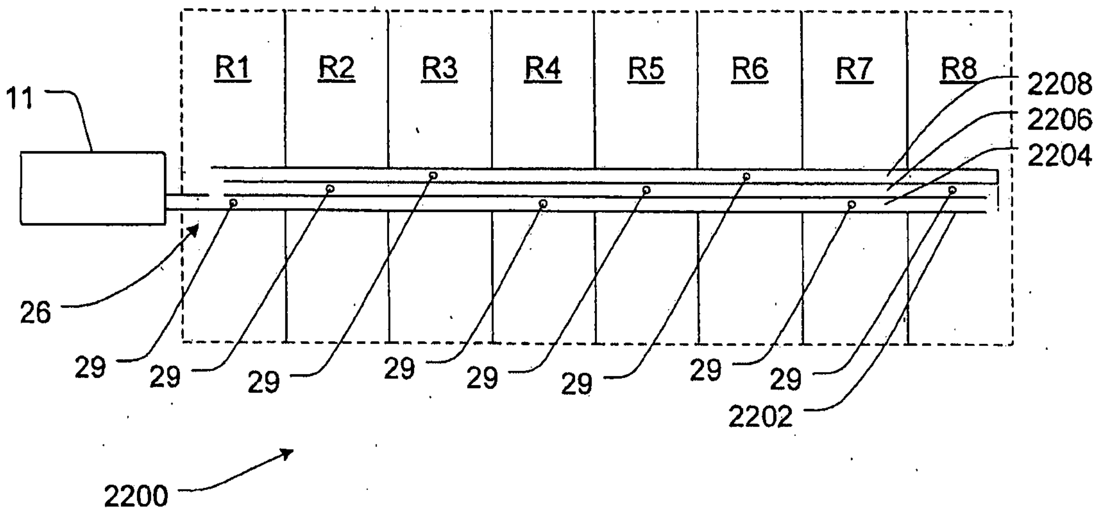

R1
R2
R3
R4
R5
R6
R7
R8
11
2208
2206
2204
26
29
29
29
29
29
29
29
29
2202
2200

图 22

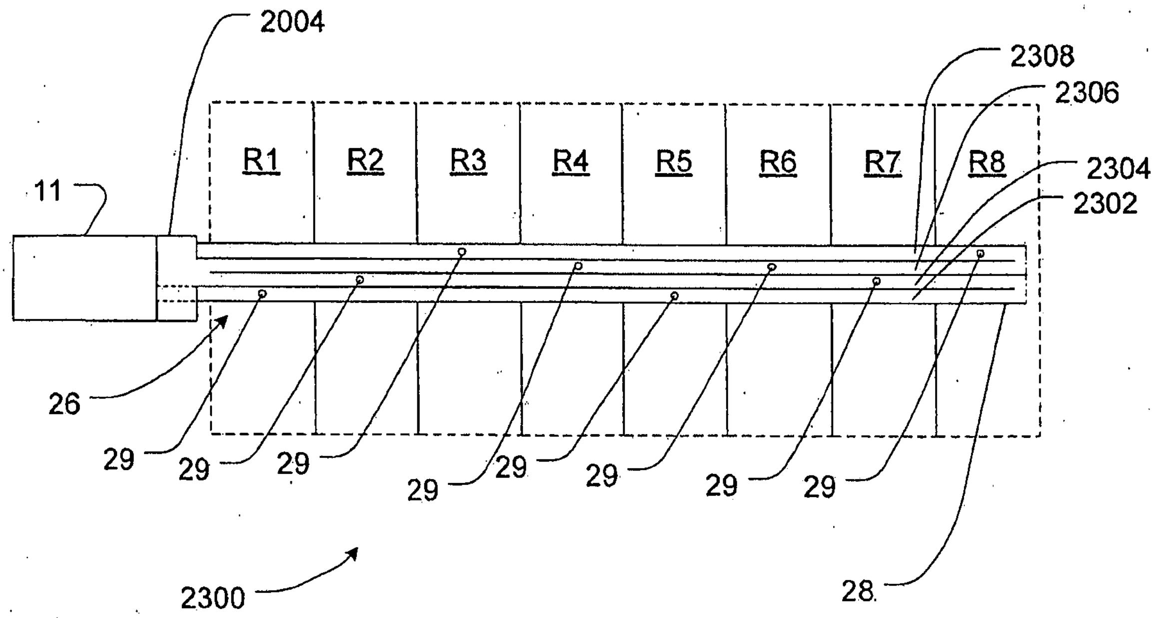

2004
2308
2306
R1
R2
R3
R4
R5
R6
R7
R8
2304
11
2302
26
29
29
29
29
29
29
29
29
2300
28

图 23

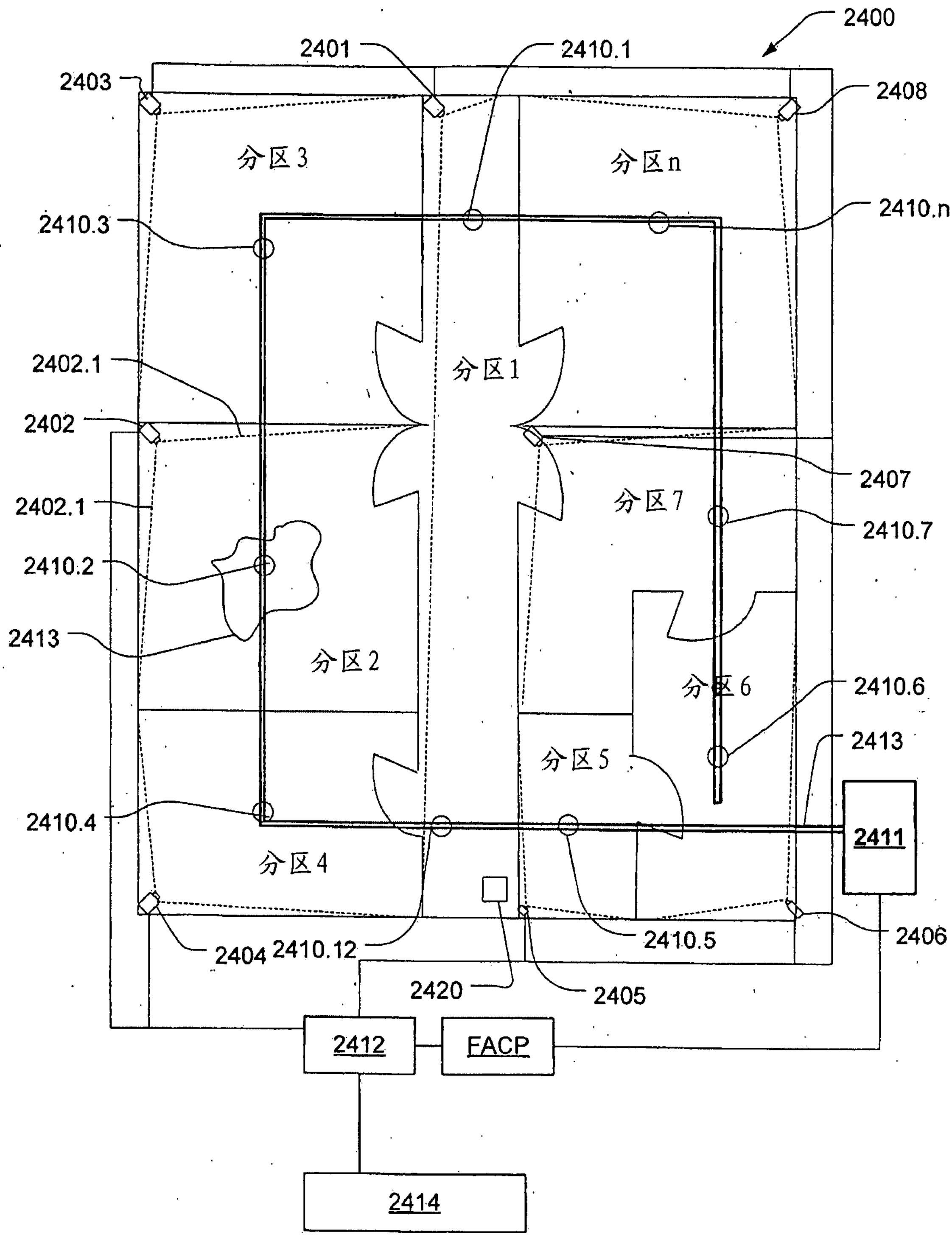

2400
2401
2410.1
2403
2408
分区 3
分区 n
2410.3
2410.n
分区 1
2402.1
2402
2407
2402.1
分区 7
2410.7
2410.2
2413
分区 2
分区 6
2410.6
2413
分区 5
2410.4
2411
分区 4
2404
2410.12
2410.5
2406
2420
2405
2412
FACP
2414

图 24

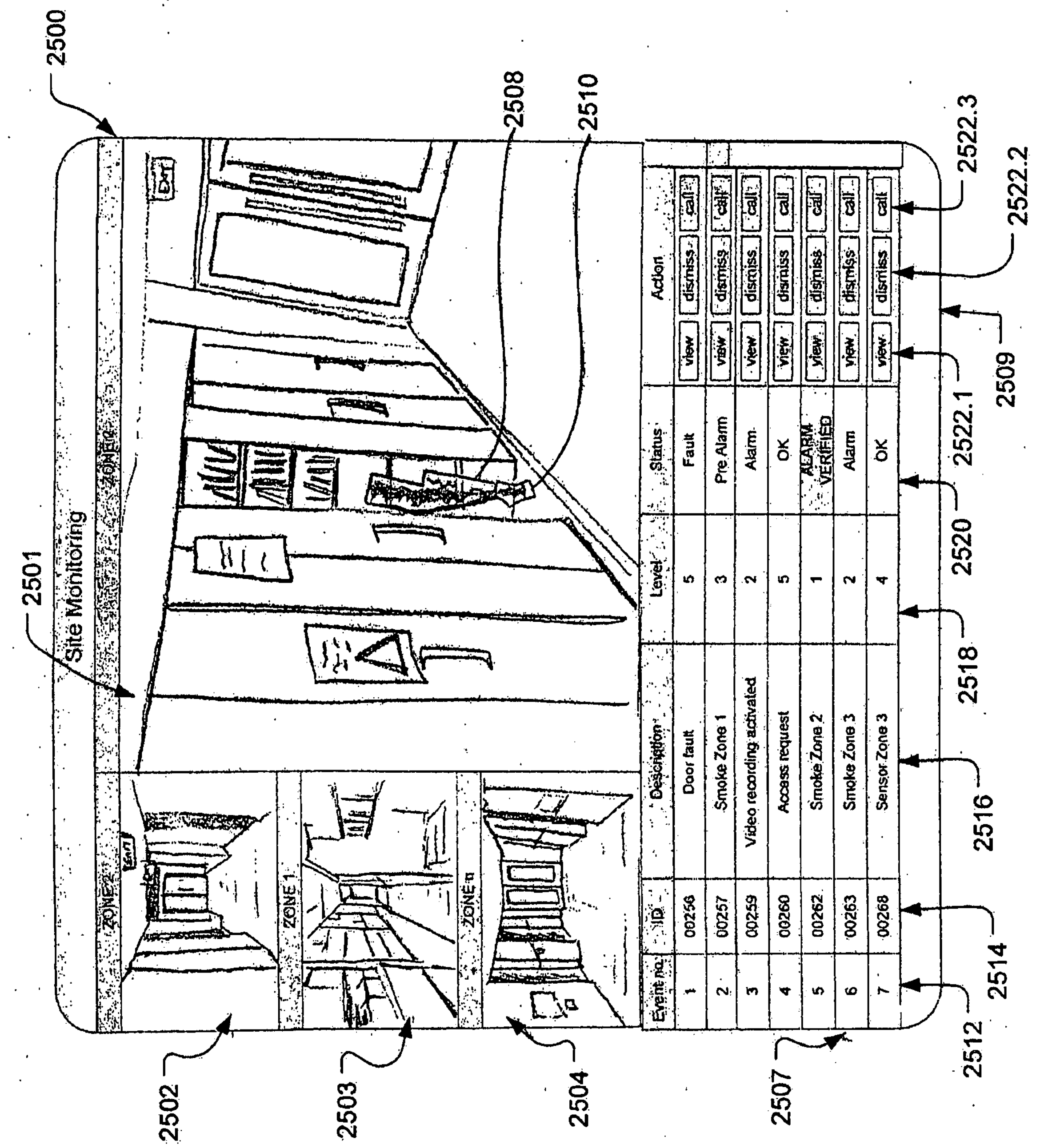

2500
2501
Site Monitoring
2508
2510
2502
2503
2504
2507
ZONE 2
ZONE 1
Event no.
ID
Description
Level
Status
Action
1
00256
Door fault
5
Fault
2
00257
Smoke Zone 1
3
Pre Alarm
3
00259
Video recording activated
2
Alarm
4
00260
Access request
5
OK
5
00262
Smoke Zone 2
1
ALARM VERIFIED
6
00263
Smoke Zone 3
2
Alarm
7
00268
Sensor Zone 3
4
OK
view
dismiss
call
2512
2514
2516
2518
2520
2522.1
2509
2522.2
2522.3

图 25

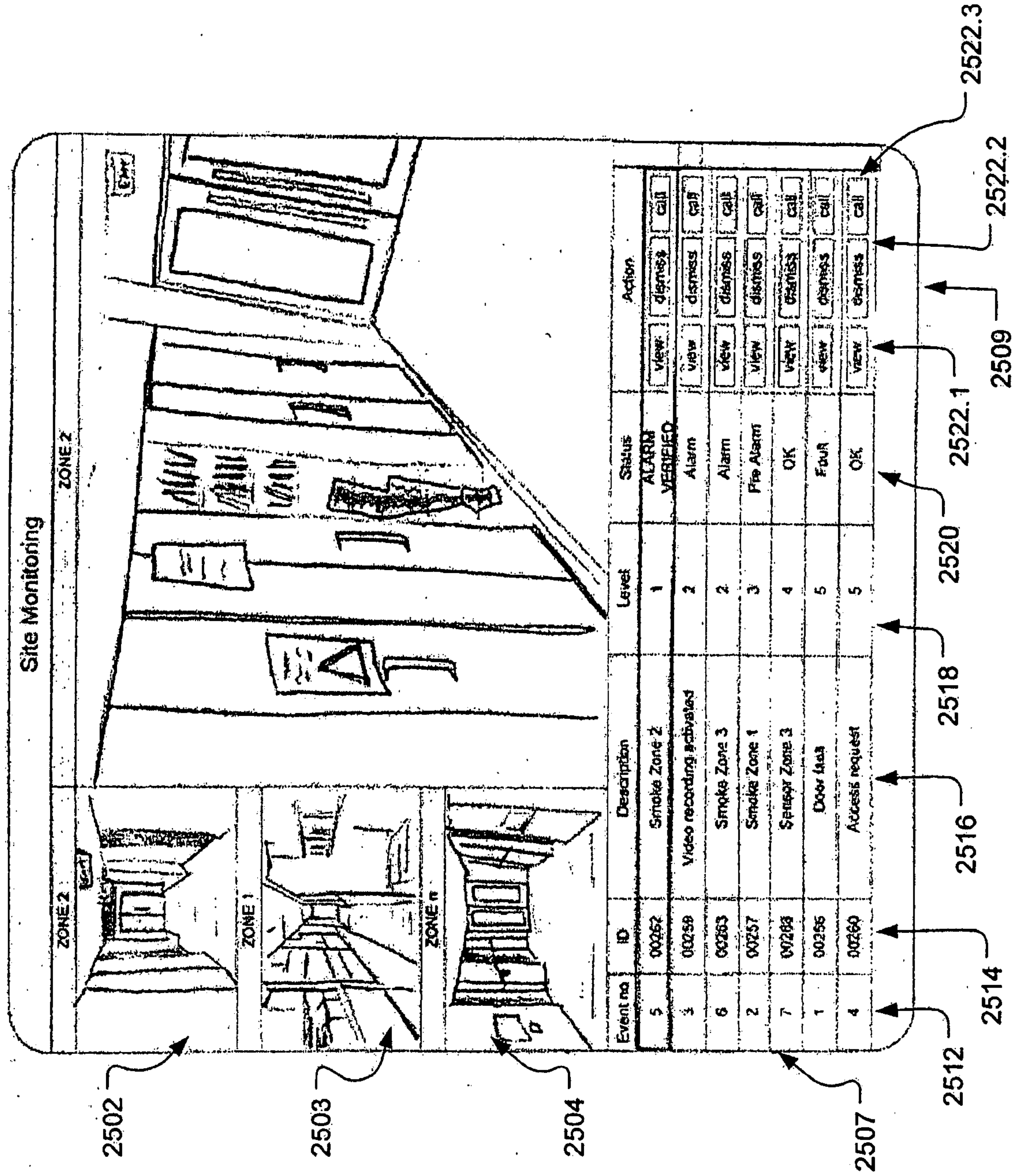

Site Monitoring
ZONE 2
ZONE 1
Event no
ID
Description
Level
Status
Action
5
00262
Smoke Zone 2
1
ALARM VERIFIED
3
00259
Video recording activated
2
Alarm
6
00263
Smoke Zone 3
2
Alarm
2
00257
Smoke Zone 1
3
Fire Alarm
7
Sensor Zone 3
4
OK
1
00256
Door Mux
5
Fault
4
00260
Access request
5
OK
view
dismiss
call
2502
2503
2504
2507
2512
2514
2516
2518
2520
2522.1
2509
2522.2
2522.3

图 26

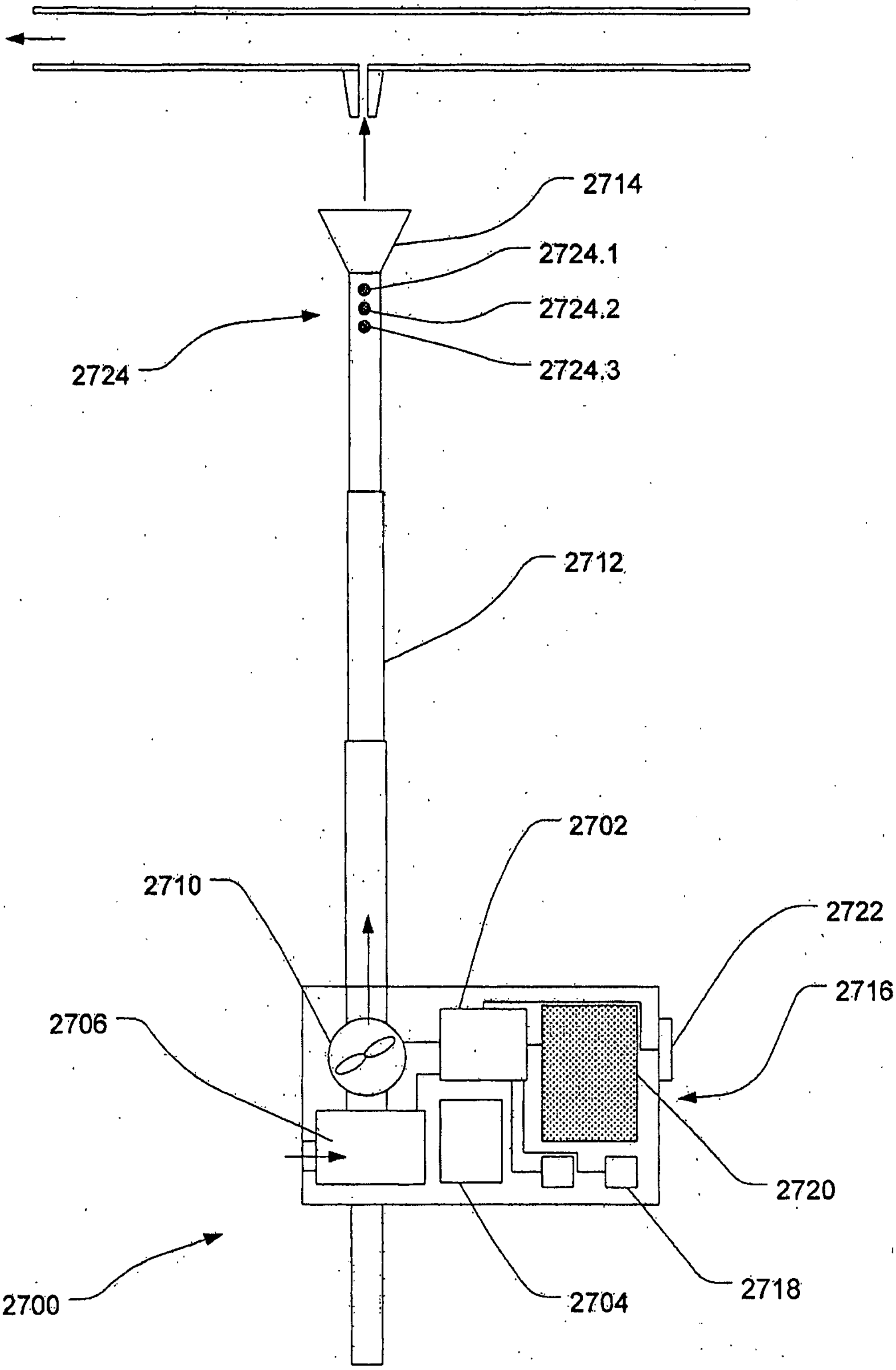

2714
2724.1
2724.2
2724
2724.3
2712
2702
2710
2722
2716
2706
2720
2718
2700
2704

图 27

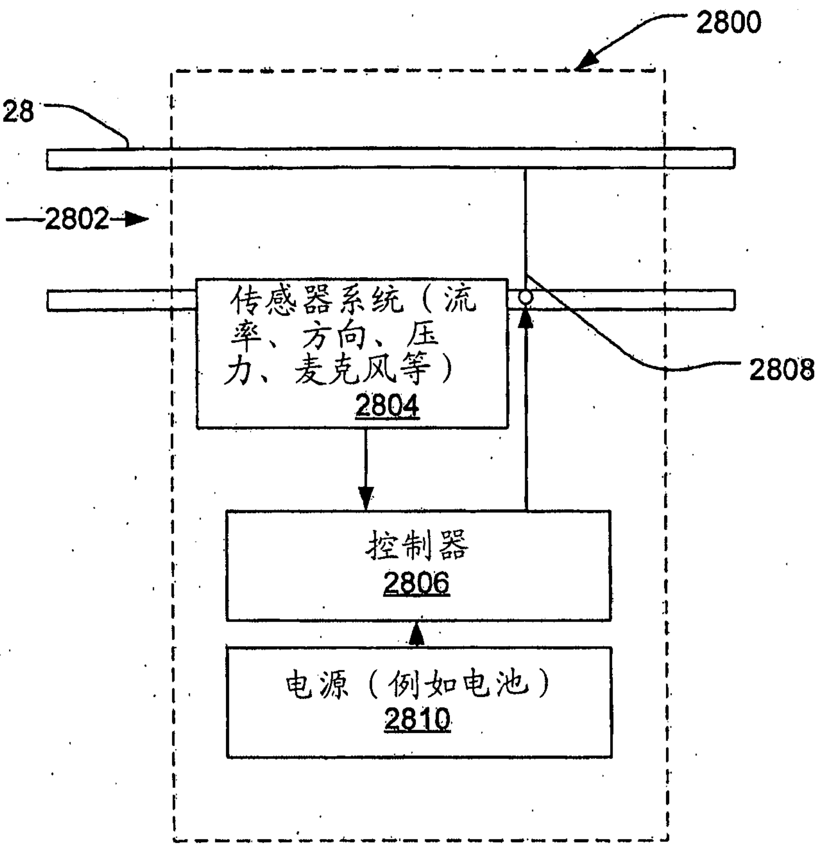

2800
28
2802
传感器系统（流率、方向、压力、麦克风等）
2804
2808
控制器
2806
电源（例如电池）
2810

图 28

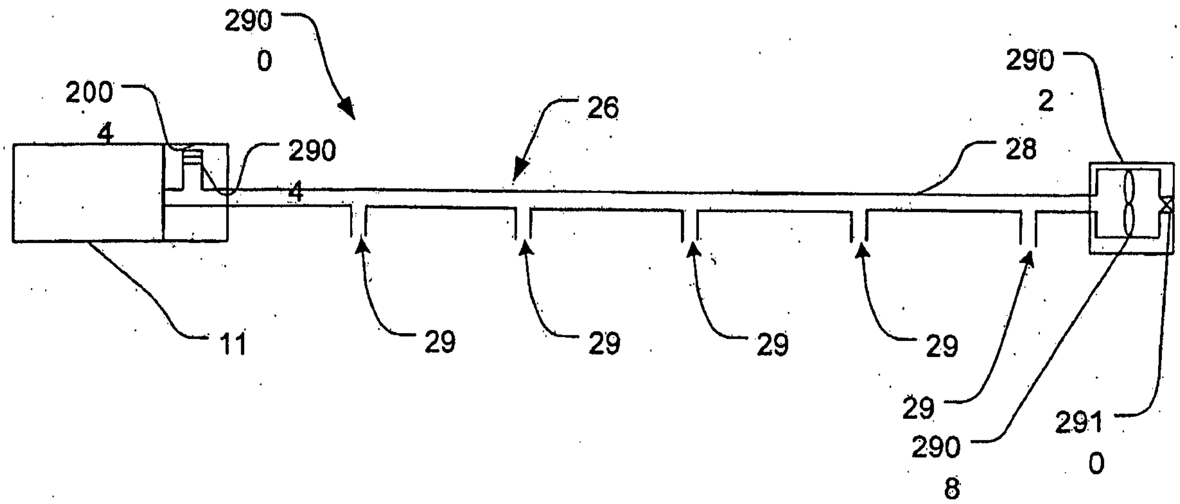

290
0
200
4
290
4
26
290
2
28
11
29
29
29
29
29
290
8
291
0

图 29

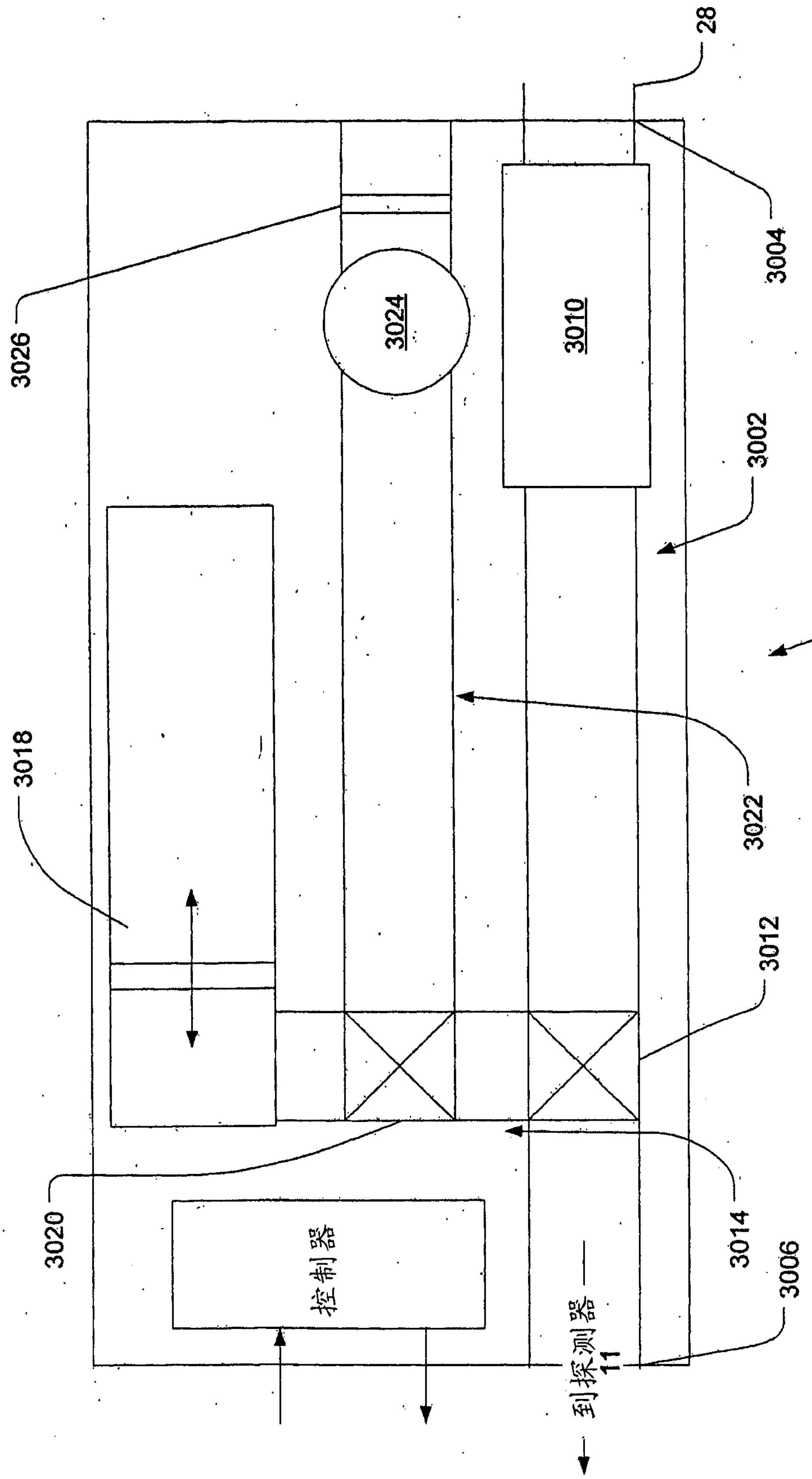

28
3004
3002
3000
3022
3012
3014
3006
3026
3024
3010
3018
3020
控制器
到探测器
11

图 30

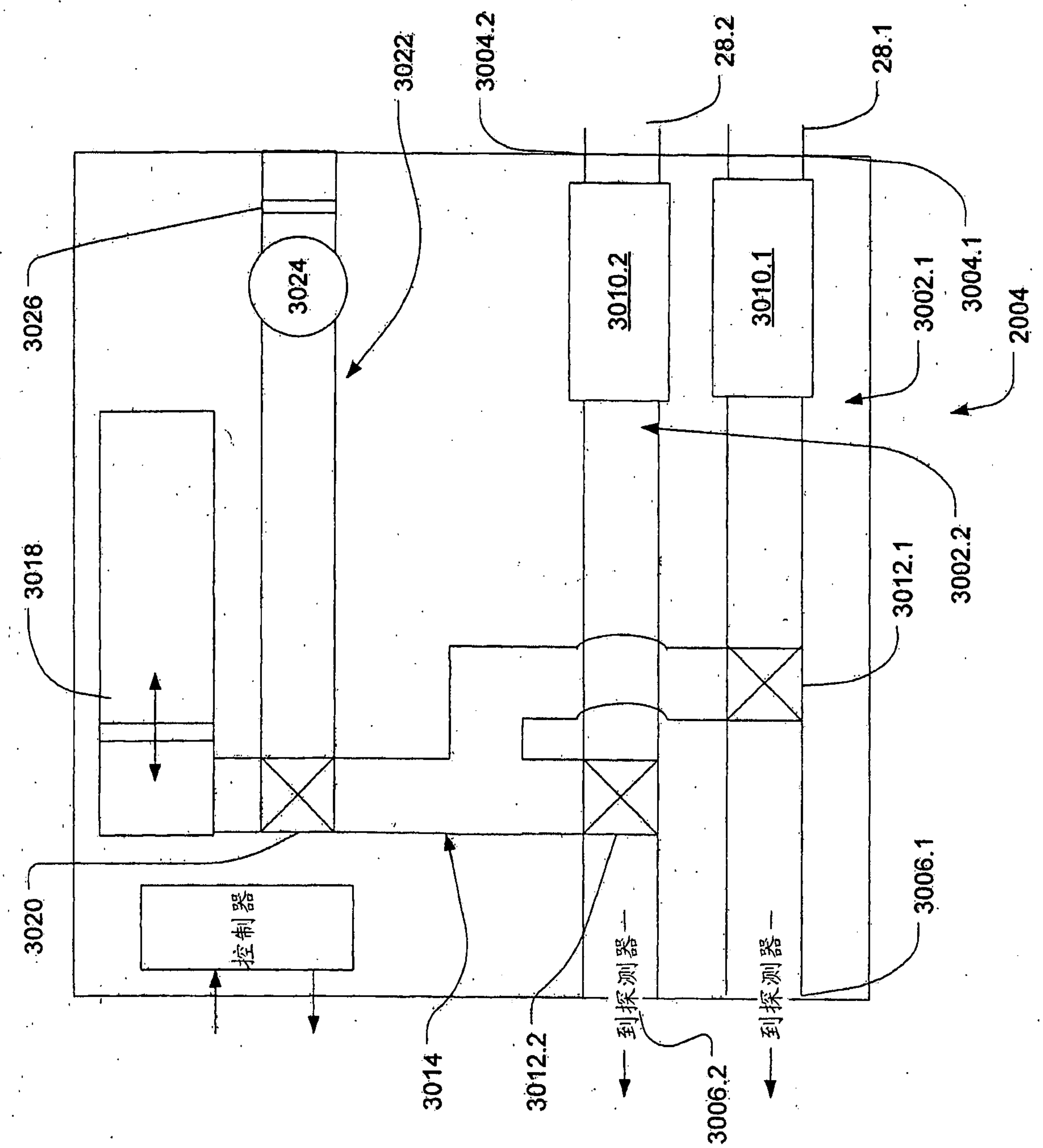

3022
3004.2
28.2
28.1
3026
3024
3010.2
3010.1
3002.1
3004.1
2004
3018
3002.2
3012.1
3006.1
3020
控制器
3014
3012.2
到探测器
3006.2
到探测器

图 31

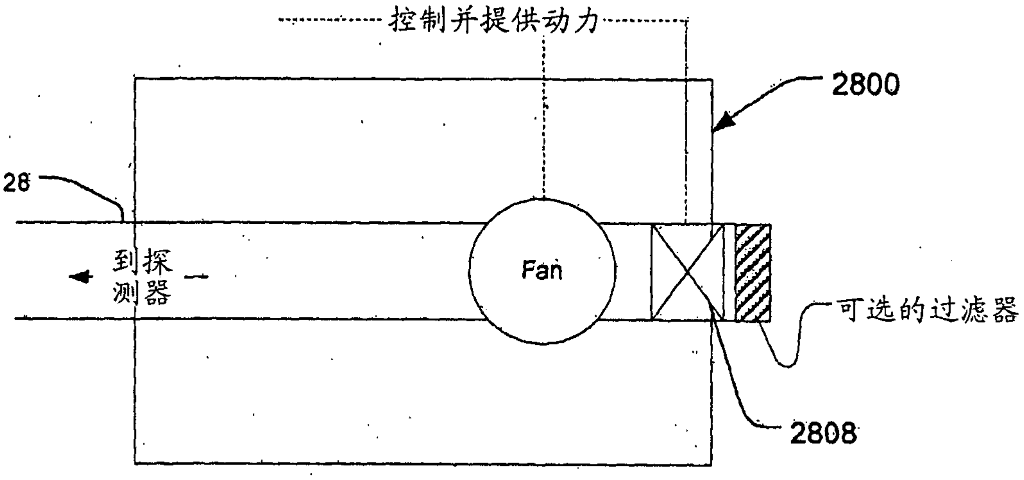

控制并提供动力
2800
28
到探测器
Fan
可选的过滤器
2808

图 32

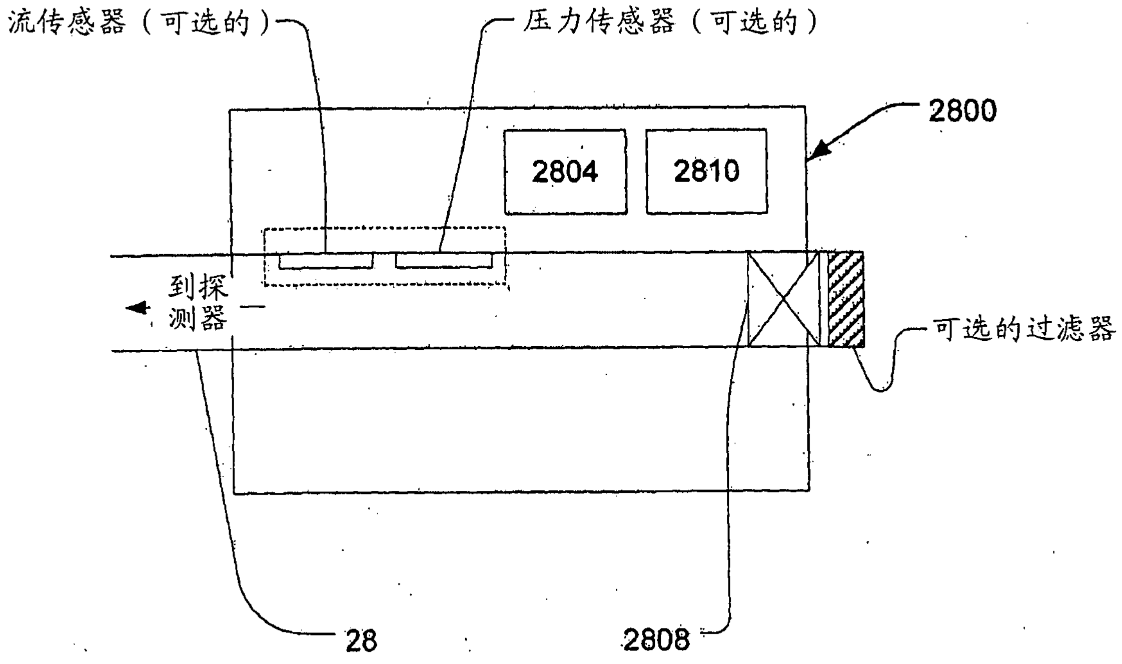

流传感器（可选的）
压力传感器（可选的）
2800
2804
2810
到探测器
可选的过滤器
28
2808

图 33

Abstract:

A method of determining at least one point of entry of smoke into a smoke detection system, the system having a sampling pipe network including at least one sampling pipe and a plurality of sampling inlets through which an air sample can enter the at least one sampling pipe of the smoke detection system for analysis by a particle detector, said method including: determining a volume of sample air that has passed through at least part of the smoke detection system since a predetermined event or a value corresponding to said volume; and determining through which sampling inlet of the plurality of sampling inlets the smoke entered the smoke detection system based, at least in part, on the determined volume or value. Systems for implementing such a method and related methods are also described.